



BSI Standards Publication

Public transport — Network and Timetable Exchange (NeTEx) — Examples, guidelines and explanatory materials

National foreword

This Published Document is the UK implementation of CEN/TR 16959:2016.

The UK participation in its preparation was entrusted to Technical Committee EPL/278, Intelligent transport systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

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ISBN 978 0 580 92319 7

ICS 35.240.60

Compliance with a British Standard cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 May 2016.

Amendments issued since publication

Date	Text affected
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TECHNICAL REPORT

CEN/TR 16959

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

May 2016

ICS 35.240.60

English Version

Public transport - Network and Timetable Exchange (NeTEx) - Examples, guidelines and explanatory materials

Transport Public - Échange des données de réseau et
d'horaires (NeTEx)

Öffentlicher Verkehr - Netzwerk- und Fahrplan
Austausch (NeTEx) - Beispiele, Vorgaben und
erläuterndes Material

This Technical Report was approved by CEN on 4 April 2016. It has been drawn up by the Technical Committee CEN/TC 278.

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CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Ref. No. CEN/TR 16959:2016 E

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European foreword

This document (CEN/TR 16959:2016) has been prepared by Technical Committee CEN/TC 278 “Intelligent transport systems”, the secretariat of which is held by NEN.

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Introduction

0.1 General information

NeTEx is a series of CEN Technical Specifications dedicated to the exchange of Public Transport scheduled data (network, timetable and fare information) based on:

- Transmodel V5.1 (see [T1], [T1] and [T3]);
- IFOPT (see [I1]);
- SIRI (see [S1], [S2], [S3], [S4], [S5]);

It supports information exchange of relevance to public transport services for passenger information and AVMS (Automated Vehicle Monitoring Systems). Many NeTEx concepts are taken directly from Transmodel and IFOPT; the definitions and explanation of these concepts are extracted directly from the respective documents and reused in NeTEx, sometimes with further adaptations in order to fit the NeTEx context.

The data exchanges targeted by NeTEx are predominantly oriented towards passenger information and also for data exchange between transit scheduling systems and AVMS. However it is not restricted to these purposes, and it can provide an effective solution to many other use cases for transport data exchange

The NeTEx series of documents is divided into three parts, each covering a functional subset of the CEN Transmodel for Public Transport Information:

- Part 1 describes the Public Transport **Network topology** (see [N1]);
- Part 2 describes **Scheduled Timetables** (see [N2]);
- Part 3 covers **Fare information** (see [N3]).

NeTEx is intended to be a general purpose XML format designed for the efficient, updateable exchange of complex transport data among distributed systems. This allows the data to be used in modern web services based architectures and to support a wide range of passenger information and operational applications.

Most public transport modes are taken into account by NeTEx, including train, bus, coach, metro, tramway, ferry, and their submodes. Moreover, it is possible to describe airports and air journeys, but there has not been any specific consideration of any additional provisions that apply especially to air transport.

While there are a number of existing documents available for Timetables, NeTEx is the first systematically engineered document that also covers multimodal Fares.

0.2 Compatibility with existing standards and recommendations

The concepts covered in NeTEx that relate in particular to long-distance train travel include:

- rail operators and related organizations;
- stations and related equipment's;
- journey coupling and journey parts;
- train composition and facilities;

- planned passing times;
- timetable versions and validity conditions.

In the case of long distance train, the NeTEx takes into account the requirements formulated by the ERA (European Rail Agency) – TAP/TSI (Telematics Applications for Passenger/ Technical Specification for Interoperability), entered into force on 13 May 2011 as the Commission Regulation (EU No 454/2011), based on UIC directives.

As regards the other exchange protocols, a formal compatibility is ensured with TransXChange (UK), VDV 452 (Germany), NEPTUNE (France), UIC Leaflet, BISON (Netherland) and NOPTIS (Nordic Public Transport Interface Standard).

The data exchange is possible either through dedicated web services, through data file exchanges, or using the SIRI exchange protocol as described in Part 2 of the SIRI documentation (see [S2]).

This Technical report is to be used in conjunction with the following documents:

- EN 15531-1, Public transport - Service interface for real-time information relating to public transport operations - Part 1: Context and framework (see [S1]);
- EN 15531-2, Public transport - Service interface for real-time information relating to public transport operations - Part 2: Communications infrastructure (see [S2]);
- EN 15531-3, Public transport - Service interface for real-time information relating to public transport operations - Part 3: Functional service interfaces (see [S3]);
- CEN/TS 15531-4, Public transport - Service interface for real-time information relating to public transport operations - Part 4: Functional service interfaces: Facility Monitoring (see [S4]);
- CEN/TS 15531-5, Public transport - Service interface for real-time information relating to public transport operations - Part 5: Functional service interfaces - Situation Exchange (see [S5]);
- EN 12896, Road transport and traffic telematics - Public transport - Reference data model (see [T1]);
- EN 28701, Intelligent transport systems - Public transport - Identification of Fixed Objects in Public Transport (see [I1]).

0.3 NeTEx exchanged information

NeTEx provides a means to exchange data for passenger information such as stops, routes timetables and fares, among different computer systems, together with related operational data. It can be used to collect and integrate data from many different stakeholders, and to reintegrate it as it evolves through successive versions.

All three parts covered by NeTEx use the same framework of *reusable components*, versioning mechanisms, validity conditions, global identification mechanisms, etc., defined in a NeTEx framework in Part 1. NeTEx also includes, container elements called “version frames” to group data into coherent sets for efficient exchange.

NeTEx schema can thus be used to exchange:

- public Transport schedules including stops, routes, departures times / frequencies, operational notes, and map coordinates;

- routes with complex topologies such as circular routes, cloverleaf and lollipops, and complex workings such as short working and express patterns. Connections with other services can also be described;
- the days on which the services run, including availability on public holidays and other exceptions;
- composite journeys such as train journeys that merge or split trains;
- information about the Operators providing the service;
- additional operational information, including, positioning runs, garages, layovers, duty crews, useful for AVL and on-board ticketing systems;
- data about the Accessibility of services to passengers with restricted mobility;
- data are versioned with management metadata allowing updates across distributed systems;
- fare structures, (flat fares, point to point fares, zonal fares);
- fare products (Single tickets, return tickets, day, and season passes etc);
- fare prices that apply at specific dates.

0.4 NeTEx exchanging data modality

Data in NeTEx format is encoded as XML documents that should conform exactly to the defined schema, and conformance can be checked automatically by standard XML validator tools. The schema can also be used to create bindings to different programming languages to assist automating part of the implementation process for creating software that supports NeTEx formats.

In this perspective, a NeTEx service need only to implement those elements of relevance to its business objectives – extraneous elements present in the binding can be ignored. Parties using NeTEx for a particular purpose will typically define a “profile” to identify the elements that have to be present and the code sets to be used to identify them.

Documents in NeTEx format are computer files that can be exchanged by a wide variety of protocols (http, FTP, email, portable media, etc). NeTEx publication documents can be used to define files suitable for the bulk exchange of XML documents representing whole data sets (for example all the timetables for an operator).

In addition, a SIRI based NeTEx protocol is specified for use by online web services. It defines NeTEx request and response messages that can be used to request and return data in NeTEx format, and also publish/subscribe messages for push distribution. The responses return a NeTEx XML document that satisfies the request criteria (and also conforms to the NeTEx schema). There is a WSDL binding for this NeTEx service to make it easy to implement services.

NeTEx XML thus serialises complex PT models into a standard flat file format that can be processed cheaply and efficiently using mainstream modern computer technologies.

0.5 Motivation

0.5.1 Business drivers

Modern public transport services rely increasingly on computerised information systems for passenger information; for example for timetables, for real time data and for ticketing. The increased use of online engines and electronic ticket products in particular requires the representation of timetables, products and fares as digitalised data sets. Such data are typically both inherently complex (since the real-world domains it describes are complex) - and subject to a complex workflow. Data are typically assembled

from many different stakeholders with different responsibilities (for stops, timetables, real time, fare products, pricing etc) and is continually changing - at intervals ranging from the intermittent periodic change of network and timetable data, to the second by second changes of real-time systems. Standardization seeks to provide effective data models that both capture these complex domains as reusable components and to support a workflow that involves continuous integration and validation of data under many different possible configurations of participants.

Well-defined, open interfaces therefore have a crucial role in improving the economic and technical viability of Public Transport Information systems. Using standardised interfaces, systems can be implemented as discrete pluggable modules that can be chosen from a wide variety of suppliers in a competitive market, rather than as monolithic proprietary systems from a single supplier. Furthermore, individual functional modules can be replaced or evolved, without unexpected breakages of obscurely dependent function. Interfaces also allow the systematic automated testing of each functional module, vital for managing the complexity of increasing large and dynamic systems.

0.5.2 Technical drivers

Increasing complexity is itself a barrier to the development and uptake of systems, and it is not uncommon to find that organisations develop multiple and sometimes conflicting models to handle different aspects of their business processes, and also to find that the difficulty of changing the system impairs development of the business. Because PT data sets are complex and shared by so many participant, they are especially hard to change and they thus represent a strategic investment. It is thus important to design them for long term use so that they are expressive enough to capture business requirements and flexible enough to evolve to meet to changing business requirements and use.

0.5.3 CEN documents context

NeTEx has been developed under the aegis of CEN and is the most recent development stage in over 15 years work to systemise and harmonize European passenger information data. The work draws on a number of existing national standards applying systematic principles of information architecture to construct flexible models that correctly separate the different concerns of representing and managing data. The keystone is the Transmodel standard (see [T1]), a conceptual model which names and represents PT info concepts for a wide set of functional areas and can be used to compare and understand different models. Transmodel project outputs have been used both to underpin a number of CEN concrete data standards such as SIRI and IFOPT, and to rationalize national standards to allow for harmonization and interoperability. Transmodel has been used to develop NeTEx and is itself being updated to include NeTEx additions. While there are a number of standards available for Timetables, NeTEx is the first systematically engineered document that also covers multimodal Fares.

CEN (European Committee for Standardization) is Europe's standardization body. It divides its work under into committees covering different aspects of industry and technology. NeTEx, as a transport Technical Specification is formally produced by Technical Committee 278, Work Group 3, Sub Group 9. Other TC278 WG3 sub groups handle the related standards Transmodel (SG4), SIRI (SG5 Service interface for real-time information) and IFOPT (Identification of Fixed Objects in Public Transport. NeTEx has thus both a concrete series of Technical Specifications, and an open consultative process for maintaining that document.

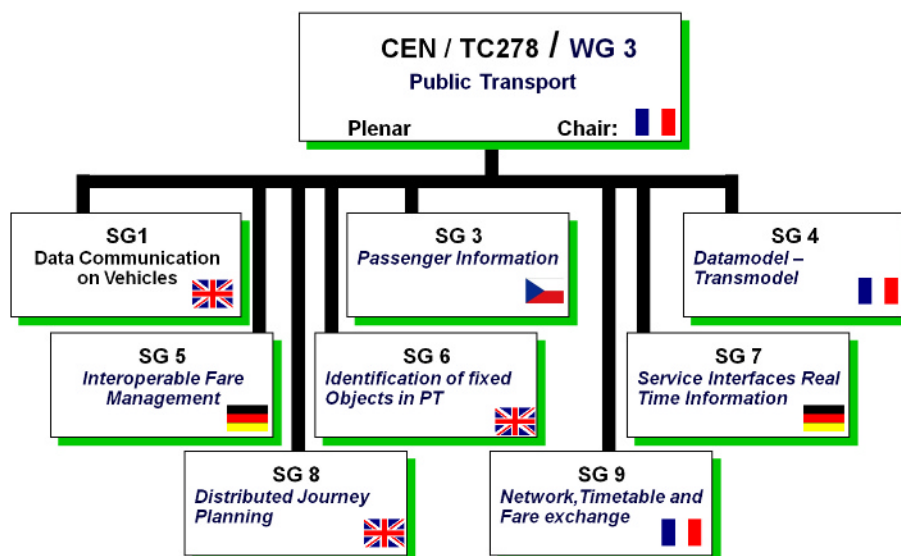


Figure 1 — CEN TC278 WG3 Sub-groups

0.5.4 CEN process and participants

Work on NeTEx has involved delegates from Austria France, Germany, Hungary, Italy, Netherlands, Slovenia, Sweden, Switzerland, UK, and the European Rail Authority. Part 1 and Part 2 were approved in 2013 and Part 3 is being finalized at the moment.

Evolution of EU PT standards and NeTEx for rail with TAP/TSI compatibility

0.5.5 Evolution of EU PT standards and NeTEx

The development of NeTEx has drawn on existing national and legacy standards such as VDV 452 (DE). BISON (NL) Neptune (FR) and TransXChange (UK) in particular to validate the NeTEx model by establishing mappings with established national standards.

The development of NeTEx also coincided with an interest by the European Rail Authority and other stakeholders in seeking a degree of data interoperability between different modes of public transport such as rail, metro and bus, that is, the ability to exchange data about routes, timetables and fares between systems, and also to supply external third party users. To this end a study was undertaken to compare the TAP/TSI B1, B2 and B3 models with the original Transmodel fare model used as the basis for NeTEx Part 3 and a number of gaps were identified and addressed. (A successful informal mapping of the MERITS data for stop and timetable data had already been achieved in Part 2).

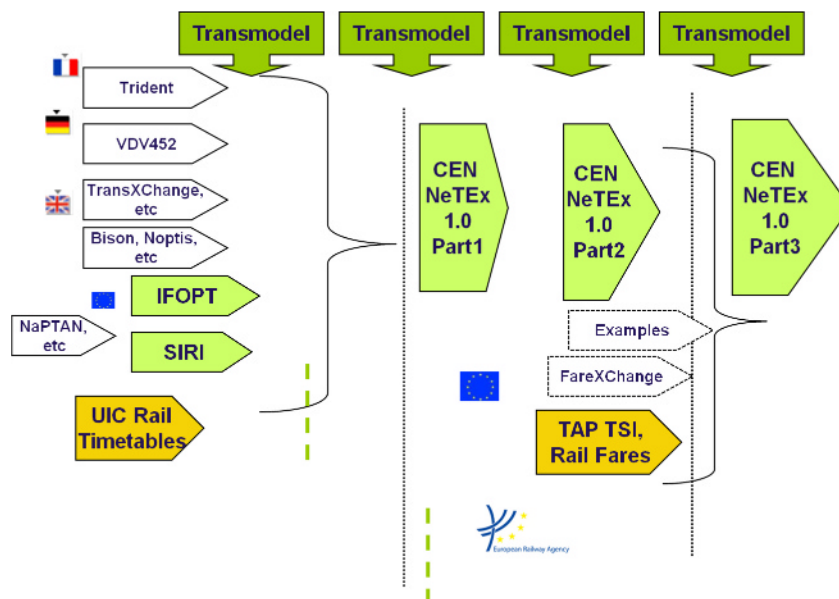


Figure 2 — Evolution of NeTEx documents

0.6 Term of Use

NeTEx is published as a series of CEN Technical Specification, (Part 1, Part 2 and Part 3). These are CEN copyright publications and are available for purchase from the shops of the respective National Standards Organisations of each CEN country: AFNOR (fr), BSI (uk), NEN (nl), SIST (si), UNI (it), DIN (de), etc).

The NeTEx XML Schema and UML models are free to use under a GPL version 3 Licence, so the use of schema and models is possible without necessarily purchasing the CEN NeTEx publications.

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1 Scope

This Technical Report provides a set of examples, white papers and explanatory material that makes it easy to understand how to use and deploy all parts of NeTEx. This will help EPTIS system providers and acquirers, providing functional scope, guidelines and terminology explanations needed to implement a system. It will also ease formalizing the requirements for the context of a procurement process.

This Technical report provides an explanatory material that makes it easier to understand how to use all parts of NETEX. This will help EPTIS system providers and acquirers, providing functional scope terminology explanations needed to implement a system. It will also ease formalizing the requirements for the context of a procurement process

2 Frequently Asked Questions (FAQ)

2.1 Introduction

In this paragraph, a set of Frequently Asked Questions (FAQ) is reported. FAQ are also maintained updated in the relevant NeTEx website section (see http://netex-cen.eu/?page_id=111).

2.2 Basic Commercial questions

2.2.1 Do I have to pay for using NeTEx?

The formal documents describing NeTEx are available as Technical Specifications (TS) from your national standardization body. A fee in the national currency is charged for such documents by each standardization body. However the actual formats and designs described by the TS may be used without charge, and without necessarily purchasing the CEN NeTEx publications. You may use the schema and models for free under a GPL license as described on NeTEx website (http://netex-cen.eu/?page_id=20). This ensures that the IPR is in the public domain and may be safely considered as a long term strategic investment.

2.2.2 What skills do I need to deploy NeTEx?

The NeTEx schema itself is a W3C XML schema, so XML technical skills are typically required to build applications to create or process data in NeTEx format. General XML skills can be used to process XML documents containing data in NeTEx format, for example, to run validators or to amend content.

At a design level, NeTEx uses a “Model Driven” approach, that is, the fundamental design is described as a high level conceptual model that tries to represent the problem domain as entities and relationships that have been identified by a set of use cases, many taken from existing systems covering the desired business scope. To understand the high level model underlying the XML schema (which is valuable for building applications) requires data modelling skills and an understanding of the UML notation. Public Transport domain knowledge will of course help (additional information available at <http://transmodel-cen.eu/>).

2.2.3 What tools are available to support NeTEx?

General purpose XML tools can be used to work with the NeTEx XML schema and XML documents that conform to it, for example either the proprietary XML SPY (<http://www.altova.com/xmlspy.html>), or Oxygen (<http://www.oxygenxml.com/>) or see free tools at <http://www.garshol.priv.no/download/xmltools/>. A wide variety of mainstream XML tools are available to validate XML and to create bindings to specific programming languages (NET, Java, PHP, C++).

To look at the design models, an interactive UML viewer such as Enterprise Architect (<http://www.sparxsystems.com/>) is extremely helpful, although a set of static web pages is also available.

To import or export transport data in NeTEx format, a number of suppliers are developing support for NeTEx for their existing products. New open source NeTEx products are also being developed such as CHOUETTE (<http://www.chouette.mobi/en/>). Sample mappings to a variety of national formats (VDV, BISON, etc) as well as GTFS have been developed and are included in the NeTEx documents. Further information on NeTEx implementations are available at http://netex-cen.eu/?page_id=65.

2.2.4 How do I get new features added to NeTEx?

CEN working groups provide a consensual process to evolve standards and have formal procedures and timeframes managed through the standards bodies of the European nations. New feature proposals can be submitted to the NeTEx working group by sending an email at info@netex-cen.eu and will be considered along with other suggestions for a future enhancement to the documents. Under the CEN process a New Work Item request is created to manage the enhancements to a specification, with a versioning process to identify sets of changes.

Adding new features specific to country, supplier or any smaller area can be done using NeTEx extension mechanisms (Key Value extensions/ Extension Tag). These can also be used to develop new candidate features ahead of formal incorporation. See also ‘Can I add my own codes to NeTEx’?

2.2.5 What is a profile?

Although NeTEx is a large document, a NeTEx service needs only to implement the specific elements relevant to its business objectives – extraneous elements present in the model can be ignored. Parties using NeTEx for a particular purpose will typically define a “profile” to identify the subset of elements that have to be present, as well as the code sets to be used to identify them. A machine readable form of this profile may be created using the NeTEx TYPE OF FRAME element, specifying which elements have to be present; this can be used to enable automatic validators for local profiles.

Following are some profile examples:

- Network-profile: <http://netex-cen.eu/wp-content/uploads/2015/06/Network-profile.pdf>
- Timing-profile: <http://netex-cen.eu/wp-content/uploads/2015/06/Timing-profile.pdf>
- Stop-profile: <http://netex-cen.eu/wp-content/uploads/2015/06/Stop-profile.pdf>
- Shared-Element-profile: <http://netex-cen.eu/wp-content/uploads/2015/06/Shared-Element-profile.pdf>
- Stop-Identification-profile: <http://netex-cen.eu/wp-content/uploads/2015/06/Stop-Identification-profile.pdf>
- Concept-selection-profile: <http://netex-cen.eu/wp-content/uploads/2015/06/Concept-selection-profile.pdf>

2.2.6 What if I find a bug in NeTEx?

Any issue on NeTEx can be communicated to the working group sending an email at info@netex-cen.eu. NeTEx schemas are in GITHUB and corrected versions, identified by an interim version number, can be created if necessary.

2.2.7 How do I get support for my NeTEx development?

Some basic support for NeTEx development can be get sending an email at info@netex-cen.eu.

2.3 Basic scope questions

2.3.1 Is NeTEx a GIS standard?

Spatial location is important for a number of NeTEx elements, for example to locate stops, but NeTEx is not of itself a GIS standard; rather it defines additional public transport related layers of information that may be projected onto a GIS data set. Thus for example a typical application such as a Journey Planner will seamlessly combine NeTEx data with map data address data to allow a user to plan travel from any location to any location.. NeTEx uses a GML based coordinate system to reference GIS data, allowing a wide variety of GIS formats to be used (WS84, National Ordnance Survey Grid, Lambert, etc). This should make it easy to combine NeTEx data with other data sets, and to support different GIS reference systems.

NeTEx also includes distinct concepts of topographic place and of administrative jurisdiction – again distinct from GIS location, but which can be mapped to other systems that give a spatial projection for reference. Thus stops can be located a serving a particular town or region (even as is sometimes the case for major interchanges, they are not physically contained within the geospatial boundaries).

2.3.2 Is NeTEx a database?

No, NeTEx defines an exchange format to exchange data between systems; it does not constrain the internal representation used by a given system to store or process the data, nor require the use of a specific database design. That said, any database supporting NeTEx data will need to have corresponding elements that can be mapped into the elements in the subset of NeTEx supported.

For more information refer to Transmodel for database modelling (<http://transmodel-cen.eu/>)

2.3.3 Is NeTEx for real-time applications?

NeTEx can usefully be used to provision systems with the reference data needed to support real-time data, such as stops, lines, routes, timetables etc, but is not envisaged as a real-time data protocol. Real-time applications typically need to be optimised to exchange the data very quickly, very efficiently and specific protocols such as CEN SIRI are designed to do this. The NeTEx model can however be used to understand how the real-time data content of SIRI messages relates to the NeTEx and Transmodel models.

NeTEx model includes additional data elements specifically to support stop and on board real-time systems, for example the headings to show on a vehicle at each stop, the stop announcements etc, that are not needed for simple timetable exchange such as by GTFS.

2.3.4 Can I use NeTEx for Rail?

Yes, NeTEx covers stations, networks, timetables and fares for Rail. The development process has involved experts from Rails (ERA, UIC, SNCF, ATOC, etc.) to make sure specific rails requirements are taken into account. The NeTEx design process included consideration of the B1, B2 and B3 Tap/TSI data models for European Rail fares as well as various national urban and suburban rail systems. NeTEx includes support for complex aspects of rail passenger information, such as journeys that join and split, train makeup, boarding positions on platforms, station and on-board facilities, accessibility and complex fare products. High value rail fare products often have complex conditions of use and NeTEx can describe these in a representation that gives both machine readable and human readable forms. Restrictions on routing (as in Tap/TSI ‘Series’) can be described. Multimodal products with rail components can also be described.

2.3.5 Does NeTEx provide web services?

Yes, NeTEx include some SIRI based http protocols that can be used to request and return data in NeTEx format, embedding XML documents in the requests and responses.

NeTEx offers predefined SOAP and REST WEB Services.

2.3.6 Does NeTEx cover ticket sales?

The NeTEx's scope doesn't include the actual retailing process – it covers only the products and fares that can be sold, along with all conditions of sale and use that accompany them. It can include information about available distribution channels and fulfilment methods needed to direct users towards the available retailing services. NeTEx can represent many of the ancillary elements relevant for retailing, since they are also relevant for some product definitions. For example passes and season tickets typically require a customer and a contract and because some modern products, are usage based such as pay as you go fares with capping, it also includes a basic record of travel purchases for account based product use.

NeTEx doesn't describe standards for the media used for tickets (for example the layout and content of a rail ticket), though it includes a 'Travel document' concept that can be used to link to downstream retail systems that prescribe how a product should be materialized.

2.3.7 Can I use NeTEx for mobile applications?

The data in NeTEx is relevant for a number of types of mobile application – for example, stop finding and journey planning. NeTEx includes web services that can be used to support certain mobile applications directly (e.g. stop finding); others such as journey planning or fare finding will typically involve a specialized API to an engine that is populated with NeTEx data. Note that the communication framework shared with SIRI v 2.0 also includes a specification for automatically mapping XML to JSON and other lightweight formats especially suitable for large scale mobile applications.

2.4 Pros and Cons questions

2.4.1 What are the advantages of using NeTEx?

Key benefits of using NeTEx can include:

- **Reducing development and support costs** (see 'How can NeTEx reduce development costs?' below, as well as 'How can NeTEx simplify my software application development'.)
- **Increasing function and design quality** See 'How can NeTEx increase capability and improve design quality?' below, as well as various answers on specific functions such as versioning, internationalization, and advanced capabilities later below.
- **Reducing complexity** See 'How can NeTEx simplify my software application development?' below
- **Protection of investment** See 'How can NeTEx protect my investment' below, as well as 'How can NeTEx increase capability and improve design quality?'

2.4.2 How can NeTEx reduce development costs?

A CEN document enables a European-wide economy of scale in developing products and tools that handle transport data, as well as a much higher degree of supplier independence for those purchasing systems. Use of a standard format reduces the number of different interfaces that have to be developed and supported to exchange data between diverse systems, NeTEx uses mainstream XML technology for which there is a large skill base and many toolsets. The NeTEx XML schema includes data and referential integrity checks that reduce development time. The presence of these checks increased data quality automatically throughout the life of the standards.

2.4.3 How can NeTEx increase capability and improve design quality?

NeTEx offers a degree of protection of investment in that not only does it use mainstream technologies and have a process to support future evolution, but it also already includes in its design a high degree of functionality. Because it has been systemised from and validated against leading National Standards it covers most of the commonly found features of public transport information systems and represents a significant amount of free, ready to use IPR in how to abstract the separate concerns of a transport information system into coherent a software model. There is a high degree of reuse of elements. The model also considers a full consideration of many advanced features, such as frequency based services, flexible services, capped fares, etc not full accommodated in many existing national standards. Not all of the features need to be implemented in a given deployment, but their presence in the design gives a clear roadmap for where to include such function if it is needed at any time.

NeTEx is the only document to put forward a comprehensive fare data standard, one that covers not only classic multimodal fares, but also modern products such as card based pay as you fare products, relating them to a common transport model.

2.4.4 How can NeTEx simplify my software application development?

NeTEx can help to reduce complexity at the design level in that it is based on Transmodel, using a well-established set of well-defined concepts with an official terminology set in different European languages. Careful abstracted to separate different design concerns. For example NeTEx separates out the concepts of a route (a sequence of possible stops), a journey pattern (a specific set of stops on the route), the timings to traverse the links of the journey pattern, and the resulting passing times at the stop making up a given timetabled journey, thereby allowing many different journeys to be computed simply by specifying a starting time. As a result of this approach, NeTEx achieves a high degree of reuse, using the same core elements in all three parts and building Part 3 from part 2, and Part 2 from Part 2 elements, reducing the overall number of elements needed. A small number of design patterns are used very consistently reducing the overall cognitive burden needed to understand a large number of different functional areas.

The existence of high level models with transforms to the detailed implementation gives developers a full documented overview of the design, making it easier to understand the purpose of specific components and to assess the impact of changes.

NeTEx can help to reduce complexity at the implementation level in that it takes a uniform approach to many common aspects of data handling, for example, versioning, data frames, data identifiers, validity conditions, etc, greatly simplifying the implementation of such features and allowing a high degree of code reuse for common services. NeTEx includes explicit mechanisms to allow the continuous, repeated large scale integration of data from different sources as is found in modern internet based environments.

2.4.5 How can NeTEx protect my investment?

As a CEN document with international support independent of any one supplier, and a process to support future evolution NeTEx offers an inherent degree of protection of investment. The use of mainstream technologies, such as UML and XML means that design and content is available in robust form with widely available skill sets.

Assembling and managing public transport content models represents a significant long term investment for a Transport Operator Much of the data are inherently complex (e.g. timetables or fares) and is changing continuously. Accurate coherent data sets need to be created to integrate many different types of data and be kept up to date though many different workflows. NeTEx is concerned precisely with such a content model including the necessary metadata to manage it, and gives a long term strategic model for exchanging data between many different systems, one that is already 'future proofed' by the inclusion of many advanced features and additional functional modules.

A significant part of the lifetime expense of a system comes from maintenance and support to meet changing business needs. Whereas with modern web technologies new web services to request data can be constructed with relative ease, (e.g. adding new syntactic views as different APIs,), changing the underlying data model is harder and shall be managed in a distributed context – different systems will upgrade at different times, so multiple versions have to be able to exist concurrently and without confusion. The NeTeX model is strictly versioned and designed to allow a managed evolution. Successive versions can easily be regression tested against existing XML documents to ensure compatibility and correctness.

2.4.6 What are the disadvantages of using NeTeX?

NeTeX is not a panacea and there are also a number of potential disadvantages to using it:

- additional complexity from using a large, generalized model. See ‘Is NeTeX hard to understand?’;
- fragmentation of semantics from generality see ‘Does increased generality make NeTeX is harder to work with?’;
- addition computational expense for processing large XML models with extensive integrity checks;
- limited expressiveness of XML;
- slow speed of standards process.

2.4.7 Is NeTeX hard to understand?

NeTeX is undoubtedly large and quite complex, and uses a sophisticated model that has been evolved over more than 15 years to cover the requirements of many different types of system – this imposes a significant learning curve, especially if you are unfamiliar with Transmodel, or with software engineering notations such as UML. However, it is also highly modular, so only the required modules need to be considered and once the core principles have been assimilated, the use of a consistent terminology and a uniform set of design patterns facilitates learning of new areas of functionality. The provision of reusable components such as calendar conditions, stops, etc also reduces the effort needed to understand the system.

2.4.8 Does increased generality make NeTeX is harder to work with?

NeTeX in some cases abstracts concepts into several separate elements in order to separate concerns, this in turn increases reusability and gives greater flexibility. This can make it harder to understand which combination of elements should be used to represent a solution, and even in some cases allows alternative representations. This can be mitigated by a profile setting out how NeTeX should be used for a specific set of data and by examples.

Although it is possible to omit most unwanted functions, certain core properties are required and this can make implementations of simple functions more complex.

2.4.9 Does NeTeX require more computing resources than other standards?

NeTeX uses XML technology; large documents require more processing power to handle than some formats with a lower semantic content, especially if extensive validation and integrity checking is done (though noted that the referential integrity checks can be omitted if documents are known to be correct). In mitigation, computer power continues to get cheaper whereas the cost of skilled resource to resolve issues arising from unchecked data errors has not.

XML is verbose, with both start and end tags being required, and NeTeX documents can be large. Various feature help to reduce size notably; the ability to declare default value at a frame and other

levels, and the ability to reference data from other frames, and the ability to exchange just elements that have changed. Bandwidth can be saved by sipping documents for transmission.

2.4.10 Are there missing validity checks in NeTEx ?

Where possible NeTEx enforces validity checks in the XML schema so that data are correct and consistent. XML schema can provide data typing and useful identity and referential integrity checks, so for example it is possible to ensure that not only are fields in the right format (as say for dates, times, email addresses or enumerated values) but also that a document is complete (every referenced element is present) and unique (a given identifier is only used once). However schema cannot describe a number of more complex integrity constraints (for example; that passing times on successive stops in a journey are monotonically increasing) and such checks need to be implemented programmatically by validation or import tools.

A deliberate decision has been made to leave out one type of validity check. In XML schema, it is also possible to specify whether an element will be present or is optional. However in order to allow a single XML schema to be used for many different uses case, NeTEx makes the majority of schema elements optional, and leaves it up to the individual application to check for completeness. (Note that NeTEx profiles can be used to express this requirement also).

2.4.11 Is it quick to add new features in NeTEx?

International standards process are consensual, with periods for review and voting. This makes it relatively slow to incorporate official changes. As an interim measure, the NeTEx extension mechanisms can be used to include additional elements informally prior to ratification.

2.5 Further Specific questions of Scope

2.5.1 Can NeTEx describe journey connection times?

In order to provide accurate journey plans, it is valuable to be able to specify realistic connection times between journeys at interchanges that take into account the mode of transport, the detailed topology of the interchange and even the mobility of the user (for example a path suitable for a wheelchair using a lift may take longer). NeTEx allows both default and specific transfers time to be specified for any connection.

NeTEx also permits complex operational rules about journey interchanges to be described so that that planned and guaranteed connections can be managed and so that real time systems and real-time journey planners can give accurate advice to users.

2.5.2 Does NeTEx support accessibility?

Yes, NeTEx supports the specification of accessibility attributes on both the fixed infrastructure (drawn from the CEN IFOPT standard) and on vehicle types used for specific journeys, so that full accessibility aware journey planning can be provided, including micro-navigation through interchanges. Both accessibility properties and equipment for different disabilities (e.g. wheelchair spaces, navigability, tactile strips etc) and accessibility services (e.g. boarding assistance) can be defined. Furthermore, NeTEx defines a set of user needs (e.g. wheelchair, blindness, push chairs, etc) that a journey planning engine can use to set criteria to find the optimal journey for a given set of accessibility criteria.

2.5.3 Can NeTEx handle frequency based services?

Frequency based services are typically specified as operating at a given interval, rather than particular times. From a passenger point of view multiple journeys will typically be presented as a single journey running at an approximate interval, for example “every six to 10 minutes”. NeTEx uses TEMPLATE VEHICLE journeys to describe such journeys. From an operational point of view there will still need to be specific service journeys scheduled to fulfil the required frequency of service and NeTEx can also include these to support real time journeys.

2.5.4 Can I have different journey timings for different times of day?

Part 2 of NeTEx includes reusable components for constructing timetables of journeys from reusable components, NeTEx separates the concerns of where the timing of a PT route takes place (The TIMING PATTERN made up of TIMING POINTs and TIMING LINKs) from the actual timing values (which are held separately as RUN TIMES and WAIT TIMES). Different sets of timing values belong to different TIME DEMAND TYPEs (Peak, off peak, late night etc) can be used with the same TIMING PATTERN to generate accurate timetables for journeys at different times of day.

2.5.5 Can NeTEx describe zone based fares?

NeTEx can be used to describe zone based fare systems of any topology ranging from a simple patchwork (adjacent zones) to the complex, (honeycomb, doughnut) etc). The TARIFF ZONE allows zones to be associated with stops and stations. Mixed zonal and stage systems are also possible. Fare pricing may be a flat fare system per zone, or zone to zone using a (DISTANCE MATRIX ELEMENT), or be differentially priced for particular sequences of zones (using FRAE STRUCTURE ELEMENTs in SEQUENCE).

2.5.6 Can I restrict certain products to certain classes of user?

Among the many different usage conditions that can be specified for NeTEx fare products are restrictions on the type of user – child, senior, student, disabled, etc using a USER PROFILE that may be given precise eligibility criteria (e.g. on age, membership, domicile, etc). A GROUP PROFILE allows the number and makeup of groups to be specified; it can also be used to specify companion criteria for disabled users and other special cases.

2.5.7 Can I specify time based constraints on travel?

Some fare products only allow travel at particular times – such constraints can be expressed using USAGE PARAMETERS. Others only allow travel for a particular duration; FARE STRUCTURE ELEMENTs with TIME STRUCTURE FACTORs can be used to describe the different durations. Furthermore, sometimes journey time is related to journey length, so for example a longer time is allowed for a two zone trip than a one zone trip; all this can be precisely specified in NeTEx.

Temporal conditions may also apply to the purchase or refund of tickets, likewise expressed as USAGE PARAMETERS attached to fare products.

As well as the routine examples given above, NeTEx can also handle more complex cases. For example, in the periphery of a large city, off peak times may start at different times in each station since by the time a journey to the centre starting from the station ends, the peak period will have ended.

2.5.8 Can I integrate data from different countries with NeTEx?

Yes, one of the strengths of NeTEx is that it takes a global view of data identification, allowing data elements from different name spaces to be exchanged in the same schema.

2.5.9 Does NeTEx support dynamic/ yield managed pricing?

For long distance travel, especially on-rail, there is increasing used of yield managed fares with dynamic pricing, provided by web services. Note that such applications increase rather than decrease the need for documents such as NeTEx as such applications nonetheless require a machine readable definition of the access rights fare structure and usage conditions that apply to the products for which prices are supplied. Furthermore the search parameters used to find the best fare for a user (such as age, possession of rail cards, fulfilment method etc) need to correspond to the properties of the fare product. The NeTEx Part 3 specification and UML model includes an annex showing a sample fare query which shows all the NeTEx model elements relevant for constructing a Fare API.

2.5.10 Can NeTEx define products for modern e-card based ticketing?

Yes. Electronic payment cards such as OV Chipkaart (NL), Oyster (London region), Navigo (Paris region) Sube T (Madrid), BIP Card (Turin) are becoming increasingly common and etc transport operators are able to devise increasingly sophisticated products. For example Oyster has fares that adjust according to consumption, capping the cost of trips made in a day to that of a day pass. NeTEx is able to describe the fare structures and scope and conditions for such complex products, as well as to supporting an record of consumption for account based products. (A NeTEx SALES TRANSACTION records an individual PRODUCT SALE).

As products on cards are physical invisible to the user, the ability to create user readable representations become increasingly important – such applications require a machine readable format with corresponding human readable rendering, such as is available through NeTEx.

2.5.11 Does NeTEx support Flexible and Demand Responsive Travel?

Yes, unlike classical route and timetable standards, NeTEx is also designed to support FTS (Flexible Transport Service) and DRT (Demand Responsive Transport). DRT and FTS often cover similar services; FTS being more generic since flexibility may not be directly linked to the demand, but may be related to some operating needs or cost optimisations.

The flexibility can be applied to the line, route and stop structure (areas, corridors, hail and ride, etc.) or to their scheduling (dynamic and/or demand responsive passing times, with all necessary booking arrangements and contact details).

2.5.12 Can I create applications to run in different national Languages?

Yes, NeTEx includes full support for internationalization. All text elements may be created in multiple languages so that place names and other names and descriptions can be provided in one or more languages. Other aspects important for multiregional use are parameterized such as time zones, currency, etc and the Calendar functions allow conditions based on different national holidays to be described.

2.5.13 Can I have different version of data for the same element extant at the same time?

Yes, every NeTEx data element can be versioned, and multiple versions can coexist. Coherent sets of data are assembled for exchange using a 'version frame', which itself has a version and knows the version of the elements in it. There are specific types of version frame for different type of data that are commonly exchanged together (SERVICE, TIMETABLE, FARE etc).

2.5.14 Can I create Network maps with NeTEx?

Yes, one of the additional capabilities of NeTEx is the ability to define and exchange the full topology of a network as presented in simplified view to a user (often with presentational attributes such as colour), with non-directional network segments, loops etc, while also retaining a projection onto the actual underlying stops and route. This allows automatic creation of interactive map applications.

- The LINE element names the line and sets basic properties;
- the LINE NETWORK and LINE SECTION elements can be used to describe the topology;
- the ROUTE, ROUTELINK, and ROUTE POINT elements can be used to define the directional elements of the underlying line;
- the SCHEDULED STOP POINT can be used to define the stops of a line.

All these objects can have their own geographic positions and geometry or can be projected onto a custom drawn map using a SCHEMATIC MAP element.

2.5.15 I have my own classification for Stops/ Lines / etc. Can NeTEx handle this?

Yes NeTEx allow arbitrary user defined code classifications for elements using the has TYPE OF STOP, TYPE OF LINE and other 'Type of Entity' elements that . In addition NeTEx, to encourage standardised use, also provides fixed enumerations of many commonly found classifications of specific elements, including types of equipment, on-board facilities, etc.. The 'Key Value' extension mechanism allows Also allows additional user defined attributes to be added, which can include classifiers.

2.6 Comparison with other documents

2.6.1 How does NeTEx relate to Transmodel?

NeTEx is primarily dedicated to data exchange, i.e. an XML message format and a protocol are specified. The content model of the NeTEx message structure is based upon the NeTEx physical data model and is derived directly from Transmodel, the CEN Public Transport Reference Data Model developed at a conceptual level and independent of an implementation in any specific technology.

As regards functional domains, NeTEx covers only a subset of Transmodel; the *Network Topology*, *Timing Information*, *Vehicle Scheduling* and *Fare Information* domains, whereas the full scope of Transmodel is broader, including in addition: *Operations Monitoring and Control*, *Fare Management* (sales, validation, control), *Management Information and Statistics*, *Driver Management*: *Driver Scheduling*, *Rostering*, and *Driving Personnel Disposition*.

The Transmodel conceptual model is broken down into modular packages with a mostly linear dependency graph between modules. The same organization of packages is used in the Physical model and XML schema so that there is a direct correspondence between the modules for each functional domain. This makes it straightforward to relate the high level design to the implementation.

2.6.2 How does NeTEx relate to IFOPT?

IFOPT, similarly to Transmodel specifies a data model, whereas the primary aim of NeTEx is to define data exchange format. IFOPT has been integrated into the latest version of Transmodel (v6) and thus (see above) builds the basis for the NeTEx physical submodel dedicated to Fixed Objects for Public Transport. This data domain is concerned with particular different types of sites (and their components), such as points of interest, parking or stops and related objects like equipment, for instance, but also pedestrian navigation paths and takes into account accessibility characteristics. NeTEx specifies the exchange of the data defined by the IFOPT model.

2.6.3 How does NeTEx compare with VDV?

Since NeTEx was influenced by existing European national standards and reference exchange protocols it also ensures compatibility with VDV452 ("VDV Standard Interface Network / Timetable" reference exchange protocol in Germany) at the level of conceptual and physical model. The aim of the VDV452 is to transfer network definitions and timetables from a source system into a target system, i.e. the timetable data from a scheduling program is transferred to consumer systems for the purpose of transit operations. NeTEx's physical model provides specific elements (i.e. ExternalStopPointRef, ExternalJourneyRef, ExternalInterchangeRef, etc.) for VDV compatibility, specifically for use in AVMS systems.

A comparison between NeTEx and VDV452 is available at: www.vdv.de/netex.

2.6.4 How does NeTEx compare with TransXChange?

TransXChange, the UK national timetable standard, together with NaPTAN, the UK stop data standard, provides a functional equivalent subset of to the NeTEx stop and timetable elements in NeTEx Part 1 and NeTEx Part 2 and it is straightforward to map these to the contents of a NeTEx timetable frame. Both documents are based on Transmodel and allow the exchange of structural information such as timing information and journey patterns, The NeTEx representation is in many respects simpler, but is

less specific about which elements shall be present, and what the restrictions of values are. NeTEx also includes many additional elements in Part 1 and Part 2 that are not in TransXChange, including support complex for rail journeys, interchanges rules, . schematic maps, etc. TransXChange does not support fares and nearly all of NeTEx Part 3 is outside of its scope. The result of 2004 FareXChange study of UK Bus Fares was a significant input into NeTEx.

TransXChange also includes a small number of additional registration elements to support the Electronic Bus Service Registration process of the UK Vehicle Licensing authority (VOSA). Some of the registration concepts (such as administrative areas) have equivalents in NeTEx, but a few of them are specific to the UK regulatory context and are not supported by NeTEx. It would be possible to add a separate UK extension to NeTEx to include these.

2.6.5 How does NeTEx compare with NEPTUNE?

NEPTUNE is a French standard for data exchange in the domain of Network Topology and Timetables. It is based upon a draft EN version of Transmodel and incorporates several features of IFOPT as regards stop typology, equipment and accessibility characteristics. It is comparable as regards the functional coverage to NeTEx-Part 1&2, but smaller regards to number of data covered.

2.6.6 How does NeTEx compare with NOPTIS?

The Transmodel based Nordic Public Transport Interface Standard (NOPTIS) provides a consistent set of XML-exchange protocols covering both planned and real time aspects. One of these exchange protocols is the Data Input Interface (NOPTIS DII). This exchange protocol is optimised to transfer version-managed information concerning Network, Timetable, Vehicle Schedule, Services and other data to a PTA integrator system and is used extensively in Sweden and Denmark. NOPTIS DII was a significant input to NeTEx. There exists a mapping between NeTEx and NOPTIS DII covering the Calendar, Timetable and Vehicle Schedule aspects showing how to use NeTEx in a way that supports parallel partial data deliveries as in NOPTIS.

2.6.7 How does NeTEx compare with IFM?

Interoperable fare management (IFM) encompasses all systems and processes designed to manage the distribution and use of fare products in an interoperable public transport environment. Such systems are called interoperable when they enable the customer to use a portable electronic medium (e.g. a contact/contactless smart card) with compatible equipment (e.g. at stops, with retail systems, at platform entry points or on board vehicles).

IFM-Part 1 is an ISO standard (ISO 24014-1) aiming at the definition of a reference functional architecture for Interoperable Fare Management System(s) and at identifying the requirements that are relevant to ensure Interoperability between several actors in the context of the use of electronic tickets. The exchanges between IFM actors are described from the functional point of view by the IFM standard, without the specification of data exchange format.

NeTEx- Part 3 describes fare elements as specified in public transport fare systems (zonal fares, flat fares, progressive fares, distance matrix, etc) and the resulting fare products using a conceptual data model, specifies a detailed physical data model for fares and derives data exchange message formats for fare exchange. The exchanges are concerning the information on fares (abstraction being made from any particular medium), on the conditions of use of fare products, on associated fare product distribution channels. Parameters necessary for the price calculation of fare products are also provided.

IFM is a process description and NeTEx is a data exchange format.

2.6.8 How does NeTEx compare with BISON ?

The official start of BISON, the platform for *Beheer Informatie Standaarden Openbaar Vervoer Nederland* (Management Information Standards Public Transport Netherlands), took place on 16 September 2008. The BISON platform is the result of an earlier decision on the part of the National Mobility Deliberations

(NMB) to set up a management organization for the further development of collective standards and the incorporation of these standards, insofar as possible, in existing concessions.

The main function of the BISON platform is to formulate, manage, harmonize and monitor all of the information standards that facilitate the exchange of information within the public transport sector.

BISON considers NeTEx to be the standard of choice for the future. Parts of NeTEx have been applied and used within BISON (e.g. Part 3 – Fares). In due time BISON will migrate from its national PT information exchange standard to NeTEx, and in due time NL specific BISON profile(s) will be developed which will help to exchange travel information with other countries such as Germany and Belgium.

2.6.9 How does NeTEx compare with the Taap/TSI standards?

There are three different TAP /TSI standards for fares; m – B1 (standard fares) B2 (Integrated Reservation fares) and b3 (special fares), each using different models (with some common elements between B1 and B3) and quite different representations of the classes of user conditions, NeTEx is able to represent the elements and attributes of all three models with a single uniform model, based on access rights, using in particular DISTANCE MATRIX ELEMENTs to describe the point to point fares and USAGE PARAMETERS to describe the different conditions applying to the rail products. Only a small number of FARE PRODUCTS are needed to describe the standard rail products. A number of sales conditions also relate to rail products and can be describe using SALES PACKAGES with NeTEx DISTRIBUTION CHANNELs and FULFILMENT elements. The mapping of most elements is straightforward and it is straightforward to create transformations using simple mapping tools such as those found in the XML SPY product suite.

The TapTSI standards make use of a number of UIC code sets (all represented in NeTEx as either sets of enumerated values or 'Types of value' or in the case of station and onboard facilities as various types of Facility or Equipment. . Stations (Locations in UIC terminology) can be uniformly represented in NeTEx as Scheduled Stop points.

For details on the Tap/TSI model see the UML model of the mapping and the mapping specifications.

2.6.10 How does NeTEx compare with GTFS?

Google General Transport Feed Specification (GTFS) is a widely used format for distributing timetables to third parties. The NeTEx and GTFS formats should be considered as complementary, covering different stages in the data management process: NeTEx is "upstream", GTFS is "downstream". NeTEx differs from GTFS in that it has a much wider scope, and that it is intended for use in back office use cases under which data are generated, refined and integrated (requiring the exchange of additional elements used to construct the timetable), rather than just for provisioning journey planning systems (the prime purpose of GTFS).

GTFS covers stops, lines, and timetabled journey information (Gtf trips) sufficient to answer basic journey planning queries. It supports only a few simple types of fare product. GTFS data identifiers are specific to each data set and require registration of an identifier with Google.

NeTEx covers many other aspects of Public Transport Information apart from timetables (e.g. network descriptions, fare products,), as well as supporting a richer timetable model for export including journey patterns, timing patterns, joined journeys, train makeup, connection timings, etc. . This makes it able to exchange the data sets used to build timetables as well as the resulting timetables themselves. NeTEx includes the additional information needed to provision real-time systems (such as destination displays) and to link to operational systems (such as blocks) It also includes versioning and validity condition mechanisms to support the repeated peer-to peer integration of many data from many different parties.

Because it uses XML, NeTEx is able to package a complete data set as a single coherent document that can be managed and validated.

GTFS uses a traditional flat file format; this is compact and efficient but requires multiple files to describe the different types of element and thus additional rules for naming and packaging the files as a zip. Custom written tools are needed to interpret and process the data.

It is possible to generate a full GTFS data set from NeTEx but not vice versa. The NeTEx UML includes a GTFS mapping package which shows how each GTFS element may be populated from the corresponding NeTEx element.

3 NeTEx covered areas description

3.1 Introduction

NeTEx covers different areas that fall into two main groups: General areas and Specific functional areas.

3.2 General areas

- NeTEx Getting Started [Annex A];
- NeTEx Design Methodology [Annex B];
- NeTEx Framework [Annex C];
- NeTEx Reusable Components [Annex D];

3.3 Specific functional areas

- NeTEx Networks [Annex E];
- NeTEx Flexible Networks [Annex F];
- NeTEx Accessibility [Annex G];
- NeTEx Timetables [Annex H];
- NeTEx Fares [Annex I].