The article presents a variety of the meanings of an object state term (notion), depending on the point of view at which it is discussed. Each of the presented meanings can constitute an identification subject in contemporary operational states. The first of these meanings is a structural state of an object. It refers to the number of the elements active in a given set and the interactions between them. Another equally important meaning is a technical state, which can be identified on the basis of both the evaluation of physical features or the correctness of the functioning of an object’s constituent elements. The operational state of an object depends on both the state of the structure and the technical state. It is the third meaning of the term of an object state. The principles of classification within all three groups of the meaning of the object state term and mutual connections between them are shown in this article.

Keywords: rail vehicles, technical operation, maintenance, technical state, operational state, classification of technical states, classification of operational states

1. INTRODUCTION

Rail vehicles constitute a specific group of technical objects which are operated by institutional users. The vehicles must fulfil a range of requirements included in international and state regulations which refer to both the security of operation and the technical-economic conditions of their operation. It results in the necessity of controlling many features of the vehicles, and then after the evaluation of the results of these checkups, adequate decisions have to be made. With a great number of features which have to be checked up, it is necessary to use proper computer aiding systems. Then, however, the need for a precise defining and describing indi-
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individual classes of rail vehicles states in a formal way arises. The problem of classification of the vehicle’s states, including technical states, is considered in many professional publications. In the case of simple devices, it can be already noticed in [2] that “the most frequently used classification is the two-state usability classification”. The author distinguishes the work usability state of a given device and the work non-usability state. Other authors consider the issues connected with the occurrence of failure states in objects [7] or damage [12] as opposed to the normal state, or the positive and negative technical state class [15].

Technical state classifications which refer to various objects are included, for instance, in [1, 8, 16], and for the land vehicles in, for instance, [3, 4, 6, 9, 10]. In the latter classifications, the division of evaluated vehicle features into the primary and secondary ones is the most frequently used. Unlike that, the classification in [5] considers the car’s capability of performing tasks as a criterion for distinguishing car technical states. It also distinguishes the states of complete (full) usability, partial (incomplete) usability, the state of incomplete task usability, and the state of complete (full) non-usability. These states are equated with the reliability states of a car. Taking into account the existing propositions, another approach to the meaning of the term object’s state is proposed in this article.

2. THE MEANINGS OF THE TERM OBJECT’S STATE

The term of the object’s state is usually equated in the literature with its technical meaning referring to the specific qualities of this object. As, for instance, in [10] where it is noticed that: “At each moment $t \in T$, the object is in one of the possible states $w(t)$ creating the set $W$, where $T$ is a set of moments at which the object’s functioning is considered. As a consequence, starting from the fact that “The state of the system should be understood as a sequence of instantaneous values of the state changing parameters. This sequence expresses the system features (properties) which are considered significant for a given problem and which clearly exist in a mathematical description of the system model”, one can define the term of the technical object’s state. This term “can be shown as an ordered sequence of the numerical values of the state variables $x_i(t) (i = 1, 2, \ldots, m)$, and it can be treated as the state vector:

$$W(t) = [x_1(t), x_2(t), \ldots, x_m(t)]$$

(1)

A such defined term of the object’s state is sufficient in operational systems in which the checkup, analytical-evaluating, and decision functions were carried out by a human. However, if there is a tendency of using modern engineering achievements in the process of vehicle operation management then other meanings of this term need to be determined.
Currently, three basic groups of the term “object’s state” meanings in the process of vehicle operation can be distinguished. These meanings are connected with:
- the inner structure of the object’s component elements,
- the fit-for-use certification of the object’s operation,
- the position of the object in the operation system.

The first of these meanings refers to the structure of the connections of the object’s component elements; the second one refers to the properties of these elements; and the third one to the organisational aspect of the vehicle operation. Respectively to that but in a different way, three distinctly different meanings which characterize the vehicle can be defined. They are the state classes:
- structural,
- technical,
- operational.

The individual states of the vehicle which belong to each of these classes can be identified on the basis of separate criteria. That is: the structural states can be identified on the basis of the quantity of the object’s elements and the scheme of relations between them; the technical state – on the basis of physical and reliability criteria; and the operational state – on the basis of the position criterion, which is understood as belonging to the specific subsystem of the operational system. Dependences which occur between the states belonging to the listed classes are shown in Fig. 1.

![Fig. 1. Sets of the object’s states and the relations between them](image-url)

A direct interaction is between structural and technical states of the object. Both, the technical state can influence the object’s structure (e.g. in the case when the imperfection appears), and the improper structure can be the reason for the occurrence of certain imperfections.

A different type of dependence is between the technical and operational states. Individual operational states should result from the current technical condition of the vehicle, which can be influenced by the current structural state of the vehicle’s systems. Depending on this technical state described during diagnostic tests, a decision about using or operating the vehicle can be made. Changes of the technical state and the structural state of the vehicle can be treated as natural consequences of the operation processes, i.e. using and maintaining. However, as far as a decision aspect is concerned, there is only a one-way relation.
In the case of vehicles, the distinguishing of individual meanings of the term state is useful for modern on-board and external control systems. The control/steering and diagnostic systems are capable of controlling the presence or the lack of the specified vehicle’s elements and monitoring the technical state of important elements and subsystems. Moreover, the locating systems can identify the location of individual vehicles. The data from these systems facilitate rational control of the operation of vehicles owned by a given firm.

3. STRUCTURAL STATES AND THEIR CLASSIFICATION

A rail vehicle, like other complex technical objects, is a set of elements which can be marked with adequate unique identifiers, e.g. numbers. It then allows for the formal defining of a rail vehicle or its systems as a non-void set of purposefully ordered co-operating elements intended to fulfil practical functions which have been planned for them. Such an object can be written in a formal way as follows [13]:

\[
E = \{e_i : i \in N \land 1 \leq i \leq k\}
\]

where \(E\) the rail vehicle as a diagnostics object, \(e_i\) the vehicle’s elements, \(i\) the identifier, \(N\) a set of natural numbers, \(k\) the number of the vehicle’s distinguished elements.

There are various connections between the elements of the vehicle. They can show as the transfer of mechanical energy, a liquid flow, gas flow, or an electric current flow. In this way, the structure of the vehicle is created where a certain element is the first one and other elements follow this one. It can be thus stated that in the vehicle, there are ordering relations \(R_{il}\) which depict mutual functional connections between the vehicle’s individual elements. These relations can be written in the following way:

\[
R_{il} = \{\forall i, l \leq k, \exists e_i, e_l \in E (e_i \prec e_l)\}
\]

where \(i, l\) identifiers \((i, l) \leq k\), \(\prec\) the operator of the relation “precede”.

In the case of numerous complex objects, there is a finite number of the work phases of this object. The individual phases can be characterized by the fact that in every phase a different number of elements of a given object can co-operate and they can create diverse structures of mutual interactions, i.e. functional structures.

Simplified schematics of the subsystems which constitute the pneumatic part of the rail vehicle brake system are examples of a change in connections between elements in the individual phases of the object’s work and the changes caused by appearing imperfections (Fig. 2).
For this object, one can distinguish the filling phase with a system of connections between its subsystems as in scheme (a), the braking phase (b), and brake release and running with the connections shown in scheme (c). The senses on the vectors marked with the dotted lines mean the direction of a possible air flow due to the untightness of the adequate valves in the brake system controller. These imperfections change both the connections between the subsystems and the amount of the subsystems active in a given phase of the system’s work.

It can be generally stated that if in the individual phases of the object’s work a determined subset of elements from the set $E$ can co-operate, then, with the finite number $f$ of the work phases, it means that:

$$E_1 \subset E \land E_2 \subset E \land \ldots \land E_f \subset E$$  \hspace{1cm} (4)

4. TECHNICAL STATES AND THEIR CLASSIFICATION

A rail vehicle is a complex technical object whose technical state results from the properties of its component elements. These properties are evaluated on the basis of the internal structure features which can change during operation according to various creating functions characteristic for the determined conditions of the vehicle’s work. The values of these functions depend on the generalized time of the vehicle’s work, i.e. the mileage in kilometres or the time of work given in motor-hours. The characteristic of the creating function is strongly dependent on the conditions of work of a given rail vehicle. Assuming a vector interpretation of the technical state, it can be determined that the technical state of the rail vehicle is its property determined by the vector of the internal structure features, i.e.:
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\[ X(t,a) = [x_1[f_{1,a}(t)], x_2[f_{2,a}(t)], \ldots, x_n[f_{n,a}(t)]] \]  (5)

where \( X(t,a) \) the vector of the technical state after the period of operation \( t \) in the operational conditions \( a \), \( x_i \) the \( i \)-th feature of the internal structure of the rail vehicle, \( f_{i,a} \) the creating function for the feature \( x_i \) in the operational conditions \( a \), \( t \) the time of operation (mileage).

In most cases, carrying out the measurements of the internal structure feature values is impossible. That is why in the technical diagnostics, the output features, i.e. the features of work and of accompanying processes are used in order to avoid the dismantling of rail vehicles. Like in the case of the internal structure features, the two mentioned types of the output features are most frequently dependant on the conditions and time of the object’s operation. Thus, two vectors can be created:

\[ R(t,a) = [r_1[\psi_{1,a}(t)], r_2[\psi_{2,a}(t)], \ldots, r_n[\psi_{n,a}(t)]] \]  (6)

\[ Q(t,a) = [q_1[\zeta_{1,a}(t)], q_2[\zeta_{2,a}(t)], \ldots, q_n[\zeta_{n,a}(t)]] \]  (7)

where \( R(t,a) \) the vector of the work processes’ features, \( Q(t,a) \) the vector of the accompanying processes’ features, \( \psi_{i,a} \) the creating function for the feature \( r_i \) in the operation conditions \( a \), \( \zeta_{i,a} \) the creating function for the feature \( q_i \) in the operation conditions \( a, u, v \) identifiers.

For the evaluation of the vehicle technical state, only certain, especially easily measurable subsets of work features, accompanying features, and the internal structure features are taken into account (Fig. 3).

Fig. 3. A rail vehicle as the technical object \( E \) and the vectors which characterize it: the vectors of the internal structure features \( X(t,a) \), the work processes vector \( R(t,a) \), the accompanying processes vector \( Q(t,a) \).
After accepting a common labelling for them, the vector $Y(t,a)$ of the diagnostic features which identify the vehicle’s technical state can be written in this form:

$$Y(t,a) = [y_1[\varphi_{1,a}(t)], y_2[\varphi_{2,a}(t)], \ldots, y_p[\varphi_{p,a}(t)]]$$

(8)

where $\varphi_{i,a}$ the creating function for the feature $y_i$ in the operation conditions $a$, $p$ the identifier.

The system of rail vehicles’ operation which exists in practice entitles the engineers to divide the diagnostic features into three sets: a set of movement safety features (vector $Y_b$) and the sets of features which characterize the basic (vector $Y_z$) and auxiliary functions fulfilled by the vehicle (vector $Y_d$).

The boundary values of the safety features are the subject to special regulations obligatory to all users of a given railway net. For each feature, one or more ranges of boundary values can be determined. With more than one range, a shift from one to another range is however connected with certain conditions which limit the maximum speed of the rail vehicle. For the remaining features, the boundary values are not determined in such a way. If there are certain boundary values of the primary and secondary features then their exceeding does not need to connect with movement limitations or instant withdrawing of the vehicle from operation. Safety feature sets, usability function sets, and auxiliary function sets are in fact three groups of criteria. On the basis of these criteria, the classes of the technical states important for the process of rail vehicle operation can be distinguished. In the formal definitions of the certain state classes, a rising or decreasing tendency of the value changes of the determined features during operation should be taken into account.

The simplest form for the identification of the rail vehicle technical state class can be described for the situation in which each diagnostic feature significant from the technical point of view does not exceed the first range of the boundary values. The rail vehicle may be then used without any limitations and it is commonly described as the usability state $S_z$:

$$S_z \iff Y^1 = \{y_i : \forall_i (y_i)_{\min} \leq y_i \leq (y_i)_{\max}\}$$

(9)

where $(y_i)_{\min}$, $(y_i)_{\max}$ the boundary values of any diagnostic feature $y_i$, $Y^1$ the vector of the diagnostic features in the usability space.

The occurrence of the conditional usability states depends exclusively on the values of the safety features; the number of these states depends on the number of the ranges of the values mentioned in the relevant regulations. For two ranges of values, the conditional usability state $S_{zw}$ can be defined. It will take place when any feature from the set of the safety features is found in the second range of permissible values, which will require, for instance, the limitation of the maximum speed to $v_{g1} [\text{km/h}]$:
\[ \forall v \leq v_{g1} S_{zw1} \iff Y_b^2 = \left\{ y_h : \exists i \in I_1 \left( \begin{array}{c}
(y_h)_{\min1} < (y_h)_{\max1} = (y_h)_{\min2} < y_h \\
(y_h)_{\max2} < (y_h)_{\max1} \vee (y_h)_{\min1} = (y_h)_{\max2} \\
y_h > (y_h)_{\min2} \end{array} \right) \right\} \quad (10) \]

where \( Y_b^2 \) the vector of the safety features in the first space of the conditional usability, \( (y_h)_{...} \) the boundary values of the safety features for the first and the second ranges of values, \( i \in I_1 \) the index of the values that limit the maximum speed of the rail vehicle to \( v_{g1} \) [km/h].

With three ranges of the values of certain safety features, the conditional usability state \( S_{zw2} \) will occur when any feature from the set of the safety values will be in the third range of the acceptable values. This range requires the limitation of the vehicle maximum speed \( v_{g2} \) [km/h]:

\[ \forall v \leq v_{g2} S_{zw2} \iff Y_b^3 = \left\{ y_h : \exists i \in I_2 \left( \begin{array}{c}
(y_h)_{\min1} < (y_h)_{\max1} = (y_h)_{\min2} < y_h \\
(y_h)_{\max2} = (y_h)_{\min3} < y_h < (y_h)_{\max3} \vee (y_h)_{\max1} > (y_h)_{\min1} = (y_h)_{\max2} \\
y_h > (y_h)_{\min2} = (y_h)_{\max3} > y_h > (y_h)_{\min3} \end{array} \right) \right\} \quad (11) \]

where \( Y_b^3 \) the safety feature vector in the second space of the conditional usability, \( (y_h)_{...} \) the boundary values of the safety features for the first, second, and third ranges, \( i \in I_2 \) the index of the features limiting the maximum speed of the rail vehicle to \( v_{g2} \) [km/h].

If the basic features have two ranges of values determined by the ordered three boundary values then the state of the partial usability \( S_{npz} \) can be distinguished. In this state, any basic feature exceeds the middle value that belongs to these three values. Then, the state of the partial usability can be defined as follows:

\[ S_{npz} \iff Y_z^2 = \left\{ y_z : \exists j \left( \begin{array}{c}
(y_z)_{\dep} < y_z < (y_z)_{\min} < (y_z)_{\max} \vee (y_z)_{\dep} > y_z > (y_z)_{\min} > (y_z)_{\max} \end{array} \right) \right\} \quad (12) \]

where \( Y_z^2 \) the vector of the basic features in the partial usability space, \( (y_z)_{...} \) the boundary values of the basic features (maximum, minimum, and permissible).

For the case when an auxiliary (secondary) feature exceeds one of the boundary values (minimum or maximum, depending on the trend of the changes of this value), the state of the incomplete usability of the rail vehicle \( S_{ncz} \) can be defined:
where $\mathbf{Y}_d^1$ the vector of the secondary features in the space of the incomplete usability, $(y_{d_i})$ the boundary values of the secondary features.

The non-usability state of the rail vehicle $S_{nz}$ is a result of exceeding one of the extreme boundary values by any basic feature or safety feature. If we assume that for the safety features the acceptable value is the maximum $(y_{b_i})_{dop_{max}}$ or minimum $(y_{b_i})_{dop_{min}}$ value of the last value range (the second one with the two ranges and the third one with three ranges) then the formula that defines this technical state can be described in the following way:

$$S_{nz} \Leftrightarrow \mathbf{Y}_0^b \lor \mathbf{Y}_0^s = \left\{ y_i : \exists y_i \left[ \begin{array}{l} y_i < (y_{z_i})_{dop} < (y_{z_i})_{min} < (y_{z_i})_{max} \\
(\exists y_i \left[ y_i > (y_{z_i})_{dop} > (y_{z_i})_{max} > (y_{z_i})_{min} \right) \\
(\exists y_i \left[ y_i > (y_{b_i})_{dop_{max}} \lor y_i < (y_{b_i})_{dop_{min}} \right) \right] \right\}$$

where $\mathbf{Y}_0^b$ the vector of basic features in the non-usability space, $\mathbf{Y}_0^s$ the vector of the safety features in the non-usability space, $(y_{b_i})_{dop_{max}}$ the maximum value of the last range of values with the growing trend of the safety feature changes, $(y_{b_i})_{dop_{min}}$ the minimum value of the last range of values with the decreasing trend of the safety feature changes.

Shifts between the rail vehicle technical states which are defined by the formulas (9)÷(14) are illustrated in Fig. 4, and the compilation of these states is included in Fig. 5.

Fig. 4. Graph of walks for the distinguished technical states with reference to: a) safety criterion, b) the criterion of the usability functions, c) the criterion of the auxiliary functions
Fig. 5. The classification of the technical states for the usability system of rail vehicles

This classification of technical states for vehicles which are in the maintenance system is insufficient. In vehicles which are maintained, there is often a necessity of the localization of the imperfections of the component elements in their complex arrangements. It requires formulating a separate classification of the technical states. This classification is useful for the process of imperfection localization.

Taking the definition of the object given in the formula (2) and the fact that each element can show the imperfection of only one type and there is no limitation to the number of simultaneously occurring imperfections, then the set of possible situations will be equipotent with the power set $2^E$ of the set $E$:

$$2^E = \left\{ \emptyset, \{e_1\}, \{e_2\},...,\{e_k\}, \{e_1, e_2\},...,\{e_1, e_2, ..., e_k\},...,\{e_{k-1}, e_k\},...,\{e_1, e_2, ..., e_k\} \right\}$$ (15)

where $\emptyset$ the empty set (the elements of the vehicle do not show imperfections).

Each of the subset of the set $2^E$ can be treated as a separate technical state according to the assigning:

$$\emptyset \rightarrow S_0, \{e_1\} \rightarrow S_1, \{e_2\} \rightarrow S_2,...,\{e_k\} \rightarrow S_k,...,\{e_1, e_2, ..., e_k\} \rightarrow S_{l_k-1}$$ (16)

in which $S_0$ the usability state of the object, $S_1, S_2,...,S_{l_k-1}$ the non-usability states of the object.

As a result, the full set of the technical states $SP$ of this object can be written as:

$$SP = \{S_0, S_1, S_2,...,S_k,...,S_{l_k-1}\}$$ (17)

where $l_k = 2^k$ – the number of the subsets of the set $2^E$. 
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The type of the imperfections of the individual elements of the vehicle can constitute an additional criterion of the classification. If for every single element more than one type of imperfections can be observed [14] then with the $m$ types of them the set of the states $SPM$ will have the following form:

$$SPM = \{S_0, S_1, \ldots, S_m, \ldots, S_{km+m+1}, \ldots, S_{k+1} \}$$

in which $l_m = (m + 1)^k$ the number of the states equal to the number of the $k$-term variations with repetitions from the set $m + 1$ elements.

To sum up, the classification of the technical states of the complex systems intended for the system of maintaining the rail vehicles can be shown in a graphical way in Fig. 6.

![Diagram](image)

Fig. 6. The classification of the technical states of the rail vehicle for the maintaining system
Formal distinguishing of the sets of the technical states as in dependences (17) and (18) has a great significance for the process of the automatic localization of the imperfections of the object’s elements. Distinguishing the individual technical states can be realized when there is a possibility to determine a unique dependence between each appearing imperfection of the element and the diagnostic features of the system. However, it frequently requires the application of a multi-valued evaluation of these features.

5. OPERATIONAL STATES AND THEIR CLASSIFICATION

Each rail vehicle can stay in the subsystems of the operational system and also move between them. It can be shown with the use of a graph whose vertices are adequate operational states and which can be written as follows:

\[ G = \{SE, R_E\} \]  \hspace{1cm} (19)

where \( R_E \) a set of pairs of the operational states \( \langle SE_i, SE_j \rangle \) which belong to the operational relation \( \alpha_E \), i.e.;

\[ R_E = \{(SE_i, SE_j): SE_i, SE_j \alpha E \} \]  \hspace{1cm} (20)

For the operational system, in which the usability state \( SE_u \) and the maintenance state \( SE_o \) were distinguished, a basic operational graph (Fig. 7) has the following form:

\[ G = \{(SE_u, SE_o), \langle SE_u, SE_u \rangle, \langle SE_u, SE_o \rangle, \langle SE_o, SE_o \rangle, \langle SE_o, SE_u \rangle\} \]  \hspace{1cm} (21)

Fig. 7. The basic operational graph of the rail vehicle

The characteristic feature of the operation states classification is the occurrence of a series of levels and various division criteria at each of them. From among various types of rail vehicles, the most expanded classification of the operational states can be created for the traction vehicles.

The processes of using passenger and freight carriages, traction vehicles, or traction units are diverse. Passenger carriages and specialized freight carriages can be used in marshalled train units, in relations selected within the operation of a carriage set. The used traction vehicles can pull various trains in relations determined by the individual operations included in the plan of their work. The individ-
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usual cycles of locomotive operations begin and finish in the railway rolling stock firm, where the determined maintenance activities are performed. It also refers to these types of locomotives which can be used in the non-pulling work.

In the set of the usability states of traction vehicles $SE_u$, the basic dividing criterion at the second level is a type of the task which a determined vehicle performs at a given moment. It can be preparing for work $SE_{up}$, the proper work $SE_{uw}$, the work ending $SE_{uz}$, and idling $SE_{ub}$, i.e.:

$$ SE_u = \{ SE_{up}, SE_{uw}, SE_{uz}, SE_{ub} \} \quad (22) $$

Each of the mentioned usability states can be divided further into elementary states in accordance to the rules of the traction vehicle usage/operation. The widest division refers however to the proper work $SE_{uw}$. In the case of locomotives, the proper work’s individual elementary usability states can be equated with the statistical numbers of the types of pulling and non-pulling work. For the former work, the division criteria are: the type of a pulled train and the type of work of the traction vehicle connected with it. Thus, on the one side, the pulling of trains: passenger, freight, service, administration and working ones can be considered as the separate usability states; on the other side, the usability states can be such work types as e.g. running with a train, manoeuvres, running without a train, emergency. Similarly, in the non-pulling work, the following states can be distinguished: light running, manoeuvres, emergency, and auxiliary work.

The participation of the individual works assigned to the traction vehicle depends on its destination. For example, the planned works performed by a certain locomotive of the EU07 series can be shown in a graphical way as in Fig. 8.

![Graph of walks between the usability states of an exemplary locomotive of the EU07 series](image)

Fig. 8. A graph of walks between the usability states of an exemplary locomotive of the EU07 series: $SE_o$ – planned maintenance, $SE_{u1}$ – running to the siding track in the mother unit, $SE_{u2}$ – stabling at a siding track of the mother unit, $SE_{u3}$ – running to the train, $SE_{u4}$ – train running, $SE_{u5}$ – running to the siding track in the destination unit, $SE_{u6}$ – stabling at a siding track at the destination unit, $SE_{u7}$ – running to the maintenance stand

A similarly complex situation is in the system of maintenance into which each imperfect rail vehicle goes. Each series of the rail vehicle has an individual sched-
ule of undergoing planned services which belong to the individual levels of maintenance. Currently, the rail vehicles of the Polish transport operators are serviced according to the service-repair cycle whose elements in the form of the so-called “maintenance levels” are defined by the Annex no. 3 to the Order of the Minister of Infrastructure from October 12, 2005. According to this document, the vehicle’s performed running or the season of the year decide about the servicing or repair of a certain type. It has to be mentioned that the performing of the planned repairs is most frequently connected with the need of moving the vehicle to specialist repair garages. For the locomotive of the EU07 series, the schedule of performing the maintenance of the adequate levels is shown in Fig. 5.3. The individual maintenances belonging to the same levels are numbered in Fig. 9.

![Fig. 9. The schedule of performing the maintenance for a locomotive of the EU07 series: P1/1, P2/1, P3/1, P4/1, P5/1 – first services of the referring maintenance levels](image)

Beside the maintenance belonging to the individual maintenance levels performed according to the schedule, rail vehicles can undergo unscheduled maintenance such as: modernizations, current repairs without excluding the vehicle from the train set, current repairs with excluding the vehicle from the train set, and after-failure repairs. Taking into consideration all the mentioned types of services, a graph of walks between the individual operational states of the exemplary locomotives of the EU07 series can be seen in Figure 10.

![Fig. 10. A graph of walks for maintenance states of a locomotive of the EU07 series: SEop – operation, SEp1 – scheduled maintenance of level 1, SEp2 – scheduled maintenance of level 2, SEp3 – scheduled maintenance of level 3, SEp4 – scheduled maintenance of level 4, SEp5 – scheduled maintenance of level 5, SEow – current repair without excluding the vehicle from the train set, SEon – current repair with excluding the vehicle from the train set, SEop – after-failure repair, SEom – vehicle modernization](image)
The maintenance states distinguished in this figure constitute a set of the following form:

\[ SE_o = \{ SE_{p1}, SE_{p2}, SE_{p3}, SE_{p4}, SE_{p5}, SE_{obs}, SE_{ow}, SE_{op}, SE_{ow} \} \]  \hspace{1cm} (23)

Moreover, from the dispatcher’s point of view, for each service such operational states can be distinguished as: waiting for the maintenance \( SE_{ow} \), the vehicle maintenance \( SE_{ow} \) and waiting for operation \( SE_{ow} \):

\[ SE_o = \{ SE_{ow}, SE_{ow}, SE_{ow} \} \]  \hspace{1cm} (24)

The need for distinguishing the individual operational states results, first of all, from the accepted system of calculating the indicators of the effectiveness of the used vehicles. Currently there are the technical means of the identification of the distinguished operational states of rail vehicles, i.e. usability and operational states, their time periods, and the localization or dislocation of the vehicles in the area. Devices which send this information can also be used for transmitting the data about the current technical state of vehicles.

6. SUMMARY

The meanings of the term “technical state of the object” presented in the article in reference to rail vehicles and the classifications of these states allow for an easy distinguishing of the factual meaning ranges of the results of the identification processes performed by modern control-measuring systems. The information which can be delivered by them in the real time makes it easier to make operational decisions which refer to the individual vehicles belonging to the set of the vehicles of a given operator.

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WSPÓŁCZESNA KLASYFIKACJA STANÓW POJAZDÓW SZYNOWYCH

Streszczenie

W artykule przedstawiono znaczenia pojęcia „stan obiektu” w zależności od punktu widzenia, z jakiego jest ono rozważane. Każde z przedstawionych znaczeń może być przedmiotem identyfikacji we współczesnych systemach eksploatacji. Pierwszym z nich jest stan strukturalny obiektu, odnoszący się do liczby czynnych elementów w danym układzie oraz oddziaływań pomiędzy nimi. Drugim, również bardzo ważnym, znaczeniem jest stan techniczny, który może być identyfikowany na podstawie oceny cech fizykalnych lub poprawności funkcjonowania elementów składowych obiektu. Zarówno od stanu struktury, jak i od stanu technicznego jest uzależniony stan eksploatacyjny obiektu, będący trzecim znaczeniem pojęcia „stan obiektu”. W artykule przedstawiono zasady klasyfikacji w obrębie wszystkich trzech grup znaczeniowych pojęcia „stan obiektu”, a także powiązania między nimi.