CEN/TC 278
ITS standardization

PUBLIC TRANSPORT
NETWORK TIMETABLE EXCHANGE
(NeTEx)

REPRESENTING TIMETABLES IN NeTEx

CEN TC278/WG3/SG9 NeTEx PT001

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OCTOBER 2015

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INTRODUCTION

The NeTEx (Network Timetable Exchange) standard is a CEN standard for exchanging public transport data. This white paper provides an overview of how Public Transport Timetables are represented in the CEN Network Exchange (NeTEx) standard.
By timetable we mean a set of journeys available to travel over a route or routes during a given period, including any conditions as to when specific services run, and possibly information about connecting services in order to consistently model a real public transport service.
The white paper outlines the main capabilities of NeTEx for describing timetables, and gives a very simple example at the end. Additional considerations for timetables for Flexible services are given in a separate white paper.

AUDIENCE

The paper is intended to convey a high level view sufficient for a technical manager to appreciate the capabilities of NeTEx, and omits detailed considerations, but is still quite technical. For a complete description, see in particular Part2 [N2], as well as generic framework concepts (points, links, zones, etc.) and PT network topology concepts (scheduled stop points, lines, routes, etc) described in [N1].

CORRESPONDING NeTEx DOCUMENTATION

Conceptually a timetable is a frame that aggregates timetable related concepts from models mainly described in NeTEx Part2. Table 1 gives a summary of models inside NeTEx Part1 and Part2 documentation, which are relevant for the interoperable exchange of timetables in NeTEx.

NeTEx parts containing frames and models that make up a timetable

NeTEx PART 1

NeTEx Explicit Frames
* Service Frame Model
* Timetable Frame Model
* Service Calendar Frame Model

NeTEx Framework
* Generic Framework Model
  — *Generic Point & Link Model*
* Reusable Components Model
  — *Service Calendar Model*
  — *Notice Model*
  — *Reusable Availability Model*
* Versions & Validity Model
  — *Generic Version Model*
  — *Generic Validity Model*

Network Description Model
* Route Model

Tactical Planning Components Model
* Journey Pattern Model
* Time Demand Type Model
* Service Pattern Model

NeTEx PART 2

Journey and Journey Times Model
* Vehicle Journey Model
* Service Journey Model
* Time Demand Times Model
* Journey Pattern Times Model
* Vehicle Journey Times Model
  — *Interchange Model*
  — *Interchange Rule Model*
  — *Coupled Journey Model*
* Flexible Service Model
* Journey Timing Model

Journey Accounting Model
* Dated Journey Model
* Passing Times Model
* Vehicle Service Model
* Vehicle Journey Assignment Model

APPROACH TO TIMETABLES IN NeTEx

NeTEx uses a consistent model (from Transmodel) to represent PT timetables for all PT modes (train, bus, coach, metro, tramway, ferry, and their sub-modes), including both the journeys of the service, and any interchanges with other services. It also includes support for advanced rail related concepts, such as coupled journeys for trains that join and split, and the makeup of trains for passenger information. Services may be scheduled with fixed departure times, or as frequency based services (say "every 5 minutes").

The NeTEx representation is designed to support the exchange of schedules throughout the operational processes of a PT operator, and therefore includes components that tie in the timetables and their journeys both to upstream planning and to downstream operations processes, making the NeTEx format richer and more flexible (and more complex) than a mere 'final timetable format' for publishing timetable data to journey planners (such as say GTFS [G1]). Timetables may be created quickly and efficiently from reusable network and timing components, with linkage references to the latter being maintained, so that any changes to the derivation can be propagated automatically into a revised timetable.
Timetables are themselves in effect reusable components as they may be specified independently of any actual dates. Actual dates are assigned to a timetable with a service calendar frame, which specifies a set of day types (e.g. "working weekday"), operating days (e.g. "Wednesday 2015-09-17") with corresponding day type assignments (e.g. "17th September 2015 is a day type 'working weekday' "). By using different service calendars a timetable may be perennial and be reused in different actual periods.
Timetable elements can also include links to data needed to support real-time operational systems including blocks and driver components, as well as additional passenger information such as on-board announcements, stop displays, equipment, etc. again enabling the automated provisioning of systems (and updating in the case of change).

One of the significant practical considerations in representing timetables digitally (and the cause of the greatest difficulty when integrating different data sets from different sources) is the representation of temporal validity conditions as to when a particular timetable, or service within the timetable, operates. The NeTEx framework provides a uniform model for defining validity conditions that helps to simplify the interpretation of temporal constraints and makes data integration a lot easier – see [W4] and [N1]. A consistent system of conditions is also useful for upstream systems, which may wish to maintain many alternative versions of timetables for different planning or contingency purposes; the validity condition mechanism allows timetables to be tagged semantically for different uses –e.g. 'Winter timetable for heavy snow conditions'.

Timetables can include additional annotations such as notices applying to particular journeys, details of facilities available for all or part of the journey and on-board equipment. Journeys can also be tagged with accounting attributes for contracts between PT organisations.

A NeTEx timetable only needs to be populated as required for a given application – most of the elements are optional, so the same format (and technology platform) may be used for both a sparsely populated summary (equivalent say to GTFS) or a richer representation for planning or operational purposes. There are mappings of timetable elements into major legacy formats such as VDV 452 and NEPTUNE.

Fares for scheduled services are added in NeTEx Part3, referencing the network and timetable components developed in NeTEx Part1 and NeTEx Part2.

THE REPRESENTATION OF A TIMETABLE

NeTEx uses a conventional representation for the core timetable, corresponding to that found in various national standards, which we outline in this section:

- A simple timetable is made up of one or more SERVICE JOURNEYs; each journey describing a scheduled journey departing at a specific time. A journey is made up of two or more CALLs, each describing arrival and or departure times at a SCHEDULED STOP POINT in sequence, along with any other information relating to a visit to a particular stop, such as notices, platforms, display headings, accessibility of the service, etc. Validty conditions as to when a particular journey runs are normally specified in terms of DAY TYPEs types which can be separately resolved to an actual calendar date.
- The journeys are grouped explicitly in a TIMETABLE FRAME, which sets global validity conditions and other defaults for all SERVICE JOURNEYs in the timetable. The frame provides a container to hold the journeys and other timetable related elements for exchange. Timetable frames can themselves be grouped in a COMPOSITE FRAME with other types of frame, for example SERVICE FRAMEs (with stop and route details), SERVICE CALENDAR FRAME (with DAY TYPEs and OPERATING DAYs) and/or FARE FRAMEs (with price details) in order to create complete and coherent self-contained data sets. DAY TYPE is used to specify the days one which a given service runs; the temporal constraints on the DAY TYPE can be specified by VALIDITY CONDITIONs that specify the day of week, holiday operation, etc.

NeTEx has many additional features to represent additional aspects of timetables that are found in different circumstances:

- To represent frequency based services; an additional types of service journey, the TEMPLATE SERVICE JOURNEY, is provided. The frequency may be specified either as an interval such as “every five to ten minutes’” (using a HEADWAY JOURNEY GROUP) or a as a regular e.g. “at 05, 25 and 45 minutes past the hour” (using a RHYTHMICAL JOURNEY GROUP). Use of a separate template component clarifies the distinction between the operational view of the timetable (which still involves individual SERVICE JOURNEYs running at specific times in operational blocks) from the passenger view, which is condensed down to a single entry with a frequency.
- PT services will often be planned so as to connect with other services, and information on these connections may be included in passenger information using the SERVICE JOURNEY INTERCHANGE element. The representation can describe interchange times and whether a connection is advertised, guaranteed (i.e. will wait a certain time) and other operational constraints. Additional complex conditions about managing journey interchanges can be specified with INTERCHANGE RULEs.
- Long distance rail may involve vehicle journeys that join or split; this can be modelled by the additional use of JOURNEY PART elements, to represent each segment of the journey which can be combined as JOURNEY PART COUPLEs to indicate a joined segment of the journey. TRAIN & COMPOUND TRAIN ELEMENTS can be used to describe the corresponding train makeup implications (i.e. which carriages go where) so that meaningful passenger information can be provided. The TRAIN NUMBER element allows the correct public identifier used for each journey to be provided, despite any intricacies of joining or splitting or international operation.

COMPONENTS TO CREATE A TIMETABLE

The operation of modern PT networks typically involves the use of computer based systems to plan and optimise the provision of services. Planning systems represent (and may need to change) not just the timetable element but also the various elements from which the timetable is built. NeTEx allows such data to be exchanged, as well as the resulting timetables. Here we outline the relationship of such elements to the timetable.

- The central timetable element is the VEHICLE JOURNEY (a generalization of SERVICE JOURNEY), which is a combination of a number of different tactical components: **(a)** the ROUTE and related JOURNEY PATTERN and SERVICE PATTERN, which dictate the route and sequence of stops (POINTs IN SEQUENCE) to be followed; **(b)** the TIMING PATTERN, and JOURNEY TIMINGs, which give the timing points and times needed to cover each link of the journey, and **(c)** the TIME DEMAND TYPE, which specifies the part of day that the journey is taking place, e.g. 'weekday', 'rush hour', etc. and so which set of timings should be used. Thus given a starting time and a SERVICE PATTERN it is possible to integrate information from the other components and automatically compute a sequence of CALLs with PASSING TIMES etc at each stop.
- The planning of services may also involve the optimisation of groups of journeys in driver and vehicle scheduling systems, to create work periods for each VEHICLE TYPE.Such periods are described as BLOCKs, worked from a PARKING POINT to another, composed of sets of VEHICLE JOURNEYs. BLOCKs may be coupled (building COMPOUND BLOCKs, representing the work of a vehicle during the time it is coupled to another vehicle) or separated for a while, building BLOCK PARTs, i.e. the parts of a BLOCK corresponding to the different JOURNEY PARTs of the VEHICLE JOURNEYs in a BLOCK.
- A DEAD RUN is another type of VEHICLE JOURNEY, an out of service journey that send out vehicles and retrieve them back to their depots, these may included to support operational and real-time systems.

COMPONENTS TO OPERATE A TIMETABLE

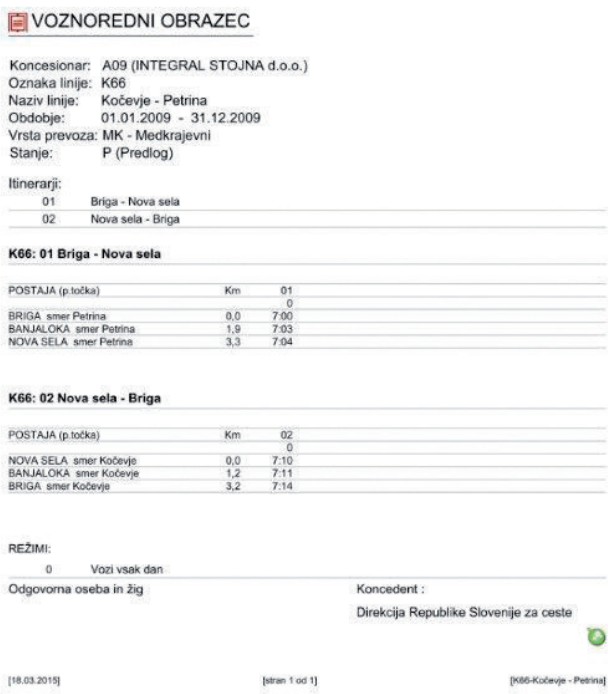
Other types of operational data may be included in the SERVICE JOURNEY representation to provision downstream systems. For example:

- JOURNEY ACCOUNTING elements can be used to apportion costs for providing services for (parts of) a journey for contracts between different organizations.
- DESTINATION DISPLAY elements can be used to drive headsign, on-board displays and next stop announcements along the journey.

APPENDIX A: EXAMPLE OF A SIMPLE TIMETABLE IN NeTEx

The example (Figure 1) shows a simple bus timetable for a linear route modelled in NeTEx. The example originates from a national PT database in Slovenia.

- The timetable includes two ROUTES (outbound – "Briga to Nova sela" and inbound – "Nova sela to Briga") belonging to one LINE (id=K66, "Kočevje – Petrina") with transport MODE "bus".
- The timetable includes three stop points (SCHEDULED STOP POINTs) (Briga, Banja Loka and Nova sela) in each DIRECTION (i.e. Briga smer Petrina, Briga smer Kočevje).
- The timetable aggregates two SERVICE JOURNEYs (i.e. specific passenger carrying VEHICLE JOURNEYs), each following its own SERVICE PATTERN (boarding/alighting status). Each SERVICE PATTERN refers to a SERVICE JOURNEY PATTERN to derive the exact order of nodes, i.e. SCHEDULED STOP POINTS for its ROUTE; this is reflected in the timetable as the sequence of CALLs
- Each SERVICE JOURNEY also refers to a TIME DEMAND TYPE, which defines a set of vehicle running times for links between stop points for a given TIMEBAND and DAY TYPE. The given TIME DEMAND TYPE is used to calculate the planned vehicle arrival and departure times for each SCHEDULED STOP POINT at the given time of day; the result is included in the CALLs.
- A reference to DAY TYPE, which has property values "Everyday" and "AnyHoliday", defines operating days for the timetable.



VOZNOREDNI OBRAZEC

Koncesionar: A09 (INTEGRAL STOJNA d.o.o.)
Oznaka linije: K66
Naziv linije: Kočevje - Petrina
Obdobje: 01.01.2009 - 31.12.2009
Vrsta prevoza: MK - Medkrajevni
Stanje: P (Predlog)

Itinerarji:

01	Briga - Nova sela
02	Nova sela - Briga

K66: 01 Briga - Nova sela

POSTAJA (p.točka)	Km	01
		0
BRIGA smer Petrina	0,0	7:00
BANJALOKA smer Petrina	1,9	7:03
NOVA SELA smer Petrina	3,3	7:04

K66: 02 Nova sela - Briga

POSTAJA (p.točka)	Km	02
		0
NOVA SELA smer Kočevje	0,0	7:10
BANJALOKA smer Kočevje	1,2	7:11
BRIGA smer Kočevje	3,2	7:14

REŽIMI:

0	Vozi vsak dan

Odgovorna oseba in žig

Koncedent :
Direkcija Republike Slovenije za ceste

[18.03.2015] [stran 1 od 1] [K66-Kočevje - Petrina]

Figure 1. The bus timetable Kočevje-Petrina converted to NeTEx (XML physical model)

The following is a minimal encoding of the outbound part of the above timetable, omitting elements that give additional information and all referenced elements:

```
<TimetableFrame version="1" id="ao:K66_01">
        <validityConditions>
                <AvailabilityCondition id="ao:k66_01_01">
                        <FromDate>2009-01-01T00:00:00Z</FromDate>
                        <ToDate>2009-31-12T00:00:00Z</ToDate>
                </AvailabilityCondition>
        </validityConditions>
        <Name> Bus timetable for line Kočevje-Petrina</Name>
        <VehicleModes>bus</VehicleModes>
        <OperatorView>
                <OperatorRef ref="ao:A09"/>
                <Name>(INTEGRAL STOJNA d.o.o</Name>
        </OperatorView>
        <vehicleJourneys>
                <ServiceJourney id="ao:K66_outbound_01">
                        <DepartureTime>07:00:00.0Z</DepartureTime>
                        <dayTypes>
                                <DayTypeRef ref="ao: Everyday-AnyHoliday"/>
                        </dayTypes>
                        <ServicePatternRef ref="ao:K66_outbound"/>
                        <TimeDemandTypeRef ref="ao:offpeak"/>
                        <LineRef ref="ao:K66"
                        <JourneyPatternView>
                                <RouteRef ref="ao:K66_out"/>
                                <DirectionType>outbound</DirectionType>
                                <DestinationDisplayRef ref="ao:NovaSela"/>
                        </JourneyPatternView>
                        <calls>
                                <Call id="ao:K66_outbound_01" order="1">
                                        <ScheduledStopPointRef ref="ao:Briga-p"/>
                                        <Arrival>
                                                <ForAlighting>false</ForAlighting>
                                                </Arrival>
                                        <Departure>
                                                <Time>07:00:00.0Z</Time>
                                        </Departure>
                                </Call>
                                <Call id="ao:K66_outbound_01" order="2">
                                        <ScheduledStopPointRef ref="ao:BanjaLoka-p"/>
                                        <Arrival>
                                                <Time>07:02:30.0Z</Time>
                                        </Arrival>
                                        <Departure>
                                                <Time>07:03:00.0Z</Time>
                                        </Departure>
                                </Call>
                                <Call id="ao:K66_outbound_01" order="3">
                                        <ScheduledStopPointRef ref="ao:NovaSela-p"/>
                                        <Arrival>
                                                <Time>07:04:00.0Z</Time>
                                        </Arrival>
                                        <Departure>
                                                <ForBoarding>false</ForBoarding>
                                        </Departure>
                                </Call>
                        </calls>
                </ServiceJourney>
        </vehicleJourneys>
</TimetableFrame>
```

ACKNOWLEDGEMENT

This White Paper has been produced thanks to the support of Fabrizio Arneodo (5T srl), Kasia Boureé (KBIC), Christophe Duquesne (Aurige), Nick Knowles (Steam Intellect), Andrej Tibaut (University of Maribor), Jan Tijmensen (InTraffic , Connekt).

FURTHER READING

THE NeTEx STANDARD

[N1] NeTEx-Part 1: *Public Transport Network Topology exchange format, CEN/TS 16614-1:2014*
[N2] NeTEx-Part 2: *Public Transport Scheduled Timetables exchange format, CEN/TS 16614-2:2014*
[N3] NeTEx-Part 3: *Fare Information exchange format, CEN/TS 16614-3:2014*

OTHER NeTEx WHITE PAPERS

[W1] NeTEx *Introduction* - White Paper
[W2] NeTEx *Getting Started* - White Paper
[W3] NeTEx *Design Methodology* - White Paper
[W4] NeTEx *Framework* - White Paper
[W5] NeTEx *Reusable Components* - White Paper
[W6] NeTEx *Networks* - White Paper
[W7] NeTEx *Flexible Networks and Multimodality* - White Paper
[W8] NeTEx *Accessibility* - White Paper
[W9] NeTEx *Fares* - White Paper

OTHER REFERENCES

[T1] *Public Transport Reference Data Model - Part 1: Common Concepts (Transmodel)*, EN12896-1
[T2] *Public Transport Reference Data Model - Part 2: Public Transport Network (Transmodel)*, EN12896-2
[T3] *Public Transport Reference Data Model - Part 3: Timing Information and Vehicle Scheduling (Transmodel)*, EN12896-3
[G1] *General Transport Feed Specification* https://developers.google.com/transit/gtfs/

FURTHER INFORMATION

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