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APPLICATION OF TELEMATIC SYSTEM FOR DIAGNOSING THE MACHINE TECHNICAL STATE

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Abstract

The necessity of rationalization of construction machine operation and maintenance processes results in development of computer diagnostic systems. Use of diagnostic systems in operation and maintenance of machines is conditioned by the accepted strategy of operation. The current method of operation with a view of the Resurs is characterized by: set the assigned operating area specific use, implementation of the agreed duration of maintenance, prioritization of maintenance. Dates and ranges of maintenance adopted in the implementation of this strategy are fixed, based on the results of years of research supplies and are independent of the state of the machine. Prioritize ongoing maintenance and repair means that the service or repair of higher-order includes the following ranges of operation, lower maintenance row. In this work there has been made an attempt to evaluate the level of threat connected with failure to perform a transport task by a technical object. Data for the assessment was obtained on the basis of information collected from used telematic systems diagnosing continuously the state of tested technical objects. In this work there has been made a survey of normalized risk assessments methods. On this basis, FMEA method has been used for risk assessment connected with failure to perform a task by the analyzed objects.

Keywords: *road transport, risk, safety*

1. Introduction

The necessity of rationalization of construction machines operation involves the need of development of diagnostic computer systems. Application of diagnostic equipment for machine operation is conditioned only by the accepted operation strategy [1-5].

The presently used operation method is characterized due to service life in the following way:

– established range of servicing activities assigned to a given service,
– periodicity of performed repairs and services,
– hierarchic organization of repairs and services.

Terms and ranges of scheduled repairs and services are fixed in this strategy, scheduled on the basis of long-term results of experimental tests, and do not depend on the machine technical state.

Hierarchic structure of the scheduled services and repairs means that the repair and service of more significance consists of services and repairs of less significance. The main disadvantage of this strategy is the necessity of performance of services and repairs of machines, which happen to be in different technical states, within a range of fixed terms [6].

The accepted strategy facilitates the process of operation and maintenance, but in reality, it generates high costs of the service subsystem maintenance – technical services. It justifies the change of the so far existing strategy for a new strategy based on the machine technical state. The new strategy involves the necessity of the machine technical state diagnosis and assessment before each servicing, which significantly increases the role of diagnostics in the system of operation and maintenance. However, the decision about handling the object during performance of servicing activities –repairs, is made on the basis of diagnostic tests results.

2. The Research Thesis and Object

There is a possibility to assess a carrier technical state on the basis of diagnostic information about the vehicle damage, provided by the system of deck diagnostics.

The purpose of this work, in an analysis and assessment of the technical state of carriers used for construction of freewayA1, is Nowe Marzy – Czerniewice section.

3. The Research Subject and Object

The research object are articulated vehicles (the so called carriers) of one of the leaders on the automobile market, these vehicles are used for carrying loose material, such as grave or, sand, in difficult or extreme conditions, without the necessity to travel long distances. In the place where rigid frame carriers and trucks have to travel long distances risking bogging down, an articulated carrier should work safely and without disturbance, travelling the distance between the place of loading and unloading in the shortest possible way. The application of a rotary joint, enabling independent mobility of the front part and the loading box, reduces torsion stresses in the frame while working in the open area. It causes that even a fully loaded machine is easy to drive as all the wheels are in continuous contact with the base.

The research subject is an assessment of the risk connected with failure to perform the assigned task due to the vehicle damage. Such an assessment is possible thanks to application of deck diagnostic equipment. A scheme of information exchange between the vehicle and the servicing system has been presented in Fig. 1.

Functions of the described system have been divided into three basic groups [7]:

– positioning on the map and monitoring of machines,
– preparation of reports on the operation,
– management of machines technical servicing.

Thanks to the first of the above listed function groups it is possible to monitor all the machines equipped with the system of deck diagnostics and define their localization in a real time - Fig. 2 provides an example of the vehicle position monitoring.

The diagnostic system makes it also possible to obtain, from the map, the following information:

– total number of hours,
– estimated number of working-hours yearly,

– state – whether the engine is running,
– localization of a selected machine by means of the address or geographic coordinates.

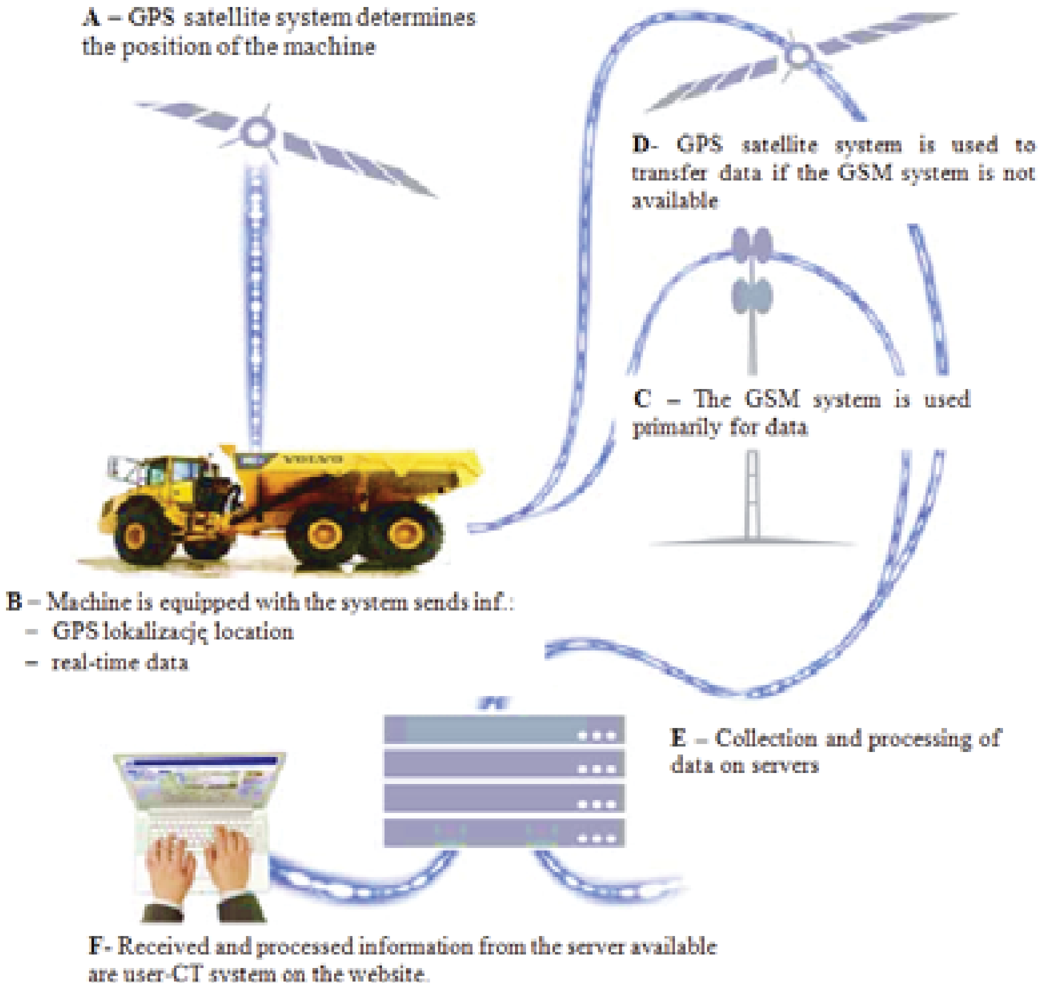

Fig. 1. Scheme of the telematics system functioning and circulation of information within this system

Fig. 2. Establishing the position of a selected vehicle with the use of a telematics diagnostic system

The system, from the level of map, allows setting the zone of work for each machine (Geofence) and the time zone (Timefence – Fig. 3). This provides the user with the possibility to control the machine time and place according to the assigned geographic and time zone. If the machine operator crosses one of the zones, the system user will be notified of this event and an e-mail or text message will be automatically generated. This function is an important tool to be used for prevention from the machine unauthorized operating, which seems to be especially useful for companies, which dispose of sophisticated machines or rent machines of this type.

Fig. 3. Schedule of utilization of a given machine within a defined period of time

The reports on the machine state provide a possibility to monitor the technical state of machines, as well as current level of the fuel. The users can generate themselves a report for the last 125 days in format XLS or PDF.

The information on the subject of the fuel level is of great significance for the process of planning the zones for the machine refuelling and servicing. The system is very simple and clearly shows which machine needs immediate refuelling. The customer has also an insight into operation reports (Fig. 4) allowing controlling and comparing actually worked hours and the used fuel with the operator's reports. The report provides data on:

- actual use of fuel per one working hour,
- total number of hours worked by the machine in a given time with a division into:
  - work with the engine and hydraulic function on (effective),
  - work with the engine on and hydraulic function off (ineffective).

As it can be seen, the system has many different functions which enable an efficient assessment of the utilization level of a particular machine or groups of machines and in consequence their more efficient and effective use for performance of a given construction project. The last group of available functions includes management of technical servicing. This enables an insight into the following recorded events:

- alarm,
- error code,
- history (possibility of editing the registered alarms and codes),
- the machine operation plan,
- notifications.

Fig. 4. Exemplary report on the machine operation

The system will inform the user about each alarm which has appeared of a display in the operator’s cabin. The alarm is generated automatically by the system if a given sensor starts recording operation within the boundary values of parameters. The error code is generated in case of exceeding a given parameter boundary value. The system automatically sends information about the registered code of the error to the authorized service assigned to it by the system.

4. Experimental tests

The experimental tests involved collecting information on the subject of the vehicles technical state in the conditions of real work. The data was recorded by means of the studied telematics system installed in articulated carriers Volvo A40E. Machines were used in the site of A-1 freeway construction, Nowe Marzy –Czerniewice. Tests were performed on the machines of the type A40E selected randomly from the whole population of 50 machines. These machines were tested during four months, from 01.03.2011 to 31.07.2011. The selected group of machines and the period of testing are reliable and enable an analysis of threats during the period of the most intensive work, at A-1 freeway construction site. In Tab. 1, there is a list of tested vehicles.

Each control unit has an integrated internal diagnostic program, which monitors the subordinate electronic system. Summing up, the monitoring is performed in three main areas:
- internal, monitoring of the control unit. E.g. auto-test detecting errors in the memory circuit,
- control of external data bus communication. E.g. error of the data bus,
- control of the entrance and exit time to/from electrical units, e.g. control of sensors, cols, control valves.

Once an error is detected its code and generated. The error code is created according to norm SAE J1587. SAE standard has been set by the Society of Automotive Engineers. J1587 is n automotive diagnostic protocol for data transmission, developed by SAE, used mainly in heavy vehicles and construction machines. It is mainly used by producers of American machines – vehicles in Europe by Volvo concern. An important feature of the system is application of a 6-stem connector. Coded according to norm SAEJ1587 is being performed in the following way:

MID (Message Identification Description) – informs what kind of control modem (ECU) generated the error. Modules are identified in the following way:
- MID128 – E-ECU module of the drive unit control and steering,

Tab. 1. Presentation of the tested vehicles

No.	Model	Serial No.	Production date	State of the counter 31-07-2011
1	A40E	A40E012531	2009-07-06	3931
2	A40E	A40E012575	2009-04-01	3977
3	A40E	A40E012578	2009-04-15	4355
4	A40E	A40E012609	2009-07-01	4193
5	A40E	A40E012610	2009-06-02	3634
6	A40E	A40E012612	2009-06-03	3971
7	A40E	A40E012613	2009-06-08	3641
8	A40E	A40E012614	2009-06-08	4250
9	A40E	A40E012615	2009-06-09	4360
10	A40E	A40E012617	2009-06-10	4067
11	A40E	A40E012618	2009-06-12	4109
12	A40E	A40E012623	2009-07-08	3857
13	A40E	A40E012624	2009-06-29	3761
14	A40E	A40E012626	2009-06-29	3552
15	A40E	A40E012627	2009-08-08	3911
16	A40E	A40E012629	2009-06-24	3779

- MID130 – T-ECU module of steering control,
- MID140 – I-ECU module of control – display,
- MID142 – C-ECU module of CT system control,
- MID187 – V-ECU module of vehicle control.

The next step of the error code generation is identification which component – parameter of the system, generated the error.

- PID (Parameter Identification Description),
- PPID (Proprietary Parameter Identification Description),
- SID (Subsystem Identification Description by component).

All these codes of failures recorded by system CT, in the period from 01-03-2011 do 31-07-2011, are presented in Tab. 2.

5. Assessment of the Risk of Failure to Perform the Task by Particular Groups of Vehicles

In result of the analysis of selected risk assessment methods used in land transportation of hazardous materials the method chosen for tests was FMFA method. This method is simple and universal and it enables precise projection of assessment of the risk likely to occur in transit of hazardous materials. MFEA method involves determination of probability of occurrence of traffic rules violations and their effects, in relation to the analyzed categories presented in this section. Assessment of risk by FMEA method, according to the need, is made more or less thoroughly and is performed through determination risk R-value, according to formula (1).

$$R = P \cdot W \cdot Z, \tag{1}$$

where:

R – overall assessment of risk (connected with occurrence of violations),

P – index of occurrence of violations taking into consideration the probability of occurrence of violations whose value refers to assessment of probability of traffic rules violation, from slight to very probable,

Tab. 2. Presentation of the tested vehicles recorded failures

MID	TYPE	PID	FMI	Serial no.	Number of events	MID	TYPE	PID	FMI	Serial no.	Number of events
130	PID	161	11	A40E012575	1					A40E012617	
142	PSID	6	12	A40E012575	8					A40E012617	
142	PSID	200	12	A40E012575	1					A40E012617	
187	PID	70	9	A40E012575	5					A40E012618	
187	SID	256	0	A40E012575	1					A40E012618	
187	SID	256	3	A40E012575	1					A40E012618	
128	PID	97	3	A40E012578	1					A40E012629	
128	PID	111	1	A40E012578	8					A40E012629	
142	PSID	6	12	A40E012578	2					A40E012629	
187	PID	70	9	A40E012578	265					A40E012624	
187	SID	256	14	A40E012578	1					A40E012624	
187	PID	98	1	A40E012578	14					A40E012626	
128	PSID	6	12	A40E012610	1					A40E012626	
142	PID	70	9	A40E012610	5					A40E012609	
187	SID	256	3	A40E012610	1					A40E012609	
187	PID	70	9	A40E012610	70					A40E012609	
187	PID	112	3	A40E012612	1					A40E012609	
187	PSID	6	12	A40E012612	162					A40E012609	
142	PSID	200	12	A40E012613	2					A40E012609	
142	PSID	6	12	A40E012614	3					A40E012609	
142	PID	70	9	A40E012613	17					A40E012609	
187	PID	70	9	A40E012614	1					A40E012609	
187	PID	111	1	A40E012615	239					A40E012609	
128	PID	127	11	A40E012615	1					A40E012609	
130	PSID	6	12	A40E012615	17					A40E012609	
142	PID	70	9	A40E012615	1					A40E012531	
187	PID	236	15	A40E012615	1					A40E012531	
187	PID	284	5	A40E012615	1					A40E012531	
187	PID	26	3	A40E012615	1					A40E012623	
187	SID	235	6	A40E012615	1					A40E012623	
128	PID	111	1	A40E012617	5					A40E012623	

W – index of the violation detectability whose value is determined on the basis of probability of detecting the violation by a driver,

Z – index of the violation effects (significance of error) defines probability of loss in effect of its occurrence.

Efficient functioning of the systems (production and transport) depends on serviceability of machines used in a given process, therefore, the authors of this paper have made an attempt to assess the influence of damage to the selected subsystems of the analyzed vehicles on the risk connected with failure to perform a task. In Fig. 5, there are results of the carried out risk assessment.

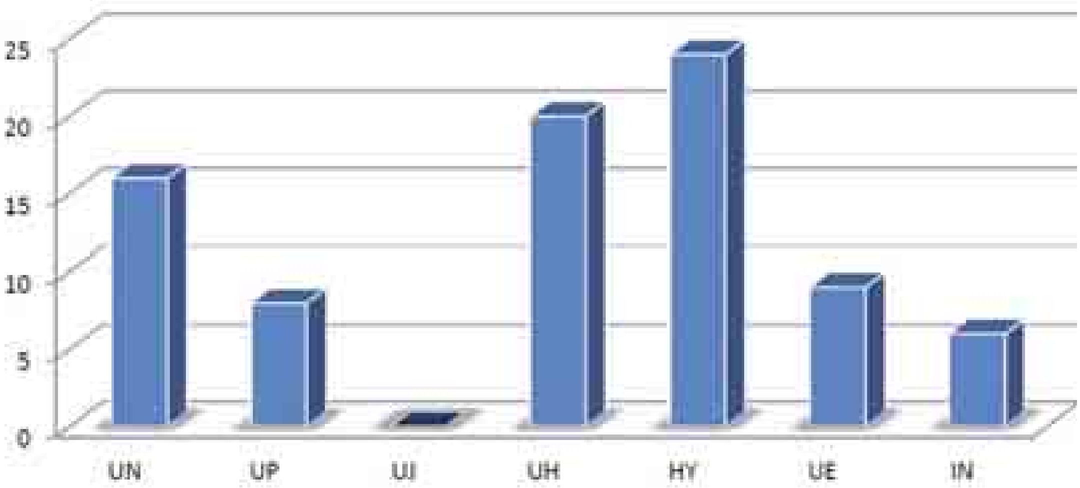

Fig. 5. Value of assessment of the risk degree connected with failure to perform a task by vehicles produced in April, 2009, UN – power transmission system, UP – driving system, UJ – wheel system, UH – braking system, HY – hydraulic system, UE – electrical system, IN – other systems

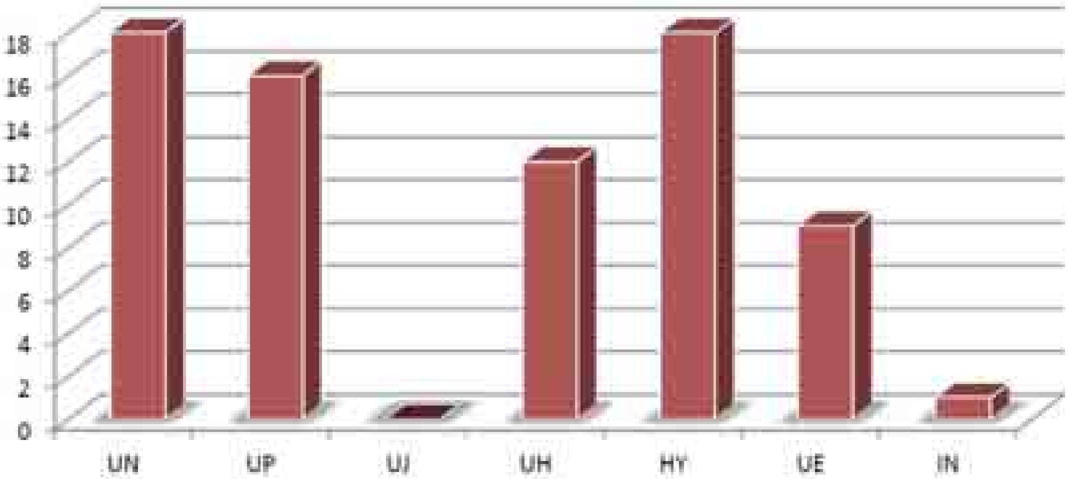

Fig. 6. Value of the assessment of risk connected with failure to perform an assigned task by vehicles produced in June 2009, UN – power transmission system, UP – driving system, UJ – wheel system, UH – braking system, HY – hydraulic system, UE – electrical system, IN – other systems

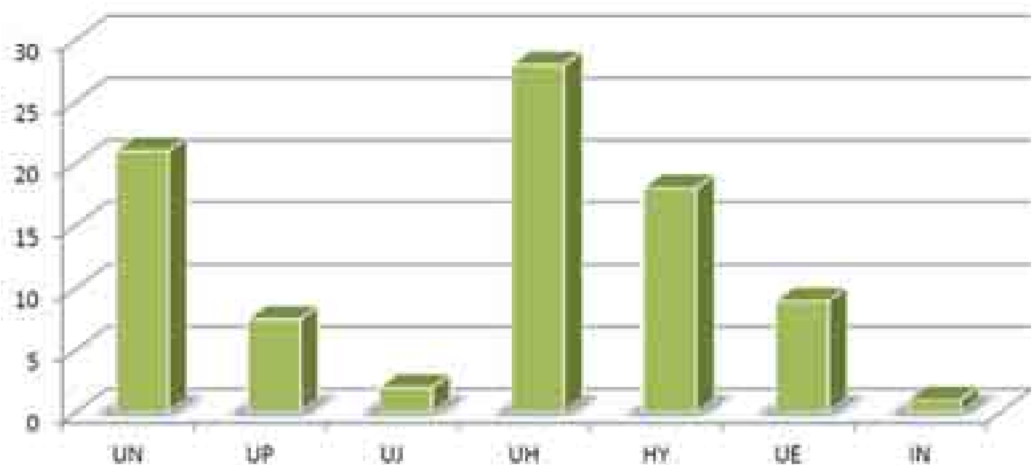

Fig. 7. Value of the assessment of risk connected with failure to perform an assigned task by vehicles produced in July 2009, UN – power transmission system, UP – driving system, UJ – wheel system, UH – braking system, HY – hydraulic system, UE – electrical system, IN – other systems

6. Conclusions

The most frequently recorded undesirable event is the error of a parking brake switch-key. The high value of risk connected with the failure was a large number of recorded undesirable events for three of thirteen machines, which reported the event. The registered errors do not play an important role, as they do not affect the machine proper operation. In order to increase operation safety, the design of the breaking system and power transmission system does not make it possible to continue riding in the event of a real failure of the parking brake switch. The main cause of the error code generation is improper operation of the machine by its operator, which involves triggering the ride in a gearbox selector without an earlier release of the parking brake.

For the hydraulic system, the most often recorded undesirable events appeared to be messages informing on a low level of oil. In each of the tested machines there were recorded, on average, 10 events of the type: 'low level of hydraulic oil'. The main cause of the failure may be a leak of oil from the hydraulic system in result of damage to rubber conduits, servomotors, or pumps, installed in the hydraulic system. As the tank of hydraulic oil may contain 245 litters, the leaks may pose a threat to the environment or lead to the pump seizing.

References

[1] Dziubak, T., Piętak, A., Trawiński, G., *Diagnostyczny Komputer Wozu Bojowego,* XXVII Ogólnopolskie Sympozium Diagnostyka Maszyn, Węgierska Górka 2000.

[2] Niziński, S., Pelc, H., *Diagnostyka urządzeń mechanicznych,* WNT, Warszawa 1980.

[3] Niziński, S., Ligier, K., *Problemy Diagnostyki Urządzeń Technicznych*, XXVII Ogólnopolskie Sympozium Diagnostyka Maszyn*,* Węgierska Górka 2000.

[4] Woropay, M., *Podstawy racjonalnej eksploatacji maszyn*, Wydawnictwo Instytutu Technologii Eksploatacji, Radom 1998.

[5] Woropay, M., Landowski, B., Neubauer, A., *Sterowanie niezawodnością w systemach transportowych,* Instytut Technologii Eksploatacji, Bydgoszcz - Radom 2006.

[6] Woropay, M., *Metoda oceny realizacji procesu eksploatacji w systemie transportowym*, Biblioteka Problemów Eksploatacji*,* Wydawnictwo Instytutu Technologii Eksploatacji, Radom 1998.

[7] Volvo CE, *Care Track - materiały marketingowe,* Eskilstuna, 2010.