PUBLIC TRANSPORT
NETWORK TIMETABLE EXCHANGE
(NeTEx)

# REPRESENTING FLEXIBLE NETWORKS AND MULTIMODALITY IN NeTEx

CEN TC278/WG3/SG9 NeTEx PT001

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# INTRODUCTION

The NeTEx (Network Timetable Exchange) is a CEN standard for exchanging public transport data. This white paper provides an overview of how Flexible Public Transport Networks can be represented in NeTEx. By a 'Flexible Network' we mean the stops, areas, lines etc that make up a public transport system that runs variably rather than to a fixed schedule. It also provides an overview of how multimodal conenctions are supported.

## AUDIENCE

This white paper is intended to convey a high level view sufficient for a technical manager to appreciate the capabilities of the CEN standard NeTEx and omits all detailed considerations - see detailed documentation [N1], [N2], [N3]. The paper builds on a related white paper [W6] to describe fixed networks, which should be read first.

## SCOPE

The NeTEx public transport network representation can be used for any mode of transport, including rail, bus, metro, ferry etc. The same model elements can be used in different ways in different views, for example ranging from a high level schematic view of the network for passengers, to a stop by stop sequence of a route for a specific scheduled journey.

In the NeTEx representation (see [W6]), both the different types of locations (stations, airports bus stops etc), their layout and their properties such as accessibility and facilities can be described (see [W7]). The relationship between the representation of a stop as a set of physical points (e.g. a station and its platforms); the stop as a point in a timetable (which may be independent of platform); and the stop as point for real-time measurement and display can all be described precisely.

The representation of multimodal features of topological elements already described in [T4] is extended in NeTEx, fully integrated into the network topology representation and may be used for instance for the description of inter-modal connections.

Alongside a more classical view of network topology, NeTEx can also describe flexibility features of topological elements that characterise flexible services. Some of the fixed network elements may be used to describe the structure of Flexible Networks, for Flexible Transport Systems or Demand Responsive Systems. This makes it possible to make Flexible Services visible in journey planners and stop finders and other applications.

## CORRESPONDING NeTEx DOCUMENTATION

A detailed specification of NeTEx capabilities as regards the public transport network representation and exchange can be found in [N1]. A short presentation of the public transport network representation is also given in [W6].

The basic network topology as described in [N1] is represented either through simple or complex object classes like:

- Paths through the network: ROUTEs, JOURNEY PATTERNs, TIMING PATTERNs, SERVICE PATTERNs, etc. which are linear features, linked to point features such as
- Operational points: TIMING POINTs, GARAGEs, CREW POINTs, BEACON POINTs, etc.
- Passenger service points: SCHEDULED STOP POINTs, STOP AREAs, CONNECTIONs, etc
- Groupings of services for marketing: LINEs.

For network topology, the main Flexible Transport Service (FTS) aspect considered is the flexible line structure, defined through:

- Additional flexible topologies FLEXIBLE ROUTEs, FLEXIBLE POINT PROPERTIES, FLEXIBLE LINK PROPERTIES
- Additional flexible service areas; FLEXIBLE STOP PLACEs, FLEXIBLE QUAYS
- Additional flexible aspects for marketing services: FLEXIBLE LINES

Service related aspects of FTS are defined in [N2]:

- Additional flexible aspects: FLEXIBLE SERVICE PROPERTIEs, BOOKING ARRANGEMENTs.

Certain other aspects of FTS passenger information such as reservation rules are defined in [N3].

## NeTEx METHODOLOGY

NeTEx uses a “model driven design”, i.e. the development starts from a conceptual model, from which a physical UML model and an XML implementation is derived.

The European Public Transport Reference Data Model, known as Transmodel, is the conceptual basis for the development (see [T1], [T2], [T3]).

# FLEXIBLE NETWORKS

## FLEXIBLE BEHAVIOUR OF PUBLIC TRANSPORT SERVICES

NeTEx is designed to support FTS (Flexible Transport Service) and DRT (Demand Responsive Transport). DRT and FTS often cover similar services; FTS being a more generic concept since flexibility is not necessarily directly linked to demand, but may be related to other factors such as operating needs or cost optimisations. The term 'FTS' will be used in the following text to cover both concepts.
NeTEx distinguishes two concerns: flexibility of the network topology (that is services that cover a variable area) and flexibility of the network services (that is services that can run at varying times or to satisfy user demand). Both may be combined to describe a flexible network (though it is possible that a network is flexible only as to its topology or its services and not necessarily as to both).

## DEFINING AREAS OF FLEXIBLE COVERAGE

Flexible services need be visible alongside fixed services, for instance in journey planners, so that passengers are aware of their existence. Zone based flexible services or a geographical area where flexible services are present (e.g. Hail and Ride services which serve a section of road) can be represented in NeTEx using FLEXIBLE STOP PLACEs and FLEXIBLE QUAYs. This allows the sections or zones to appear as named "stops" in their own right in a journey planner. Flexible services can also use regular STOP PLACEs and QUAYs for all or part or all of their journeys.

The following figure describes a Hail and Ride section along a bus lines (in red). It has two separated start and end points, one for each direction. Between start and stop point, the vehicle can be stopped on any point (on passenger demand) for boarding or alighting.

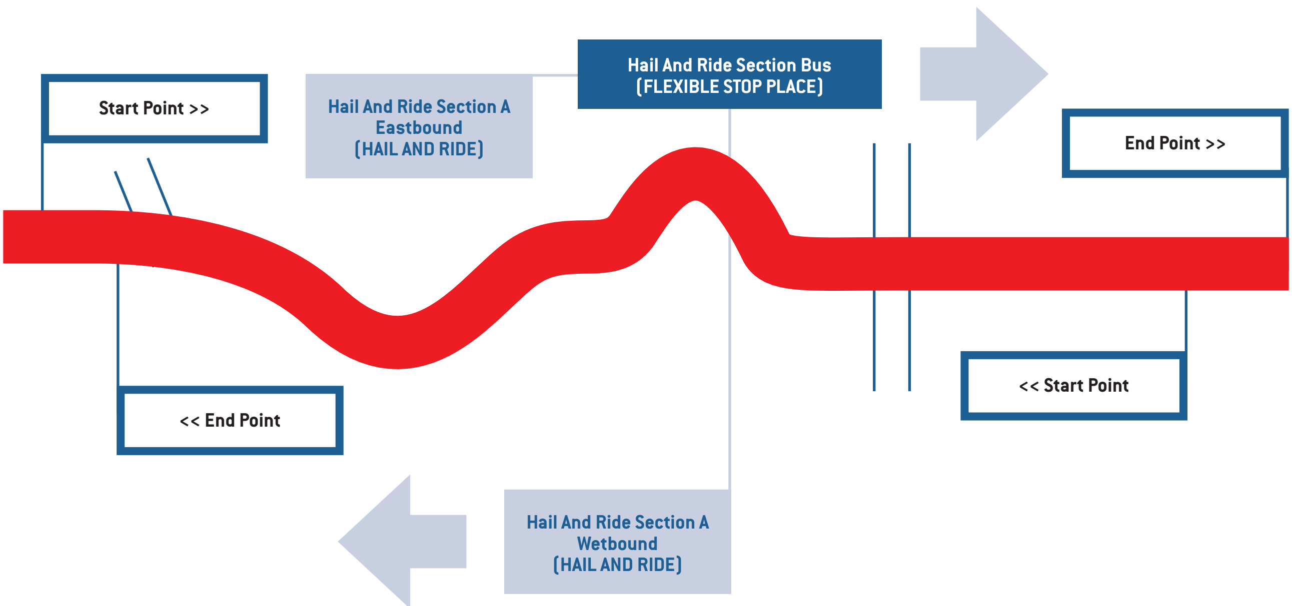
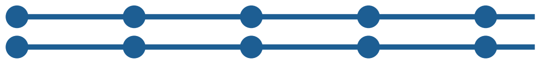
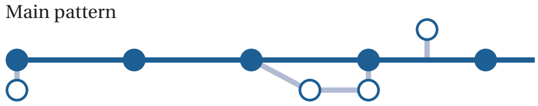
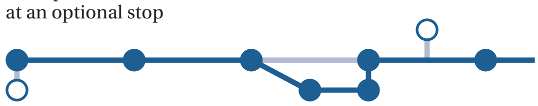
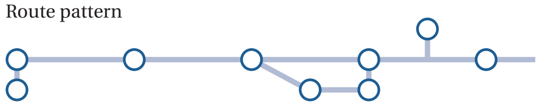
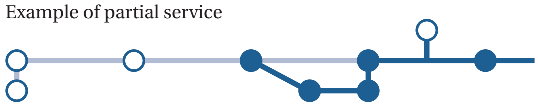
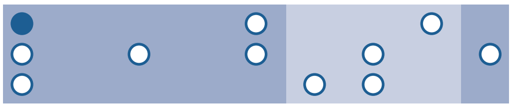
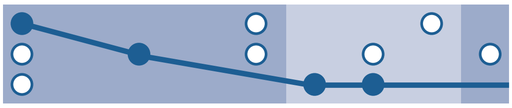
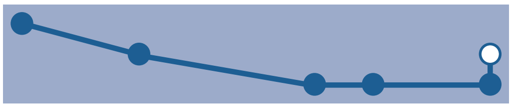



*Figura 1 - Hail and Ride Stop example*

## DEFINING FLEXIBLE ROUTES

The flexible topologies available in NeTEx are summarised in the table below.
Flexible services can operate on regular line topologies or on a flexible topology. The FLEXIBLE LINE element describes common flexible properties of a LINE and the FLEXIBLE LINK PROPERTY and FLEXIBLE POINT PROPERTY elements can be used to add attributes to fixed elements to describe flexible behaviour.

| *NAME* | *DESCRIPTION* | *FIGURE* |
|---|---|---|
| **Virtual Line** (fixed topology) | This case is very similar to fixed line operation: JOURNEY PATTERNs are defined as usual, but stops are served only if there is a passenger booking for it. Virtual line can be operated with fixed or dynamic passing times. The virtual line topology is therefore fixed. | Journey pattern  Partial service  High level of demand: 2 vehicles on the line  |
| Flexible line with **main route** | A minimal list and order of stops are defined determining a “main and minimal” journey pattern. Possible additional stops are defined but will be served only in case of passenger reservation. The JOURNEY PATTERN is determined through a stop list and order defined dynamically according to the passenger reservations and “around” the “main and minimal” journey pattern. | Main pattern  Example of deviated route due to a reservation at an optional stop  |
| **Corridor** (Flexible line without main route) | The possible stops of the JOURNEY PATTERN are known, and the possible stop sequences are also defined and the real stop list and order are defined dynamically according to the passenger reservations without any reference to a main pattern. | Route pattern  Example of partial service  |
| **Flexible zone with fixed stops** | The service is defined by one or several zones (in sequence). Each zone is defined by a set of possible stops. Stops served, and stop order are defined for each VEHICLE JOURNEY according to the reservations. PASSING TIMES (entry and exit time) are usually defined for each zone. They may also be defined for each stop. | Route pattern (may contain same same stop served without reservation)  Example service  |
| **Flexible zone without fixed stops** | The service is defined by one or several zones (in sequence). A stop can occur anywhere in each Zone. Stops served, and stop order will be defined four each VEHICLE JOURNEY according to the reservations. PASSING TIMEs may be defined for each zone (entry and exit time), or for each stop. | No route pattern, no schedules.  Example service  |

| *NAME* | *DESCRIPTION* | *FIGURE* |
|---|---|---|
| **Hail & Ride** | The ROUTE is defined, but the journey pattern only has a start and an end.<br>Boarding or alighting is obtained by signalling the driver that one wishes to board/alight, and can occur anywhere along the Route. | No Stops are defined on the journey Pattern, but the Route are fixed<br><br>Stops occur dynamically during service<br> |
| Combination of any of the previous FTS structure | A lot of FTS services are defined as a sequence of the above described FTS types. | |

## TIMING OF FLEXIBLE SERVICES

Even if a service does not have a fixed timetable, a flexible service will normally operate within a certain time band and on particular day types (weekdays, holidays etc). This operational window can be specified for a FLEXIBLE LINE using NeTEx generic components for specifying temporal conditions (VALIDITY CONDITION etc), allowing journey planners to make intelligent decisions as to when to include flexible services in their results.

The scheduling of flexible services that run to a timetable can be described with the same elements as used for fixed services and described in [W8]. Several types of flexible services are available, for example:

- Fixed PASSING TIMEs: meaning scheduled passing time: there is a timetable, but the service will only run under condition, mainly depending on sufficient demand)
- Dynamic PASSING TIMEs: times at stop will vary according to when the service runs
- Fixed HEADWAY FREQUENCY: in this case, a maximum waiting time is available through a HEADWAY JOURNEY GROUP, but no passing times are defined, all is done dynamically depending on the demand.

Two additional properties can also be supplied:

- Whether cancellation is possible or not, even after booking, meaning that the operator can decide to cancel a service or a stop, usually because there is not enough demand, or the service is too busy.
- Whether the PASSING TIME and place may be updated or not, even after booking (usually passing times are updated to optimise the service).

## INFORMATION ON USING SERVICES

FTS require user interaction to invoke the services. Booking arrangements can be associated with a FLEXIBLE LINEs in order to define the contact point (telephone, URL, etc.), the booking authorisation, and booking conditions such as:

- the passenger must/can/cannot make a reservation
- the reservation must be done x minutes/days/… before the vehicle departure time, etc.

# MULTIMODALITY

## MULTIMODAL NETWORK FEATURES

NeTEx has a generalised model that allows transport data for all modes to be represented and exchanged. Common representations can be used for most aspects of public transport data, with mode and submode indicated by standard attributes. Certain modes have characteristics specific to the mode (for example rail journeys may involve multi carriage trains that join or split for part of the route) and NeTEx has specific features to cover these (see [M1]). Here we illustrate how a common stop place model is used for all modes of physical transport, making it easier to integrate data from different modes to create a joined up trip planning system.

## MULTIMODAL STOP PLACES

NeTEx provides a way to exchange a detailed and unambiguous description of the physical layout of stops making possible the multimodal use of the same stop – and also allowing detailed accessibility information to be provided (see [W7] or [T1], [T2], [T3]).

The STOP PLACE model describes different aspects of a physical point of access to transport, such as a stop or station. For locations with a complex structure, such as a station, this includes all the component areas of the station: the entrances, concourses, platforms, the levels they are on, the paths through the station and the various types of equipment found in the station, such as ticket machines and lifts, barriers, signs and seating. It also allows detailed accessibility attributes to be recorded at both the element and the station level.

A STOP PLACE may represent a pair of physical stops or a cluster of physical stops. A STOP PLACE may contain other STOP PLACEs.
A STOP PLACE is composed of different spaces, such as platforms (QUAYs), and concourses (ACCESS SPACEs), etc. The physical point of access to transport is always a QUAY ENTRANCEs describe the internal and external entrances to the STOP PLACE.

An example of a complex STOP PLACE is a large rail station which may contain a metro station as a child STOP PLACE and have associated STOP PLACEs for the stops of the bus routes that pass by it, as shown on the figure below.

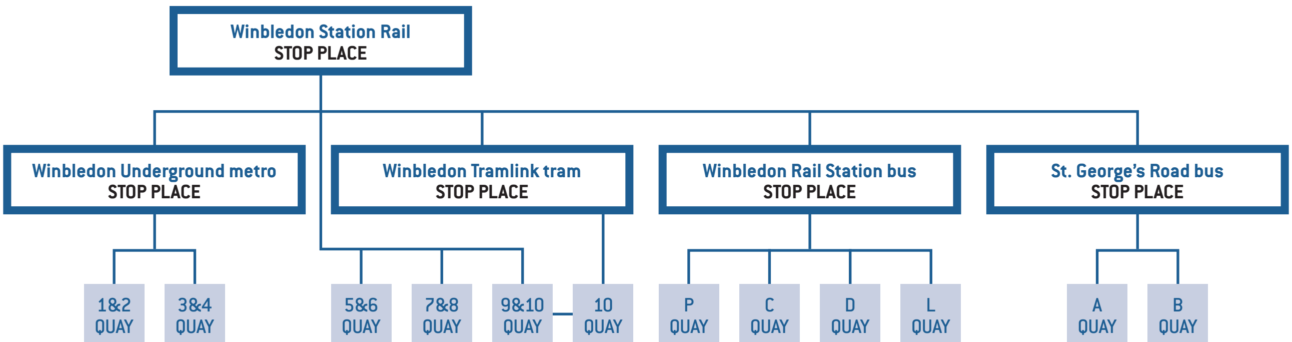



*Figure 2 - Nesting of Stop Places example*

In such cases a general recommendation is that

- There should be a separate STOP PLACE for each pair of bus or tram stops (or isolated stop) on street
- There should be a separate STOP PLACE for each transport mode each with its own QUAYs, and with distinct ENTRANCEs.

Sometimes however different modes may share the same platform, for example between rail, tram or metro, or between bus and coach. In this case it is recommended that:

- A separate STOP PLACE should be created if an area of a station can be referenced as a separate station by a timetable or other passenger information usage
- Where platforms are shared between modes, a single definition of the platform i.e. QUAY can be made. The STOP PLACE for the major mode (e.g. rail) can contain the QUAY definition.

Two alternative approaches are possible:

- (i) Create a separate STOP PLACE for the additional mode; the STOP PLACE mode can reference the QUAY definition.
- (ii) Simply specify multiple modes for the STOP PLACE and the QUAY (e.g. rail, metro).

## PHYSICAL VERSUS LOGICAL STOPS

A STOP PLACE, a physical description of a location at which public transport stops, is a distinct concept from the representation of the stop (logical stop) in a timetable – the SCHEDULED STOP POINT. The former has a spatial geometry which can be related to the underlying Geographic Information System (GIS) features; the latter is defined within the overall topology of the transport network and its routes as a simple point (thus for example the SCHEDULED STOP POINT 'Gare du Nord' in Paris has long distance, suburban, metro and bus services, corresponding to a number of different STOP PLACEs at a multiplicity of physical locations). The two concepts can be explicitly connected using a STOP ASSIGNMENT. Often there is a one-to-one correspondence between the two, and the same identifier is used for both (amounting to an implicit assignment), but in other cases – as say when a bus stop is moved, or a platform reassigned, or one transport mode uses a different set of identifiers from another mode, the use of separate elements for the separate concepts allows a more precise representation (and also different assignments to be made to cover different circumstances). In also enables detailed passenger information on interchange navigation to be provided (see [W7],[W9]).

## MULTIMODAL CONNECTION POSSIBILITIES

The STOP PLACE model in particular allows the nature of the possible connections between services that may be made at a transfer to be described very precisely and to be related to the physical paths through the station, as well as the paths to access a station. This representation can include timing information for different times of day, allowing more accurate journey planning (see concepts of ACCESS and CONNECTION in [W7] or [T1], [T2],[T3]).
Gathering such a data set for many large transfer locations requires a significant investment so, as elsewhere, NeTEx allows an incremental approach to be taken. Global default values for transfer possibilities between modes on any SITE or OPERATOR can be specified for where there is no more specific value for a SITE.

# ACKNOWLEDGEMENT

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# 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 *Accessibility* - White Paper
[W8] NeTEx *Timetable* - 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
[T4] *Identification of Fixed Objects for Public Transport*, EN28701

## FURTHER INFORMATION

NeTEx website: **www. netex-cen.eu**
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