Calculation of indicators of annual train timetable in the Czech Republic

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Abstract—The paper describes way of railway transport indicators calculation in application for ordering train paths by railway undertakings. The application is a part of the information system of annual train timetable design in the Czech Republic. It is a distributed application composed of a database server, application server and a client program. Indicators calculation module offers basic indicators designated for planning and appraisal of designed timetable. Both railway undertaking and infrastructure manager use this tool. Indicators are calculated for selected trains, areas and tractions. Trains selection can by realized manually in the trains list or automatically according to defined criterions. The area can be predefined (Czech Republic and its regions) or defined by user. User area represents arbitrary set of transport points and sections of required type. Type of transport point and section determines including/excluding of the train path in/from the appropriate area. With the other parameters, the user can influence the selection of sections of train paths to be included in the calculation. After the calculation is done, selected train paths can be excluded or additionally included, which issues in immediate recalculation of the results.

Keywords—timetable, train, information system, transport indicator, train editor.

I. Introduction

THE annual train timetable in the Czech Republic is designed using the KANGO and KASO information system. One of its components is the KANGO-Vlak application, which primarily serves to acquire train paths required by a railway undertaking from an infrastructure manager.

The KANGO-Vlak program also provides several analytical tools. One of them is a module to calculate transport indicators, which is the content of this article.

II. Information Systems for Timetable Creating

The structure of the KANGO a KASO systems [1] and links to external information systems are shown in Fig. 1.

The KANGO system is primarily intended for an infrastructure manager while KASO is used exclusively for the needs of a railway undertaking.
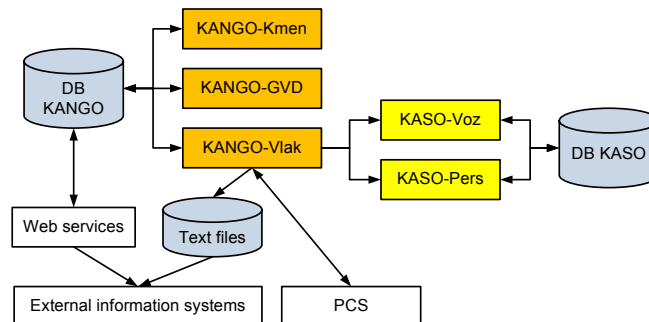

Fig. 1 Information systems for creating a train timetable

Creating a timetable starts with the preparation of master data (rail network, engines, etc.) in the KANGO-Kmen module. The railway undertaking acquires basic data in the KANGO-Vlak module [2], whereby it orders train paths with the infrastructure manager. Construction of train paths is performed by the infrastructure manager in the KANGO-GVD module in which time positions are set for trains, driving station and track rails along with other data. After completion of the construction of trains, circulations of engines and trains are created in the KASO-Voz module and turns of engine and train crews are projected in KASO-Pers.

KANGO subsystems work over a common central database, which contains a database of master data, trains and users. KASO-Voz and KASO-Pers applications read master data and data of trains from the KANGO database through KANGO-Vlak. For information about circulations and runs, they make use of using its own central database. The central databases are stored in the ORACLE database server.

The master data and data of trains are available for other information systems operated in the Czech Republic in the original and the new format. The original format is represented by text files, the export of which is provided by the KANGO-Vlak application. The new format is provided through web services. Trains data interchange with the international PCS system [3] (formerly Pathfinder) is provided by KANGO-Vlak through export and import of XML files.

III. Structure and Features of the Train Editor

Each KANGO and KASO subsystem uses its application server that provides an interface to access the database and

provides control of the recorded data. In most cases, the application server reads and writes from / to the database only the data that belongs to him. It reads and updates the data it uses only for reading from another application server. For example, the KANGO-Vlak application server reads the data on the trains from the database server, while the master data are read from the KANGO-Kmen application server.

The KANGO-Vlak system is developed in the C# programming language. It is executable under operating systems that support the Microsoft .NET Framework platform. It consists of a client program and an application server. Its structure is shown in Fig. 2.
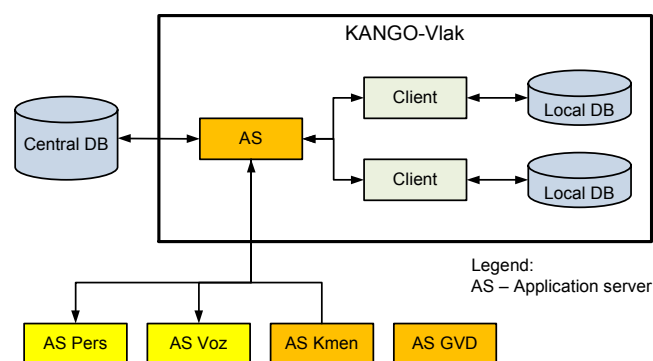

Fig. 2 Structure of KANGO-Vlak with links to the other parts of KANGO and KASO

The client program maintains a copy of the central database. This copy is stored in the local database. If a client connects to a database for the first time, a new local database is created; otherwise automatic synchronization is performed of the local and remote databases. The application also allows working offline without connecting to the application server. In this case, it reads the data from the local database and does not allow the user to make any changes.

The local database is stored in a Microsoft SQL Compact Edition Database Server, which is freely available. The database is encrypted and password protected.

KANGO-Vlak is a distributed application based on Microsoft .NET Remote technology [4], [5]. The client communicates with the applications server in TCP channel via a binary formatter. Such a communication according to [6] is the fastest type compared to HTTP channel communication or SOAP formatter.

If the client changes an appropriate object, it synchronously sends the application server the data to be entered into the database. After the data are successfully written, the client may continue working. Then the application server in the asynchronous mode assigns the change event to each logged-in client into its queue located on the server. The client inquires about the change event at specified intervals, and if a change exists, it loads it, incorporates it in its memory and writes it into its local database.

The KANGO-Vlak application is designed primarily for editing trains. For this purpose, it includes the following features:

- selection of trains and the train list filter according to a specified combination of various parameters,
- creation and cancellation of trains,
- defining and changing a train path in a graphical view of the railway network,
- editing one or a group of trains,
- copying a train with an option to turn its path,
- connecting trains whose paths are successive,
- mass renumbering of trains,

For analysis of the proposed timetable, the application includes the following tools:

- comparing two databases of trains,
- calculation of basic indicators of transport,
- searching for existing and nonexistent connections between trains,

The program provides a variety of printed outputs intended for railway staff or passengers.

IV. SELECTING AND FILTERING TRAINS

Indicators are calculated for selected trains. Selection of trains can be done manually in the list of trains or automatically according to specified criteria. The tool to select trains offers a large number of criteria covering most of the train data, such as the interval of train numbers, a calendar, an engine of the train, and others. The user may specify any combination of the offered criteria. A train is chosen if it meets all the entered criteria. The tool also offers an option to maintain the current selection of trains. This allows adding more trains matching the criteria to the current set of selected trains (selected manually or using the tool to select trains).

Fig. 3 shows an example of dialog box for selection of trains. There will be selected train numbers 1 to 19999 that run at least partially under the transport train type IC or EC.
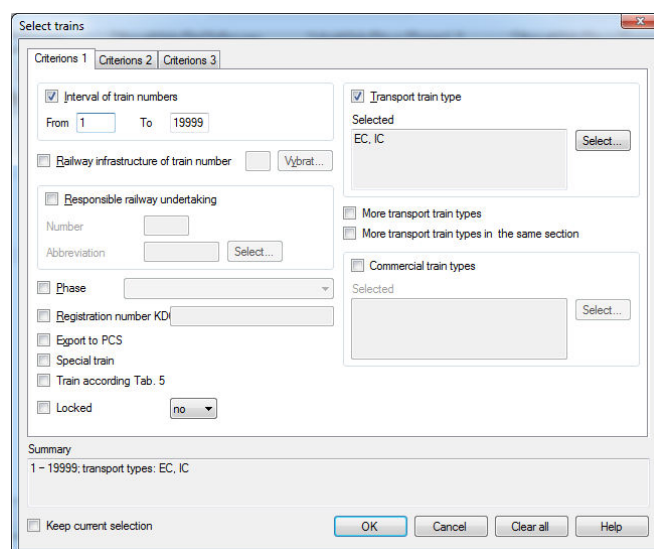

Fig. 3 Dialog box for criterions setting of trains selection

In addition to the tool to select trains, the application provides a tool to filter trains, which offers the same criteria as in selecting trains. After they are entered in the list of trains,

only such trains are displayed that meet all specified criteria. It is an active filter that is automatically performed with any change received from the application server. The filtered list can be also created from selected trains.

V. USER AREAS

Calculation of the indicators can be done not only for the standard areas (the Czech Republic and its regions), but also for the user areas. User area is an arbitrary set of transport points and sections. An area may contain a name and comment.

To prevent anyone from modifying or deleting a given area, the user may lock it. In this case, it can be modified or deleted only by the user who locked it or the administrator. Other users may view it and use it.

Transport points of the user area can be of the following types:
- Normal – common points of the area.
- Facultative – a train that runs within the area through the facultative points, facultative stopping points, and facultative sections:
  o and goes on through points or sections not belonging to the area is not included in the area,
  o and does not run through other points and sections not belonging to the area is included the area.
- Normal stopping – if a train runs through normal stopping points, it has to stop in all these points in order to be included in the area.
- Facultative stopping – if a train goes through the facultative stopping points, it has to stop in all these points in order to be included in the area. Furthermore, if the train goes only through the facultative points, facultative stopping points and facultative sections:
  o then goes on through points or sections not belonging to the area, it is not included in the area,
  o does not go through other points and sections not belonging to the area, it is included in the area.

A train stopping point means the starting and destination point and also a track point where the train stops.

User area transport sections can be of the following types:
- Normal – common sections of the area.
- Facultative – see facultative points.
- Prohibited – a train that goes through some of the prohibited sections is not included in the area.

Facultative points, facultative sections and prohibited sections are used mainly in defining tracks of a book timetable, where there are points and sections that are part of several tracks.

Fig. 4 shows two fictitious lines: A – E and A – G. Track A – E represents a user-defined area. It contains the points A and B and the section between them, which are part of both lines. In order to avoid including the trains running along A – G track were not included in the A – E track, the points A, B and the section between them are marked as facultative. Endpoints of the track A – E must be marked as facultative because they

are also part of other tracks. If there was a train that would only go from point A to point B or vice versa, it would be included in the track A – E. In Table I there are examples of train paths running through this area.
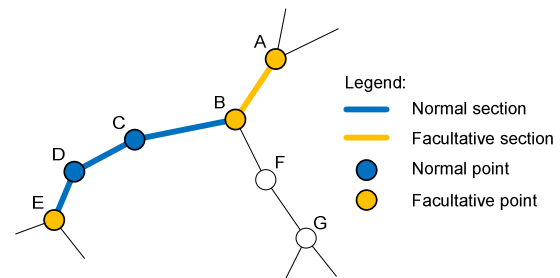

Fig. 4 Example of user area – facultative points and sections

TABLE I TRAIN PATHS FOR USER AREA IN FIG. 4

Train path	Included
A – B	yes
A – E	yes
A – G	no

Stopping points have been introduced to define the book timetable lines, which form a subset of a longer line and do not include trains that pass through certain points of this line.

Fig. 5 shows instance of user area of A – H line containing stopping points. Examples of train paths running through this area are in Table II.
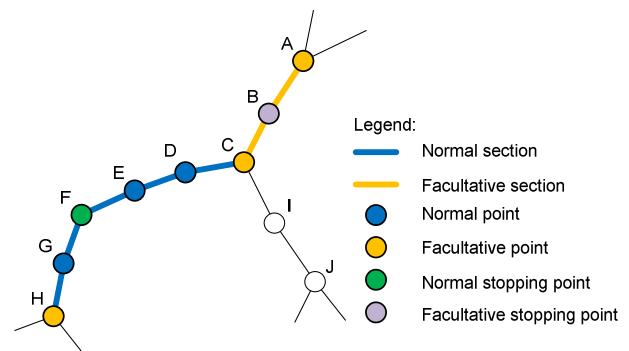

Fig. 5 Example of user area – stopping points

TABLE II TRAIN PATHS FOR USER AREA IN FIG. 5

Train path	Condition	Included
D – E		yes
D – F		yes
D – H	stops in F	yes
D – H	passes by F	no
A – H	stops in B and F	yes
A – H	passes by B and/or F	no
A – C	stops in B	yes
A – C	passes by B	no
A – J		no

Forbidden sections serve for separation out of train paths running along sections not belonging to the user area. Fig. 6 shows user area of the A – E line. For that trains running along B – F – D track would not be included into A – E line, they are forbidden. In Table III there are shown instances running across this area.
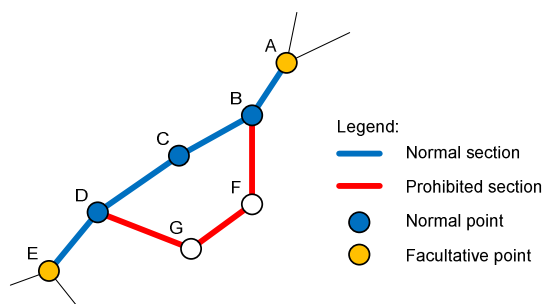
Fig. 6 Example of user area – prohibited sections

TABLE III TRAIN PATHS FOR USER AREA IN FIG. 6

Train path	Included
A – C – E	yes
A – F – E	no

Transport points and sections can be added/removed to/from the area in the dialog box, in a tabular or graphical form in the window of the railway network.

In the railway network window, color-highlighted are the paragraphs and sections that belong to the area. The application offers modes such as transport or section points between which one can switch – only one of them is active. Clicking the mouse at a given point/section will:

- Add this point/section into the area under the active type unless it has been included in the area.
- Change its type into active one if it is included in the area under a different.
- Remove this point/section from the area if it is included in the area under the active type.

In addition to this method, a rectangle can be defined by dragging the mouse. With points and segments that fall within the defined rectangle, an operation is carried out corresponding to the active type of the point/section and the active highlighting mode, which are as follows:

- Add highlighting – points/sections will be added to the area under the active type, or their type will change to the active type.
- Remove highlighting – points/sections will be removed from the area.
- Invert highlighting – for each selected point/section, an action is performed corresponding to a mouse click at such point/section.

If the mode of the transport point type is active, a tool may be selected to highlight transport points by the value, or by the interval of values of the selected database entry. Using this tool, the same action is performed for the points to be highlighted, as if the mouse dragging described above was performed for these points. For example, if using the tool is to highlight transport points of the selected region and the mode "Add highlighting" is active, points of the selected region are added to the area under the active type, or more precisely their type will change to the active type.

An uninhibited section can be included in the area only partly. The portion of the inclusion of a section in the area can be defined by a coefficient, e.g. 0.25 of the length of the section. This functionality is used in calculating transport indicators for a track section, whose borderline can be within of the transport section. If a part of the section is included in the area, then only its equivalent part is highlighted in the rail network window. To modify the proportion of the section to the area, there is a special mode available that can be switched into between the mentioned modes of the type of the point/section. If the mode to edit the proportion of the section is active, clicking the mouse in the section that belongs to the area opens a dialog box used to edit the proportion of the section to the user area.

Fig. 7 shows railway network window with the user area of chosen track of book timetable for passengers belonging to one of the Czech Republic regions.

VI. CALCULATING INDICATORS

Indicators are calculated for selected areas, tractions and the specified period within the validity of the annual timetable. The selected indicators are calculated for each combination of the selected areas and tractions separately.

The areas include the following:

- the Czech Republic,
- regions of the Czech Republic,
- user areas.

The traction is determined by the decisive engine in the given section of the train path. On the train, engines are entered with a section, validity calendar and functions on the train (train, pusher etc.). The decisive engine is the engine with the train function.

The calculation can be done for the following tractions:

- electric locomotives,
- electric units,
- electric – electric locomotives and multiple units,
- diesel locomotives,
- railcars,
- motorized – diesel locomotives and railcars,
- all – regardless of traction.

For a given area and traction, only such sections are taken into account (further on referred to as the compliant sections) that meet all the following conditions:

- the section belongs to the relevant area,
- in the section, the decisive engine of the relevant traction is indicated on the train,
- the train runs in the section in the specified period,
- in the section, some of the selected transport types of trains is indicated on the train (such as passenger, InterCity),
- in the section, a selected general note is indicated on the train,
- in the section, the selected party to have ordered the train (Ministry of Transport, the regional authority or municipality) is indicated on the train.

Last three conditions are applied only if defined by user.

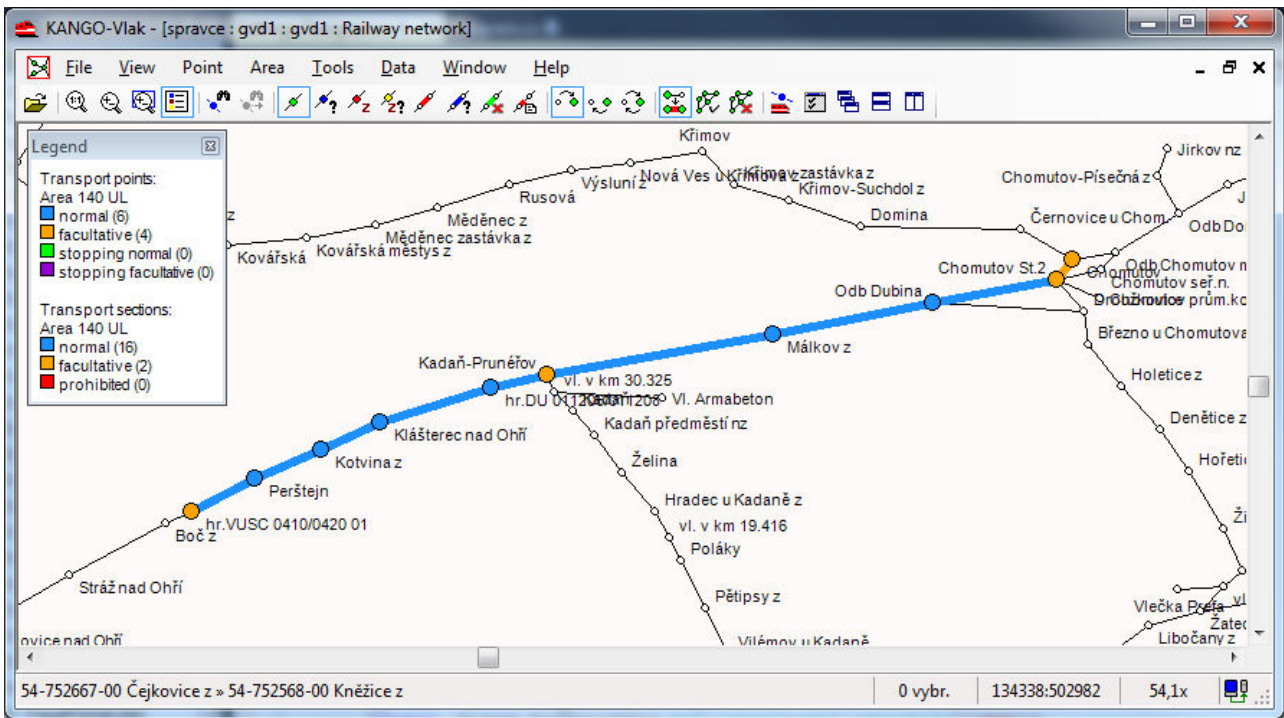General notes are notes that appear in the timetable for

Fig. 7 User area in the railway network window

passengers, for example, "seat reservation can be bought for marked passenger cars".

Transport types, general notes and ordering parties are entered on the train similarly to engines, i.e. with a section and validity calendar.

These conditions must be met also in terms of calendars. For a given traction and train path section, A set of days is calculated resulting from intersection of these sets:

- a set of all days in the specified period,
- union of sets of calendar days of the decisive engines of the given traction,
- union of sets of calendar days of selected transport types of trains,
- a set of calendar days of selected general notes,
- a set of calendar days of the party to have ordered the train.

If set A is empty, the given section of the train is excluded from the calculation for the given area and traction.

Some indicators are calculated with data of the parameters of the train. The parameters of the train include weight, length, number of cars, rolling resistance, maximum speed, etc. On the train they are entered with the section and the validity calendar.

The following examples of calendars make use of the numbers 1 to 7 representing the day of the week Monday to Sunday in the given period. The term "number of days the train runs", which is also used, means the number of days of the set A in the given compliant section.

For the purpose of indicators calculating a pertinence of transportation point is defined as follows. Transportation point belongs to the appropriate area when it belongs to it and following section of train path belongs to it as well.

Next text includes following symbols:

$|X|$ ......cardinality of set X.

V ....set of trains for indicator calculating.

U_v ......set of compliant sections of train path $v \in V$.

A_u ....set A for section $u \in U_v$.

n_{do} .....number of days of preset period.

The module offers calculation of the following indicators.

Total number of trains

The number of trains running at least in one compliant section multiplied by the number of days the trains run:

$$N_{tr}^c = \sum_{v \in V} |B_v| \qquad (1)$$

$$B_v = \bigcup_{u \in U_v} A_u \qquad (2)$$

For example, the train runs in the first compliant section on $1 - 4$ and in the second compliant section on $4 - 6$. The value of days $1 - 6$ is added to the indicator for this train.

Daily number of trains

The number of trains running at least sometime in one compliant section:

$$N_{tr}^d = \sum_{v \in V} f(U_v) \qquad (3)$$

$$f(U_v) = \begin{cases} 1 & (|U_v| > 0) \\ 0 & (U_v = \emptyset) \end{cases} \qquad (4)$$

If the train runs at least sometime in one compliant section, the value 1 is added to the indicator for this train.

Reduced number of trains

Indicator is calculated as:

$$N_{tr}^r = \frac{N_{tr}^c}{n_{do}} \qquad (5)$$

Total train kilometers

The sum of multiples of lengths of compliant sections and the number of days the trains run:

$$L_{tr}^c = \sum_{v \in V} \sum_{u \in U_v} l_u k_u |A_u| \quad [\text{km}] \qquad (6)$$

where:

l_u .... length of compliant section u of train path [km].

k_u .... coefficient of pertinence of transport section u of train path into the area.

For example, a train in the first compliant section 10 km long runs in $1 - 4$ and in the second compliant section 20 km long it runs in $4 - 6$. The value $(10a + 20b)$ is added to the indicator for this train where a is the number of days $1 - 4$ and b is the number of days $4 - 6$.

Daily train kilometers

The sum of the lengths of the compliant sections of the trains:

$$L_{tr}^d = \sum_{v \in V} \sum_{u \in U_v} l_u k_u \quad [\text{km}] \qquad (7)$$

Reduced train kilometers

Indicator is calculated as:

$$L_{tr}^r = \frac{L_{tr}^c}{n_{do}} \quad [\text{km}] \qquad (8)$$

Technical speed

A quotient of daily train km and the sum of travel time of individual trains in compliant sections not including the stay in the intermediate transport points of the train path:

$$V_t = \frac{60 L_{tr}^d}{\sum_{v \in V} T_{jv}} \quad [\text{km} \cdot \text{h}^{-1}] \qquad (9)$$

$$T_{jv} = \sum_{u \in U_v} t_{ju} k_u \quad [\text{min}] \qquad (10)$$

where:

t_{ju} ...... travel time of train in compliant transport section u [min].

Travel speed

A quotient of daily train km and total travel time of individual trains in compliant sections including the actual travel time and the duration of stay at intermediate transport points of the train path:

$$V_c = \frac{60 L_{tr}^d}{\sum_{v \in V} T_{jv} + \sum_{v \in V} T_{pv}} \quad [\text{km} \cdot \text{h}^{-1}] \qquad (11)$$

$$T_{pv} = \sum_{c \in C_v} t_{pc} + \sum_{d \in D_v} \frac{t_{pd}}{2} \quad [\text{min}] \qquad (12)$$

where:

t_{pc} ...... time of train stay at intermediate transport point b of train path [min].

C_v .... set of intermediate transport points of the train path v that belong to the area and also its precedent and successive transport section of the train path are compliant sections.

D_v ...... set of intermediate transport points of the train path v that belong to the area and one of the following conditions complies at the same time:

- its precedent transport section of the train path is compliant section and successive transport section is compliant section except the condition of traction,
- its precedent transport section of the train path is compliant section except the condition of traction and successive transport section is compliant section.

Sectional speed

A quotient of daily train km and total travel time of individual trains in compliant sections including the actual travel time and the duration of stay at intermediate points of the train path where a starting or intermediate technical inspection is not performed and neither is customs clearance and passport control:

$$V_s = \frac{60 L_{tr}^d}{\sum_{v \in V} T_{jv} + \sum_{v \in V} T_{pv}^*} \quad [\text{km} \cdot \text{h}^{-1}] \qquad (13)$$

$$T_{pv}^* = \sum_{c \in C_v^*} t_{pc} + \sum_{d \in D_v^*} \frac{t_{pd}}{2} \quad [\text{min}] \qquad (14)$$

where:

C_v^* .... set of transport points C_v with exception of transport points in which starting or intermediate technical inspection or customs clearance and passport control is performed.

D_v^* ...... set of transport points D_v with exception of transport points in which starting or intermediate

technical inspection or customs clearance and passport control is performed.

Ascertainable loss

An ascertainable loss from the operation of passenger trains in CZK in individual regions of the Czech Republic. It is calculated by multiplying the rate of the ascertainable loss for the region and the total train kilometers:

$$Z = L_{tr}^{c} z \quad [\text{CZK}] \tag{15}$$

where:

z .... rate of the ascertainable loss for the region $[\text{CZK} \cdot \text{km}^{-1}]$

Total gross ton kilometers – freight transport

The sum of the multiples of the weights of the train parameters, the lengths of the compliant sections and the number of days the trains run. If there are multiple variants of parameters of trains in a section on the train, the weight of the train is calculated by the weighted average with regard to the number of days of the validity of individual variants of the parameters of the trains:

$$Q_{grf}^{c} = \sum_{v \in V} \sum_{u \in U_v} M_u^{p} l_u k_u |A_u| \quad [\text{tkm}] \tag{16}$$

$$M_u^{p} = \frac{\sum_{i \in P_{v_u}} m_i^{p} \left| A_u \cap A_i^{p} \right|}{\left| A_u \right|} \quad [\text{t}] \tag{17}$$

where:

P_{v_u} ..... set of train parameters in the transport section u of the train path v.

m_i^{p} ...... weight of the train parameters $i \in P_{v_u}$ [t].

A_i^{p} ...... set of calendar days of the train parameters $i \in P_{v_u}$.

Daily gross ton kilometers – freight transport

The sum of the multiples of the weights of the train parameters and the lengths of the compliant sections. If there are multiple variants of the parameters of the trains in a section on the train, the weight of the train is calculated by the weighted average with regard to the number of days of the individual variants of the parameters of the trains run:

$$Q_{grf}^{d} = \sum_{v \in V} \sum_{u \in U_v} M_u^{p} l_u k_u \quad [\text{tkm}] \tag{18}$$

Reduced gross ton kilometers – freight transport

Indicator is calculated as:

$$Q_{grf}^{r} = \frac{Q_{grf}^{c}}{n_{do}} \quad [\text{tkm}] \tag{19}$$

Total gross ton kilometers – passenger transport

Indicator is calculated as the sum of:

- Multiples of the carriage groups weights, the lengths of

the complying sections and the number of days the carriage groups run. For passenger train with passenger transportation the sum of occupied carriages is considered as the carriage group weight. For other trains it is the sum of empty coaches;

- Multiples of the engines weights, the lengths of the complying sections and the number of days the engines run. For passenger train with passenger transportation the gross weight of engine is considered as the engine weight. For other trains it is the net weight of engine.

$$Q_{grp}^{c} = \sum_{v \in V} \sum_{u \in U_v} \sum_{i \in S_{v_u}} l_u k_u m_i^{sg} \left| A_i^{s} \cap A_u^{c} \right| +$$

$$+ \sum_{v \in V} \sum_{u \in U_v} \sum_{i \in S_{v_u}} l_u k_u m_i^{sn} \left| A_i^{s} \cap A_u^{w} \right| +$$

$$+ \sum_{v \in V} \sum_{u \in U_v} \sum_{i \in E_{v_u}} l_u k_u m_i^{eg} \left| A_i^{e} \cap A_u^{c} \right| + \quad [\text{tkm}] \tag{20}$$

$$+ \sum_{v \in V} \sum_{u \in U_v} \sum_{i \in E_{v_u}} l_u k_u m_i^{en} \left| A_i^{e} \cap A_u^{w} \right|$$

where:

S_{v_u} ..... set of carriage groups in the transport section u of the train path v.

E_{v_u} ..... set of engines in the transport section u of the train path v.

m_i^{sg} ..... weight of occupied carriage group $i \in S_{v_u}$ [t].

m_i^{sn} ..... weight of empty carriage group $i \in S_{v_u}$ [t].

m_i^{eg} ..... gross weight of the engine $i \in E_{v_u}$ [t].

m_i^{en} ..... net weight of the engine $i \in E_{v_u}$ [t].

A_i^{s} .... set of calendar days of the carriage group $i \in S_{v_u}$.

A_i^{e} .... set of calendar days of the engine $i \in E_{v_u}$.

A_u^{c} .... set of train calendar running days with passenger transportation on section u of the train path v.

A_u^{w} ...... set of train calendar running days without passenger transportation on section u of the train path v.

Daily gross ton kilometers – passenger transport

Indicator is calculated as the sum of:

- Multiples of the carriage groups weights, the lengths of the complying sections. If there is more carriage groups noted in the section the weight of the carriage group is calculated as the weighted average with regard to the number of running days of individual carriage groups. For passenger train with passenger transportation the sum of occupied carriages weights is considered as the carriage group weight. For other trains it is the sum of empty coaches weights;

- Multiples of the engines weights, the lengths of the complying sections. If there is more engines noted in the section the weight of the engine is calculated as the

weighted average with regard to the number of running days of individual engines. For passenger train with passenger transportation the gross weight of engine is considered as the engine. For other trains it is the net weight of engine.

$$Q_{grp}^d = \sum_{v \in V} \sum_{u \in U_v} \left(M_u^s + M_u^e \right) l_u k_u \quad \text{[tkm]} \tag{21}$$

$$M_u^s = \frac{\sum_{i \in S_{v_u}} m_i^{sg} \left| A_i^s \cap A_u^c \right| + \sum_{i \in S_{v_u}} m_i^{sn} \left| A_i^s \cap A_u^w \right|}{\left| A_u \right|} \quad \text{[t]} \tag{22}$$

$$M_u^e = \frac{\sum_{i \in E_{v_u}} m_i^{eg} \left| A_i^e \cap A_u^c \right| + \sum_{i \in E_{v_u}} m_i^{en} \left| A_i^e \cap A_u^w \right|}{\left| A_u \right|} \quad \text{[t]} \tag{23}$$

Reduced gross ton kilometers – passenger transport

Indicator is calculated as:

$$Q_{grp}^r = \frac{Q_{grp}^c}{n_{do}} \quad \text{[tkm]} \tag{24}$$

Average weight of the train

Indicator is calculated as:

$$M_{tr} = \frac{Q_{grf}^c}{L_{tr}^c} \quad \text{[t]} \tag{25}$$

Total, daily and reduced carriage kilometers

They are calculated the same way as the gross ton kilometers with the difference that instead of the weight of the train parameters is used the number of cars.

Total, daily and reduced axle kilometers

They are calculated the same way as the gross ton kilometers with the difference that instead of the weight of the train parameters is used the number of axles.

In the passenger transport, the calculation of the indicators is used mainly for detecting the total and reduced train kilometers and the "ascertainable loss" indicator. These indicators serve as a basis for concluding contracts for public passenger transport services between the railway undertaking (Czech Railways) and regional offices according to [5]. The "ascertainable loss" indicator is an ascertainable loss in the public rail passenger transport from the public service obligation. It is calculated by multiplying the rate for a subsidy unit (in CZK per 1 train km) for a relevant region and the total train km of the regional passenger transport trains (by the transport type of the train) in the region which are covered by this contract. Such trains have a special general note indicated in their path for which the calculation can be performed. Rates for a subsidy unit for each region can be edited in the program.

During the calculation of indicators, completion and accuracy is checked of the information needed for the selected indicators. The calculation will take place even if errors have been found in some sections or points of train paths. These sections and points are not, however, included in the calculation. Detected errors are recorded in a protocol file.

Fig. 8 Window of the calculated indicators

The result is a window containing a list of indicators calculated for the selected area and tractions and, if need be, a list of trains, from which the indicators for each area and traction have been calculated. Fig. 8 shows an example of such a window containing the indicator of the reduced and total number of trains (TTr and RTr columns), total and reduced train km (TTrKm and RTrKm columns) in one region and on one track of the book timetable for passengers for the entire 2010/2011 season of the timetable. The bottom of the window contains a list of trains for the selected line at the top of the window. For each train is given its starting point and destination, path section, which belongs to the area and traction and partial values of the calculated indicators (TrD column represents the number of the days the train runs). The train or the section of its path can be excluded from the calculation, which will automatically recalculate the total values of the indicators. The excluded trains are shown in the Figure with a crossed grey lettering.

The list of indicators, including the list of trains, can be saved to a text file and subsequently loaded into a spreadsheet or word processor for further processing.

VII. EMERGING TRENDS

System KANGO was originally designed for unitary railway represented by Czech Railways. It fulfilled both the function of railway undertaking and infrastructure manager. During the development of this system the function of railway undertaking was taken over by Railway Infrastructure Administration. Modules determined exclusively for railway undertaking Czech Railways were split into new system KASO. Module KANGO-Vlak remained common to both organizations.

Czech Railways have not their own train database and master data, in which the latter could maintain both the data for the infrastructure manager, as well as specific data for their own use. Now all these data are stored in a common database KANGO. Railway operator thus has access to all train data, and at the time of their entering by the railway undertaking.

The current KANGO architecture does not moreover allow connection of information systems of other railway undertakings. Therefore, in 2012, began an analysis of the splitting both systems into two separate systems and the design of a uniform data interface KANGO that would allow other railway undertakings to submit requests for train paths through their information systems.

To ensure the liberalization of the European rail market and the interoperability of infrastructure managers and railway undertakings European Union issued the technical specifications for interoperability (TSI) relating to Telematics Applications for Freight (TAF) [9] and Passenger Transport (TAP) [10].

In accordance with those EU Regulations Railway Infrastructure Administration plans to create Web services KANGO-TSI that will communicate with information systems of railway undertakings through standardized XML messages.

The railway undertaking will be able to send the following messages:

- path request,
- acceptance of the proposed path,
- refusal of the proposed path,
- path cancellation,
- path modification,

Infrastructure manager will provide the following reports:

- proposal of the path,
- reservation of the path,
- refusal of the path request,

Fig. 9 shows the planned architecture of the systems KANGO and KASO after splitting.

KANGO-Vlak will be divided into two modules:

- KANGO-Tras – will manage path requests of railway undertakings and proposed paths by infrastructure manager. It will communicate with Web services KANGO-TSI.
- KASO-Vlak – will be used to create timetable of the railway undertaking. It will communicate with Web services KANGO-TSI.

International paths will be solved in the target state solely through the PCS, which will communicate with modules KANGO-Tras and KASO-Vlak.

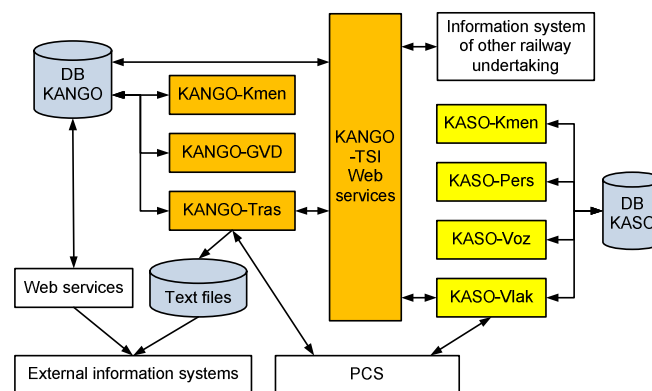Master data management of the railway undertaking will be realized by KASO-Kmen module.

Fig. 9 Divided systems KANGO a KASO.

VIII. CONCLUSION

The application KANGO-Vlak along with other applications of the KANGO and KASO systems were deployed in routine operation at the end of 2010. Their introduction resulted in improving and accelerating the work on the design of the annual timetable.

KANGO-Vlak represents distributed application composed from database server, application server and client program. Data changes made by one client are realized at the other clients within few minutes.

In information system used until 2010 [6] each client had own local database that he operated independently to the other clients. Data exchange was made once 24 hours via export and import of change files through central workstation. Export and import did not perform automatically at the client. User was

the only responsible for execution.

System enables modification of the same record by several clients in the same period of time between to data exchanges. If such a state occurred, system accepted the last updated record. The earlier modification of this record made by other clients did not realized in the database.

New system includes module of the indicators calculation that offers basic indicators for planning and appraisal of the designed timetable. Calculation could be influenced by set of the parameters.

Indicators are calculated for selected trains and or geographical areas. Selection of trains is possible effectuate manually in the trains list or automatically according to defined criterions. The area can be predefined (Czech Republic and its regions) or defined by user.

User area represents arbitrary set of transport points and sections of required type (e.g. stopping point, prohibited section). Type of transport point and section determines including/excluding of the train path in/from the appropriate area. After the calculation is done, selected train paths can be excluded or additionally included, which issues in immediate recalculation of the results.

In the future, division of KANGO and KASO into two separate systems and web services KANGO development are planned that will interact with information systems of railway undertakings using of messages complying with TSI-TAF and TSI-TAP specifications issued by the European Union. Messages allow receiving path request from railway undertakings applications and sending proposed or reserved path by infrastructure manager.

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