Implementing the TSI EU into the System of Developing the Annual Train Timetable of the Infrastructure Manager

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Abstract: – The paper describes a new method of developing the annual train timetable in the information system of the infrastructure manager in the Czech Republic. The system is accessible to the information systems of railway undertakings through a data interface that allows receiving and providing messages compliant with the TAF / TAP TSI specifications of the European Union. In order to develop a timetable, processes are designed for processing a new request, modifying and cancelling a request by the railway undertaking, deleting a route by the infrastructure manager, and processing data that is not needed at the time of path construction.

Key-Words: - Timetable, train, path, information system, KANGO, TSI

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1 Introduction

In the past, the annual train timetable in the Czech Republic was developed at the level of the national railway undertaking České dráhy, which acted as both railway undertaking and infrastructure manager.

In 2006, the development of the new KANGO system was initiated for the company České dráhy, which at that time also served as the infrastructure manager. During the development of this system, the role of the infrastructure manager was taken over by the state organisation Správa železnic. The KANGO system was divided into two systems, but the module for entering railway undertakings' requirements for train paths remained common for both organisations. Routine operation of these systems commenced at the end of 2010.

The other railway undertakings passed their orders outside the system to the infrastructure manager's staff who entered them into the KANGO system.

To make the KANGO system accessible to the information systems of different railway undertakings and to meet the interoperability conditions of the European Union, it was necessary to develop the infrastructure manager's data interface and redesign the train path requirements module.

2 Original System

The concept of the annual train timetable compilation in the Czech Republic was based on two information systems, KANGO and KASO, [1]. The structure of these systems is shown in Figure 1.

The KANGO system was primarily designed for infrastructure managers, while the KASO system was used exclusively by the national railway undertaking České dráhy.

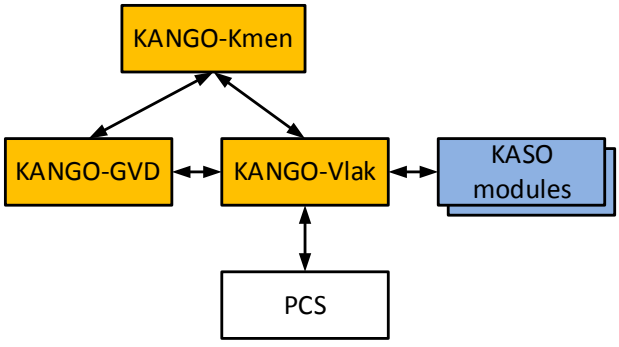

Fig. 1: Earlier architecture of information systems for the development of the annual train timetable

The development of the timetable starts with the preparation of master data (railway network, traction vehicles, etc.) in the KANGO-Kmen module. The basic train data are acquired by the railway undertaking or on its behalf by an employee of the infrastructure manager in the KANGO-Vlak module, [2]. The train construction is performed by

the infrastructure manager in the KANGO-GVD module, which determines the time positions of trains, the station and line tracks travelled, and other data. In the KASO modules, the traction vehicle and carriage group circulations are also developed, and locomotive and train crew rotations are drafted.

The KANGO modules work on a common central database that contains a database of master data, trains, and users. KASO modules read master data and train data from the KANGO database via KANGO-Vlak. They use their central database for circulations and rotations data. The mutual exchange of train data with the European PCS system, [3], is handled by KANGO-Vlak.

The train data requested by the railway undertaking and the actual data maintained by the infrastructure manager are recorded in a pair of trains: required and actual. The required train is entered by the railway undertaking in the KANGO-Vlak module as a train requirement for the infrastructure manager. The actual train is created by copying the required train and modified by the infrastructure manager in KANGO-GVD (hereafter referred to as the constructor). The constructor can enter time, station, and line track data in the path of the actual train within the KANGO-GVD construction area (approximately the territory of the Czech Republic).

The data relating to the part of the path that does not belong to the KANGO-GVD construction area is filled into the required train by the KANGO-Vlak user directly or imported from the PCS.

During the process of developing the timetable, the requested train passes through the phases *Transferred Requirement*, *Requirement Creation*, *Ready for Construction*, *Construction*, *Constructed*, *Requirement Change*, *Ready for Construction – Change*, *Agreed by Railway Undertaking*, and the corresponding actual train through the phases *Construction*, *Constructed*, *Agreed by Railway Undertaking*. The train phases are described in more detail in [2].

The train object contains the following data groups:

- Train header – path-independent data, e.g. train number and name.
- Train path – a sequence of transport points and their associated data, e.g. time data, train running calendar, and activities.
- Objects in the train path that have a defined section and validity calendar, e.g. railway undertakings, traction vehicles, and train parameters.

The sequence of path transport points is hereinafter referred to as a *route*.

The architecture of the KANGO system did not allow attaching information systems of other railway undertakings. The railway undertaking České dráhy did not have its database of trains and master data, in which it could maintain both data necessary for infrastructure managers and specific data for its use.

3 New System

It was for these reasons that in 2013 a development was initiated to split the KANGO and KASO systems into two separate systems.

To ensure the liberalisation of the European rail market and the interoperability of infrastructure managers and railway undertakings, the European Union has issued technical specifications for the interoperability of telematic applications:

- in freight transport (TAF TSI), [4], [5],
- in passenger transport (TAP TSI), [6], [7].

These regulations had to be respected when developing the new system. Therefore, a data interface has been developed that allows communication between the information system of the railway undertaking and that of the infrastructure manager using standardised TSI messages in XML format. The basic TSI messages that KANGO works with are as follows:

- *Path Request* – a request for a path sent by the railway undertaking to the infrastructure manager.
- *Path Details* – a constructed path sent (provided) by the infrastructure manager to the railway undertaking. In the KANGO system and other information systems in the Czech Republic, the term data timetable (hereinafter referred to as DTT) has been introduced for the constructed path.

The structure of the transformed KANGO and KASO systems is shown in Figure 2. The structure of the KASO system is shown in a simplified form as it is not the focus of this paper.

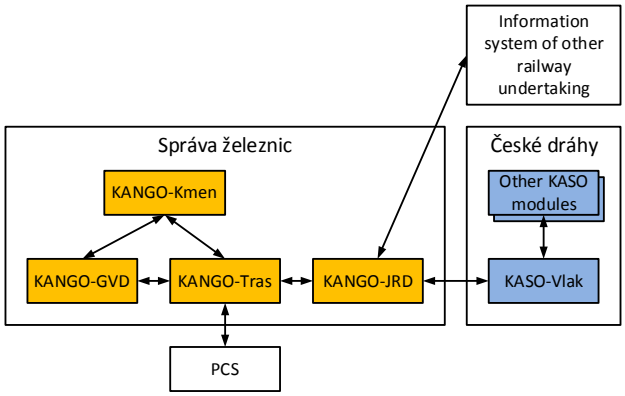

Fig. 2: Current architecture of information systems for the development of the annual train timetable

The KANGO-Vlak module was divided into two modules:

- KANGO-Tras – manages route requests from railway undertakings and DTTs created by the infrastructure manager.
- KASO-Vlak – used to develop the railway undertaking's timetable.

The communication interface of the KANGO system for the information systems of railway undertakings is the KANGO-JRD module, which receives TSI messages from individual railway undertakings via web services and provides messages to railway undertakings based on their query. KANGO-Tras queries the KANGO-JRD module at regular time intervals for new messages, which it then processes. The messages intended for railway undertakings are generated by KANGO-Tras and sent to KANGO-JRD, which after validation stores them in a message table from which they are provided to the individual systems of the railway undertakings. Interstate path data is exchanged between KANGO-Tras and the PCS.

The KANGO-Kmen and KANGO-GVD modules play the same role as in the original KANGO architecture.

The *Path Request* and *Path Details* messages are almost identical in structure, containing mainly the following information:

- Message header – contains message type, status, and identifier, information about the sender and recipient of the message, and date and time of message creation. The message status can take the values *Creation*, *Modification*, and *Deletion*.
- Information type – indicates the status of the request or DTT.
- Identifiers related to the request or DTT.
- The sequence of path transport points and the data relating to them. Only significant transport points can be included in the request, the complete route is given in the DTT, i.e. there must be a transport section between two transport points in the railway network database.

In a path request and DTT, unlike a train object, a calendar (running days bitmap) can only be specified at a single, reference transport point. According to the TSI, this can be any transport point in the path. In KANGO, only the starting point can be a reference point. In the other transport points of the path, only the information about the number of days of calendar offset with respect to the reference transport point is given. Train data (length, weight, traction vehicles, etc.) can change at each transport point, but cannot be defined with a custom calendar. Exceptions are passenger timetable notes and integrated passenger transport systems, which have a defined section and validity calendar and are part of the structured national message parameters. The transport point data also includes the train number, which is not mandatory in the request. The train number can only change from even to the nearest odd number in the path and vice versa. In this case, the train number is given as a slash number, e.g. 170/1.

The following transport identifiers appear in TSI messages:

- Path Request ID (PRID) – created by the railway undertaking, it identifies the path request. The identifier is also included in the DTT to determine the link between the path request and the DTT.
- Train ID (TRID) – created by the railway undertaking, it identifies the business case (from the perspective of the infrastructure manager). Multiple path requests can have the same TRID – the relationship between TRID and PRID is 1:N. As a rule, these are path requests related to the same train. A TRID cannot be given in two path requests with overlapping calendars. The TRID is contained in the path request and is repeated in the DTT.
- Path ID (PAID) – created by the infrastructure manager, it identifies the DTT. According to the TSI, more than one DTT can be provided for one path request – the relationship between PRID and PAID can be 1:N. In KANGO, only a 1:1 relationship is handled.

The KANGO-Tras module works with 4 types of trains:

- Request – originates from the *Path Request* message. The user can only view it.
- DTT – is created from the request.
- Required train – is created by KANGO-Tras from one or more DTTs. The user can only view it.
- Actual train – is created by KANGO-GVD from the required train. It is edited by the user in KANGO-GVD.

The required and actual trains correspond to the same named train types in the original KANGO architecture.

There are two types of DTTs:

- DTT with a request – is created from a request sent via the KANGO data interface. There is only one request for each of these DTTs.
- DTT without a request – is created by the KANGO-Tras user without sending a request via the KANGO data interface. A special type of DTT without a request is a catalogue DTT, whose requesting railway undertaking is a railway undertaking with the *Catalogue* flag. It is used for sample DTTs offered to railway undertakings and auxiliary DTTs created during the timetable creation process described below.

The relationship between the required train and the DTT is 1:N. The required train data is the union of the attached DTT data. The DTT route is a subset of the route of the required train. The time position of the DTT is the same as the required train. DTT calendars in the same section must not overlap. At least one DTT must be attached in each section of the required train.

An example of the relationships between these train types is shown in Figure 3.

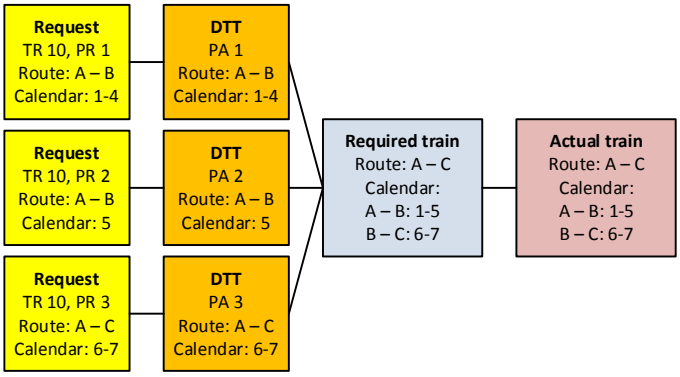

Fig. 3: Example of relationships between train types

4 Procedure for Developing the Annual Timetable

When a new timetable is being developed, it is based on the previous timetable. The database contains only DTTs without request that is in the *Transferred DTT* phase.

For each message sent by the railway undertaking, KANGO-Tras sends one of the following messages:

- *Receipt Confirmation* – the message from the railway undertaking has been successfully processed.
- *Error* – the message from the railway undertaking was erroneous. The message contains the text of the error.

KANGO-Tras does not respond to any *Receipt Confirmation* or *Error* messages sent by the railway undertaking. These messages are not required from the railway undertaking.

If no status is specified for the TSI messages described below, the message has the *Creation* status.

4.1 New Path Request

The processing of a new path request sent by the railway undertaking via the KANGO data interface is carried out as follows (see Figure 4):

1. The railway undertaking sends a *Path Request* message (*Harmonisation – Completed* information type) containing a new path request.
2. If the message contains errors, KANGO-Tras does not create the request and sends an *Error* message to the railway undertaking.

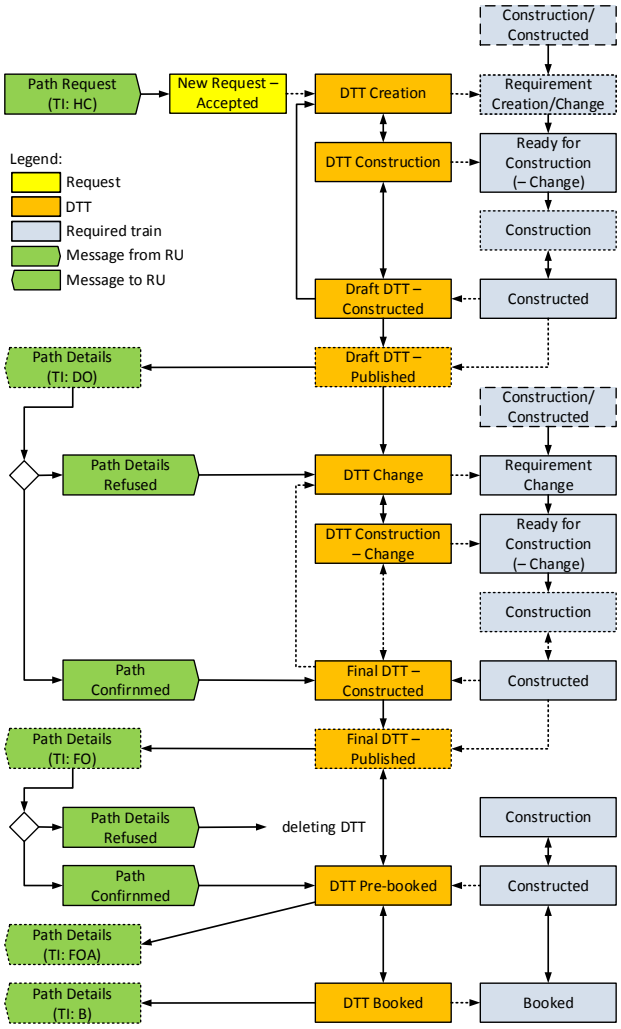

Fig. 4: Processing a new path request

3. If the message is error-free, KANGO-Tras creates a request from this message in the *New Request – Accepted* phase. It fills in the missing transport points in the requested route using the shortest path method of Dijkstra's algorithm, [8]. If the request does not contain a train number, the request is assigned the smallest available train number from the user-defined interval. It also creates a DTT from the request in the *DTT Creation* phase.
4. After creating the DTT, the program tries to automatically attach the DTT to the required train. One of the following trains will be used:
   - A new required train, if there required train with the same number, does not exist.
   - The required train with the same route in the section of the DTT route, the same train number, and the requesting railway undertaking, if it is linked to another non-catalogue DTT in this section and the train calendar does not overlap with the DTT calendar in this section.
   - The required train with the same route in the section of the DTT route and the same train number, if it is linked to the catalogue DTT of this section.
   - The required train with the same train number and the requesting railway undertaking, whose route can be extended by a section of the DTT route.

   In the DTT section in which the required train is attached to the catalogue DTT, the catalogue DTT is replaced by the attached DTT. If the DTT is to be attached to an existing train that is in the *Ready for Construction* or *Ready for Construction – Change* phase, the request, and the DTT shall not be created, and the message is only processed when the train reaches the next phase – *construction*.
5. If the DTT does not automatically attach to the required train, it must be attached by the KANGO-Tras user. The user can choose one of the following commands:
   - Create – A new required train is created with data taken from the DTT.
   - Use – the user selects an existing required train.
6. When the DTT is attached to the required train, either automatically or manually, the new required train enters the *Requirement Creation* phase, the existing required train remains in the *Requirement Creation* phase or, if it has already been previously passed to construction in KANGO-GVD, it is transferred to the *Requirement Change* phase.
7. DTTs in the *DTT Creation* phase can be modified by the KANGO-Tras user according to his/her rights. If the DTT is attached to the required train after editing the DTT the data corresponding to the required train is automatically updated.
8. If the DTT is attached to the required train and contains the requested data, the user can pass it to the construction in KANGO-GVD by transferring it to the *DTT Construction* phase. If the DTT has been automatically attached to the requested train (on receipt of the *Path Request* message), it is automatically transferred to this phase. Most of the data in the DTT cannot be modified in this phase. If neither DTT attached to the required train is in the *DTT Creation* or *DTT Change* phase (see below), the required train is transferred out of the phase:
   - *Requirement Creation* to the *Ready for Construction* phase – if it has not already been submitted for construction,

- *Requirement Change* to the *Ready for Construction – Change* phase – if it has already been submitted for construction.

9. KANGO-GVD automatically creates a new actual train for the required train in the *Ready for Construction* phase, copying all data from the required train into it. If the required train is in the *Ready for Construction – Change* phase, it imports the data that cannot be edited in KANGO-GVD from the required train into the existing actual train. It then takes the required and the actual train to the *Construction* phase.
10. After the construction of the actual train is completed in KANGO-GVD, the actual train is transferred from the *Construction* phase to the *Constructed* phase.
11. KANGO-Tras detects train phase changes at regular time intervals. Once the actual train has reached the *Constructed* phase, KANGO-Tras imports the data that can be edited in KANGO-GVD from the actual train to the corresponding required train and its associated DTTs. It transfers the required train to the *Constructed* phase and the DTT from the *DTT Construction* phase to the *Draft DTT – Constructed* phase. Most of the data in the DTT cannot be modified in this phase. If the KANGO-GVD user later transfers the actual train back to the *Construction* phase, KANGO-Tras automatically transfers the required train back to the *Construction* phase and the attached DTTs back to the *DTT Construction* phase.
12. The KANGO-Tras user can transfer the DTT from the *DTT Construction* or *Draft DTT – Constructed* phase back to the *DTT Creation* phase to modify it. The related required train is transferred from the *Construction* or *Constructed* phase to the *Requirement Change* phase or remains in the *Requirement Creation* phase. Step 8 follows to transfer the DTT back to construction.
13. The infrastructure manager provides the railway undertaking with the DTT draft by moving the DTT from the *Draft DTT – Constructed* phase to the *Draft DTT – Published* phase. The transfer of a DTT to this phase can only be done by a KANGO-Tras user with the *Important Phases* right. The railway undertaking is sent a *Path Details* message (*Draft Offer* information type). At this stage, most of the data cannot be edited in DTT and the response of the railway undertaking is awaited. The KANGO-GVD user can still transfer the related train to the *Construction* phase in this phase, but the DTT phase does not change. Once the related train is back in the *Constructed* phase, the DTT is updated without changing the phase, and the *Path Details* message (*Draft Offer* information type) is sent again to the railway undertaking. The possibility to provide a new draft DTT without the railway undertaking's response is not in accordance with the TSI but was requested by the users.
14. The railway undertaking may send one of the following messages in response to the draft DTT:
    - *Path Confirmed* (*Observation – Complete* information type) – the railway undertaking accepts the draft DTT, the message does not contain a text of comments.
    - *Path Details Refused* (*Observation – Complete* information type) – the railway undertaking rejects/refuses or has commented on the draft DTT, the message contains the text of the comments.
15. In the case of *Path Confirmed* message processing, KANGO-Tras sets the information in the DTT about the approval of the draft DTT and transfers it to the *Final DTT – Constructed* phase. This is followed by Steps 21 or 22.
16. In the case of *Path Details Refused* message processing, KANGO-Tras sets the information in the DTT about the disapproval of the draft DTT with the text of the comment and transfers it to the *DTT Change* phase. It transfers the related required train to the *Requirement Change* phase. If the required train is in the *Ready for Construction – Change* phase, the message is only processed when the train reaches the next phase – *construction*.
17. The DTT in the *DTT Change* phase can be modified by the KANGO-Tras user according to his/her rights. If the DTT is attached to the required train, after it is modified the data of the attached required train is updated automatically.
18. In exceptional cases, the KANGO-Tras user can transfer the DTT from the *Draft DTT – Published* phase to the next phase (*DTT Change, Final DTT – Constructed, DTT Pre-booked*) by him/herself without any response from the railway undertaking. This operation can only be performed by a user with the *Important Phases* right. If later a *Path Confirmed* or *Path Details Refused* message is received, the DTT sets the information about the acceptance or refusal of the draft DTT with any comment text, but the DTT phase does not change.
19. If the DTT in the *DTT Change* phase is attached to the required train and contains the requested

data, the user can pass it to the construction by transferring it to the *DTT Construction – Change* phase. In this phase, most of the data in the DTT cannot be modified. If neither the DTT attached to the required train is in the *DTT Creation* or *DTT Change* phase, the required train is transferred to the *Ready for Construction* or *Ready for Construction – Change* phase and then to the *Construction* and *Constructed* phase as described in Steps 9 and 10.

20. Once the actual train reaches the *Constructed* phase, KANGO-Tras automatically imports the data that can be edited in KANGO-GVD from the actual train to the corresponding required train and attached DTTs. It transfers the required train to the *Constructed* phase and the DTTs from the *DTT Construction – Change* phase to the *Final DTT – Constructed* phase. Most of the data in the DTT cannot be modified in this phase. If the KANGO-GVD user later transfers the actual train back to the *Construction* phase, KANGO-Tras automatically transfers the required train back to the *Construction* phase and the DTT back to the *DTT Construction – Change* phase.
21. The KANGO-Tras user can transfer the DTT from the *DTT Construction – Change* or *Final DTT – Constructed* phase back to the *DTT Change* phase to modify it. The related required train is transferred from the *Construction* or *Constructed* phase to the *Requirement Change* phase or remains in the *Requirement Change* phase. Step 19 follows to transfer the DTT back to construction.
22. The infrastructure manager provides the railway undertaking with the *Final DTT* by transferring the DTT from the *Final DTT – Constructed* phase to the *Final DTT – Published* phase. The transfer of the DTT to this phase can only be done by a KANGO-Tras user with the *Important Phases* right. The railway undertaking is sent a *Path Details* message (*Final Offer* information type). In this phase, most of the data in the DTT cannot be edited and awaits the railway undertaking's response. The KANGO-GVD user can also transfer the related train to the *Construction* phase in this phase, but the DTT phase is not changed. When the related train is transferred back to the *Constructed* phase, the DTT is updated without changing the phase and the *Path Details* message (*Final Offer* information type) is sent again to the railway undertaking. The possibility to provide a new final DTT without the railway undertaking's response is not in accordance with the TSI but was requested by the users.
23. The railway undertaking may send one of the following messages in response to the final DTT:
    - *Path Confirmed* (*Final Offer – Accepted* information type) – the railway undertaking accepts the final DTT, the message does not include a text of comments.
    - *Path Details Refused* (information type not specified in the message) – the railway undertaking does not accept the final DTT, the message contains the text of the comment.
24. If the *Path Confirmed* message is processed, KANGO-Tras sets the information in the DTT about the approval of the final DTT and transfers the DTT to the *DTT Pre-booked* phase.
25. If the *Path Details Refused* message is processed, KANGO-Tras sets the information about the rejection of the final DTT in the DTT with the comment text and performs the DTT deletion operation (see below).
26. In exceptional cases, the KANGO-Tras user can transfer the DTT from the *Final DTT – Published* phase to the next phase (*DTT Pre-booked*) by him/herself without any response from the railway undertaking. This operation can only be performed by a user with the *Important Phases* right. If later a *Path Confirmed* or *Path Details Refused* message is received, the DTT sets the final DTT acceptance or rejection information with any comment text, but the DTT phase is not changed.
27. Once the DTT reaches the *DTT Pre-booked* phase, the railway undertaking is sent a *Path Details* message (*Final Offer – Accepted* information type). In this phase, most of the data in the DTT cannot be modified. The KANGO-GVD user can also transfer the related Path to the *Construction* phase in this phase, but the DTT phase does not change. Once the related train is back in the *Constructed* phase, the DTT is updated without changing the phase, and the *Path Details* message (*Final Offer – Accepted* information type) is sent again to the railway undertaking.
28. In exceptional cases, the KANGO-Tras user can transfer the DTT from the *DTT Pre-booked* phase back to the *Final DTT – Published* phase to allow the railway undertaking to modify or cancel the request. The *Path Details* message (*Final Offer* information type) is sent again to the railway undertaking and the information about the acceptance or refusal of the final DTT

is deleted in the DTT. This operation can only be performed by a user with the *Important Phases* right.

29. On the date of allocation of the railway capacity, the KANGO-Tras user transfers the DTT from the *DTT Pre-booked* phase to the *DTT Booked* phase. The DTT can be transferred to this phase if the related required train is in the *Constructed* phase and the other DTTs attached to this train are also in the *DTT Pre-booked* phase. The related required and actual train is transferred to the *Booked* phase. Only a user with the *Important Phases* right can transfer the DTT to this phase. A *Path Details* message is sent to the railway undertaking (*Booked* information type). Most of the data of the DTT cannot be edited in the *DTT Booked* phase. The actual train in the *Booked* phase cannot be edited in KANGO-GVD.

The *DTT Pre-booked* phase is not mentioned in the TSI. It has been introduced to allow modifying the train in KANGO-GVD even in this phase, to update the DTT with railway undertaking data not needed at the time of construction in KANGO-GVD, or possibly to return the DTT to the previous phase to allow the railway undertaking to modify the request.

If the infrastructure manager processes a request that the railway undertaking has not sent via the KANGO data interface, it creates the DTT without request in the *DTT Creation* phase or transfers it from the *Transferred DTT* phase. The procedure is then the same as for a DTT with a request, except that no messages are sent to the railway undertaking. The railway undertaking's response to the draft and final DTT is entered into the DTT by the KANGO-Tras user.

4.2 Modifying the Path Request

When modifying a path request sent by a railway undertaking via the KANGO data interface is as follows (see Figure 5):

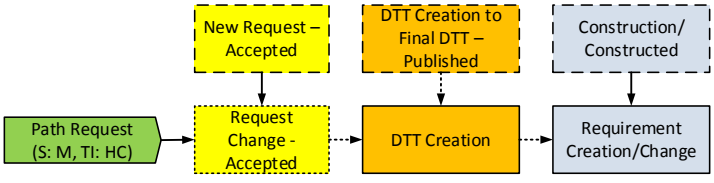

Fig. 5: Path request modification process

1. The railway undertaking may make a modification to its request if the DTT is in the *DTT Creation* to the *Final DTT – Published* phase. The railway undertaking sends a *Path Request* message (*Modification* status, *Harmonisation – Completed* information type).
2. If the message contains errors or the request cannot be modified (the DTT is in an unauthorized phase), KANGO-Tras does not process the modification of the request and sends an *Error* message to the railway undertaking.
3. If the message is error-free and the request can be modified, KANGO-Tras creates a request from the message that overwrites the original request. The request enters the *Request Change – Accepted* phase. The DTT attached to this request enters the *DTT Creation* phase. If the DTT is attached to the required train, this train is transferred to the *Requirement Change* phase or remains in the *Requirement Creation* phase. All data from the request, including the route, is transferred to the DTT. Next, the data of the required train is updated according to the DTT. However, if a change to the required train would cause modification of another non-catalogue DTT attached to this train, the DTT shall be detached from the train. If the related required train is in the *Ready for Construction* or *Ready for Construction – Change* phase, the message is only processed when the train reaches the next phase – *construction*.
4. The procedure is then the same as for a DTT created from a new path request, except that the DTT is automatically transferred from the *DTT Creation* phase to the *DTT Construction* phase if all the following conditions are met:
   - The DTT was not originally in the *DTT Creation* phase.
   - The DTT is attached to the required train.
   - There is no other DTT with request and the same train number as the modified DTT that is not attached to the required train and is in a different phase than the *DTT Deleted* or *DTT Cancelled*.

If, after the DTT has been detached from the train, there is a section of the train that is not attached to any DTT, the detached DTT shall be replaced by the catalogue DTT in that section. The new catalogue DTT will enter the *DTT Creation* phase.

4.3 Cancelling the Path Request

The procedure for cancelling a request by the railway undertaking via the KANGO data interface is as follows (see Figure 6):

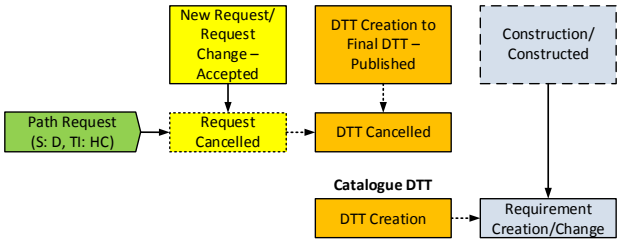

Fig. 6: Path request cancellation process

1. The railway undertaking may cancel the request if the DTT is in the *DTT Creation* to *Final DTT – Published* phase. The railway undertaking sends a *Path Request* message (*Deletion* status, *Harmonisation – Completed* information type).
2. If the message contains errors or the request cannot be cancelled (the DTT is in an unauthorised phase), KANGO-Tras does not process the cancellation and sends an *Error* message to the railway undertaking.
3. If the message is error-free and the request can be cancelled, KANGO-Tras transfers the request to the *Request Cancelled* phase. The DTT attached to this request is transferred to the *DTT Cancelled* phase and detached from the required train. If the related required train is in the *Ready for Construction* or *Ready for Construction – Change* phase, the message is only processed when the train reaches the next phase – *construction*.

If, after the DTT has been detached from the train, there is a section of the train that is not bound to any DTT, the detached DTT is replaced by a catalogue DTT in this section. The new catalogue DTT enters the *DTT Creation* phase.

A DTT in the *DTT Cancelled* phase can only be deleted by a user of the administrator type. In this case, the DTT is irreversibly deleted from the database together with the request.

4.4 Deleting the DTT

The infrastructure manager may later discover that the DTT cannot be allocated after receiving a new path request or modifying it and deleting the DTT. The procedure for deleting a DTT is as follows (see Figure 7):

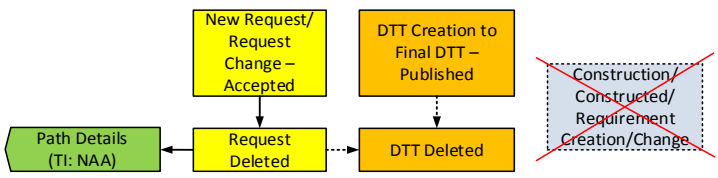

Fig. 7: DTT deletion process

1. The KANGO-Tras user can delete the DTT if it is in the *DTT Creation* to *Final DTT – Published* phase. After entering the text of the reason for deletion, the DTT is transferred to the *DTT Deleted* phase and detached from the required train. The corresponding request is transferred to the *Request Deleted* phase.
2. The railway undertaking is sent a *Path Details* message (*No Alternative Available* information type) containing the reason for the deletion.

If, after the DTT has been detached from the train, there is an internal section in the train that is not attached to any DTT, the detached DTT is replaced by the catalogue DTT in this section. The new catalogue DTT will enter the *DTT Creation* phase. If there is no start or end section of the train attached to the DTT, the train shall be shortened by this section.

4.5 Non-construction Data

Data that is not needed at the time of construction in KANGO-GVD is sent by the railway undertaking via the KANGO data interface in *Path Request* and/or *Object Info* messages. These are passenger timetable notes, integrated passenger transport systems, lines, etc.

The infrastructure manager sends this data in the *Path Details* message. In those messages, this data is contained in structured national parameters.

The *Object Info* message can be used by the railway undertaking to update the data in the DTT, which can be in the *DTT Creation* to *DTT Pre-booked* phase. After receiving the message, KANGO-Tras modifies these data in the DTT and the related train.

5 Conclusion

Since the end of 2010, the annual timetable in the Czech Republic has been developed using the KANGO system on the side of Správa železnic, an infrastructure manager, and KASO on the side of České dráhy, a railway undertaking, which had a common KANGO-Vlak module for ordering train paths. The architecture of the KANGO system did not allow attaching the information systems of other railway undertakings, which had to request train paths through the infrastructure manager's staff. Moreover, the railway undertaking České dráhy did not have its database of trains and master data in which it could maintain its specific data for its own use.

Therefore, in 2013, the development was started to separate the KANGO and KASO systems and to create a web services-based data interface for the railway operator, with which the information systems of railway undertakings can communicate using XML messages. These messages correspond to the TAF/TAP TSI of the European Union with minor national differences. The railway undertaking's information system sends messages and queries the messages provided by the infrastructure manager. The basic messages are the *Path Request* sent by the railway undertaking and the *Path Details* (constructed path – DTT) sent by the infrastructure manager.

A new KANGO-Tras module was developed to replace the KANGO-Vlak module. KANGO-Tras handles the processing of messages from railway undertakings, the creation of messages for railway undertakings, and the management of path requests, DTTs, and required trains that arise from one or more DTTs by merging their data. The required trains are the basis for the construction of the actual trains in KANGO-GVD, from which time data and other data entered by the constructors into the DTT are fed back.

For the development of the annual timetable, processes were designed for processing a new path request, modifying and cancelling the path request by the railway undertaking, deleting the DTT by the infrastructure manager, and processing non-construction data that are not needed at the time of construction in KANGO-GVD.

The new KANGO system was deployed into routine operation at the beginning of 2020 and the 2019/2020 timetable was successfully developed in it. The KASO systems of the railway undertakings České dráhy and ARRIVA and information systems of other railway undertakings communicate via the KANGO data interface.

The Czech Republic is currently the only European country in which an information system for developing train timetables that meets the TSI EU specifications is in routine operation. In other European countries, the implementation of the TSI is in the development phase.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

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Conflict of Interest

The author has no conflict of interest to declare.