Outline comparison and Mapping between NeTEx & GTFS

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Purpose of this document

- Help data providers to understand better the common points and the differences between NeTEx and GTFS specifications as to content and other different aspect of use.
- Enable the correct conversion between the two formats whenever is needed
- Enhance knowledge on how to make a comparison and a detailed mapping between standards/ specifications using the Transmodel conceptual model for Public Transport - Using the concrete example of NeTEx versus GTFS
- Support decision making about using the available standards in the best way

Why create mappings?

- **To help bridge**
  - GTFS Schedule and NeTEx
  - GTFS Realtime and SIRI

- **To facilitate interoperability between systems**
  - Further alignment and long-term harmonisation
  - Integration of data from different sources
  - Creation of open-source conversion tools

- **But…**
  - Consumes lot of resources
  - Never ends: must be constantly updated (new extensions)

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OUTLINE COMPARISON BETWEEN NETEX /SIRI AND GTFS / GTFS RT

Use cases and modes

GTFS

GTFS Schedule & GTFS Realtime

- Use-case:
  - Passenger information
- Peer-to-peer exchange of data
- Modes:
  - Conventional public transportation
  - Demand-responsive transit
  - On-demand services

NeTEx

Network Timetable Exchange

NeTEx & SIRI

- Use-cases:
  - Passenger information
  - Schedule building, planning Operations, fleet management and (i.e., complex data preparation)
  - Fare specifcation and sales
- Multiple workflows including peer-to-peer, via aggregators, NAPs etc.
- Modes:
  - All modes (conventional & shared)
  - All types of operation (scheduled, demand-responsive, on-demand, shared)

The data model

GTFS

GTFS Schedule & GTFS Realtime

- No formal data model
- Addition of elements/concepts whenever needed
- Pro: Very straightforward
- Con: Longer discussion for extensions of concepts

NeTEx
Network Timetable Exchange

NeTEx & SIRI

- Single data model, **Transmodel**, modularised by functional area, formal definitions (with translations to national languages)
- All definitions taken from the same source for extensions
- Pro: Reliable basis for extending model, richer semantics (e.g. complex fares), much wider functional scope
- Con: Longer modelling for initial consensus. Uniform implementation

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The governance

GTFS

GTFS Schedule & GTFS Realtime

- Change proposals: anyone
- Facilitator: MobilityData or others
- Vote: anyone via GitHub
- Pro: rapid change process up to a certain number of stakeholders
- Con: extensions exist outside of the canonical model

NeTEx
Network Timetable Exchange

NeTEx & SIRI

- Change proposals: anyone
- Facilitator: CEN via ITxPT
- Vote: any representative of CEN members
- Pro: consistency of the model for extensions, harmonised with other CEN standards
- Con: slower change process to include all members

CSV AND XML

The technology

GTFS

CSV (GTFS Schedule)

- Flat file format
- One type of record per file
- Simple objects only
- Limited description of entities
- Some overloading of attributes to allow alternative meanings (complex to process)
- Packaged as a zip file
- Versioning at the feed level

NeTEx
Network Timetable Exchange

XML (NeTEx)

- W3C XML Schema
- Multiple data elements per file
- Complex object structures allowed
- Uniqueness and integrity constraints
- Explicit objects (no overloading)
- Responsibility model
- Single (or linked) documents
- Version Frames to organize
- Uniform versioning (fine grain possible)

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Pros and Cons

GTFS

CSV (GTFS Schedule)

- Pros
  - Simple flat files easy to read
  - Import/Export from/to spreadsheets possible
  - Compact and Efficient
- Cons:
  - All validation is programmatic
  - Complex rules to assemble (open- source tools to assist exist)

NeTEx

Network Timetable Exchange

XML (NeTEx)

- Pros
  - stronger expression of the underlying model (Easier implementation of changes)
  - Automatic validation (content, data types, referential integrity and uniqueness)
  - Simple packaging (everything in one file)
- Cons:
  - Technical sophistication to use (open-source tools to assist creation)
  - Larger files (tools to compress)

CANONICAL MAPPING

Main principles

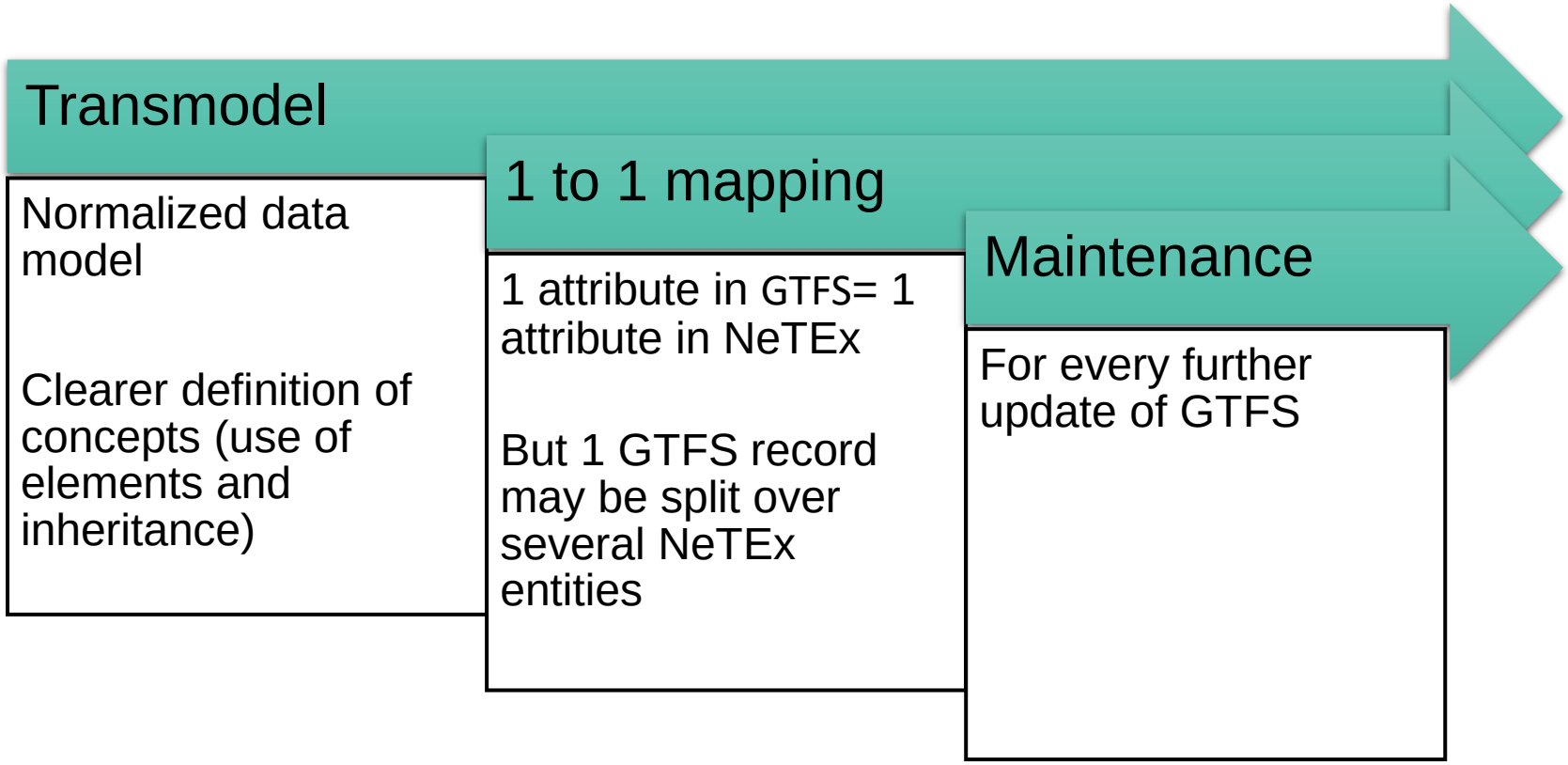
Canonical Mapping: GTFS ↔NETEX

Transmodel / NeTEx and GTFS experts have established a systematic mapping

- All GTFS elements/attributes / restricted values mapped to Transmodel / NeTEx entities / attributes / enumerations
- Preferred approaches to handling identifiers, versioning, organisation of elements within a document, etc
- Examples of a converted GTFS data set are in NeTEx XML examples

==> Suppliers of data management tools should conform to mapping when importing exporting data

How we envision mapping



Mapping Example - The GTFS Agency Record

GTFS

NeTEx
Network Timetable Exchange

GTFS record	GTFS Attribute	NeTEx element	NeTEx attribute	Type	Alt Text
agency.csv	agency_id	***Operator***	***id***	*OperatorIdType*	
	agency_name		***Name***	*MultilingualString*	Y
	TimeZone		***Timezone***	*xsd:string*	
	agency_language		***DefaultLanguage***	*xsd:lang*	
	agency_phone		***ContactDetails.Phone***	*PhoneNumber*	Y
	email		***ContactDetails. Email***	*Email*	Y
	agency_url		***ContactDetails. Url***	*xsd:anyURI*	Y
	agency_fare_url		Keylist.gtfs_fare_url	*xsd:string*	

GTFS record / NeTEx basic correspondences

GTFS

GTFS Schedule & GTFS Realtime

- The same GTFS record may used to represent several different concept
  - Fewer Records, more complex interpretation

Examples

- **stops: = Station, Platform, Node, etc**
- **transfer: physical connection, service to service connection, connection rules,**
- **fare attributes = Fare, fare price, etc etc**

NeTEx
Network Timetable Exchange

NeTEx & SIRI

- One element per concept
  - Simpler, unambiguous interpretation
  - Reusable in different domains
  - Extensible without side effects
  - Traceability to design model
  - One-for-one binding to object model
- Explicit views where efficient: systematically derived from separate elements
  - **E.g. CALL is (POINT IN JOURNEY PATTERN + PASSING TIMES etc.**

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GTFS record / NeTEx basic correspondences:

GTFS record	Transmodel / NeTEx	Notes
agency	**OPERATOR** or AUTHORITY	
stops	**SCHEDULED STOP POINT**, STOP PLACE + QUAY	Complex mapping
pathways	**PATH LINK,** SIGN EQUIPMENT	
transfers	CONNECTION SERVICEJOURNEY | INTERCHANGE, **INTERCHANGE RULE**	Complex mapping
routes	**LINE**	
calendar	DAY TYPE, **DAY TYPE ASSIGNMENT**	
calendar_dates	**DAY TYPE ASSIGNMENT** and OPERATING DAY	
trips	**SERVICE JOURNEY** + DESTINATION DISPLAY	
stop_times	**STOP POINT IN PATTERN** + PASSING TIMES + DESTINATION DISPLAY &/ or CALL	Complex mapping
frequency	**HEADWAY JOURNEY GROUP,** RYTHMICAL JOURNEY GROUP with TEMPLATE SERVICE JOURNEY	
shapes.txt	ROUTE LINK, **POINT ON LINK,** LINK PROJECTION, LineString,	
levels	**LEVEL**	

Simple Mapping Example - GTFS Agency Mapping Intro

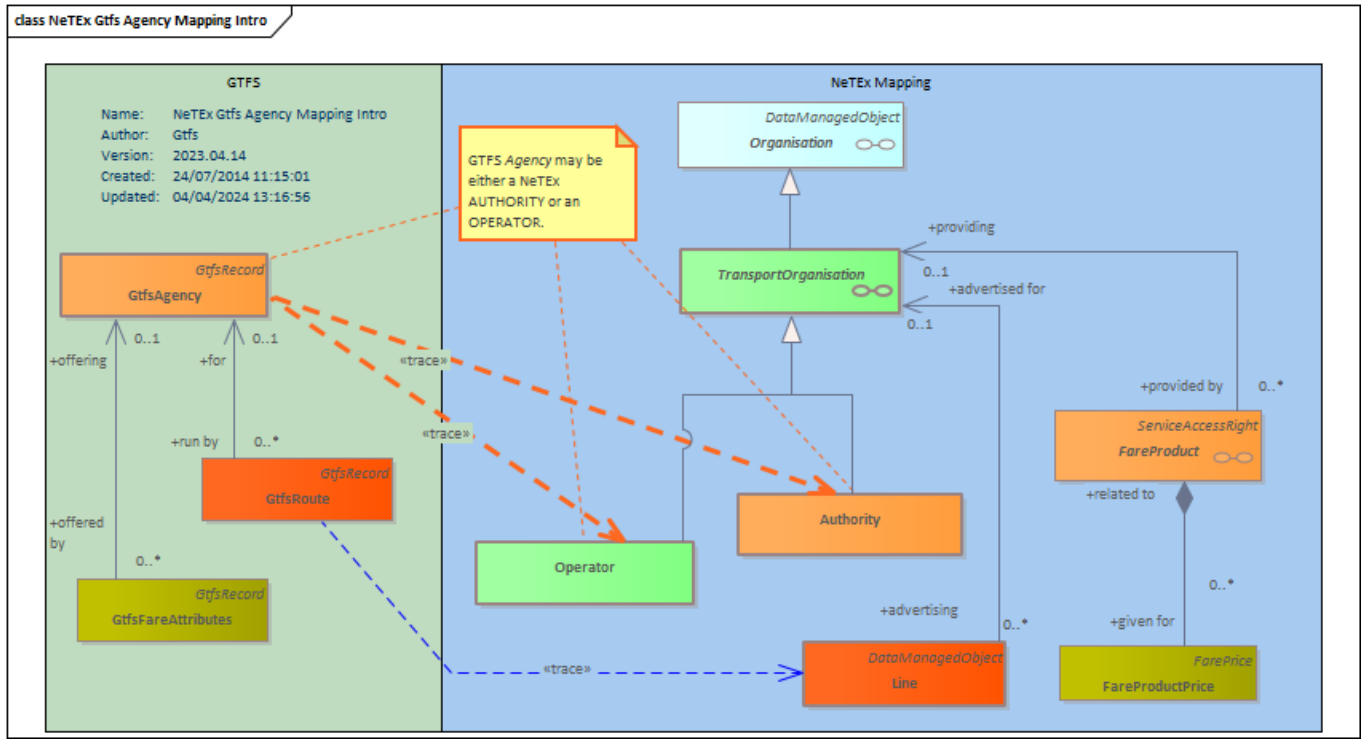
Mapping

- **GTFS Agency record ➔** NeTEx OPERATOR (or AUTHORITY)

- NOTES ;

Conceptual mapping of entities is usually one to several

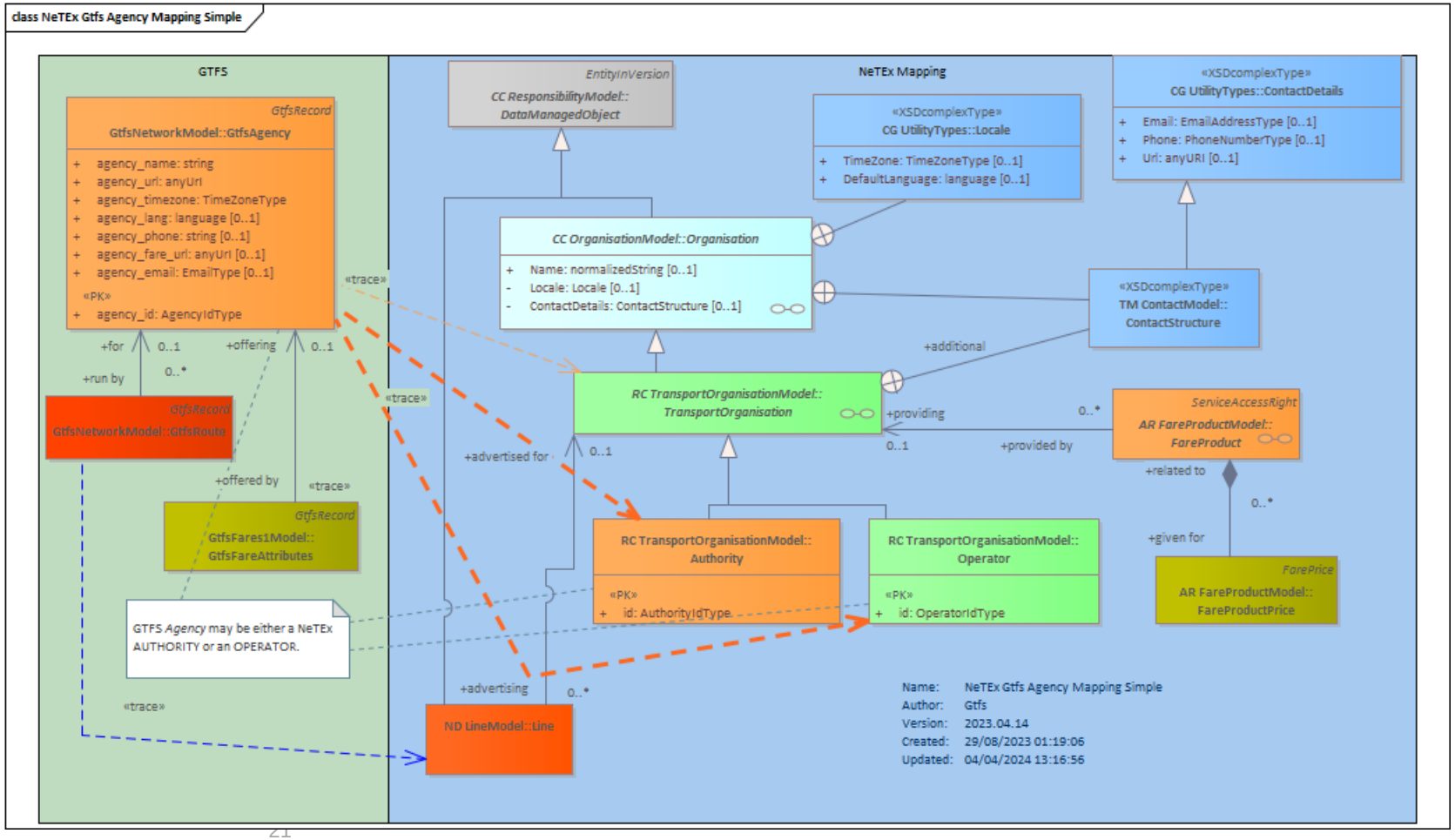
- GTFS records are simplified views
- Transmodel/NeTEx
  - Separates concerns into separate elements
  - Uses inheritance



Mapping Example : GTFS *Agency* Mapping - Details

Network

- **GTFS *agency* record**
  ➔ NeTEx OPERATOR (or AUTHORITY)
  - + CONTACT DETAILS

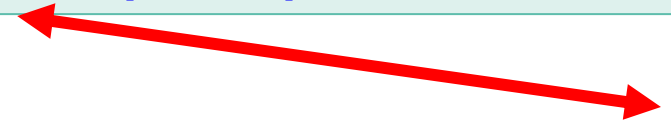


An Example mapping - GTFS Agency to NeTEx OPERATOR

GTFS

CSV

```
agency_id,agency_name,agency_url,agency_timezone,agency_lang,agency_phone,
10000,Transport For Ireland,http://transportforireland.ie,Irish Standard Time,en,1-800-300-604
```



NeTEx Network Timetable Exchange

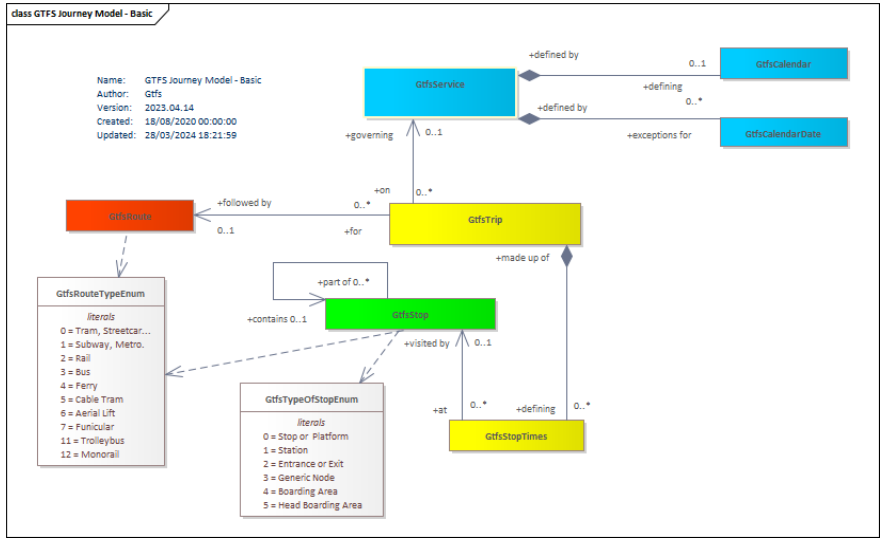

```
<Operator version="any" id="10000">
<Name>Transport For Ireland</Name>
   <Locale>
      <TimeZone>Irish Standard Time</TimeZone>
      <DefaultLanguage>en</DefaultLanguage>
   </Locale>
   <ContactDetails>
      <Phone>1800 300 604</Phone>
      <Url>http://www.transportforireland.ie</Url>
   </ContactDetails>
</Operator>
```

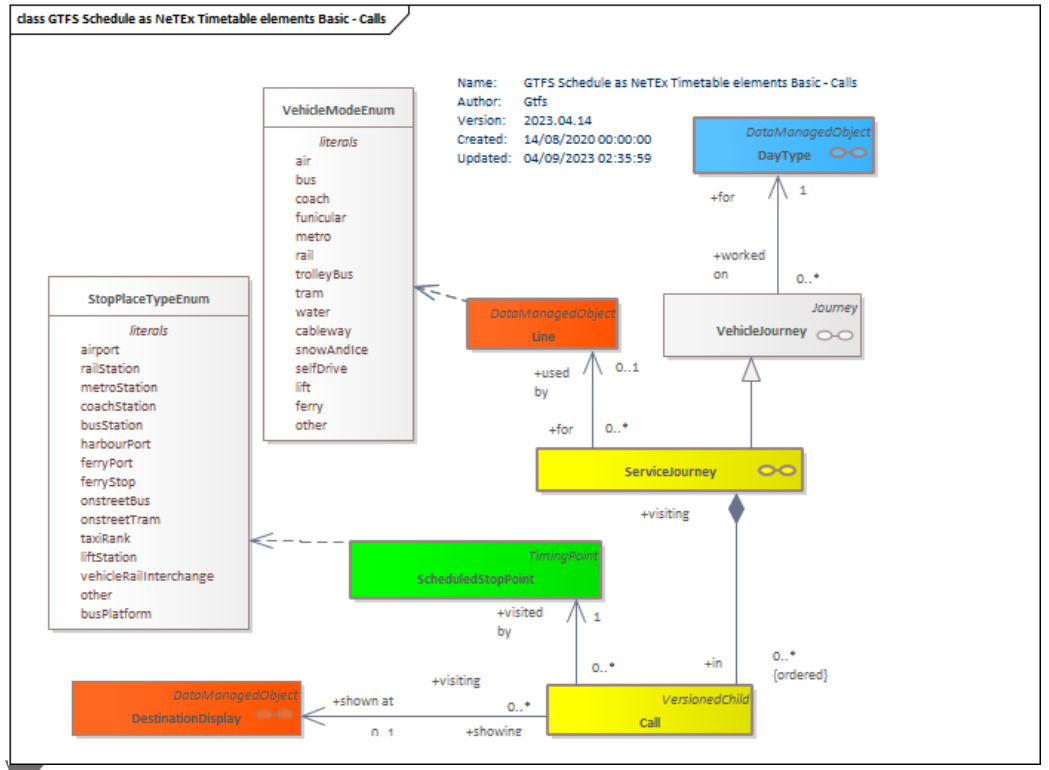
Mapping GTFS Trips to NeTEx Journeys – The basics

Terminology differences

Easy!

- **You say *route*, we say LINE…**
- **You say stop, we say SCHEDULED STOP POINT**
- **You say *trip*, we say VEHICLE JOURNEY...**
- **You say *stop_times*, we say CALL…**
- **You say *headsign* ,we say DESTINATION DISPLAY**





Supporting multiple use cases – Different considerations for using NeTEx

Functional scope, (From Profile) Which Elements?
- Strict profile or allow extensions?
- Completeness: required elements?

Granularity of XML documents - Choose for efficiency/workflow
- One document per timetable, operator, network, region, country, etc ?
- One document per product, set of products, operator, etc

Organisation of data elements - Choose for easy human verification
- Version Frames, by function, operator , line
- Nested in-line or flat.

Identifier scopes - Choose to be unique in integration context
- Single local codespace, per object type
- Shared codespaces W3C domains, e,g., national +Local:

Versioning – Choose for workflow
- Whole Dataset, Whole Frame, Individual element
- Full data set vs Deltas

Additional Validation rules – Choose for data quality requirements
- Completeness, semantics

Protocols to exchange documents
- Periodic FTP output for preset parameters
- SIRI Request for dynamic parameters

Organising data sets : NeTEx allows Different groupings

Timetable Examples

A) Separate timetable per line?

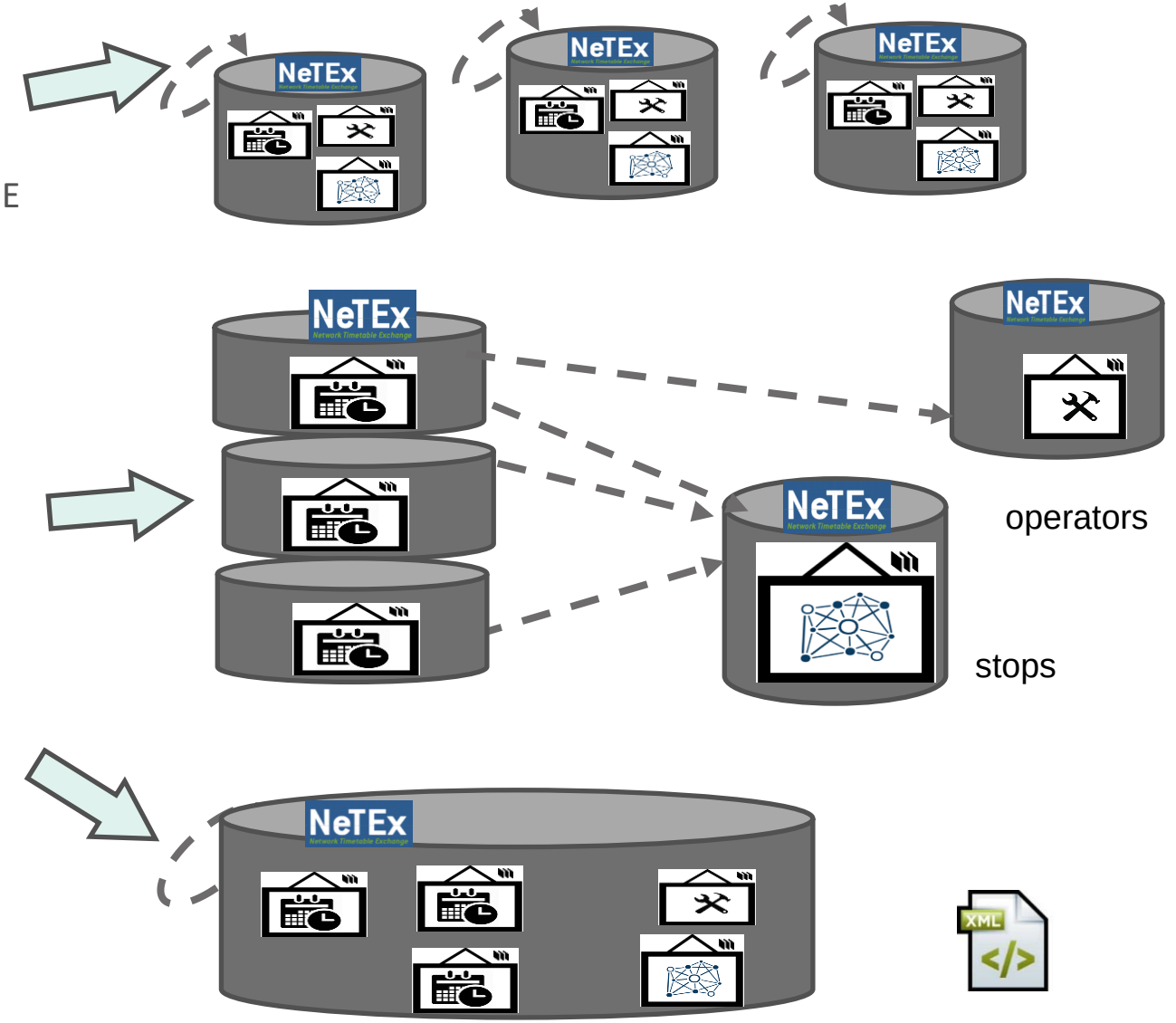
E.g. Each XML document contains STOPs and JOURNEYS for one LINE of a given OPERATOR

B) Shared Network, e.g.

- One document for each LINE with all its JOURNEYs
- One document with all the STOPs
- One document for all the OPERATORs

Whole Network, e.g.

One document with all the JOURNEYS for all the LINEs



Fare examples (Not shown)

Products per operator, network, city, etc

Products Vs Prices

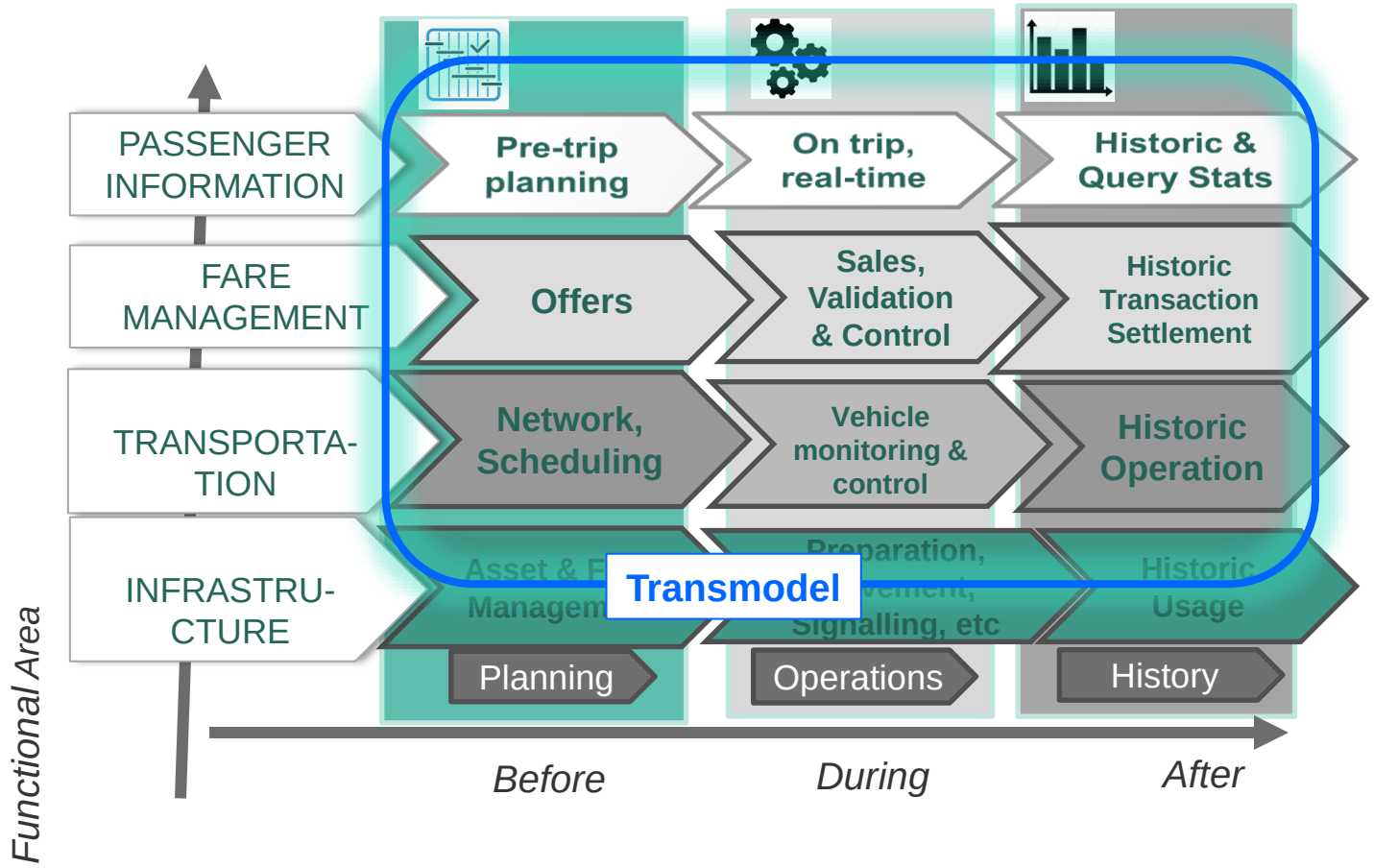
Depends on Workflow, and data volumes– Choose for efficiency

GRAPHICAL DESCRIPTION OF TRANSMODEL FUNCTIONAL SCOPE IN RELATION WITH GTFS SCOPE

Public Transport data - Functional Activity vs Time of Travel

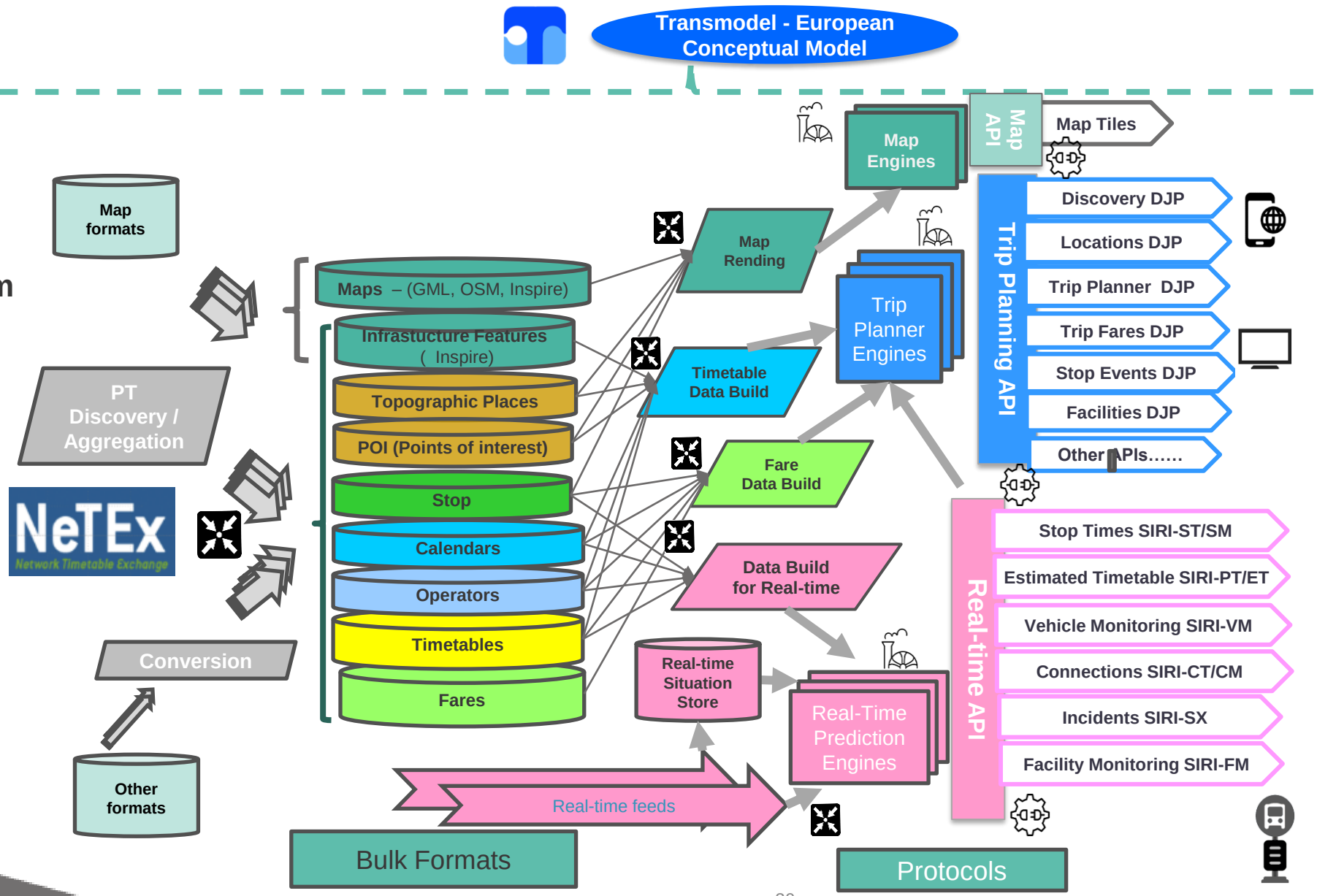
Transmodel covers wide range of PT function including **planning and operational data to run the transport**

Single consistent conceptual model spans all functions
Limited Fares: prices only



Transmodel supports both upstream and downstream data flow

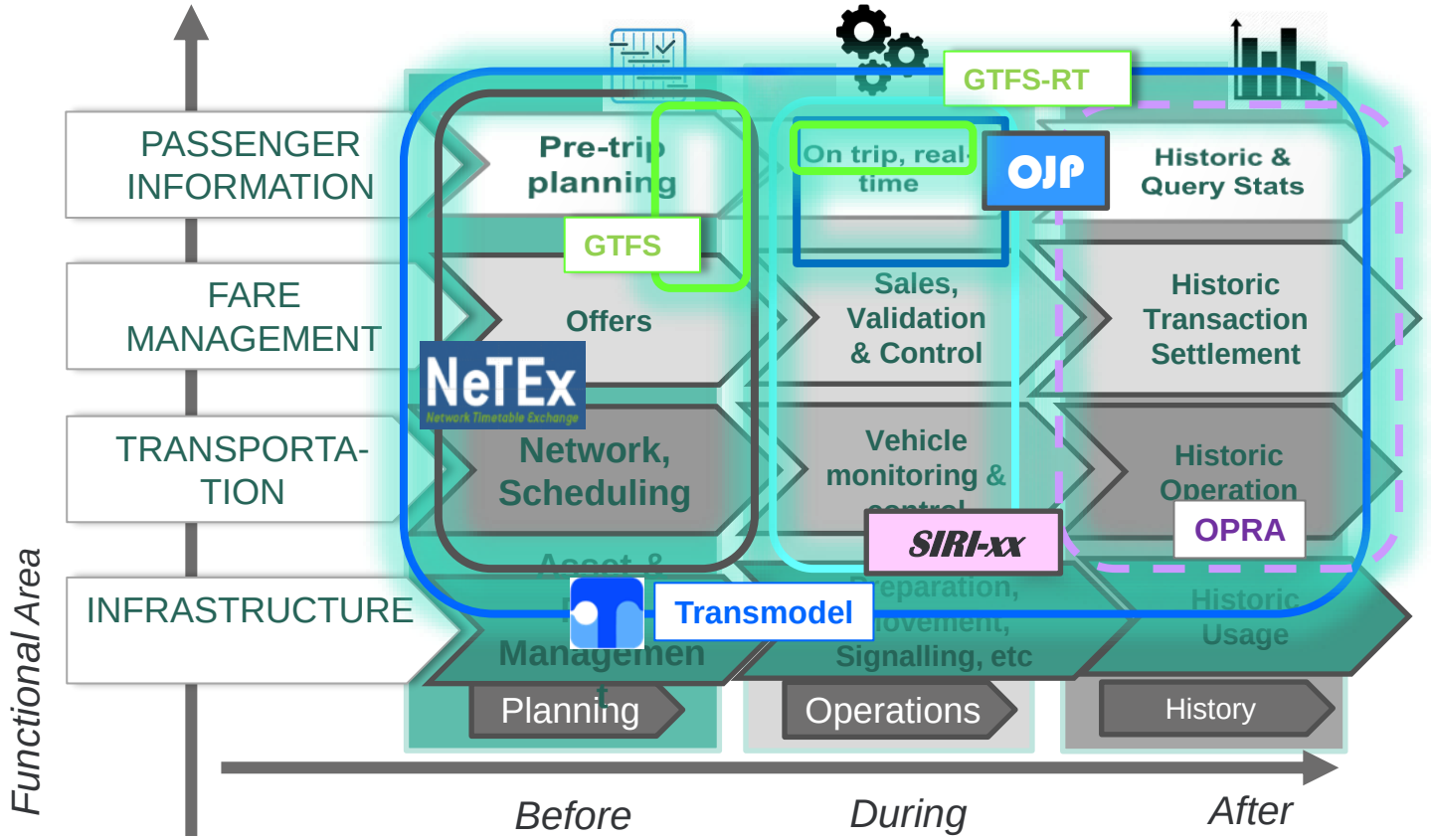
- upstream creates,
- downstream consumes



Scope of GTFS and GTFS RT in relation to Transmodel based standards (NeTEx, SIRI, OJP, OpRA)

GTFS and GTFS RT covers certain types of end user passenger Information

All use cases addressed by GTFS and GTFS RT are covered by NeTEx and SIRI.



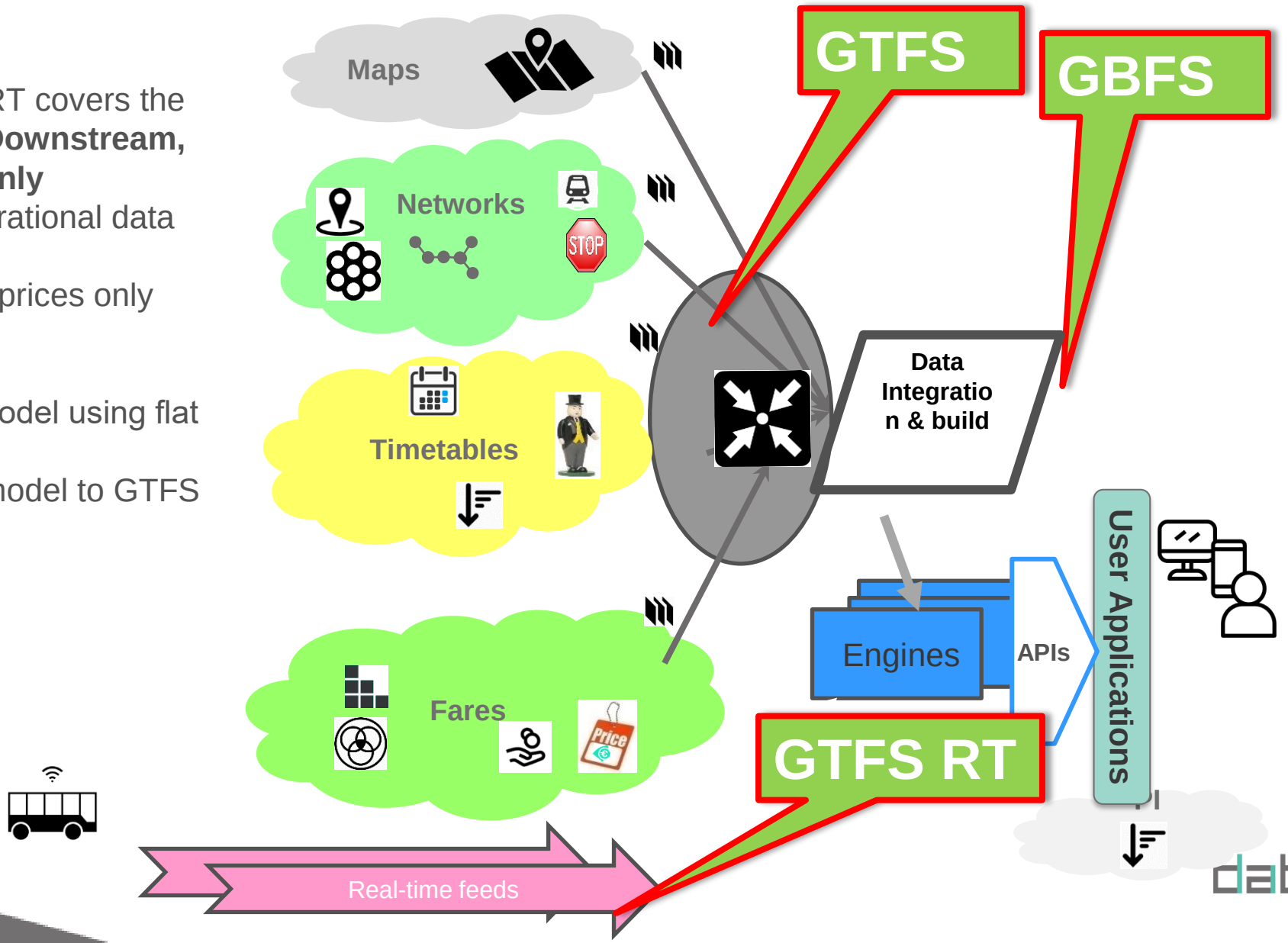
GTFS: A format for downstream

GTFS and GTFS RT covers the simple use case**: Downstream, passenger info only**

- Leaves out operational data sets, e.g timing
- Limited Fares: prices only

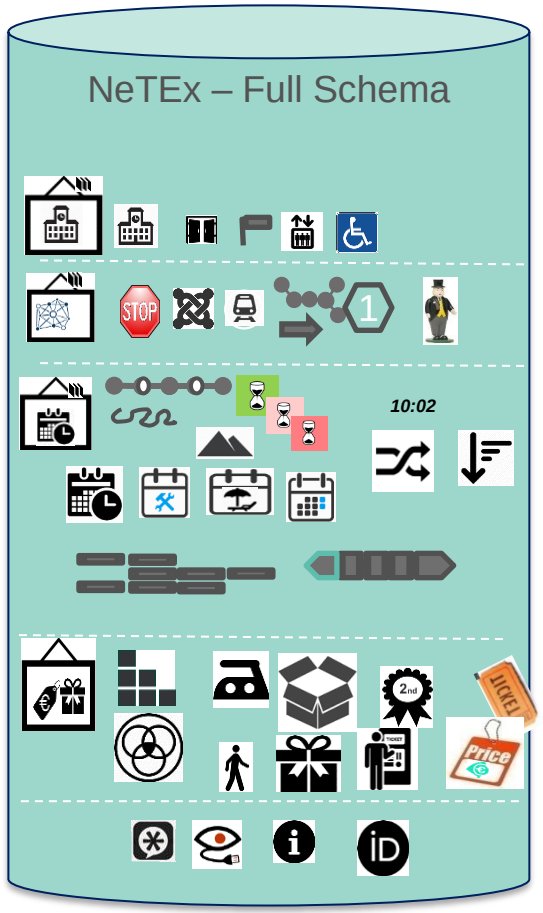
Simplifies ‘deep’ model using flat views

- GBFS different model to GTFS



Functional scope Example of choosing a subset of Transmodel/NeTEx for a specifc business case: **European** PI **Timetable Profile (EPIP) -**

Rich scope



EPIP Timetable Profile

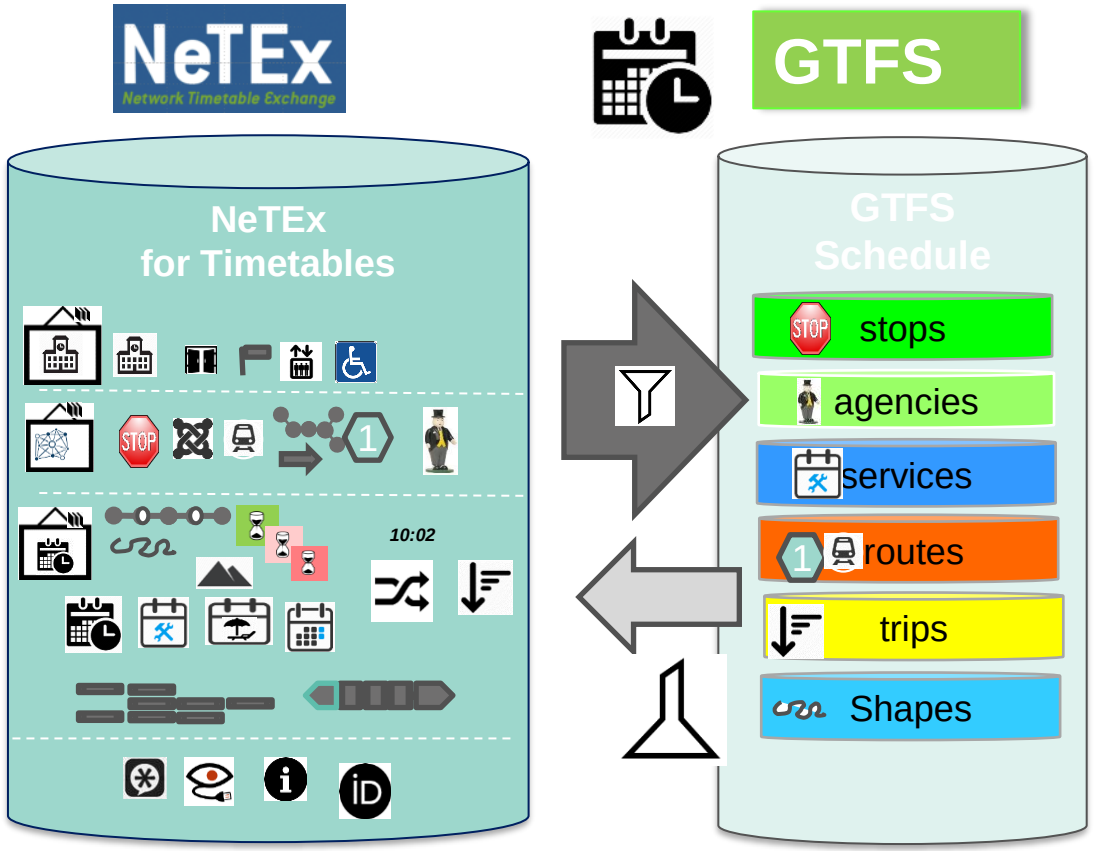
Specific Scope: timetables for trip planners

Simpler to implement!

NeTEx & GTFS Interoperation - Timetables

GTFS Schedule is useful subset of timetable data for trip planners

- Does not have underlying reusable elements to build data sets
  - e.g. journey patterns, routes.
    - Simple view for consuming system: Layers & times at stop resolved to single sequence
- Does not cover complex aspects
  - e.g. grouping, connections, join/spilt, makeup, etc
- Does not cover some operational data



Round trip is “lossy”

- ❑ NeTEx to GTFS: OK
- ❑ GTFS to NeTEx: limited function

Type of information (1/2)

that can be exchanged in both NeTEx and GTFS (up to June 2024)*

**Special thanks to Mobility Data Association provided input regarding the use cases and the features included in GTFS and GTFS RT

All Information which can be exchanged by GTFS and GTFS RT **is covered** by NeTEx and SIRI elements/attributes

Type of information
Information about the entity responsible for the transit service, such as their name, website URL, and the language and time zone in which the service operates.
Information about the stops and stations where a transit service picks up and drops off passengers. This could be a metro station or a bus stop. It is also possible to describe the interior of larger stations, such as a train station or bus depot.
Information about the route as a group of trips under the same branding that are displayed to riders as a single service. Type of service could be referred to all scheduled transport modes (such as a bus, a subway or metro, ferry, etc.).
Information about the range of dates on which a service is running, as well as creating service exemptions such as holidays and other special services on specific dates.
Information about the journeys that can be taken by passengers.
Information about individual stop arrival and departure times, allowing passengers to know precisely at what time the bus, train or ferry is arriving and departing a specific location.
Information about the color scheme assigned to specific routes based on service design guidelines from the entity responsible for the transit service. This enables users to easily identify transit services by their official color.
Information about whether vehicles are able to accommodate bicycles or not, helping users to plan and access services that enable them to make multimodal trips.
Information about the destination of a trip/journey, making it easier for users to identify the correct transit service.

Type of information
Information enabling trip planning applications to display trips on a map and inform passengers of the distance they need to travel in a transit vehicle.
Information about key areas inside stations such as exits/entrances, nodes or boarding areas, as well as their relationship.
Information about the feed, such as its validity (start and end date), the publishing organization, and contact information for inquiries regarding GTFS dataset and data publishing practices.
Additional details regarding the organisations involved in the creation of the dataset (producers, operators and/or authorities, etc.).
Details about transitions between different travel segments (or legs), enabling trip planners to determine the feasibility of journeys that include transfers. Specifying transfers does not imply passengers can't transfer elsewhere, it just shows whether certain transfers are not possible or require a minimum time to transfer.
Information about operation on a regular frequency, such as buses running every 10 minutes or subway services operating 2 minutes within specified time intervals.
Service information such as station names in multiple languages, enabling travel planners to display the information in a specific language depending on the user's language and location settings.
Information whether wheelchair boarding is possible or not from the specified location.
Information about whether a vehicle can accommodate or not passengers using wheelchairs. Both the stop and trip must be wheelchair accessible for a passenger to be able to access a trip at the given stop.

Primary Use Cases for GBFS/NeTEx Mapping

- Exchange of stop data for trip planning and passenger information.
- Exchange of transport interchange data for trip planning, including normal transfer times between stops at an interchange.
- Exchange of timetable data for trip planning including journeys, day types, planned interchanges.
- Exchange of information about paths between entrances and platforms at a transport interchange for trip planning, including accessibility constraints.
- Exchange of data for spatial plots of journeys for trip planning.
- Exchange of tariff zones for fare finding by trip planners.
- Exchange of origin / destination pairs for point-to-point and zone to zone fares for trip planning.
- Exchange of simple static fare price data for point-to-point, zone and flat tariff stuctures.

Type of information (2/2)

that can be exchanged in both NeTEx and GTFS (up to June 2024)*

All Information which can be exchanged by GTFS and GTFS RT is covered by NeTEx and SIRI elements/attributes
Inputs to convert text into audio, ensures that passengers using assistive technology to read text aloud are getting the right stop names when using the transit service.
Types of tickets or fares (i.e. single-trip fare, monthly pass, transfer fees, etc.) offered by a transit entity to access a service. Association between fares or tickets and various travel conditions, such as routes, areas, and times, determines the fare costs for individual travel segments and transfers.
Information about the supported media that can be used to hold and/or validate a fare product (such as a paper ticket, a rechargeable transit card or even contactless payment with credit cards or smartphones).
Information about special fares for express services or differentiating fares between a Bus Rapid Transit service versus traditional bus services.
Information about fares assigned to specific time-of-day or day-of-week, such as peak and off-peak fares and/or weekend fares.
Information about zone-based systems where a specific fare applies when traveling from one particular zone to another.
Information about rules applicable when transferring between legs (or individual travel segments). This allows to model the total cost of a multi-leg travel journey, accounting for special transfer policies, such as free transfers for a specific time limit, or applying fare discounts based on legs already traveled.
Information that enables users to obtain precise directions (e. g. from an entrance to the boarding area), which is particularly useful in navigating large and complex transit stations.

All Information which can be exchanged by GTFS and GTFS RT is covered by NeTEx and SIRI elements/attributes
More details about physical characteristics inside a station, including length, width and slope (for ramps) or the number of stairs (for stairways). This helps riders anticipate the conditions and accessibility of the pathway they need to navigate.
List of all different levels within a station, providing users with an additional layer of information to stations.
Additional level of detail to in-station directions, giving users an estimated time required to navigate stations, resulting in better travel directions and travel times.
information displayed in trip planners bridged with real-world signs. If this is represented in a feed, trip planners can provide directions such as 'follow signs to '.
Information for passengers when can be picked up and/or dropped off between scheduled stops. Passengers can be picked up or dropped off at any point along the vehicle's travel path for every trip of the route, for a specific section of a route.
Information to enable users to reserve a trip on a demand-responsive service. These rules outline the necessary prerequisites for successful bookings and provide contact information where users can make trip reservations.
Information about vehicles that can briefly deviate from a specific route to pick up users that booked a trip within a specific area along the route.
Information about pick up and/or drop off at any location within a specific area for users that book a trip with flexible services.
Information regarding pick up and/or drop off at any location within a group of pre-defined stops for users that book a trip with flexible services

Use cases(1/2)

covered in both **SIRI and GTFS RT**(up to June 2024)*

**Special thanks to Mobility Data Association provided input regarding the use cases and the features included in GTFS and GTFS RT
All Information which can be exchanged by GTFS and GTFS RT **is covered** by NeTEx and SIRI elements/attributes

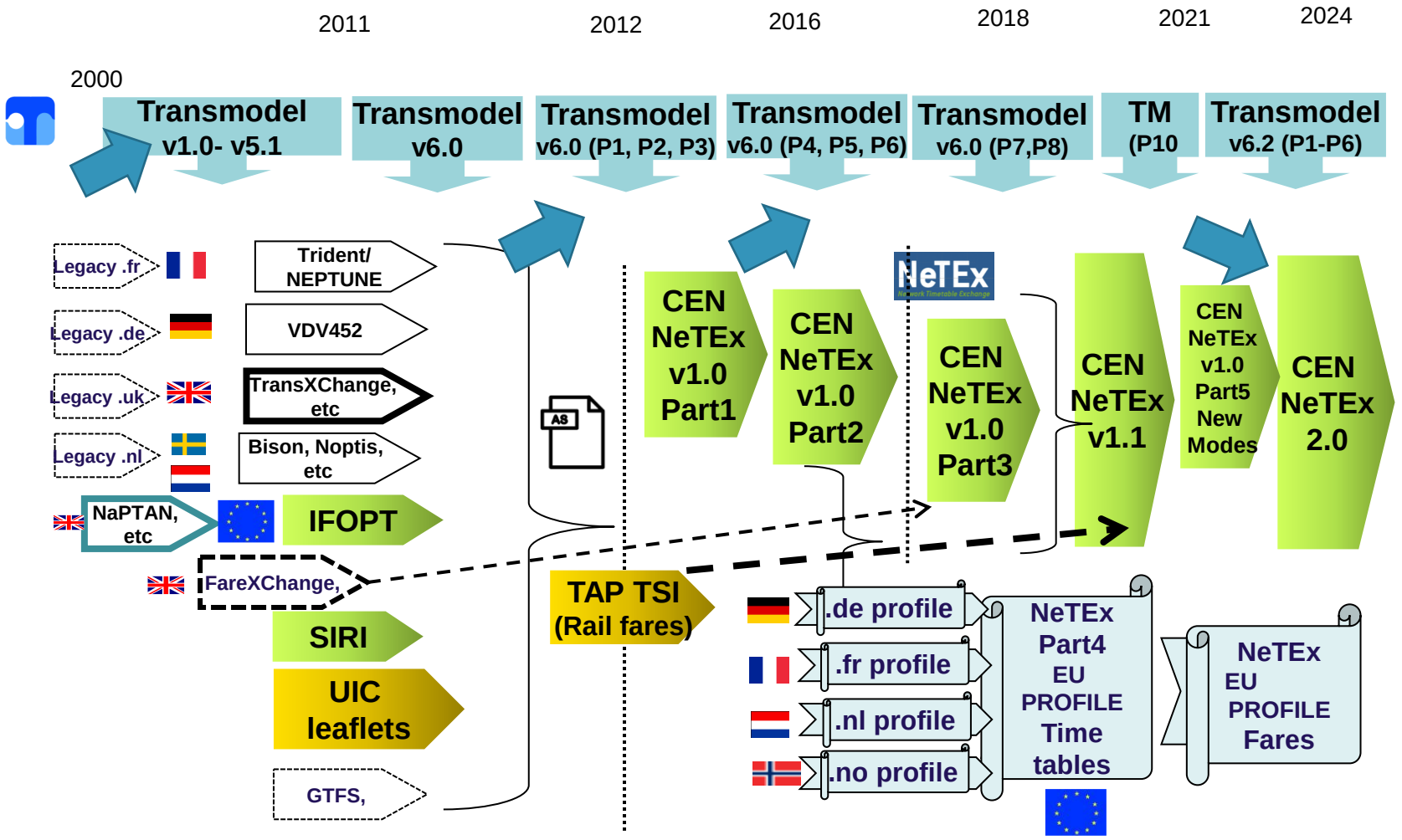
Use cases
"Bus X is delayed by 5 minutes"
"Station Y is closed due to construction”
"This bus is at position X at time Y"
"These trips are affected by a detour on certain days"

NeTEx and GTFS Evolution

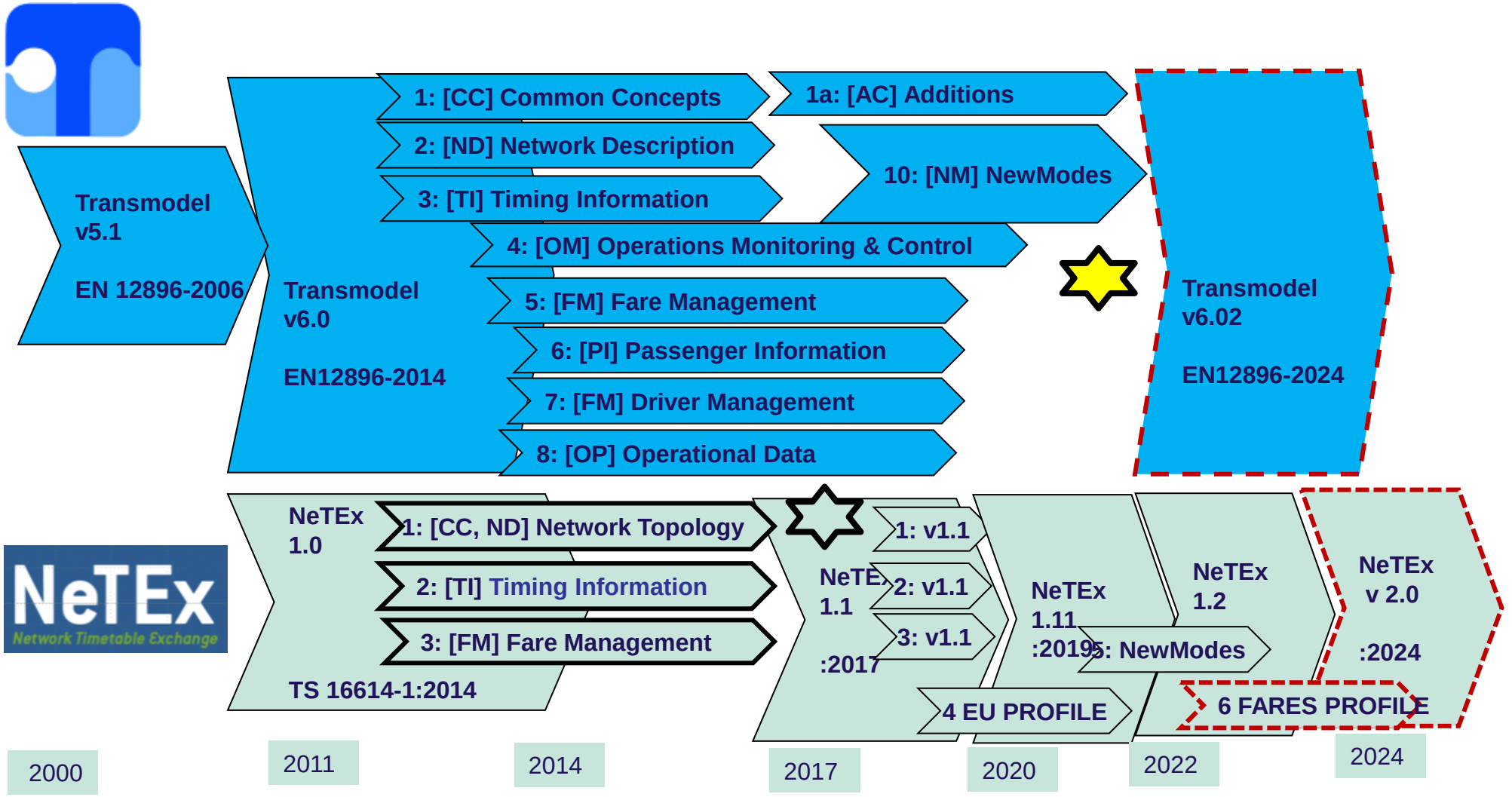
NeTEx – Evolution from National Standards

Not invented overnight – would be alarming in a complex subject area

In 2001 to bring Naptan & TXC together



CEN TC278 PT Modular Standards Parts



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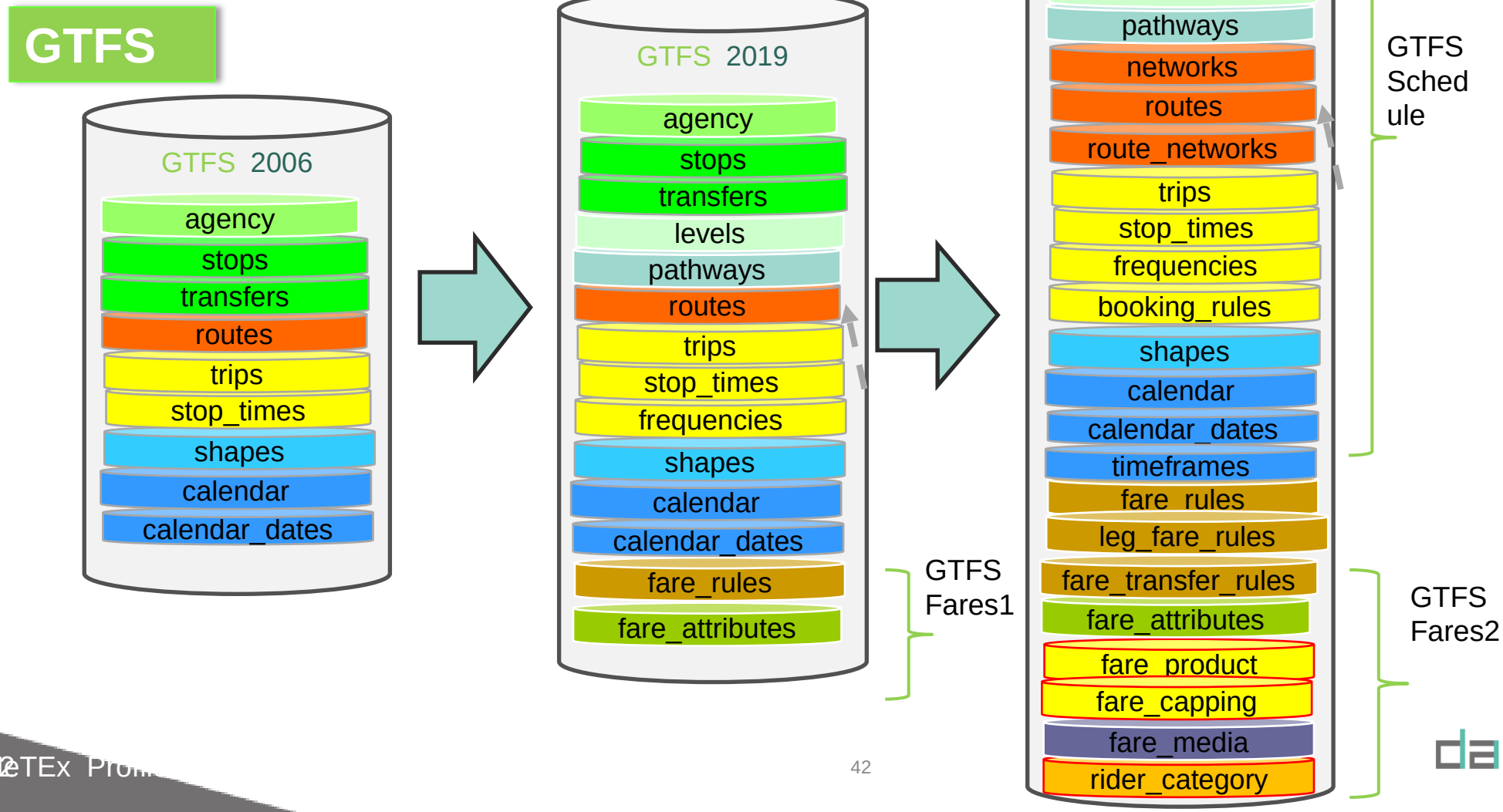
Of course, GTFS is also evolving
(and becoming more complex....)

- Any Mapping needs maintaining
- Opportunities to align terms and concepts



METHOD OF COMPARISON

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TRANSMODEL /NETEX METHODS

-

MODEL DRIVEN DESIGN

Differences between Standards - Data Interoperability & Mapping with non-Transmodel Standards – Use cases

1. To establish boundaries between standards covering different functional areas
   - Equivalent concepts in overlapping standards that allow separate data sets to be integrated as one uniform data set for use in an enquiry engine
     - Eg NeTEX/Inspire - Overlap: GIS FEATURE, ADDRESS, LOCATION
     - Eg NeTEx/Datex - Overlap: PARKING, ROAD ELEMENT, SITUATION
2. To import from legacy & existing data sets with similar scope (Open Data is Good!)
   - Individual specific mappings needed
     - Eg Rail Tap TSI B1, B2, B3 □ NeTEx Fares
     - E.g. GTFS Timetable □ NeTEx Timetable
     - E.g. GBFS □ NeTEx New modes
3. To export to other systems that want our data (Open Data is Good!)
   - Individual specific mapping for a given 'Profile'
     - E.g. NeTEx Timetable □ GTFS
     - E.g. NeTEx New Modes □ GBFS

Transmodel: #1 Using model driven design to engineer exchange formats

The ***Conceptual Model*** is implementation independent

"Joined up" architecture over a large functional domain.
Addresses multiple use cases.
Modularised to separate concerns.

A ***Physical Model*** maps to each target implementations

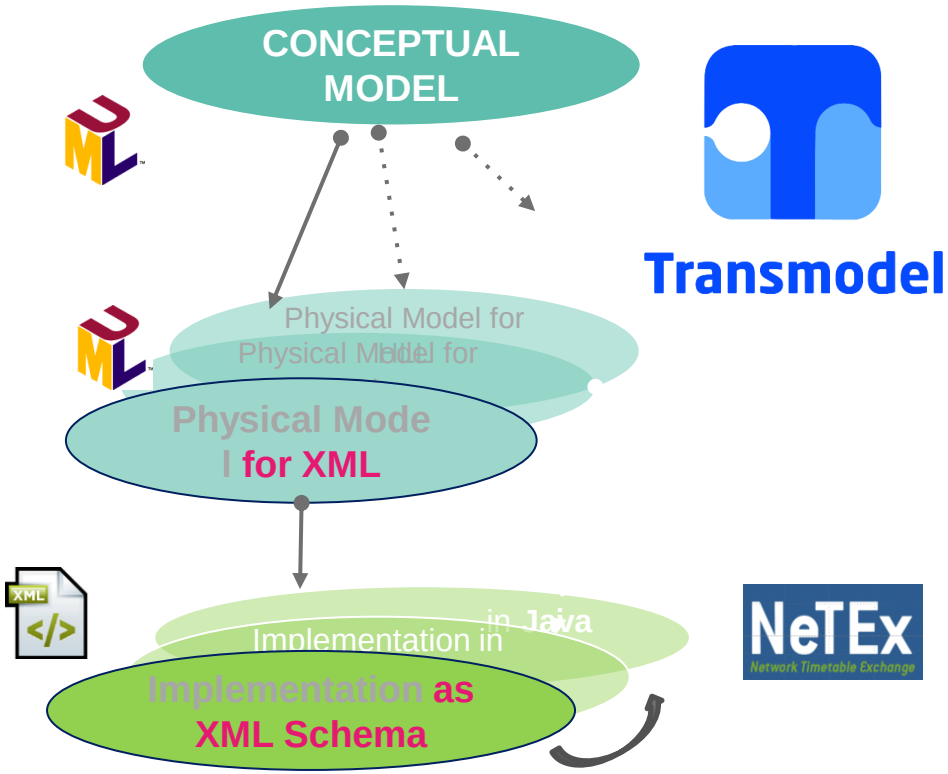
Selective functional scope
e.g. NeTEx Timetable exchange; SIRI RT

A ***Format*** implements in a specific technology

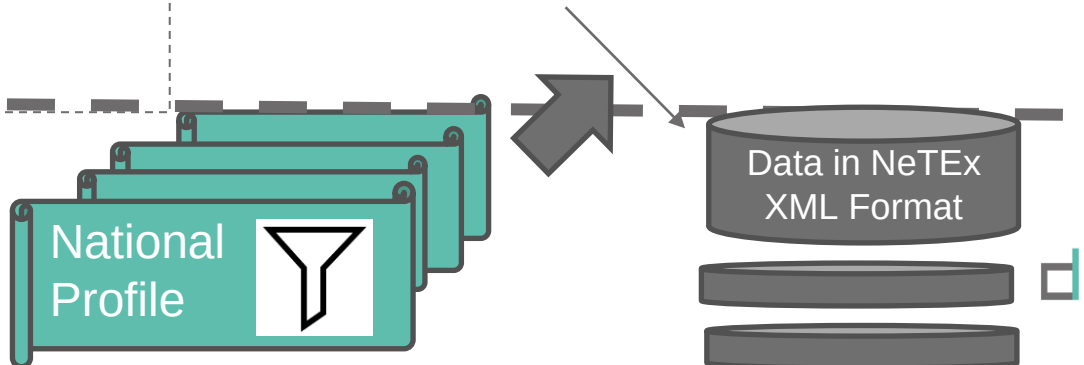
Mapped from physical model, e.g.
NeTEx XML Schema for Timetables

A ***Profile*** specifies how to use the XML in a specific context

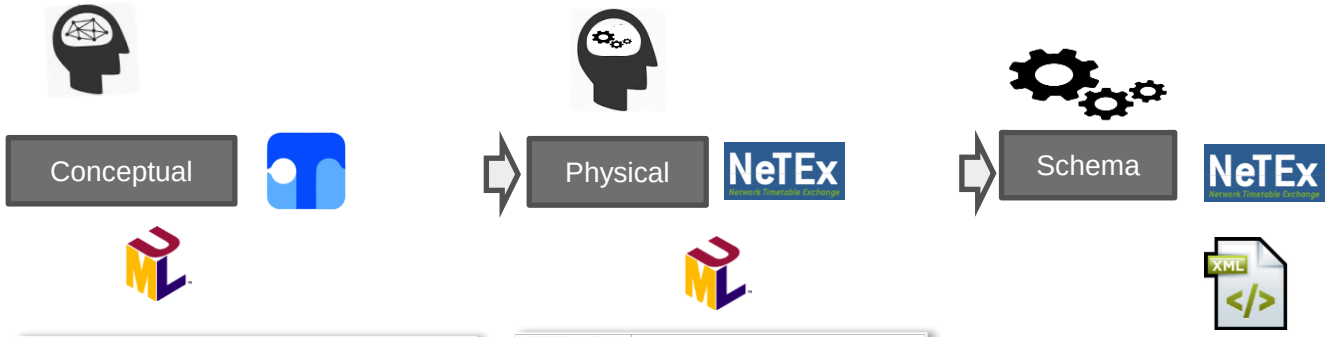
Functional scope, use cases, workflow and data identifiers
e.g. Euripean Timetabl eprofile

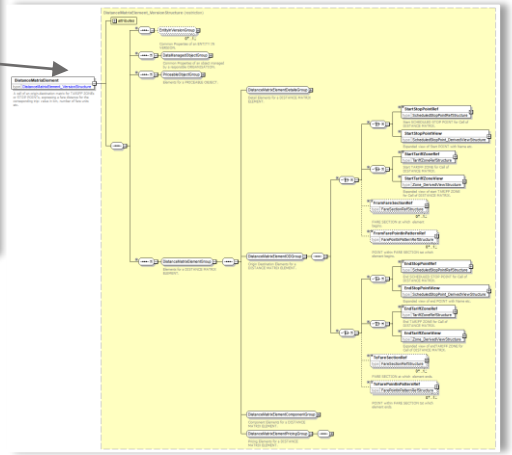


- **Allows impact analysis**
- **Avoid ad hoc reworking!**



Designing a CEN Exchange format - Package & Element level traceability





- **Traceability**
  - Equivalent elements can be found at each level
  - Physical design and Implementation each add further detail and constraints
- **Tool support (EA, XML SPY, OXYGEN, etc)**

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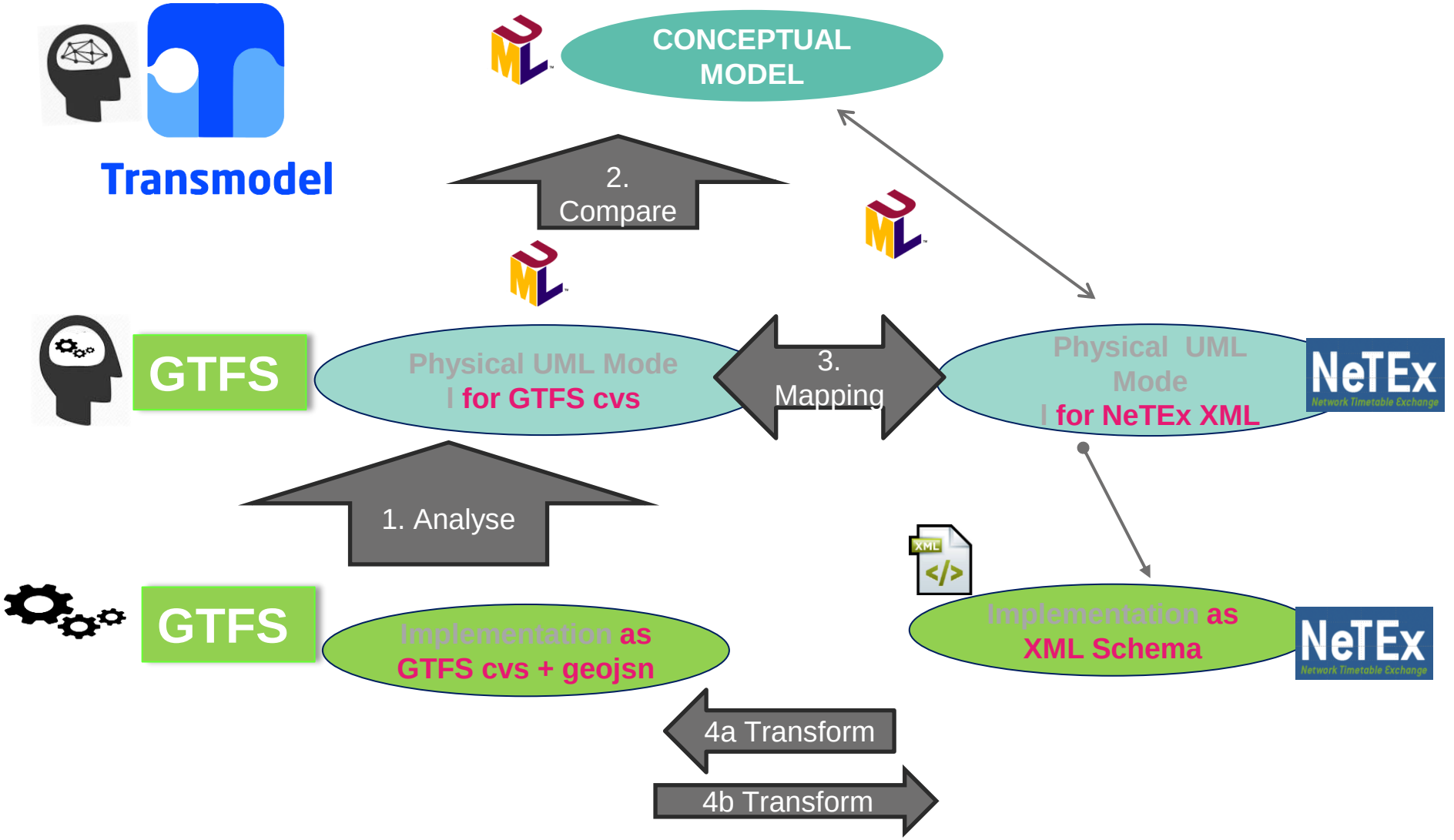
Transmodel #2: Using model driven design to systematically compare different standards and create mappings

1. Conceptual mapping (Against Transmodel)
   - Functional scope,
   - Conceptual Elements: differences in separation of concerns, views
   - Granularity of exchange
2. Physical mapping (against NeTEx, SIRI, DJP, etc)
   - One-to-one or one-to–several mapping of individual elements
   - One-to one mapping of attributes
   - Translation of data types, values
3. Technology mapping against NeTEx, SIRI, DJP, etc)
   - eg XML, CVS, JSON, WSDL etc
   - Metadata:: data source, versioning etc

Transmodel: #2 Using model driven design to systematically compare different standards and create mappings



THE GTFS "MODEL" EXPRESSED IN UML
OVERVIEW

Notes on the GTFS “UML Model”

- NB GTFS data representation originated as a “bottom up” set of records, not model based
- In the following presentation a “GTFS model“ is reverse engineered from the GTFS record structure and described in UML.
  - We use the presence of foreign keys on a record to infer a relationship to another entity.
  - Some GTFS relationships are not explicitly expressed by foreign keys but are assumed from the records being in the same GTFS zip. E.g., GTFS trips are for the given agency.
  - Some GTFS records are overloaded to mean different things in different contexts, so interpretation of some relationships is complex. E.g., GTFS stop nodes, stop areas, fare rules).
  - Not all concepts are reified as GTFS records (e.g., GTFS zone, GTFS service are implicit)
- GTFS has become quite large and complex – So split into submodels
  - **Network (stops, routes, networks,** etc**)**, **Flexible Network (locations,** etc**).**
  - **Timetable/Schedule (trips, stop times,** Etc, including **service calendar**).
  - **Fares (fare rules, fare attributes,** etc**).**
  - Common **Framework** aspects e.g., GTFS record headers, zip packages, etc .

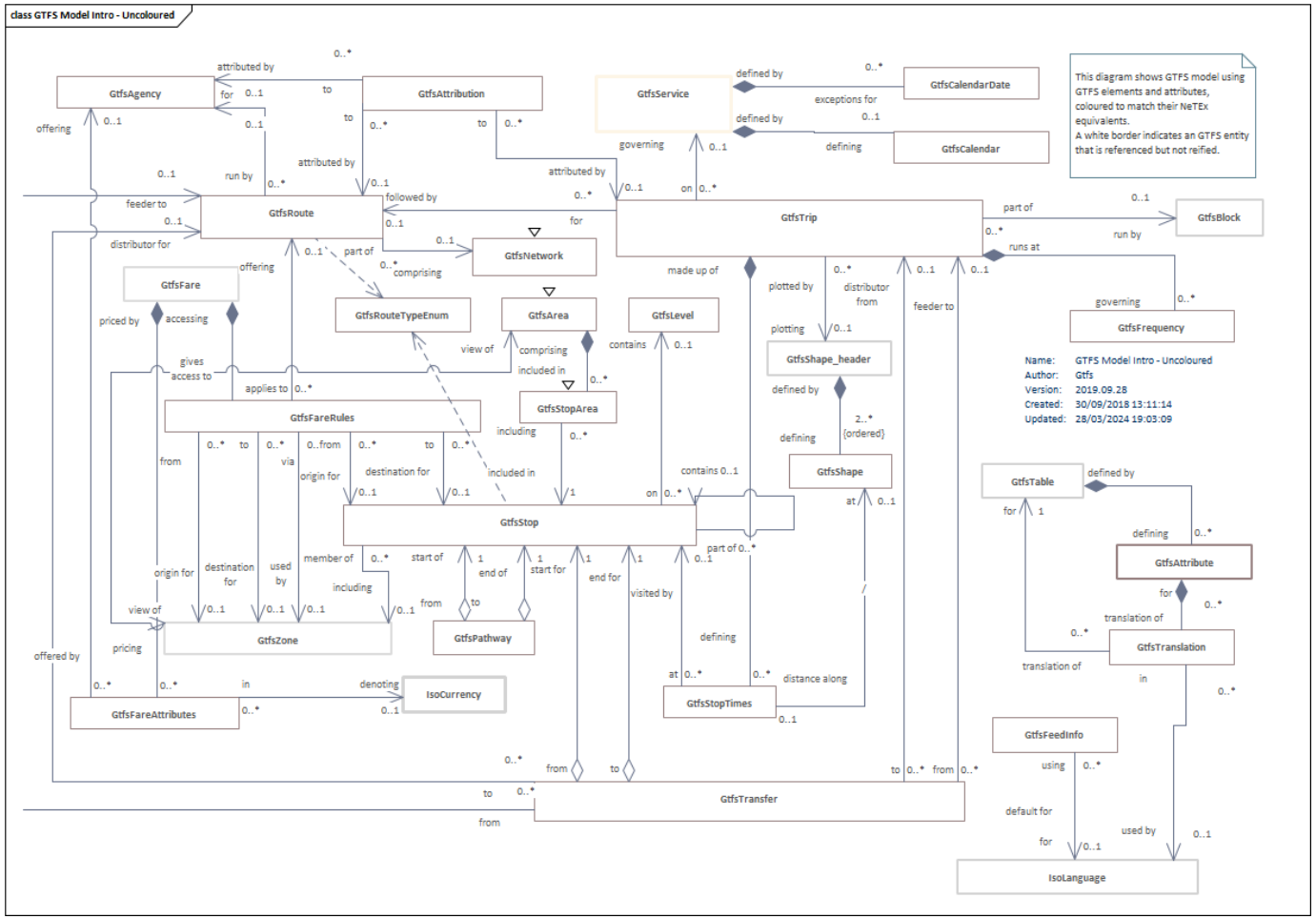
GTFS base “Model” Overview - uncoloured

Network
- **agency** (OPERATOR)
- **stops**
  - (SCHEDULED STOP POINT)
  - (STOP PLACE + QUAY)
- **transfers** (CONNECTION)
- **levels** (LEVEL)
- pathways (PATH LINK)
- **routes** (LINE)

Timetable/Schedule
- **trips** (SERVICE JOURNEY)
- **stop_times** (POINT IN PATTERN + PASSING TIME + DESTINATION DISPLAY)
- **frequency** (HEADWAY JOURNEY GROUP)
- **calendar** (DAY TYPE)
- **shapes** (ROUTE LINK + LINK PROJECTION)

Fares
- **fare _rules** (DISTANCE MATRIX ELEMENT
- **fare_attribute**(s FARE PRICE)

Other
- **translations** (ALTERNATIVE TEXT)
- **feed_info** (DATA SOURCE)
- attribution (RESPONSIBILITY SET)



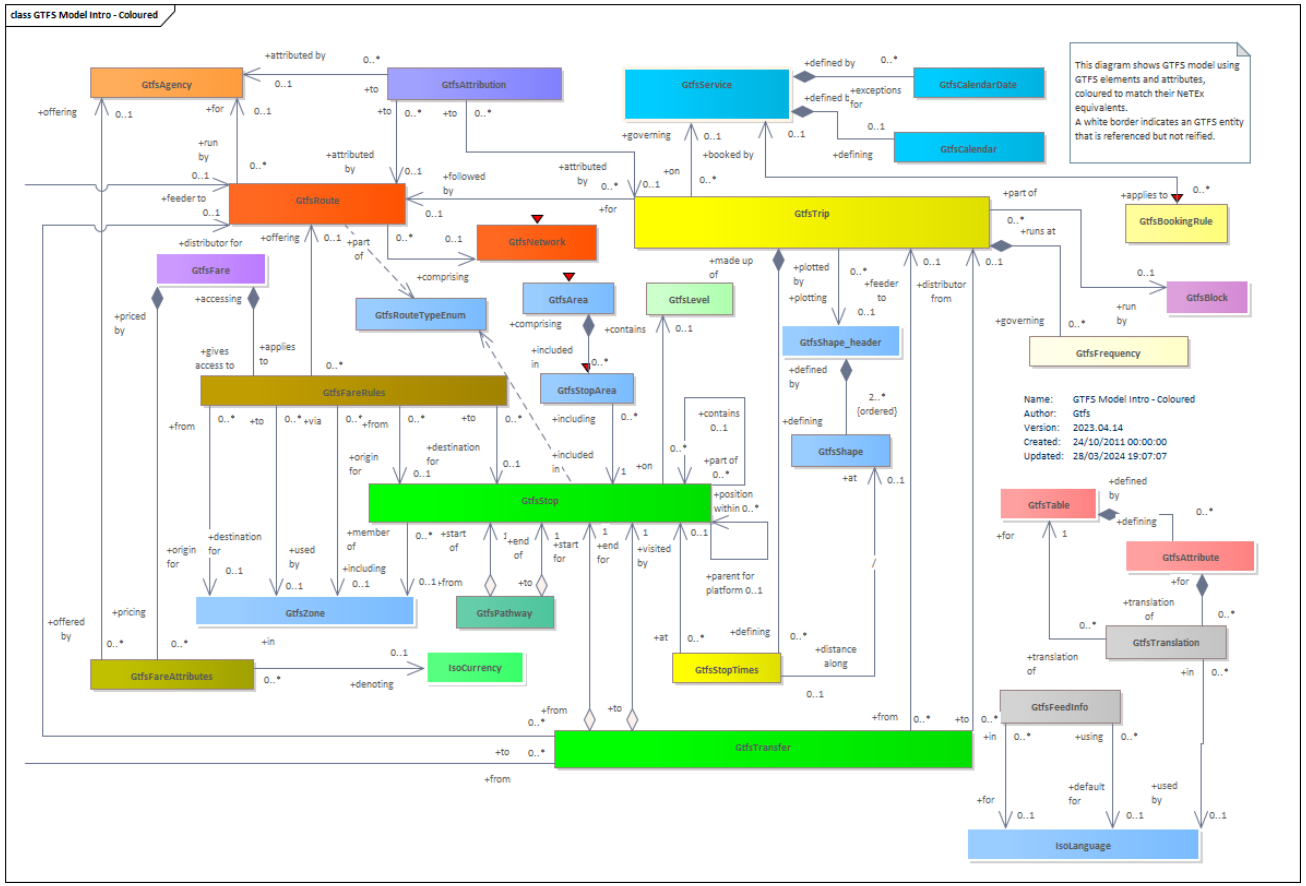
GTFS base “Model” Overview – in Transmodel/NeTEx colours!

Network
- agency (OPERATOR)
- stops
  - (SCHEDULED STOP POINT)
  - (STOP PLACE + QUAY)
- transfers (CONNECTION , INTERACHANGE, INTERCHANGE RULE)
- levels (LEVEL)
- pathways (PATH LINK)
- routes (LINE)

Timetable/Schedule
- trips (SERVICE JOURNEY)
- stop_times (POINT IN PATTERN + PASSING TIME + DESTINATION DISPLAY)
- frequency (HEADWAY JOURNEY GROUP)
- calendar (DAY TYPE)
- shapes (ROUTE LINK + LINK PROJECTION)

Fares
- fare _rules (DISTANCE MATRIX ELEMENT
- fare_attributes (FARE PRICE)

Other
- translations (ALTERNATIVE TEXT)
- feed_info (DATA SOURCE)
- attribution (RESPONSIBILITY SET)



THE GTFS "MODEL" IN UML - (1) NETWORK DESCRIPTION

GTFS records describing just a basic Network - Overview

GTFS

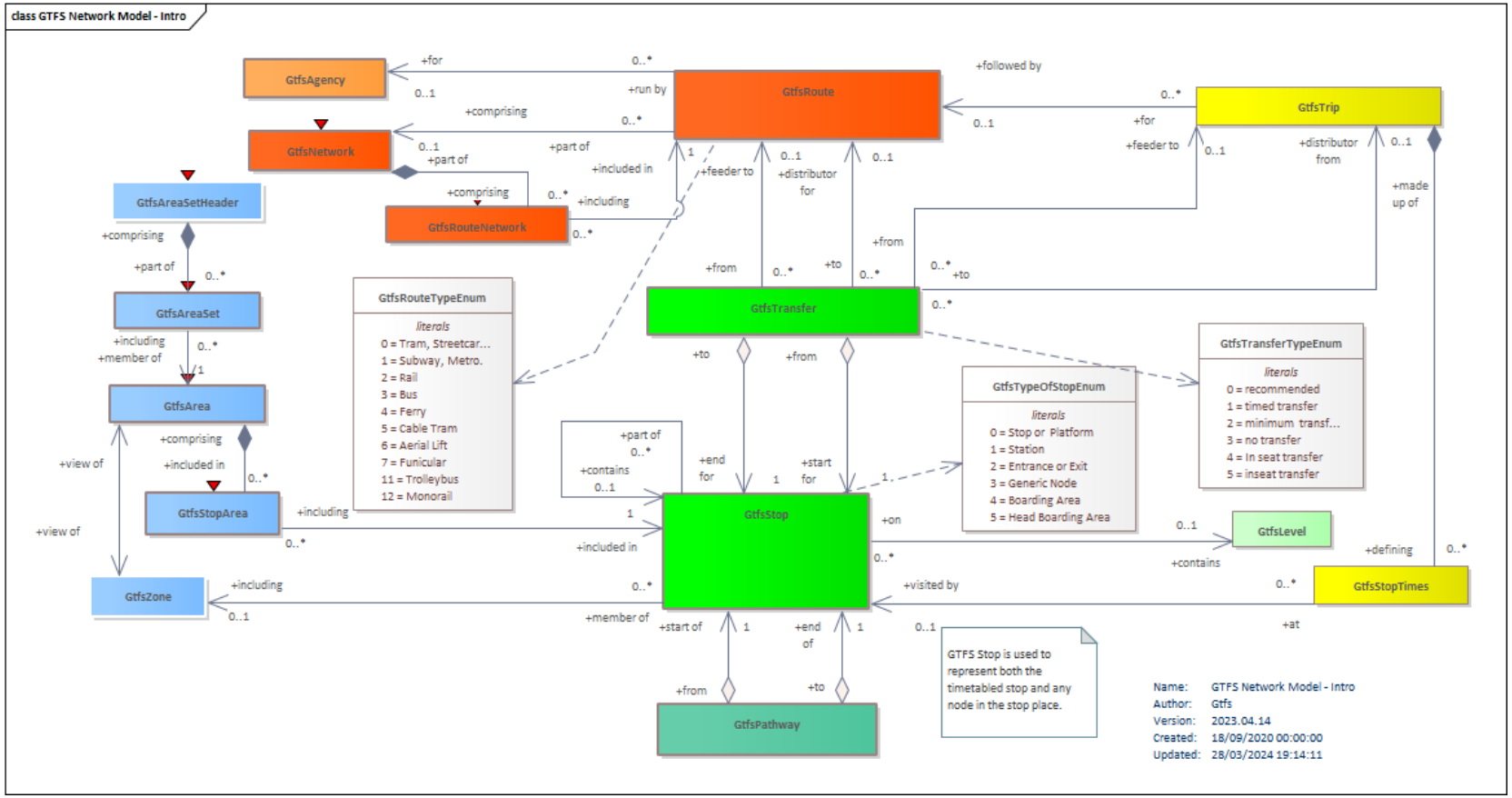
Stops and lines (routes) for an operator (agency)

Network

- agency (OPERATOR)
- stops
  - (SCHEDULED STOP POINT)
  - (STOP PLACE + QUAY)
- transfers (CONNECTION)
- levels (LEVEL)
- pathways (PATH LINK)
- routes (LINE)
- network (NETWORK)

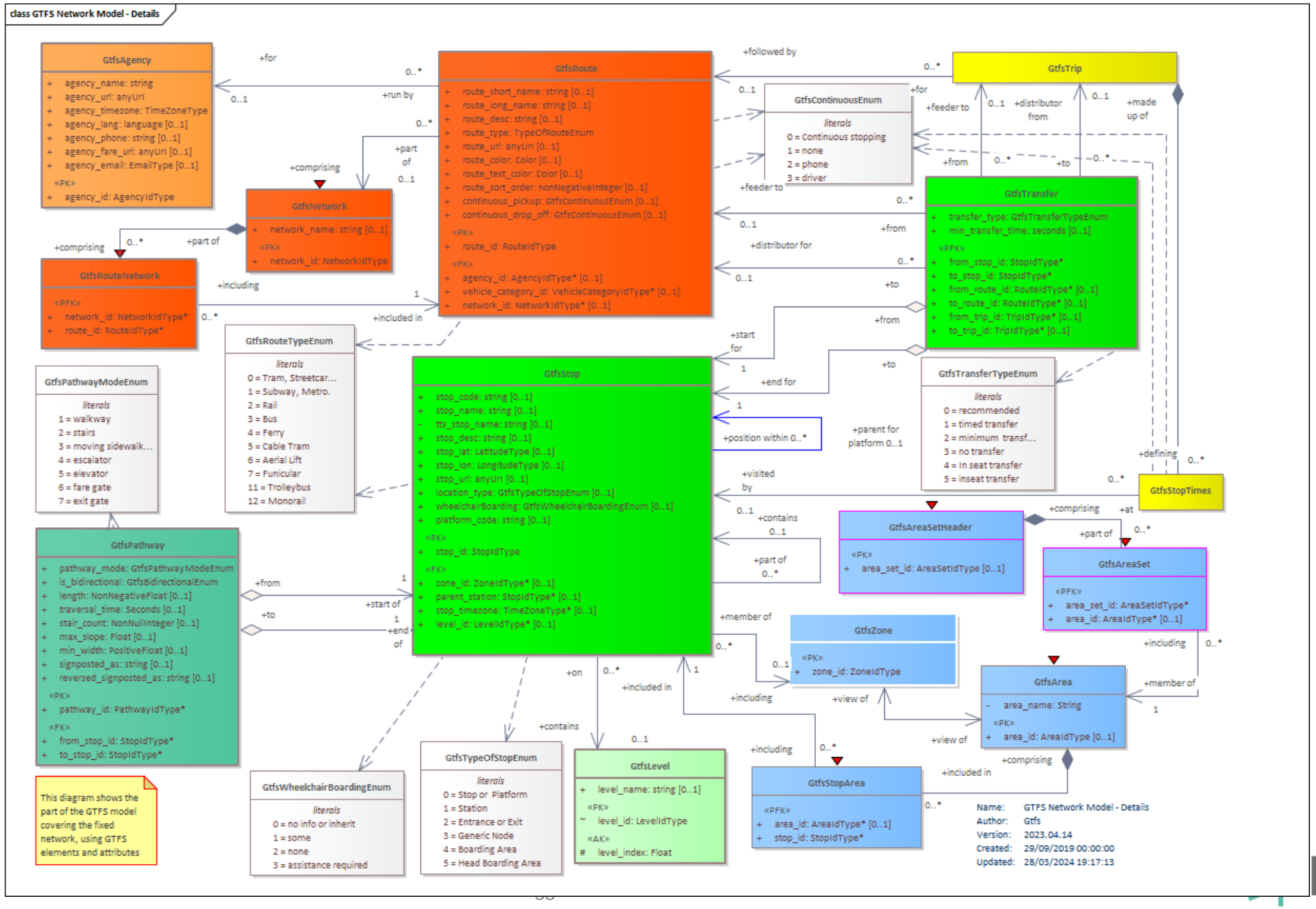
Timetable/Schedule

- trips (SERVICE JOURNEY)
- stop_times (CALL)



GTFS records describing the Network - With attributes

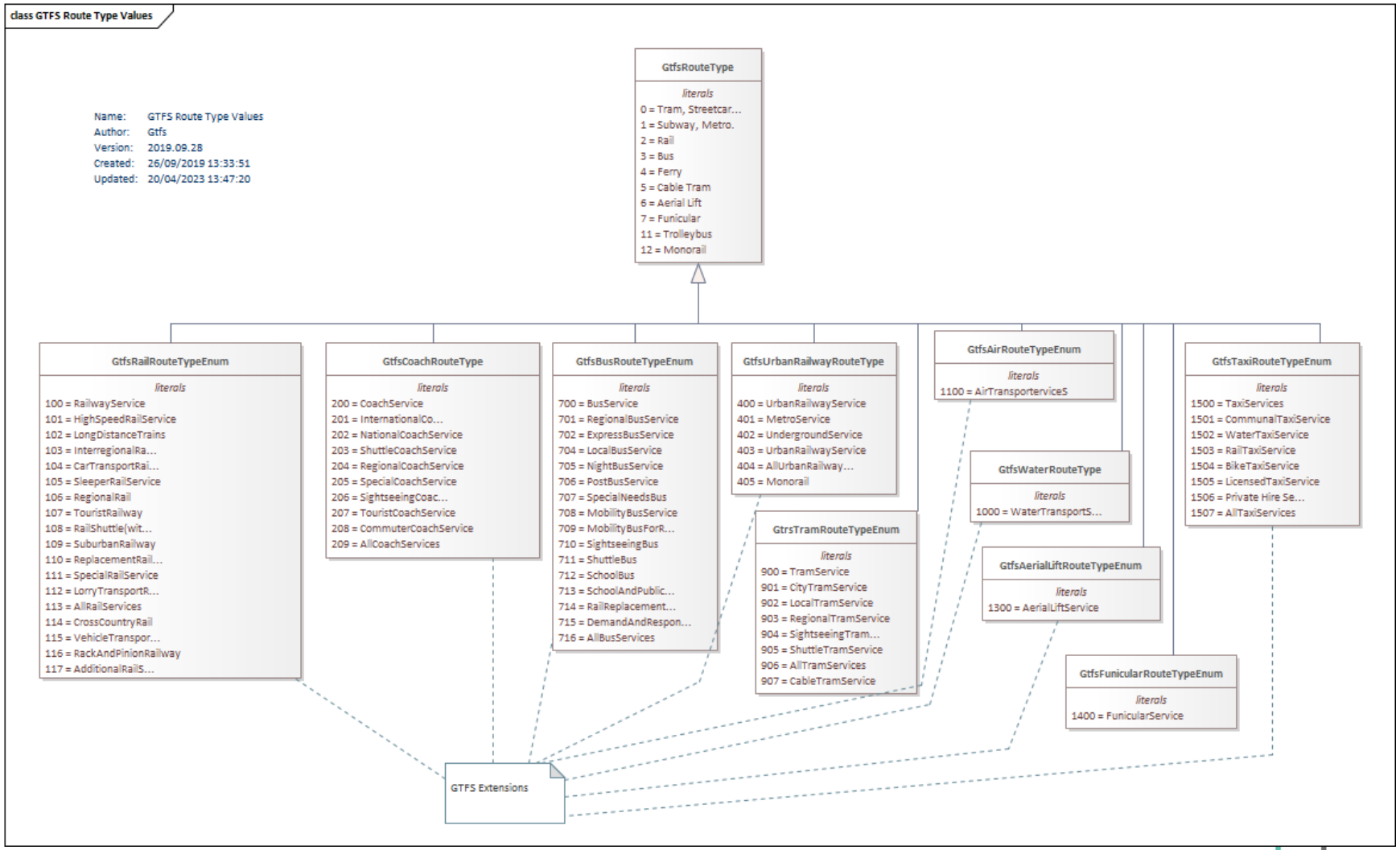
GTFS



GTFS Route Types (With GTFS extensions)

GTFS

- GTFS Extended routes cover subtypes for each mode

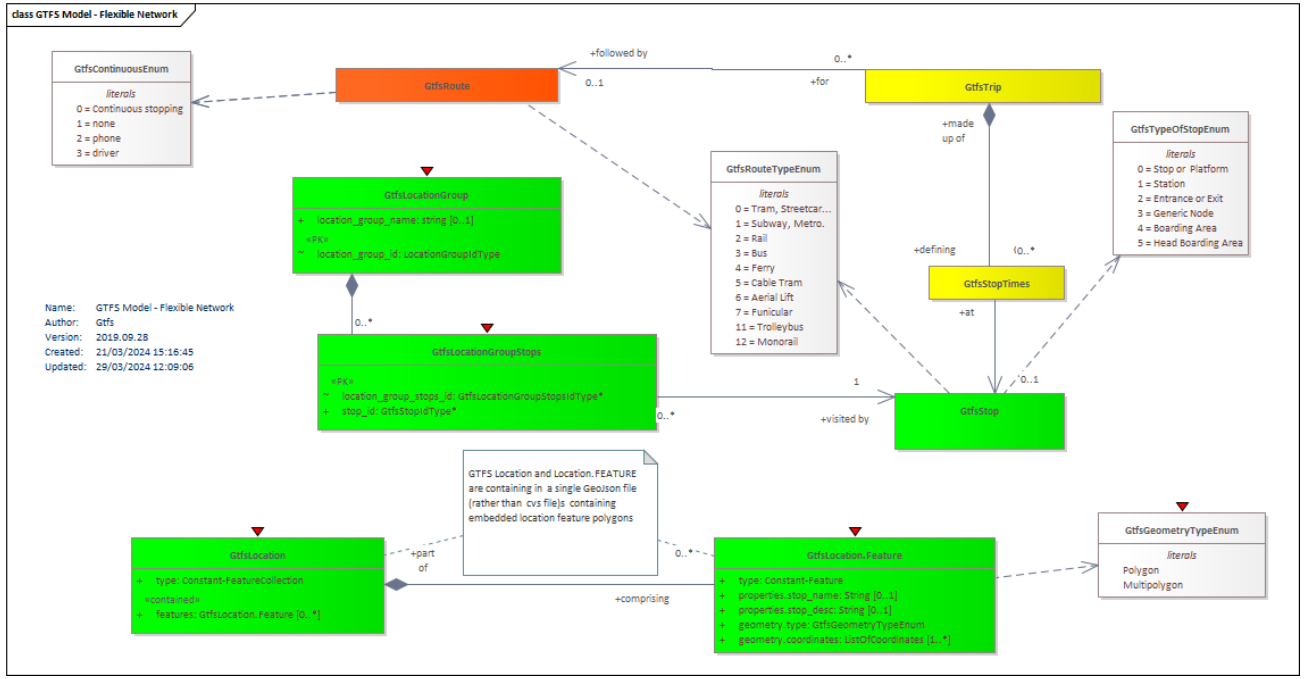


Gtfs location records describing the Flexible Network - i.e. Hail and ride stops and flexible stop locations

GTFS

- **Stops** →
  - (SCHEDULED STOP POINT)
  - (STOP PLACE + QUAY)
- **location** →(FLEXIBLE STOP PLACE)
- **location.feature** →(HAIL AND RIDE QUAY), FLEXIBLE AREA

- NB pickup drop off areas described as GeoJSON file



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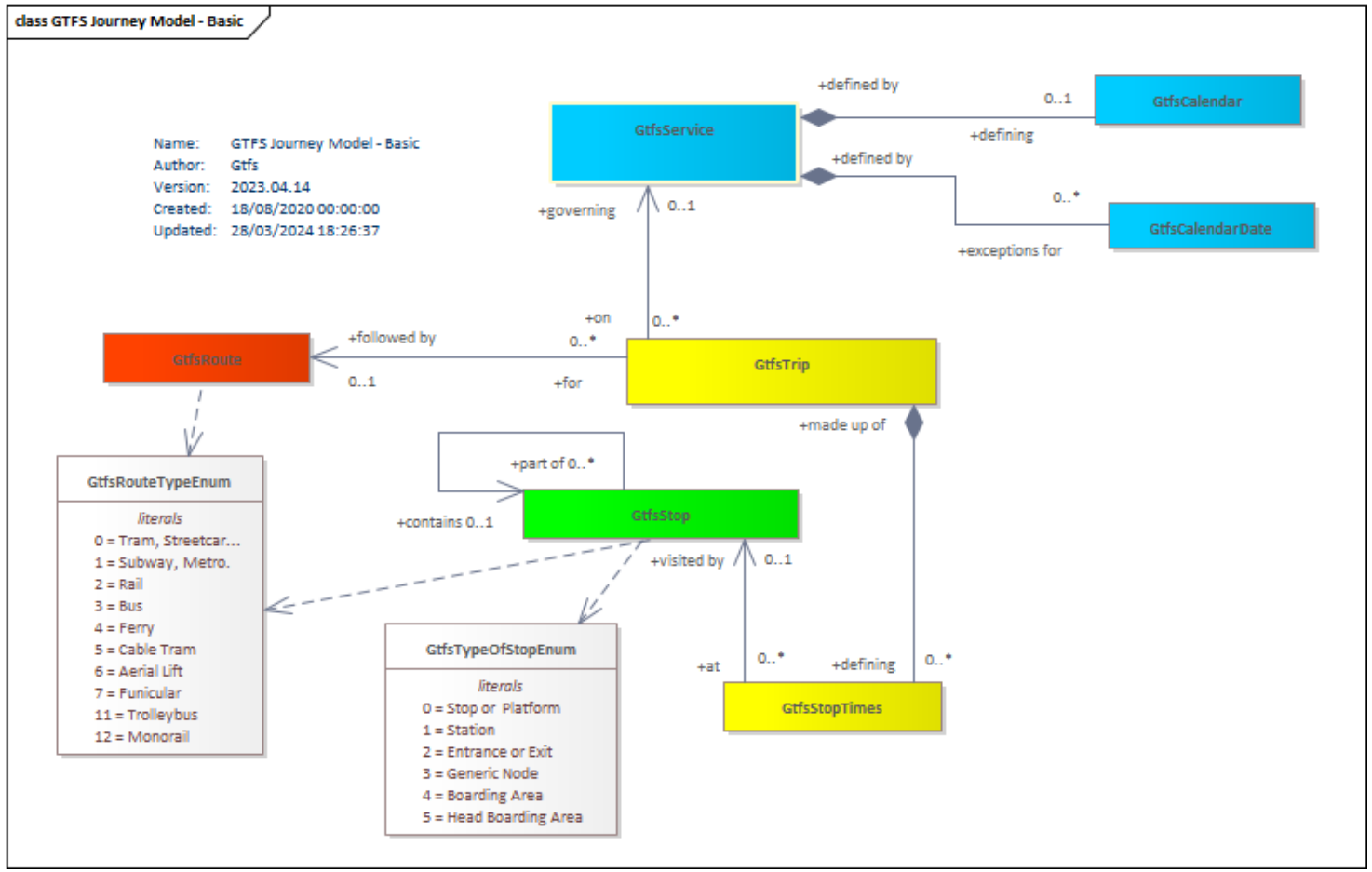
THE GTFS "MODEL" IN UML - (2) TIMETABLE/SCHEDULE DESCRIPTION

GTFS Trips (Transmodel/NeTEx JOURNEY) – Basic “Model”

GTFS

Timetable/Schedule

- **trips** → NeTEx SERVICE JOURNEY
- **stop_times** → NeTEx CALLS – or POINT IN PATTERN + PASSING TIME + DESTINATION DISPLAY
- **calendar** → NeTEx DAY TYPE

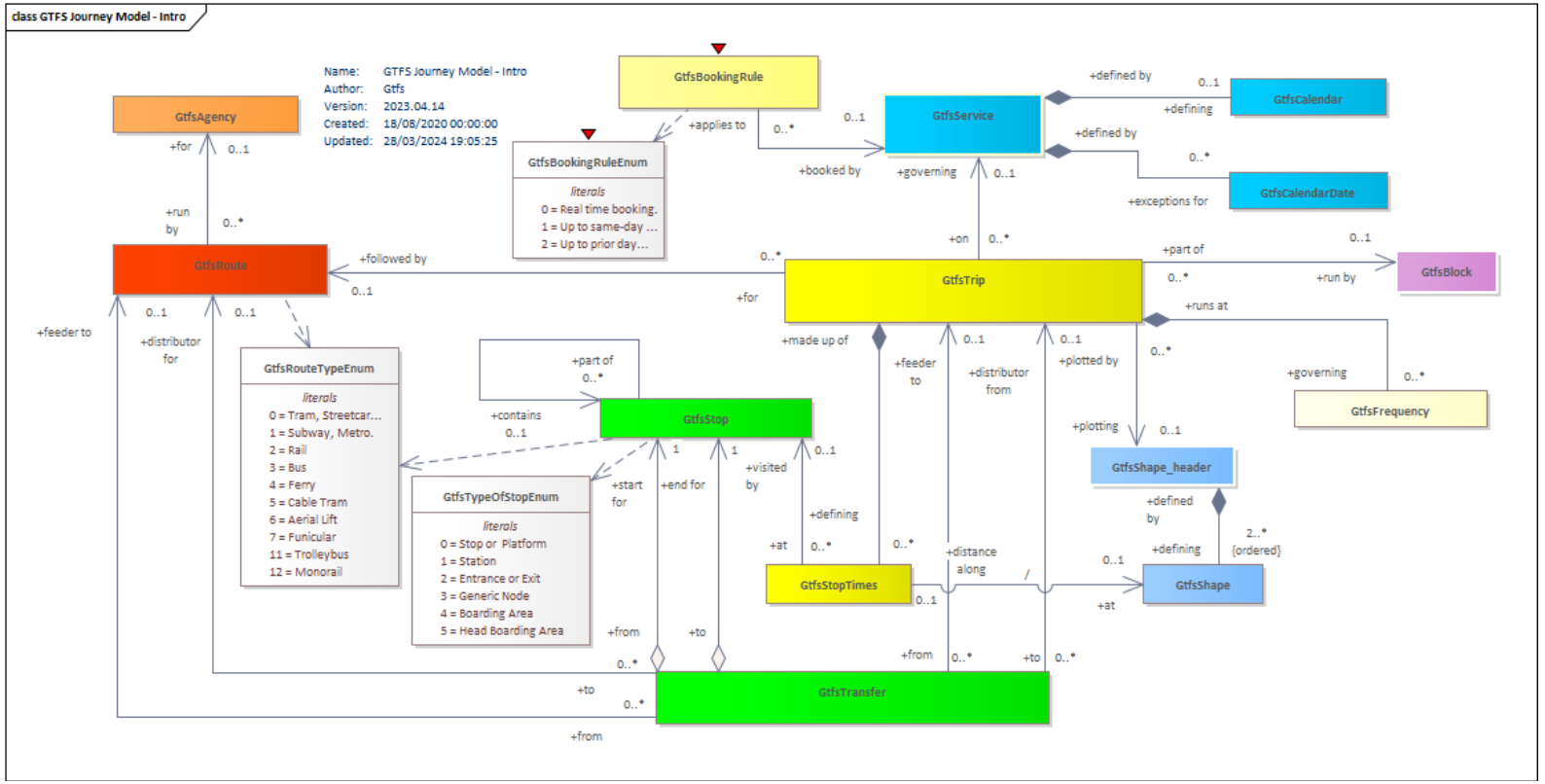


GTFS

GTFS trips record – Further Overview

Timetable

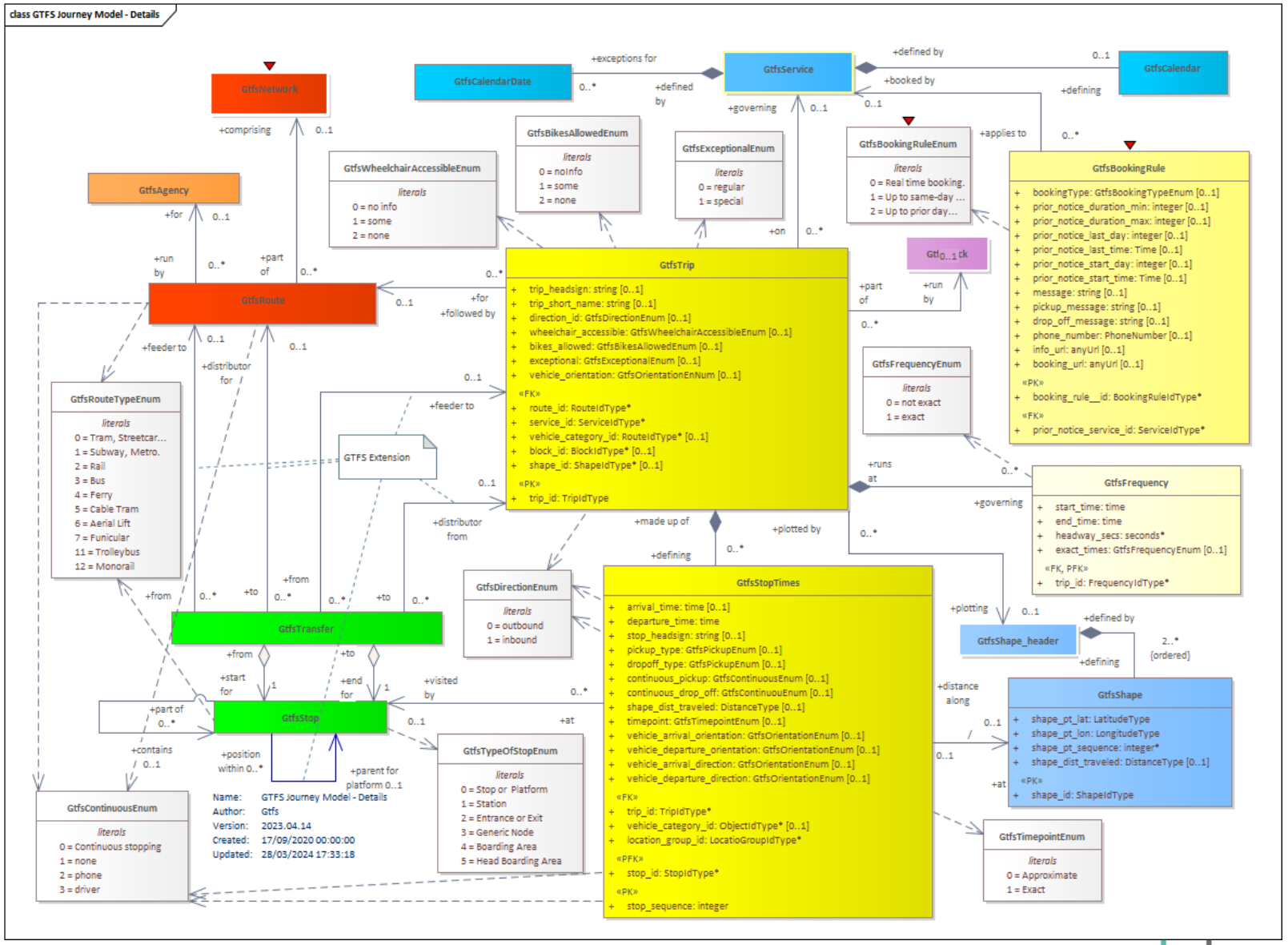
- **trips** →(SERVICE JOURNEY)
- **stop_times** →(CALLs – or POINT IN PATTERN + PASSING TIME + DESTINATION DISPLAY)
- **shape** →(ROUTE LINK + POINT ON LINK)
- **frequency** →(HEADWAY JOURNEY GROUP)
- **calendar** (DAY TYPE)
- **calendar_date** →(DAY TYPE ASSIGNMENT)
- **booking_rule** →(BOOKING ARRANGEMENTS)



GTFS GTFS Trips & Stop_times record – With attributes

trips →(SERVICE JOURNEY)

stop_times →(CALLs – or POINTs IN PATTERN + PASSING TIME + DESTINATION DISPLAY)

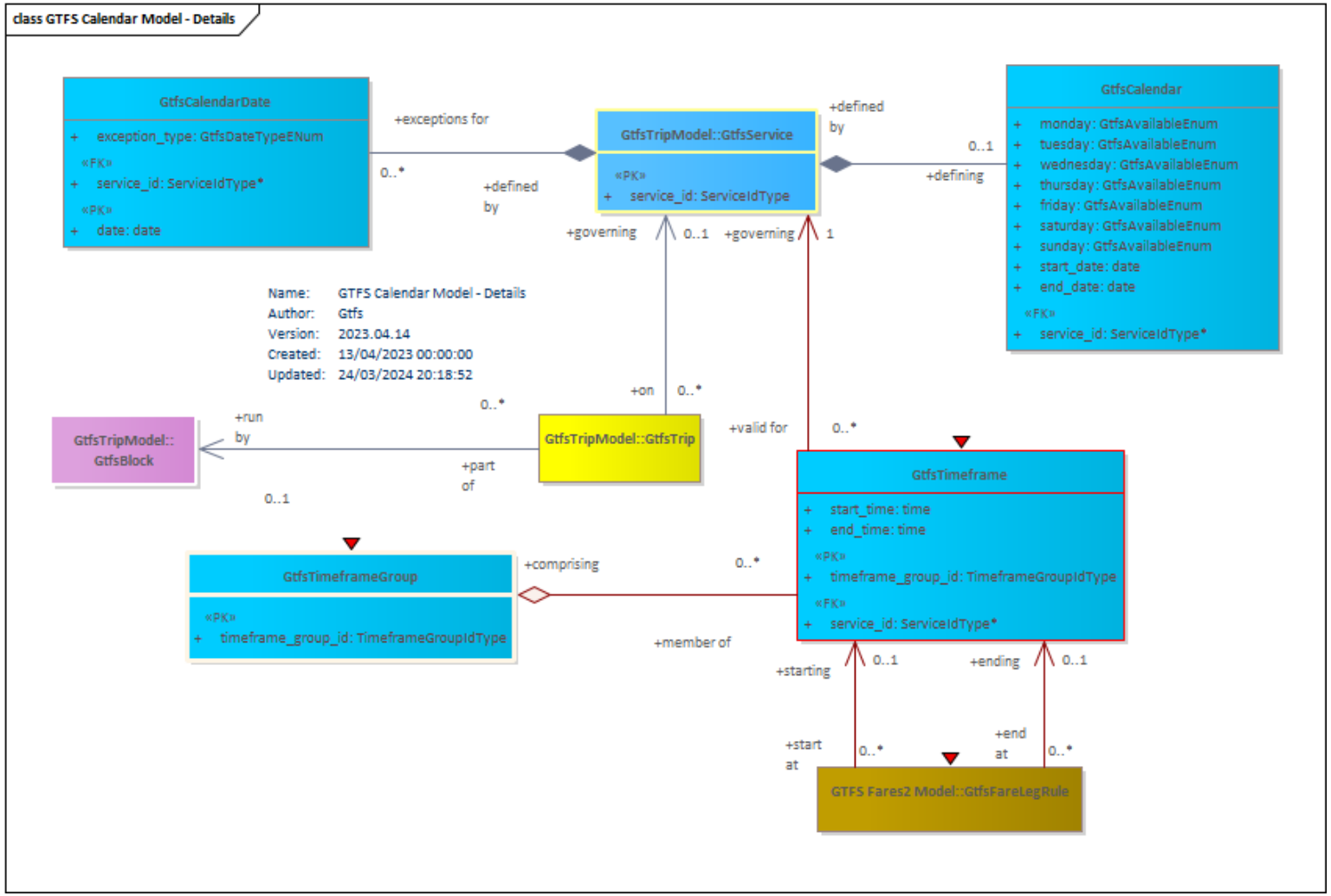


GTFS GTFS Calendar Dates and Calendar records

Specifies the dates a trip runs or when a fare can be used

Service Calendar

- **service** →(DAY TYPE)
- **calender_date** →(DAY TYPE ASSIGNMENT)
- **calendar** →(Property of day / OPERATING PERIOD)
- **timeframe** →(TIMEBAND)



THE GTFS "MODEL" IN UML - (3) BASIC FARES

GTFS Fares 1 - Overview

GTFS

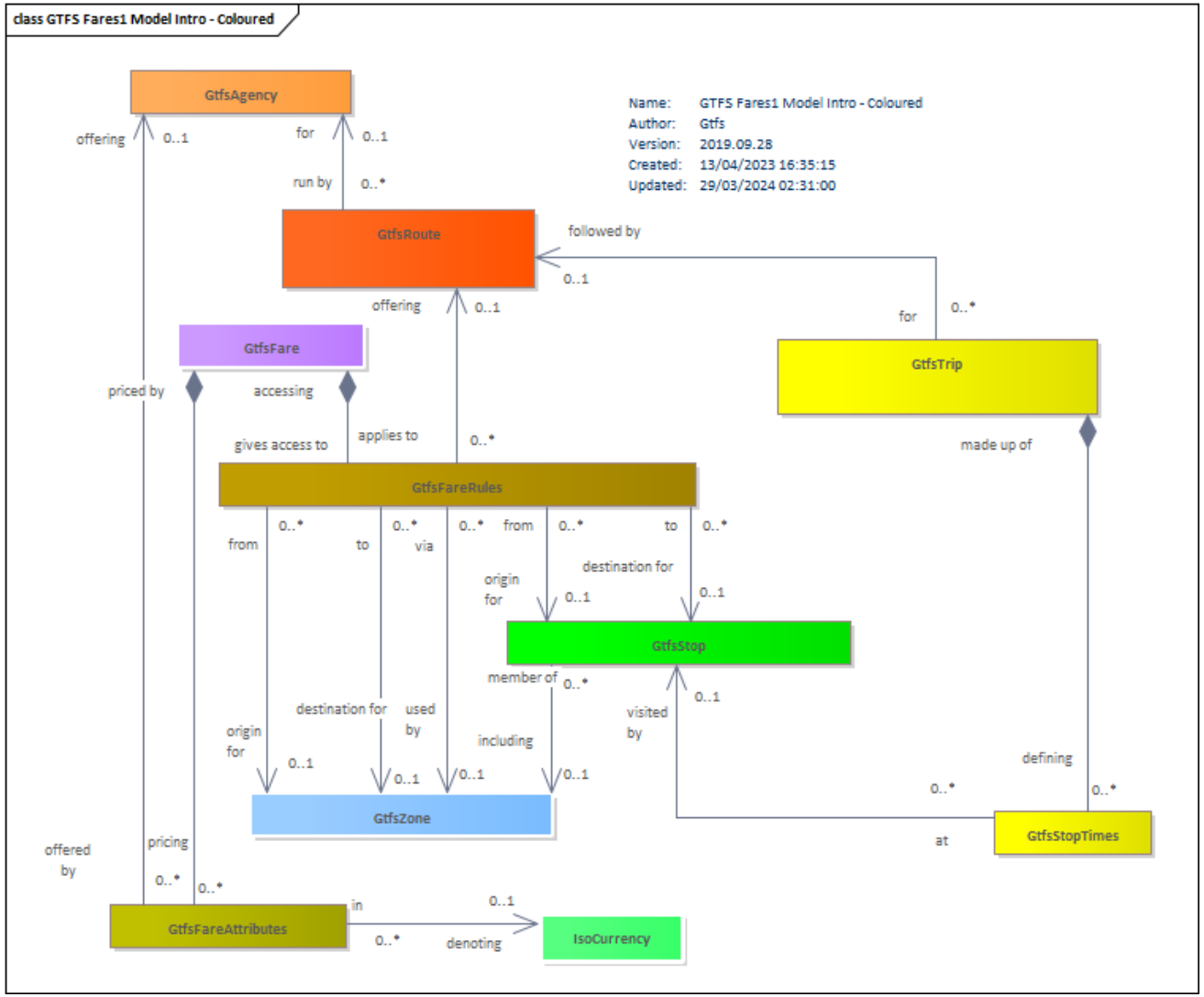
GTFS Fares cover basic prices and flat and point to point tariff elements

Network

- GTFS **stop** →(SCHEDULED STOP POINT)
- GTFS zone →(TARIFF ZONE)

Fares

- **fare _rules** →(DISTANCE MATRIX ELEMENT)
- **fare_attributes** →(FARE PRICE



GTFS Fares 1 With attributes

GTFS

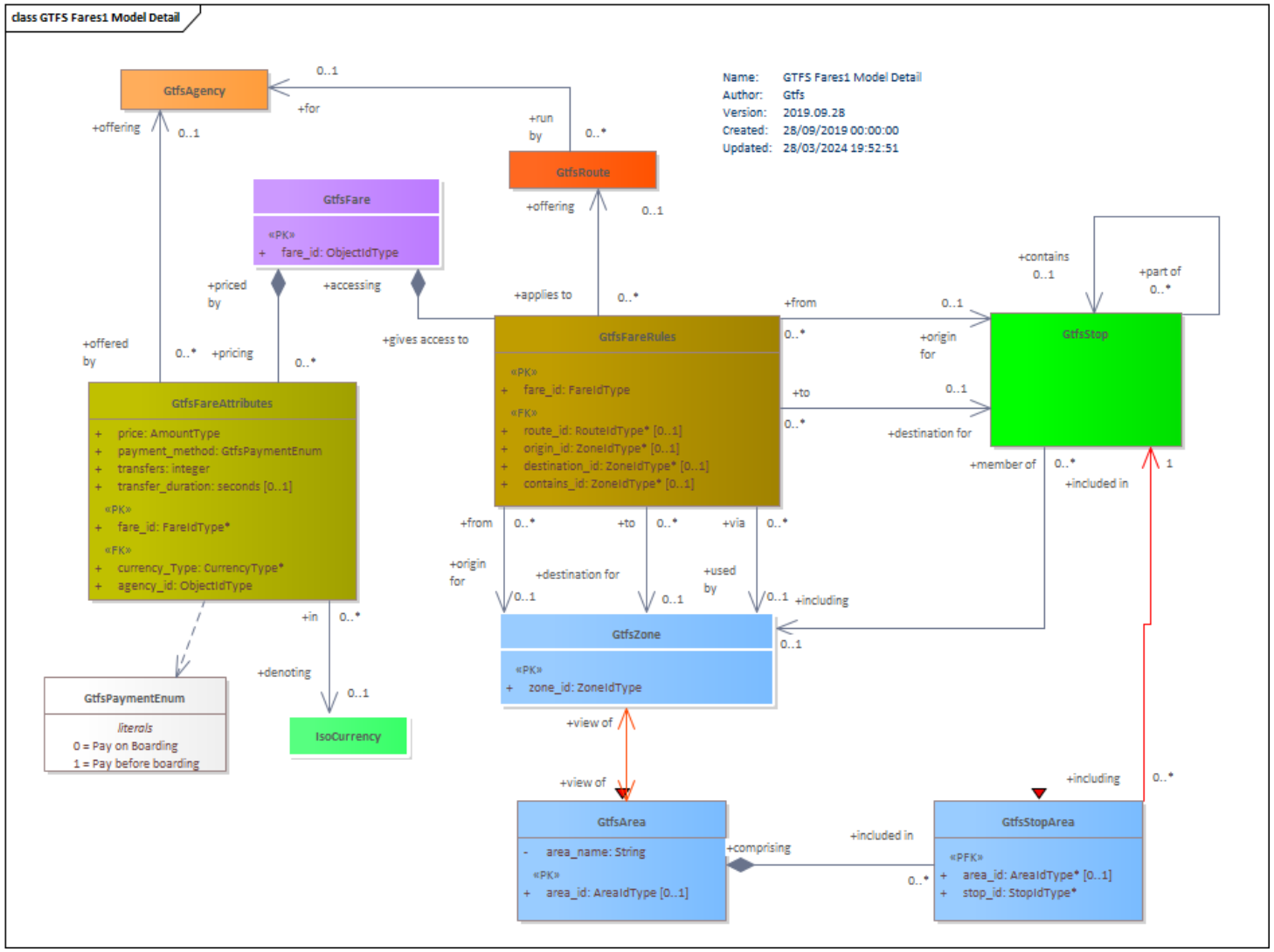
GTFS Fares cover basic prices and flat and point to point tariff elements

Network

- GTFS stop →(SCHEDULED STOP POINT)
- GTFS zone →(TARIFF ZONE)

Fares

- **fare _rules** →(DISTANCE MATRIX ELEMENT)
- **fare_attributes** →(FARE PRICE)



GTFS Fares 2 Overview

GTFS

Network

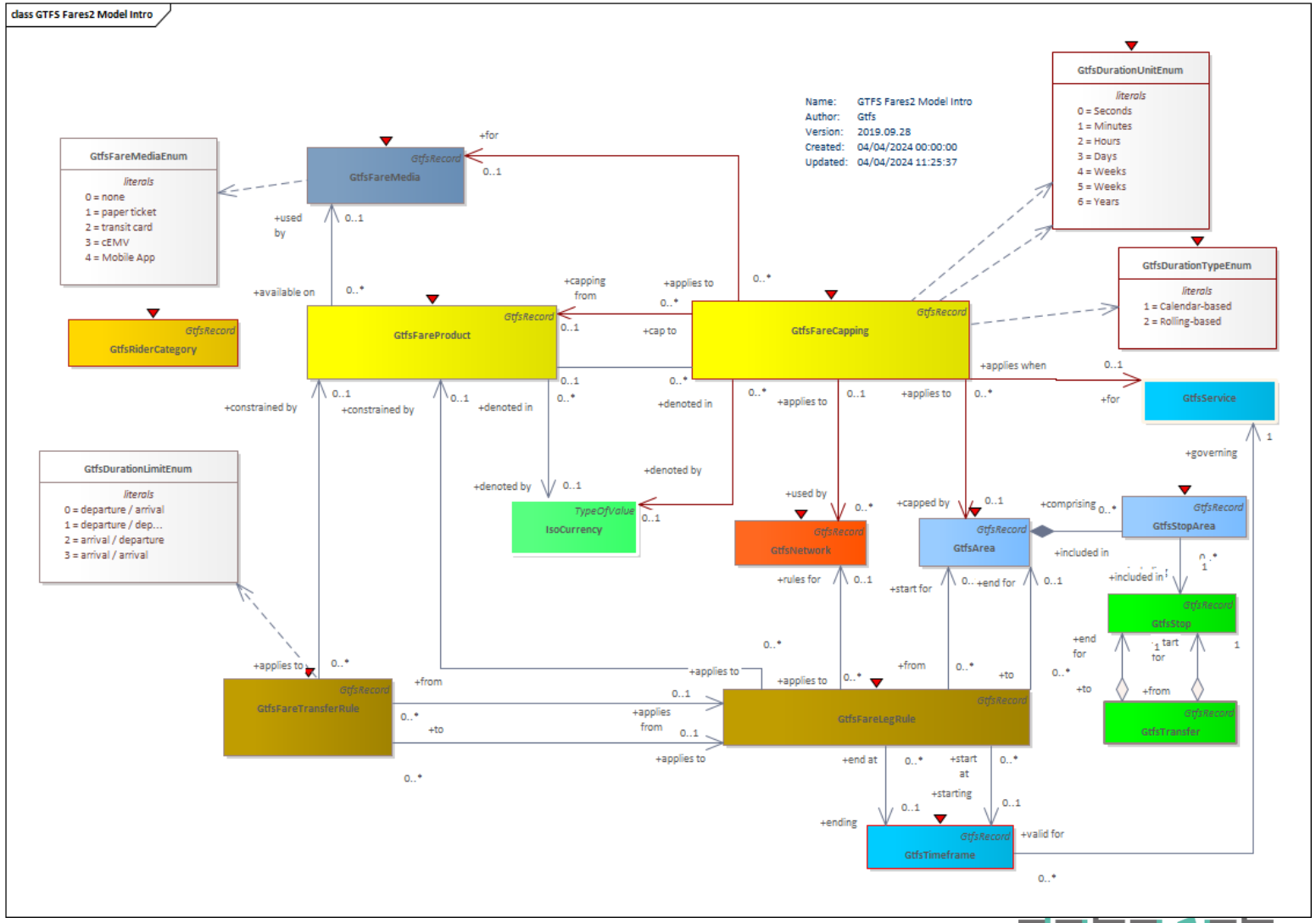
- GTFS **stop** →(SCHEDULED STOP POINT)
- GTFS area →(TARIFF ZONE)

Fare Products

- **fare _product** →(SALES OFFER PACKAGE + FARE PRODUCT + GENERIC PARAETER ASSIGNMENT)
- **fare _capping** →(SALES DISCOUNGT RIGHT + CAPPING RULE)
- fare_media (TYPE OF TRAVEL DOCUMENT)
- rider caetgory (USER PROFILE)

Fares

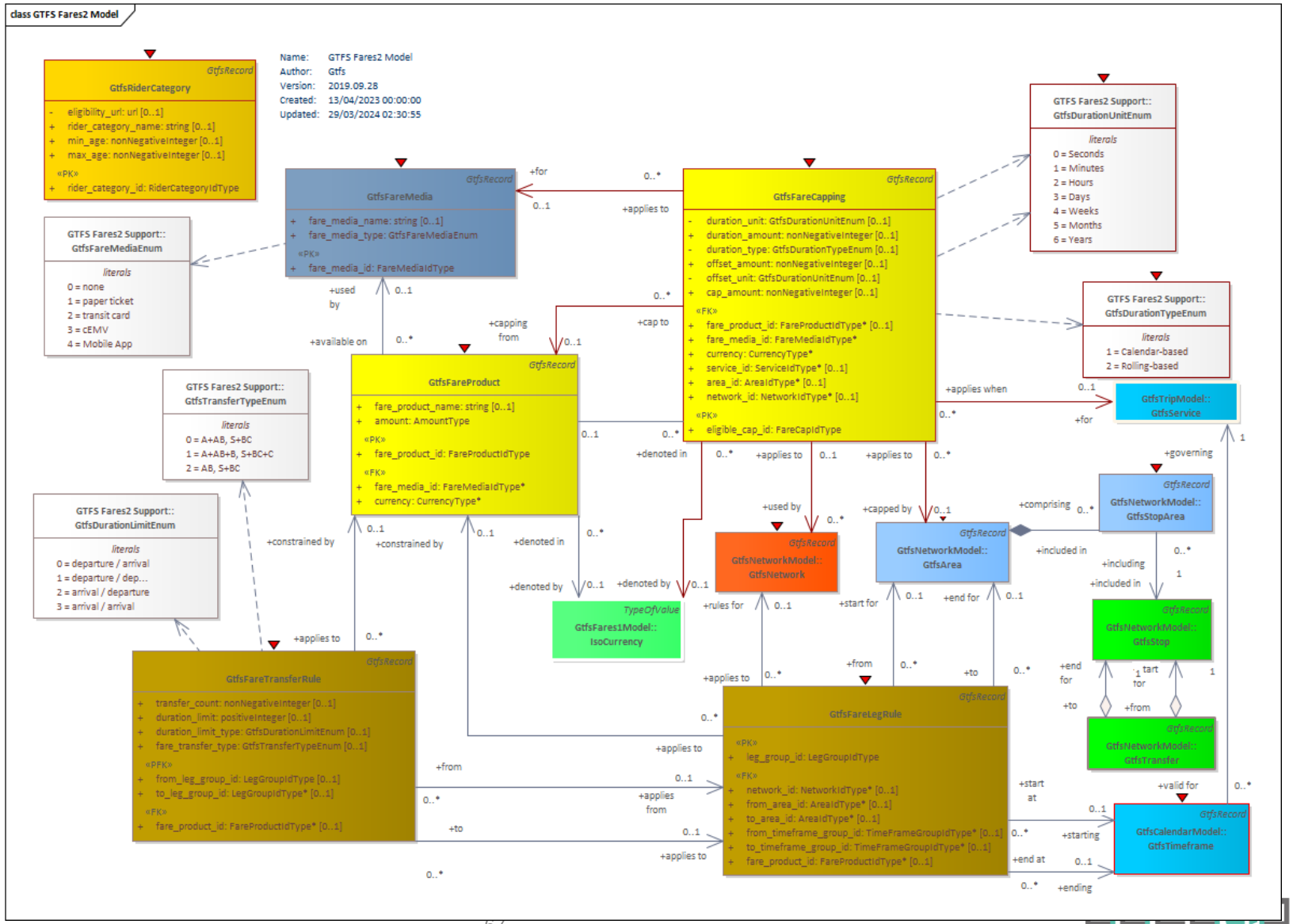
- **fare _leg_rules** →(DISTANCE MATRIX ELEMENT + FARE STRUCTURE ELEMENT)
- **fare_transfer_rule** →(INTERCHANGING + FARE STRUCTURE ELEMENT + GENERIC PARAMETER ASSIGNMENT)



GTFS Fares 2 -Attributes

GTFS

- GTFS Fares cover basic prices, and flat and point-to-point tariff structures
- NB NeTEx model covers additional tariff structures and conditions.

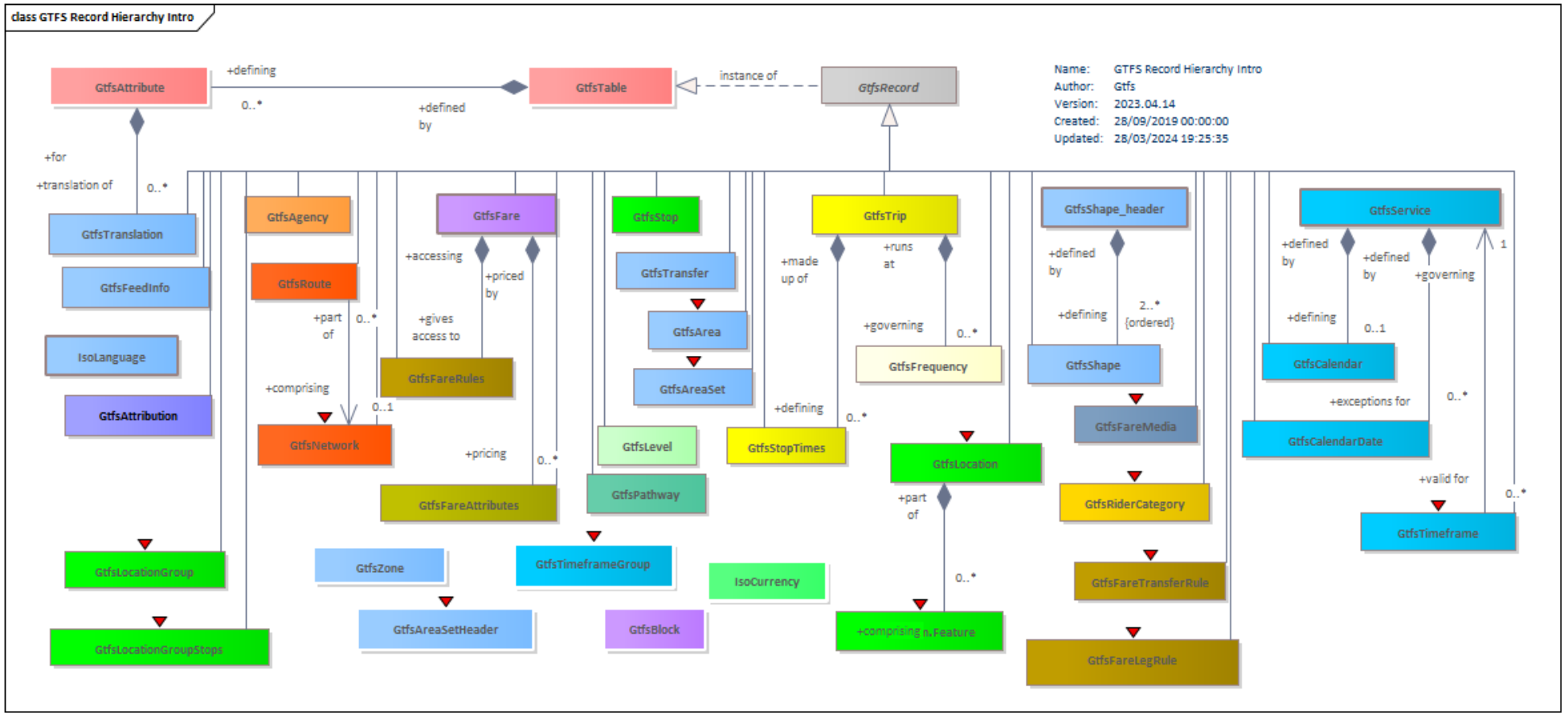


THE GTFS "MODEL" IN UML - (5) FRAMEWORK ASPECTS

GTFS Framework - Overview

GTFS

- Many different types of of GTFS records – all csv, c
  - Common approach to translation

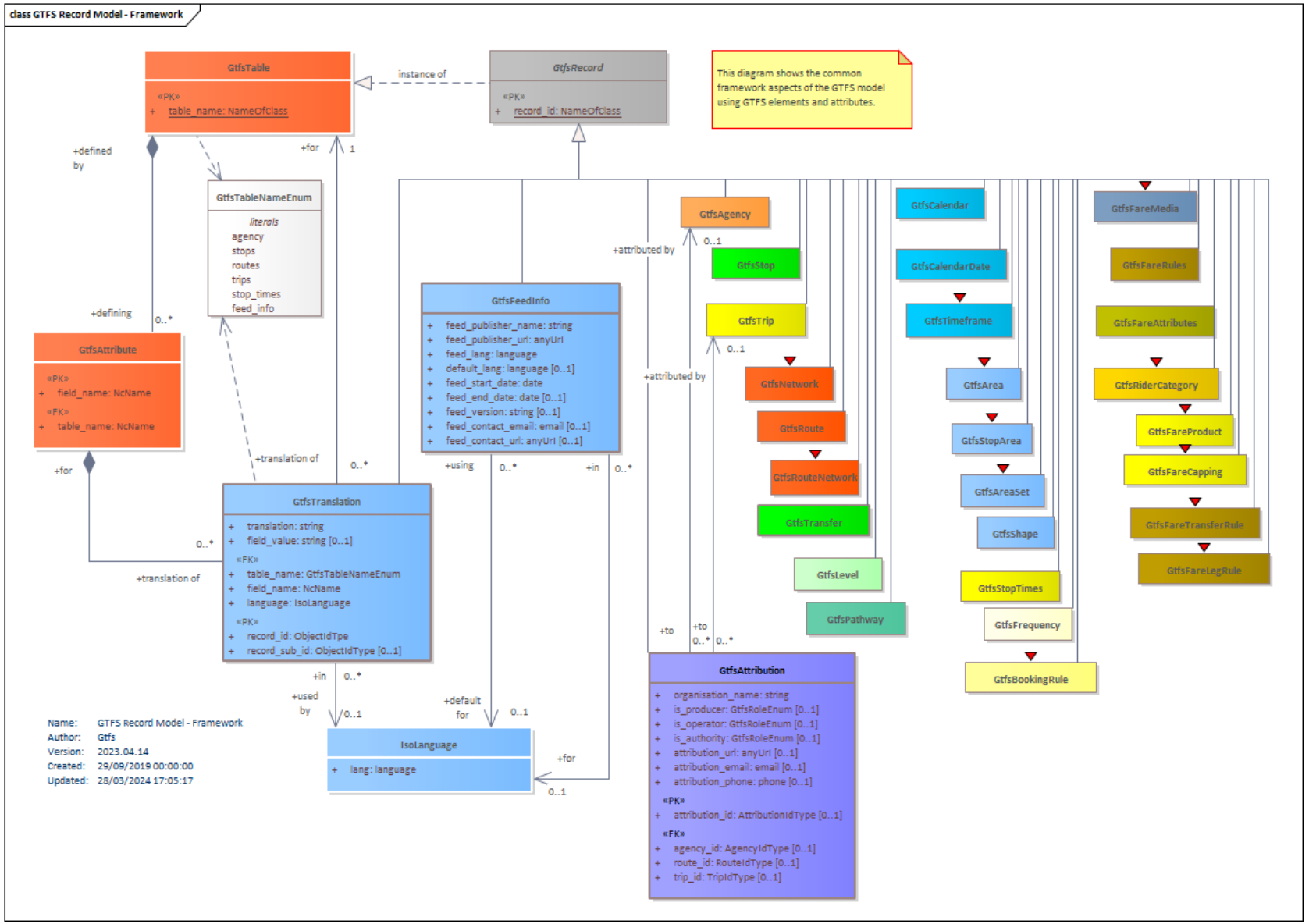


GTFS Framework: Feed_info, translations, attributions

GTFS

GTFS Common properties

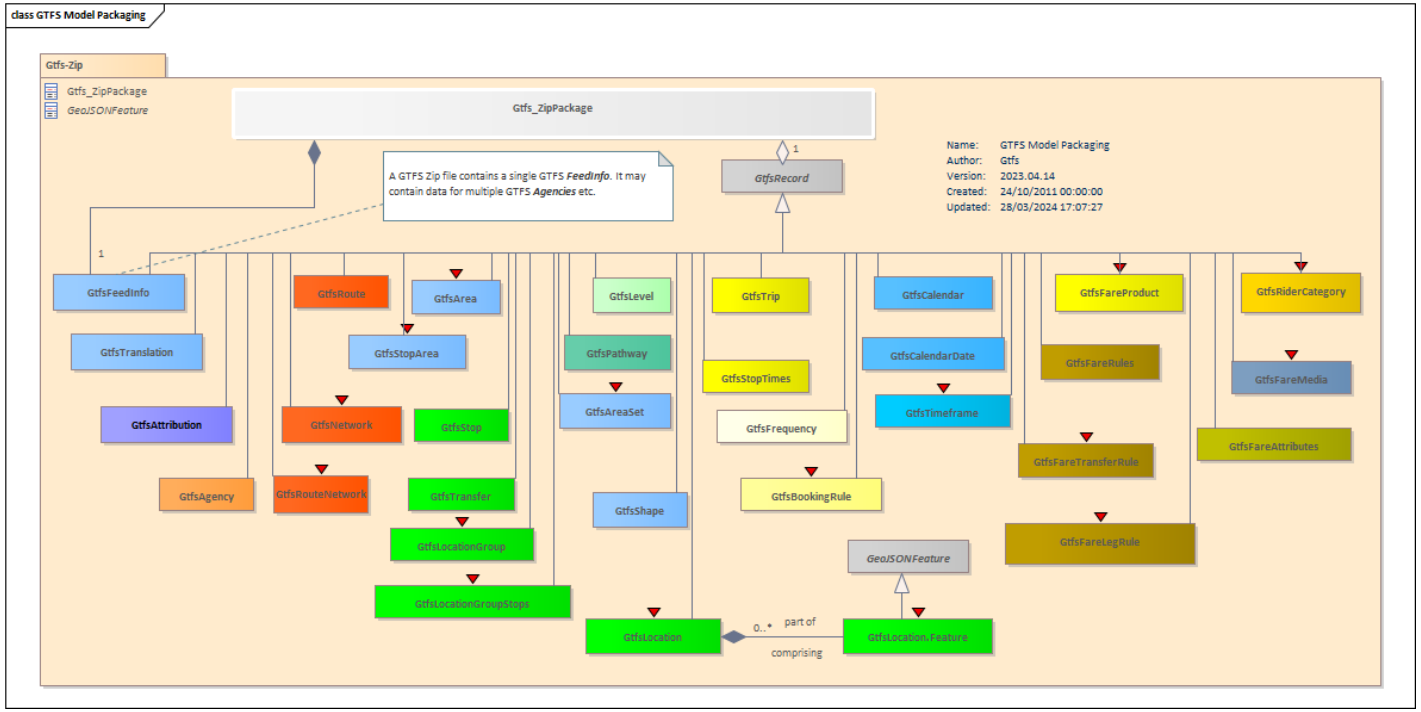
- translation →(ALTERNATIVE TEXT, ALTERNATIVE NAME)
- feed_info →(DATA SOURCE, VERSION FRAME, VALIDITY CONDITION)
- attribution → (RESPONSIBILITY ROLE ASSIGNMENT)



GTFS Packaging as a Zip file

GTFS

- Zip used as container. Implies relationship between agency and orher records
- Cardinalities
  - 0:1 Gtfs feed_info record
  - 1:1 Gtfs agency record
  - 0:* other Gtfs records



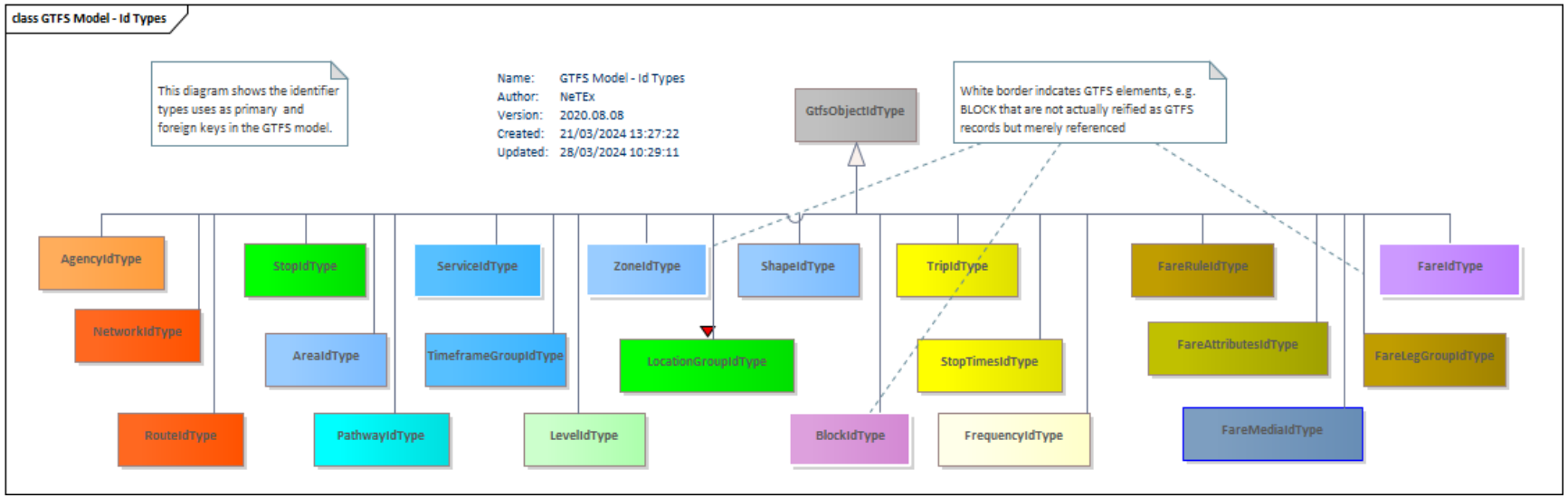
GTFS ids used as primary and foreign keys

GTFS

Ids attributes of keys and foreign keys
indicate relationships.

Not all foreign key ids are reified as records (e.g. block, service)

In some cases an association is assumed because in same zip e.g. stop --> agency



THE GTFS "MODEL" TO NETEX

Mapping GTFS records to NeTEx elements

- Most GTFS records are one-to-one with a specific NeTEx concrete element.
  - ❑ E.g. GTFS **route**→ NeTEx LINE
  - NB NeTEx model uses inheritance & embedded groups, so NeTEx UML diagram may show multiple entities that are implemented as a single XML element
- In a number of cases GTFS records give rise to multiple different NETEX elements representing separate concerns. In this case multiple XML elements with the same id value can be created (since NeTEx identtifiers are unique within each type of element.).
- Some complex cases
  - GTFS **stops**
    - GTFS uses a single record for multiple concepts (Physical and logical stops)
    - NeTEx separates the concepts (STOP PLACE, QUAY, ENTRANCE, SCHEDULED STOP POINT etc)
  - GTFS **stop_times**
    - GTFS includes times and headings in record – no concept of SERVICE PATTERN or DESTINATION DISPLAY
    - NeTEx has separate POINT IN PATTERN , PASSING TIMES and DESTINATION DISPLAY
    - NB NeTEx CALL element gives an equivalent one-for one mapping
  - GTFS **transfers**
    - GTFS uses a single record for multiple concepts (physical proximity, planned interchange, guaranteed connection)
    - NeTEx separates the concepts CONNECTION, INTERCHANGE, INTERCHANGE RULE ,etc)
  - GTFS **fare_attributes**
    - GTFS uses a single record for multiple concepts products, prices, ect
    - NeTEx separates the concepts FARE PRODUCT, FARE PRICE, ,etc)
  - GTFS **feed_info**
    - GTFS uses a single record for multiple concepts (ownership, feed source, validity)
    - NeTEx separates the concepts DATA SOURCE, RESPONSIBILITY SET, VALIDITY CONDITION)

GTFS record / NeTEx basic correspondences: #1 Network & Journeys

GTFS

NeTEx Network Timetable Exchange

GTFS record	Transmodel / NeTEx	Notes
agency	**OPERATOR** or AUTHORITY	
stops	**SCHEDULED STOP POINT**, STOP PLACE + QUAY	Complex mapping
pathways	**PATH LINK,** PATH INSTRUCTION , TRANSFER DURATION	Complex mapping
transfers	CONNECTION SERVICEJOURNEY | INTERCHANGE, **INTERCHANGE RULE**	Complex mapping
routes	**LINE**	
network + route_network	**NETWORK**	
calendar	DAY TYPE, **DAY TYPE ASSIGNMENT**	
calendar_dates	**DAY TYPE ASSIGNMENT** and OPERATING DAY	
trips	**SERVICE JOURNEY** + DESTINATION DISPLAY	
stop_times	**STOP POINT IN PATTERN** + PASSING TIMES + DESTINATION DISPLAY & / or CALL	Complex mapping
frequency	**HEADWAY JOURNEY GROUP,** RYTHMICAL JOURNEY GROUP with TEMPLATE SERVICE JOURNEY.	
shapes.txt	ROUTE LINK, **POINT ON LINK,** LINK PROJECTION, LineString,	
levels	**LEVEL**	

GTFS record / NeTEx correspondences #2 Fares

GTFS

NeTEx Network Timetable Exchange

	GTFS record	NeTEX equivalent	Notes
Gtfs1	fare_attributes	**FARE PRICE**	
Gtfs1	fare_rules	**FARE PRODUCT**, SALES OFFER PACKAGE, USAGE PARAMETER	Complex Mapping
Gtfs2	fare_transfer_rules	**INTERCHANGING** (USAGE PARAMETER) + FARE STRUCTURE ELEMENT	Complex Mapping
Gtfs2	fare_leg_rules	**DISTANCE MATRIX ELEMENT** + FARE STRUCTURE ELEMENT	Complex Mapping
Gtfs2	rider_category	**USER PROFILE**	
Gtfs2	*fare_media*	**TYPE OF TRAVEL DOCUMENT**	
Gtfs2	fare_product	**SALES OFFER PACKAGE + FARE PRODUCT**	
Gtfs2	fare_capping	**SALES DISCOUNT RIGHT + CAPPING RULE**	

GTFS record / NeTEx correspondences #3 Framework

GTFS

NeTEx
Network Timetable Exchange

GTFS record	NeTEX equivalent	Notes
translations	**ALTERNATIVE TEXT**,	
feedinfo	**DATA SOURCE**, VALIDITY CONDITION, RESPONSIBILITY SET BRANDING	Complex mapping
attributions	**RESPONSIBILITY SET** + RESPONSIBILITY ROLE + ORGANISATION	

datagpt

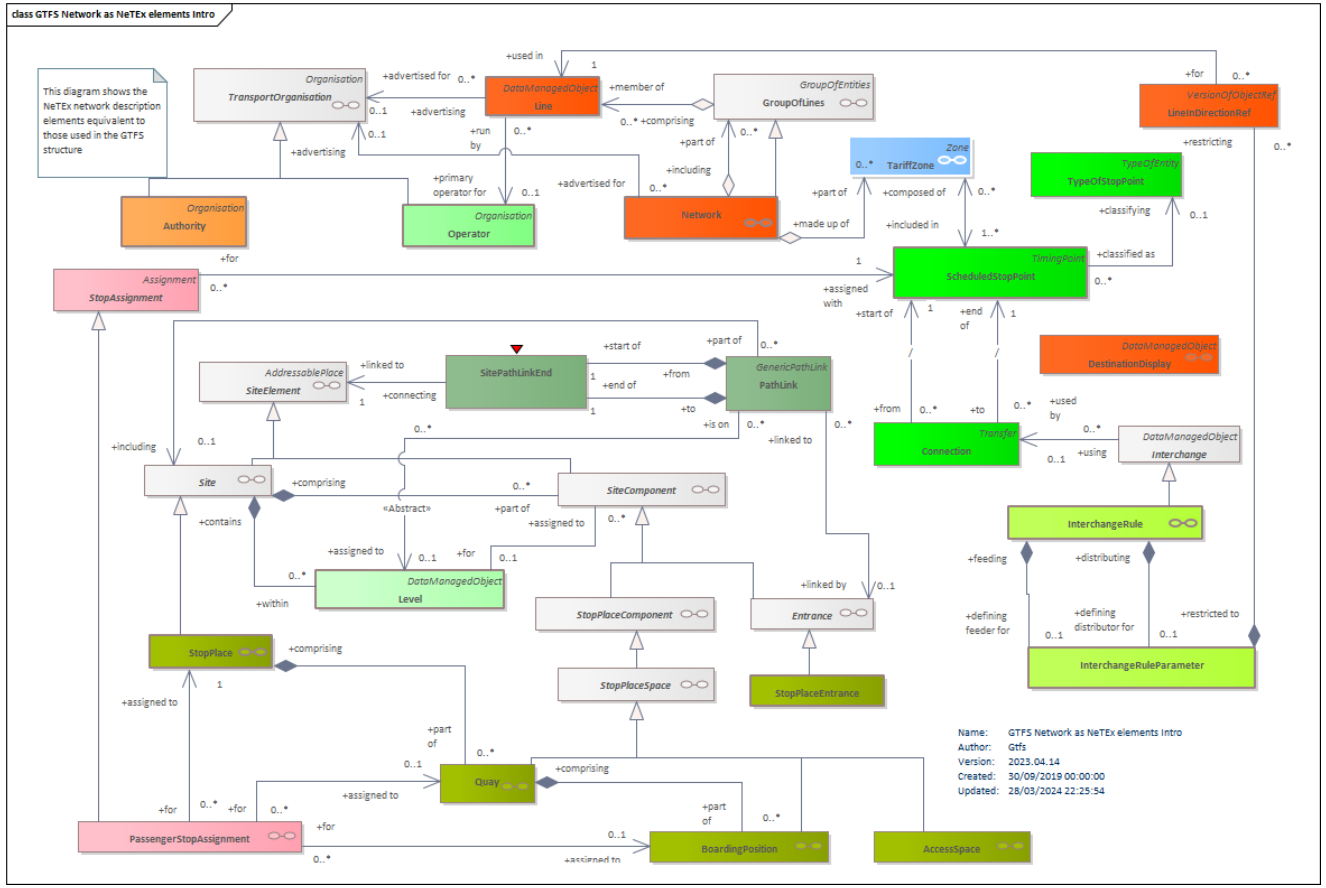
NeTEx elements equivalent to GTFS – 1. Network

Using

- Gtfs **agency** →·OPERATOR
- Gtfs **network**→ NETWORK

- Gtfs **stops** →
  - SCHEDULED STOP POINT
  - (STOP PLACE + QUAY + ENTRANCE)
  - (STOP ASSIGNMENT)
- Gtfs **transfers** ➔ CONNECTION
- Gtfs **levels** ➔ CONNECTION
- Gtfs **pathways** ➔ PATH LINK

- Gtfs **routes** ➔ LINE

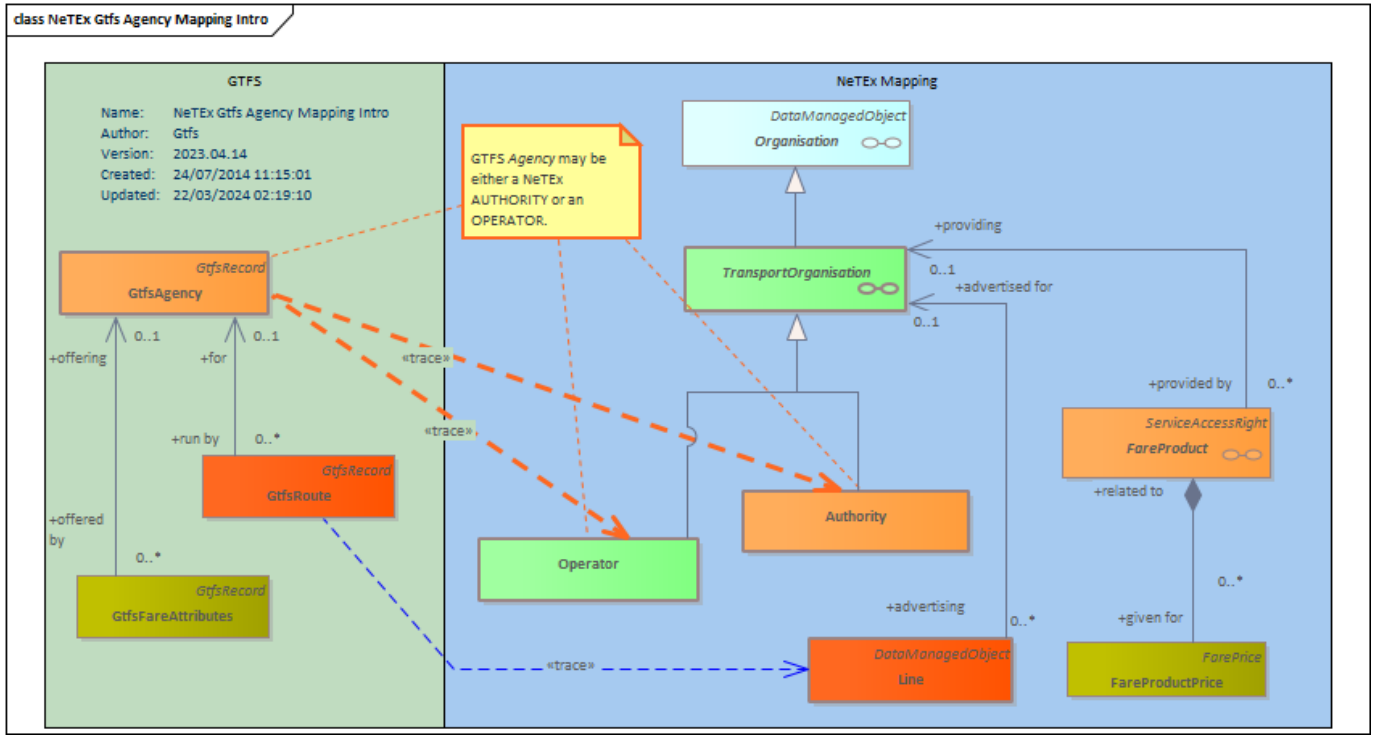


MAPPING :
(1)
GTFS AGENCY
→
NETEX OPERATOR

Simple Mapping Example GTFS Agency Mapping Intro

GTFS

NeTEx Network Timetable Exchange



Mapping

- **Gtfs agency record ➔**
  - NeTEx OPERATOR (or AUTHORITY)

- NOTES ;

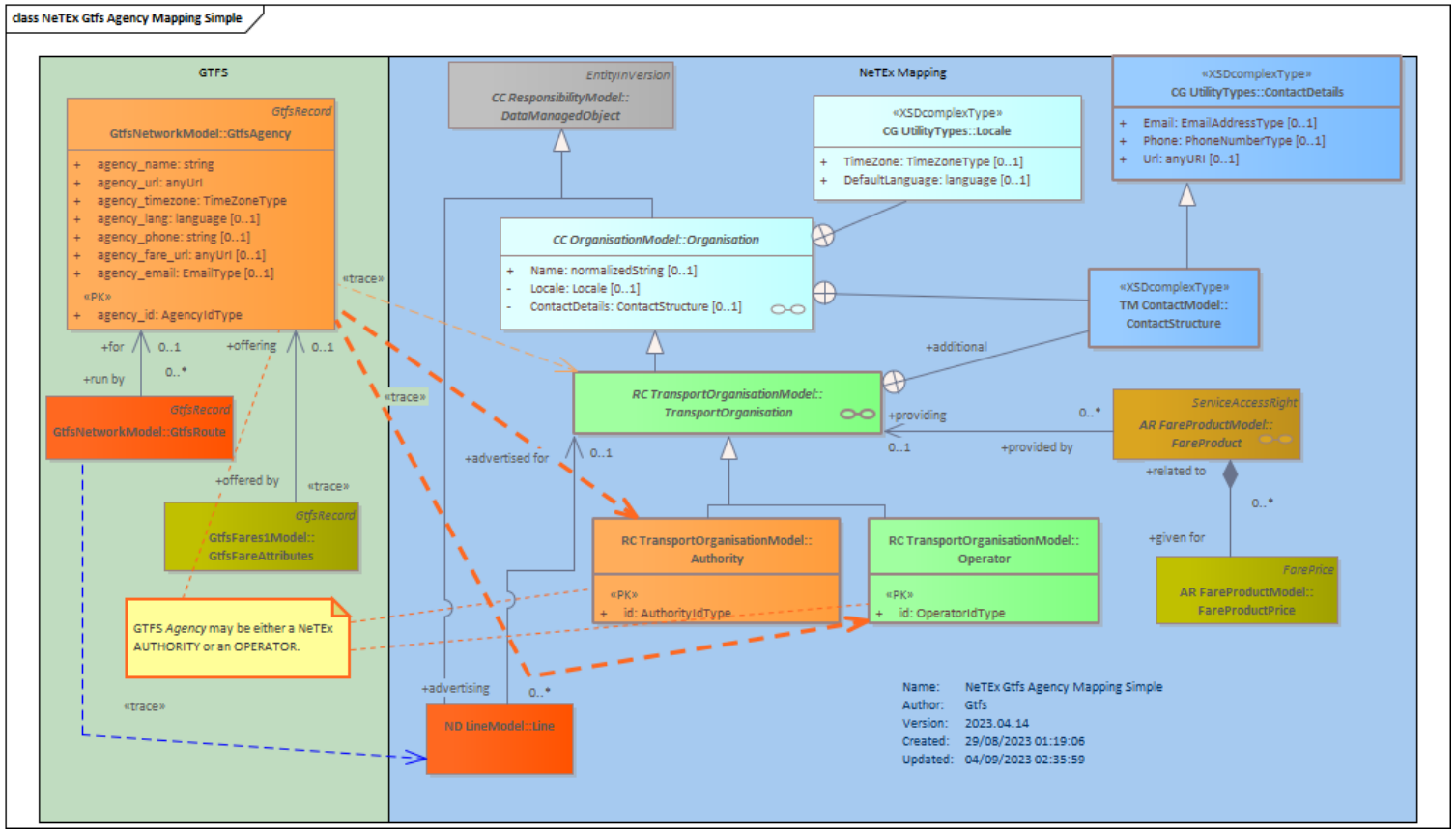
Conceptual mapping of entities is usually one to several

- GTFS records are simplified views
- Transmodel/NeTEx
  - Separates concerns unto separate elements
  - Uses inheritance from ORGANISATION to get common properties for a legally incorporated body.

Mapping Example : GTFS Agency Mapping - Details

Network

- **Gtfs agency record ➔**
- NeTEx OPERATOR (or AUTHORITY)



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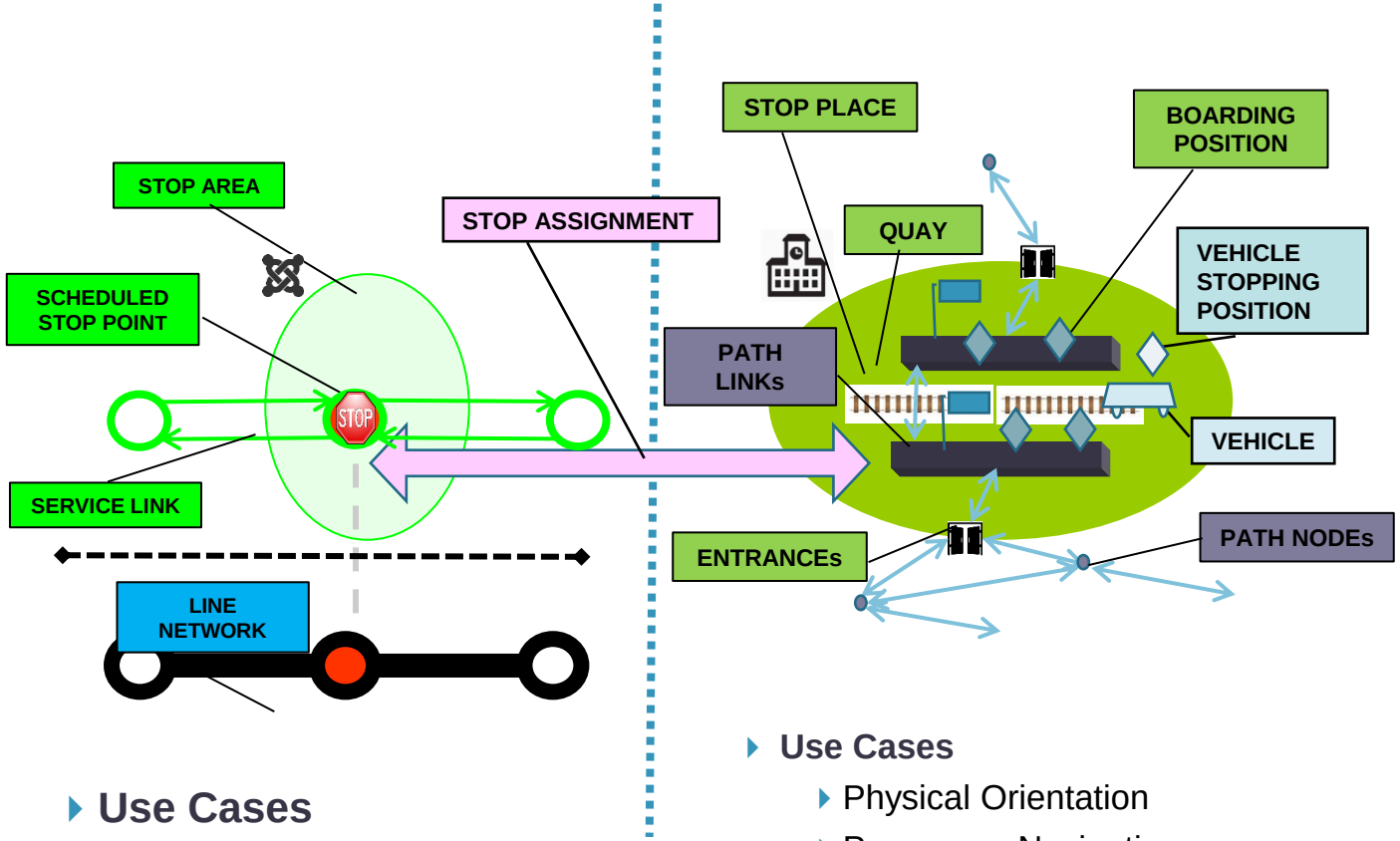
MAPPING :
(2)
GTFS STOPS
→
NETEX SCHEDULED STOP POINT / STOP PLACE

Timetable Stop vs Physical Stop

Named access point in the transport network that timetables refer to



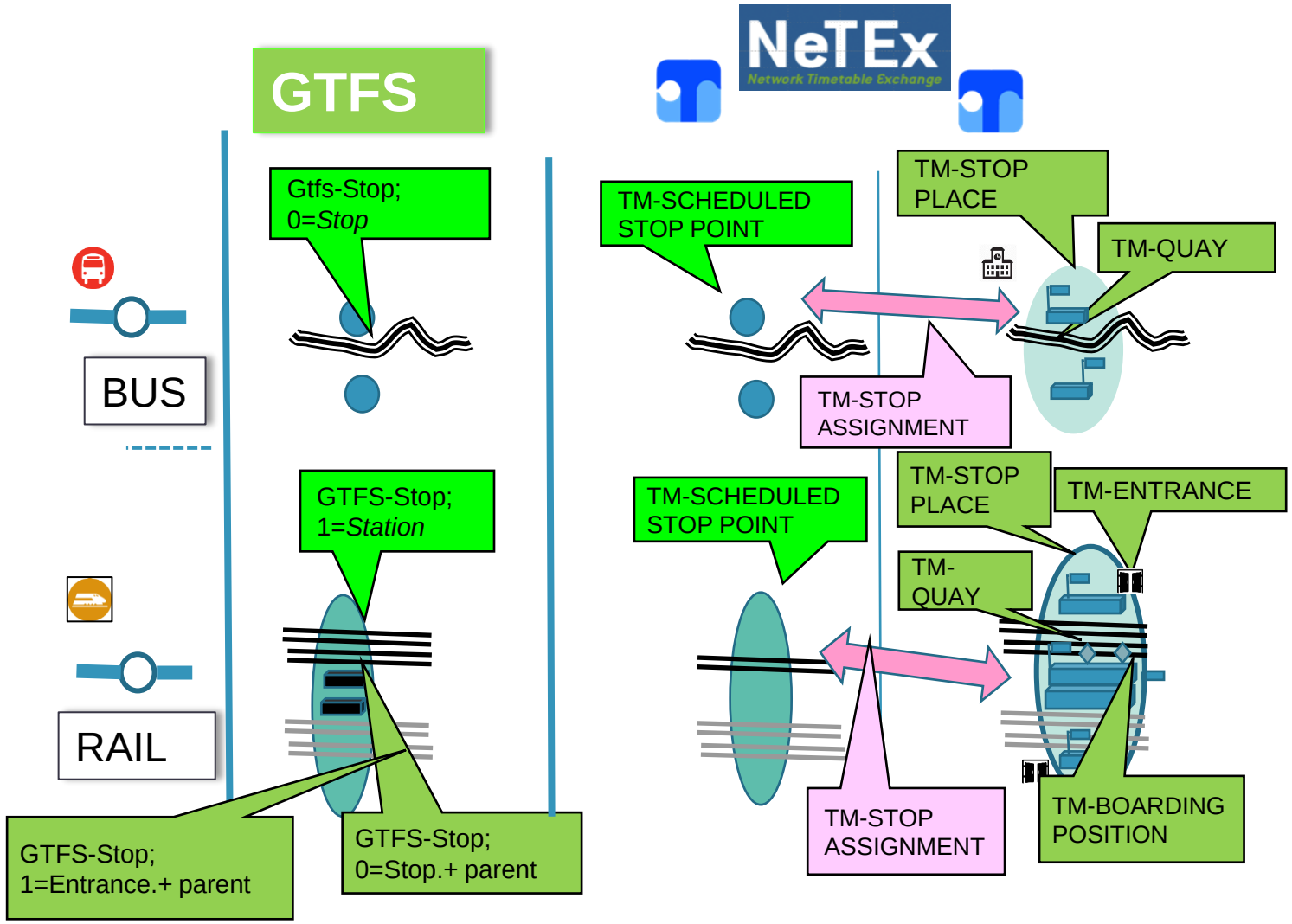
- **Use Cases**
  - Scheduling
  - Trip Planning

Physical transport interchange with pathways between entrances, halls, platforms etc. Corresponds to a point in the timetable

- **Use Cases**
  - Physical Orientation
  - Passenger Navigation
  - Vehicle Positioning
  - Trip Planning
  - Boarding directions

Logical vs Physical Stop

- Transmodel separates scheduled & physical stop concepts
- GTFS uses stop for both scheduled stop (NeTEx SCHEDULED STOP POINT) and physical stop (NeTEx STOP PLACE), and all physical nodes of physical stop (QUAY, ENTRANCE, ACCESS SPACE, BOARDING POSITION)
- GTFS uses stop differently for different modes
- GTFS is “overloading” the stop record semantics - mst be interpreted in context by importing program



GTFS Stops Mapping Overview - Stop in Schedule Basic

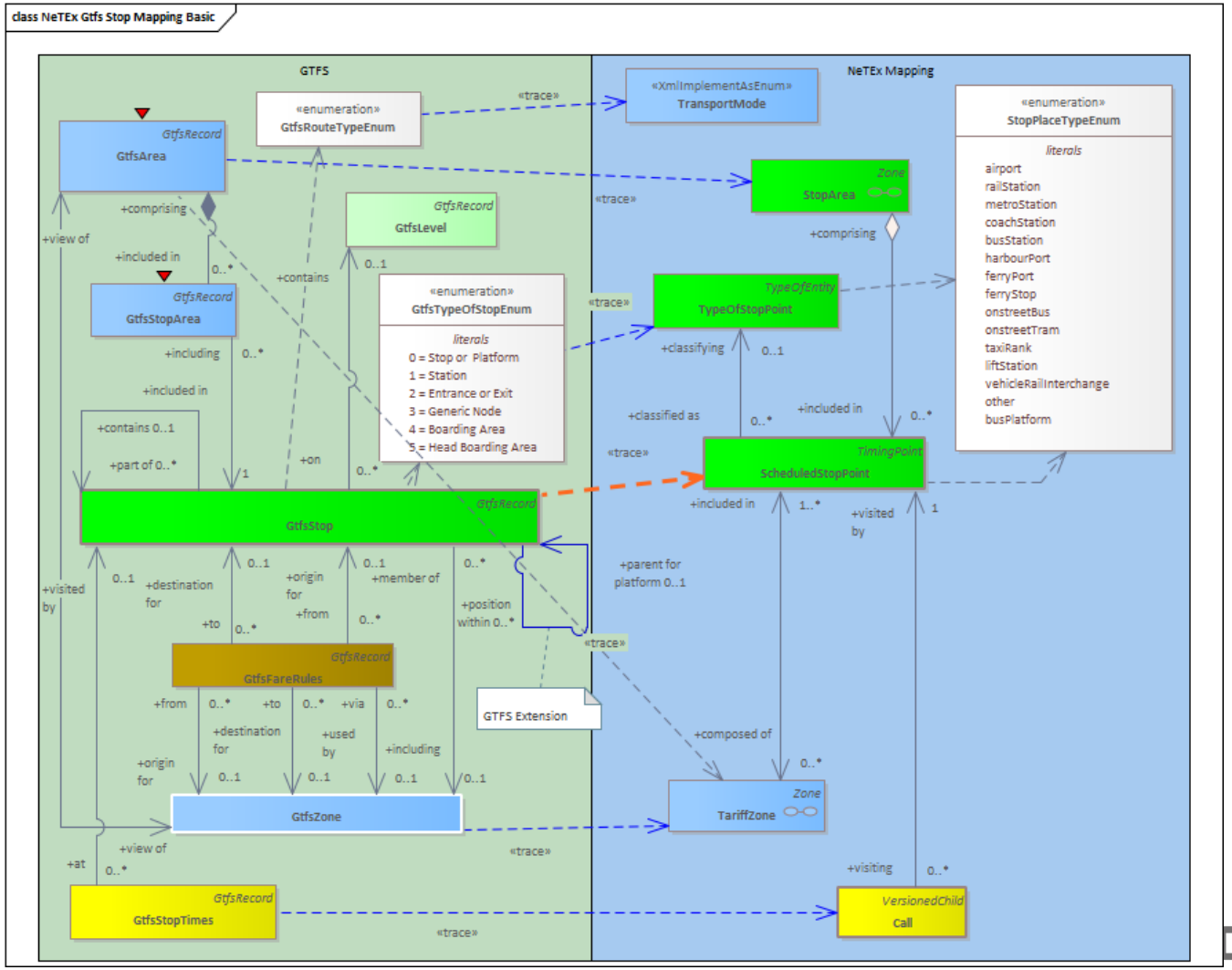
GTFS

NeTEx
Network Timetable Exchange

Network

Simple timetable reference to a stop

- **GTFS stops record**
  ➔ NeTEx SCHEDULED STOP POINT



GTFS Stops Mapping - Physical stop – entrances, platforms connected by pathways

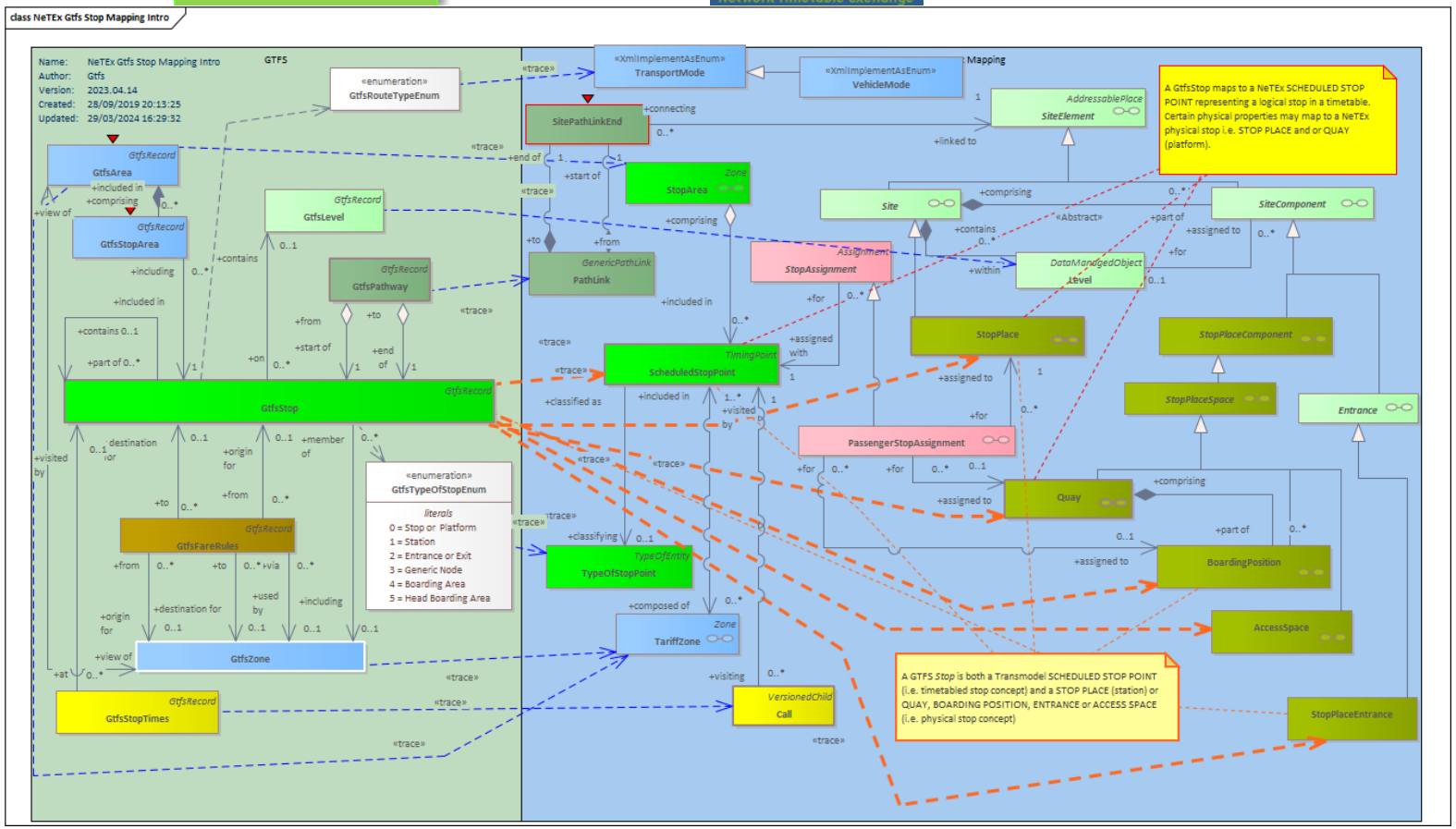
Network

As locations within a station

Gtfs stops record ➔ NeTEx STOP PLACE +

- QUAY or
- ENTRANCE or
- ACCESS SPACE or
- BOARDING POSITION

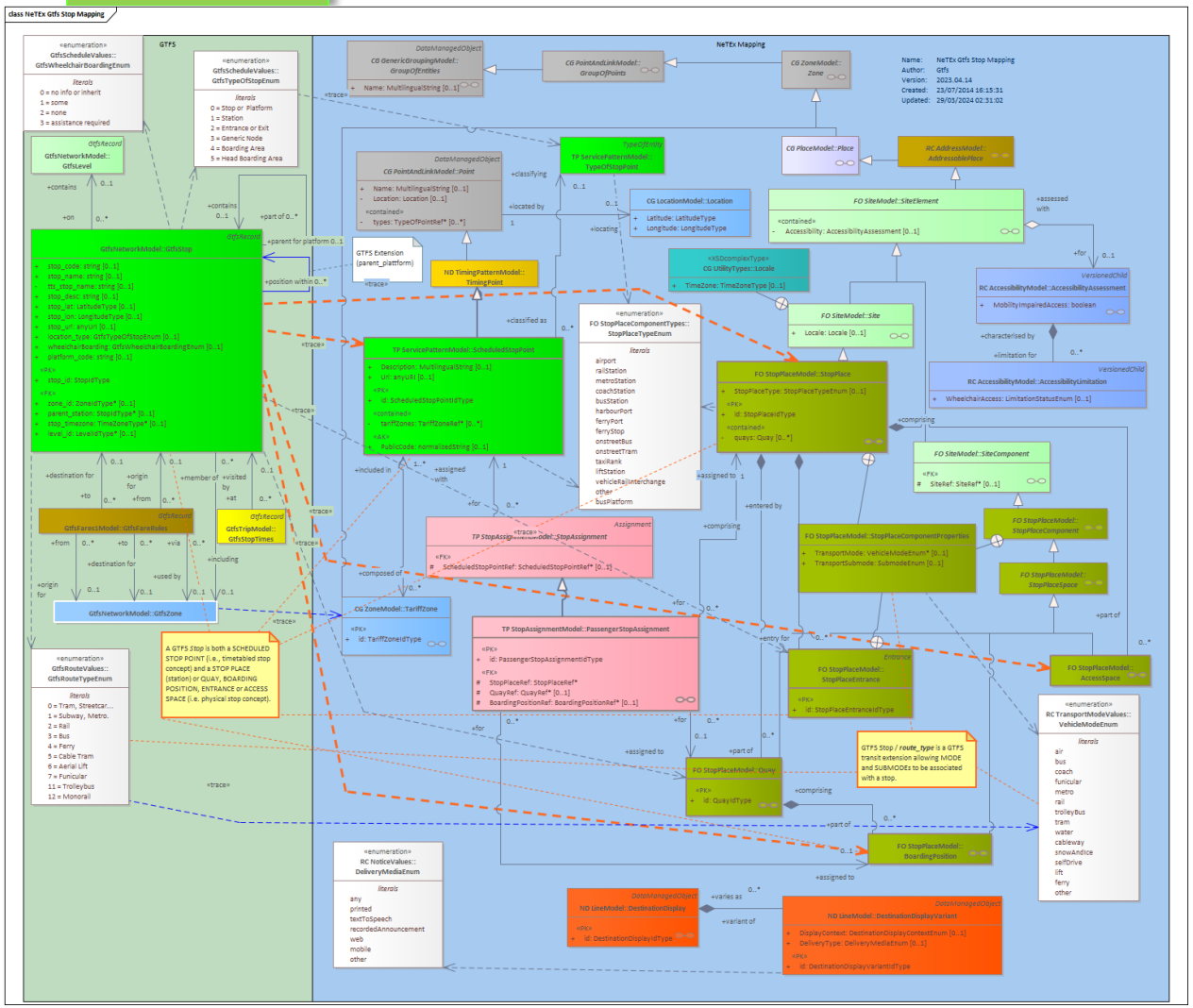
- Node type given by GTFS location type
- **Gtfs** pathway connects nodes (PATH LINK)



GTFS Stops Mapping With attributes -

GTFS

NeTEx
Network Timetable Exchange



Network

Gtfs stops record ➔

- NeTEx SCHEDULED STOP POINT
- + STOP PLACE + QUAY | ENTRANCE | ACCESS SPACE | BOARDING POINT
- + DESTINATION DISPLAY
- + STOP ASSIGNMENT to link SCHEDULED STOP POINT with STOP PLACE
- GTFS stops.Headsign attribute → NeTEx DESTINATION DISPLAY element (A reusable element with variants for use in different formats eg TTS, mobile app, etc)

- NB See also pathways mapping

MAPPING:
(3)
GTFS LEVELS
→
NETEX LEVEL

GTFS Levels Mapping Overview

GTFS

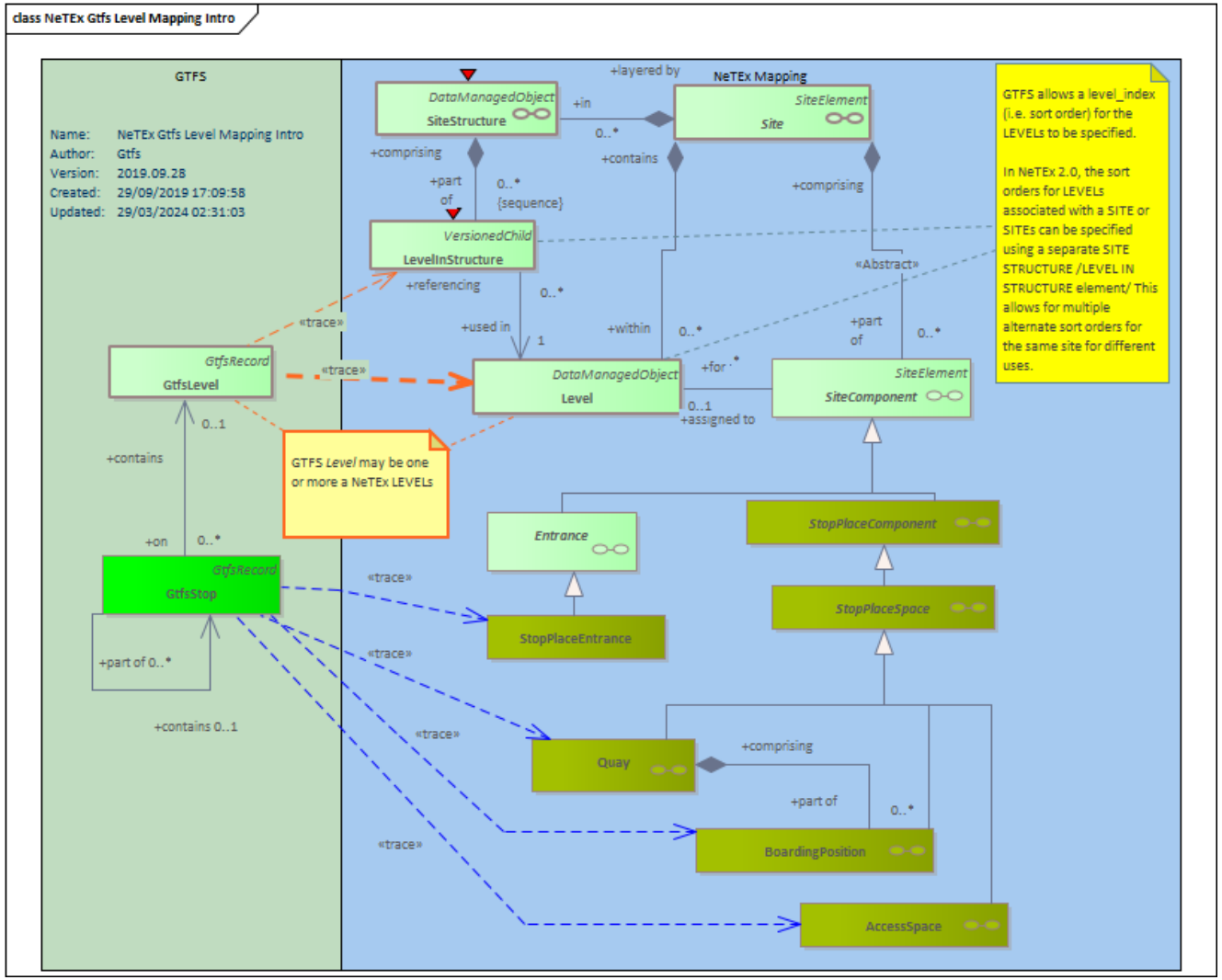
NeTEx
Network Timetable Exchange

Network

- **Gtfs levels record ➔**
  - NeTEx LEVEL

- NB. NeTEx LEVELs are specific to a SITE. (GTFS levels are global?)

- NB. NeTEx allows for alternative labels to be given to the same level in different contexts (LEVEL IN STRUCTURE)

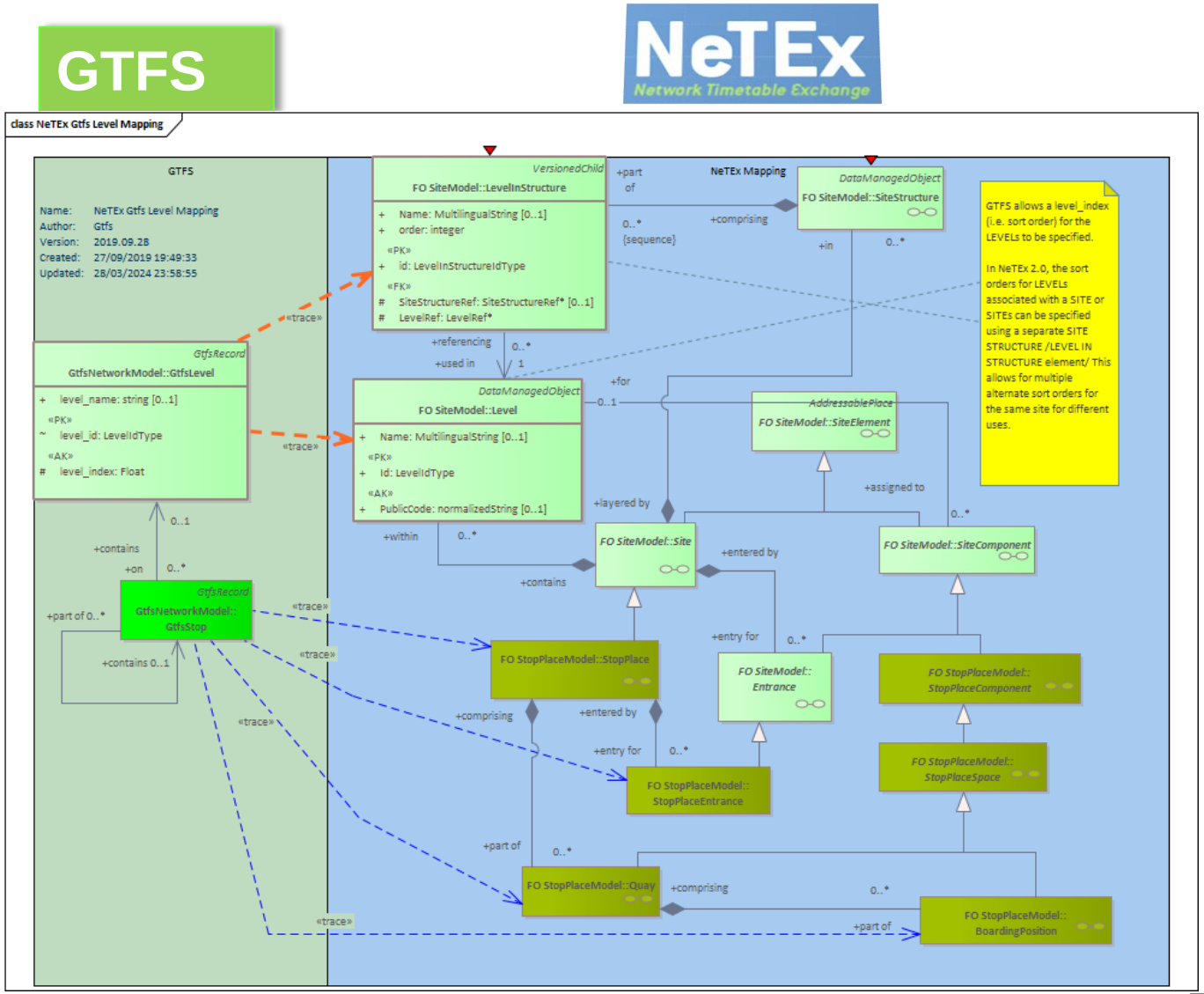


GTFS Levels Mapping - Details

Network

- **Gtfs levels record**
- ➔ NeTEx LEVEL

- STOP PLACES are sites. Can also use for other SITES such as POINTS of INTEREST and PARKINGs



MAPPING:
(4)
GTFS PATHWAYS
→
NETEX PATH LINK

Logical vs Physical Stops - Connection….

- Accessibility information & timings
- Detailed interchange directions
  - (NAVIGATION PATHS)
- Default & Specific TRANSFER TIMEs
- Journey specific interchanges

GTFS Pathways Mapping Overview

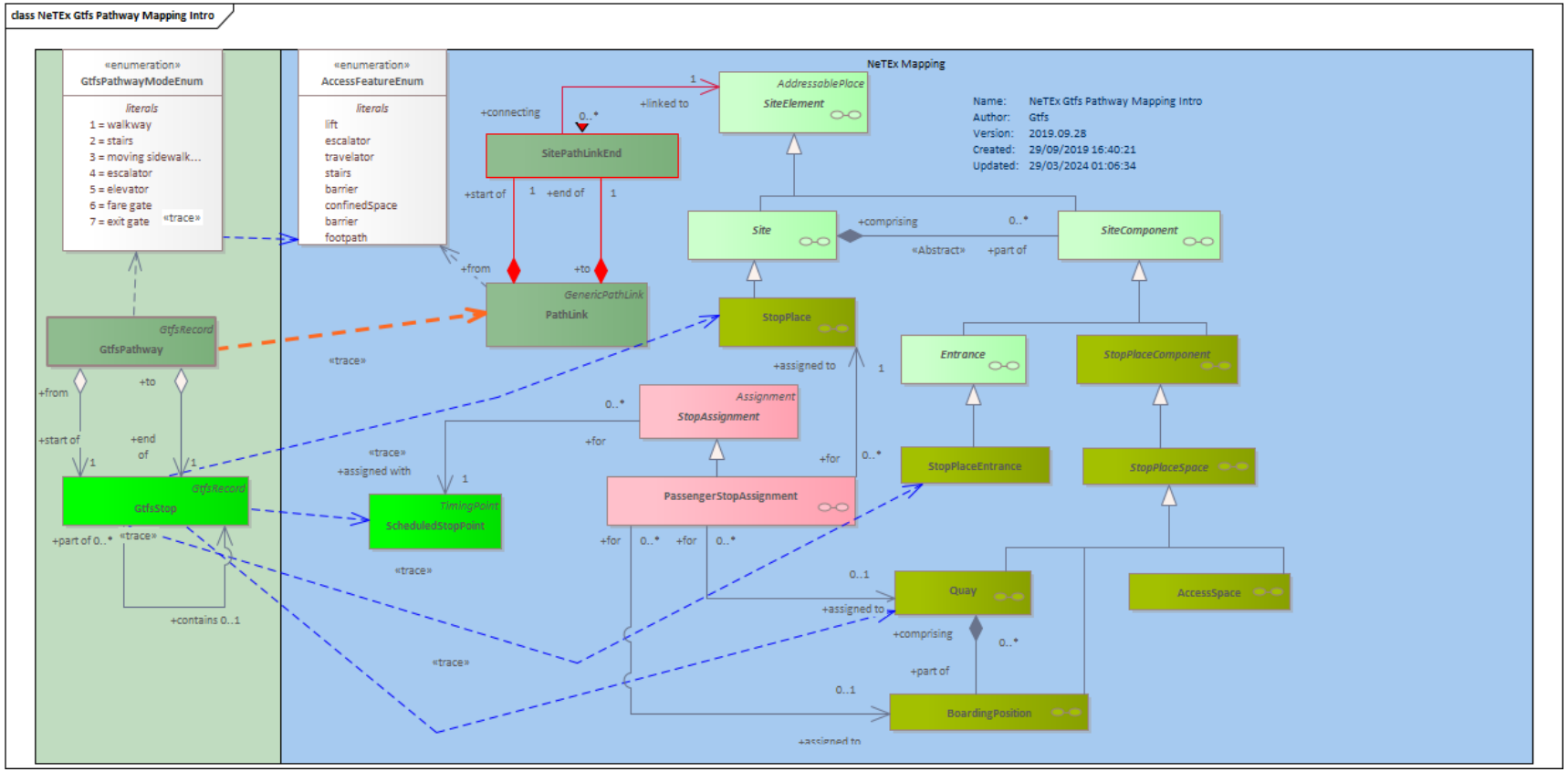
GTFS

NeTEx
Network Timetable Exchange

Network

- **Gtfs pathway record➔**
- NeTEx PATH LINK

- NeTEx distinguishes between physical stop components eg QUAY, ACCESS SPACE, BOARDING POSITION., Also PATH JUNCTIONS for intermediate points



GTFS Pathways Mapping - Details

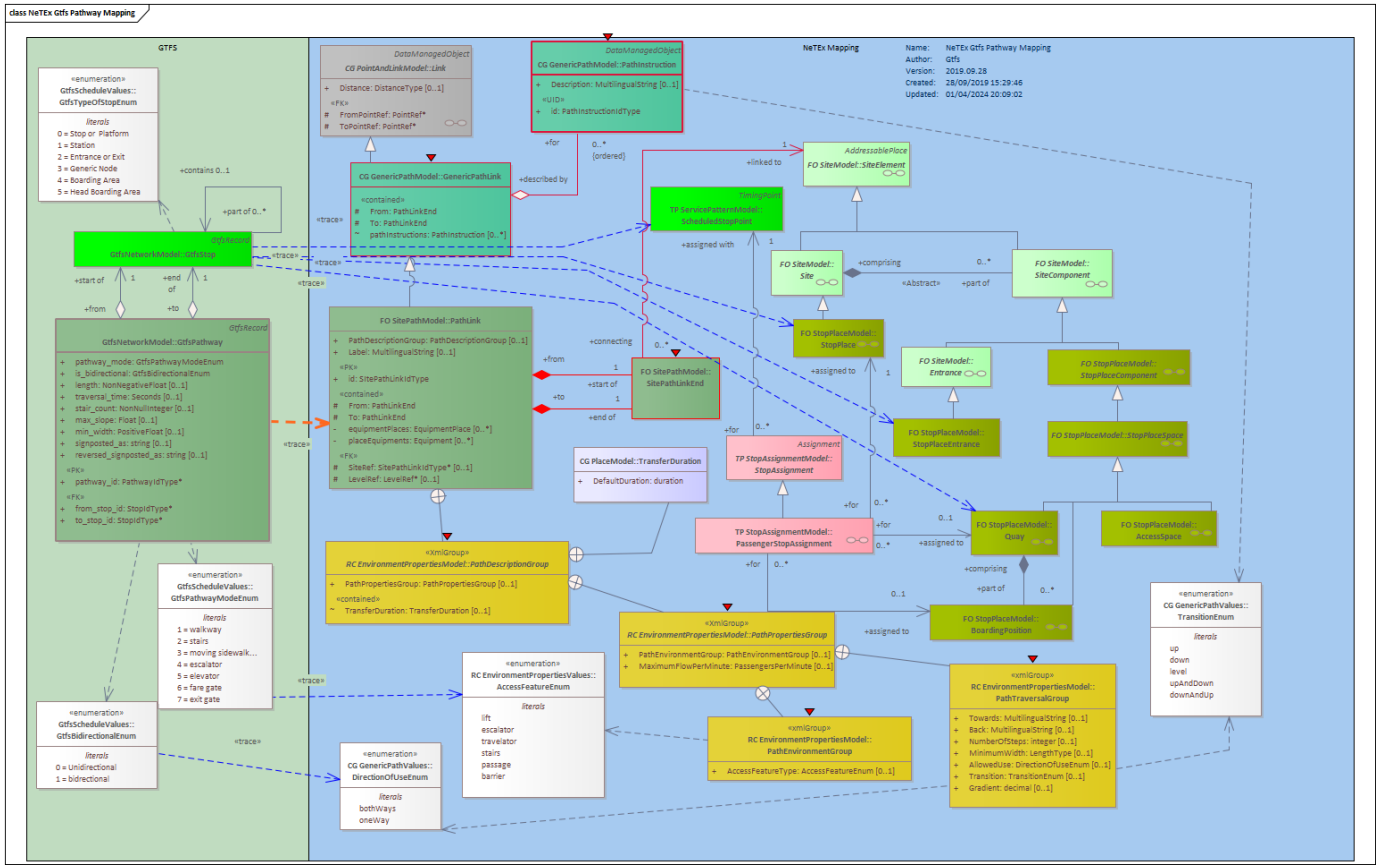
GTFS

NeTEx
Network Timetable Exchange

Network

- **Gtfs pathways record**
- ➔ NeTEx PATH LINK

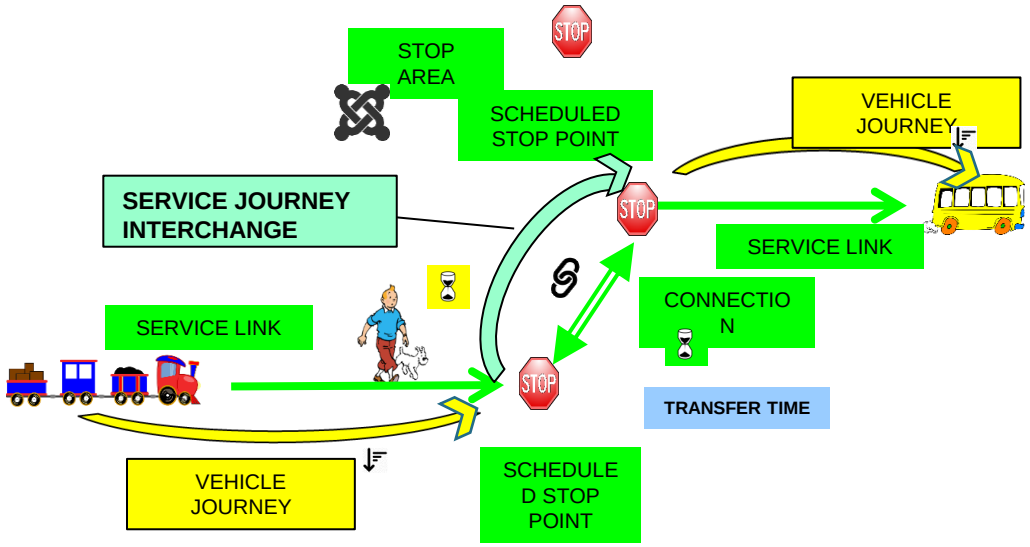
NB NeTEx also has NAVIGATION PATH made up of a series of PTAH LINKs.



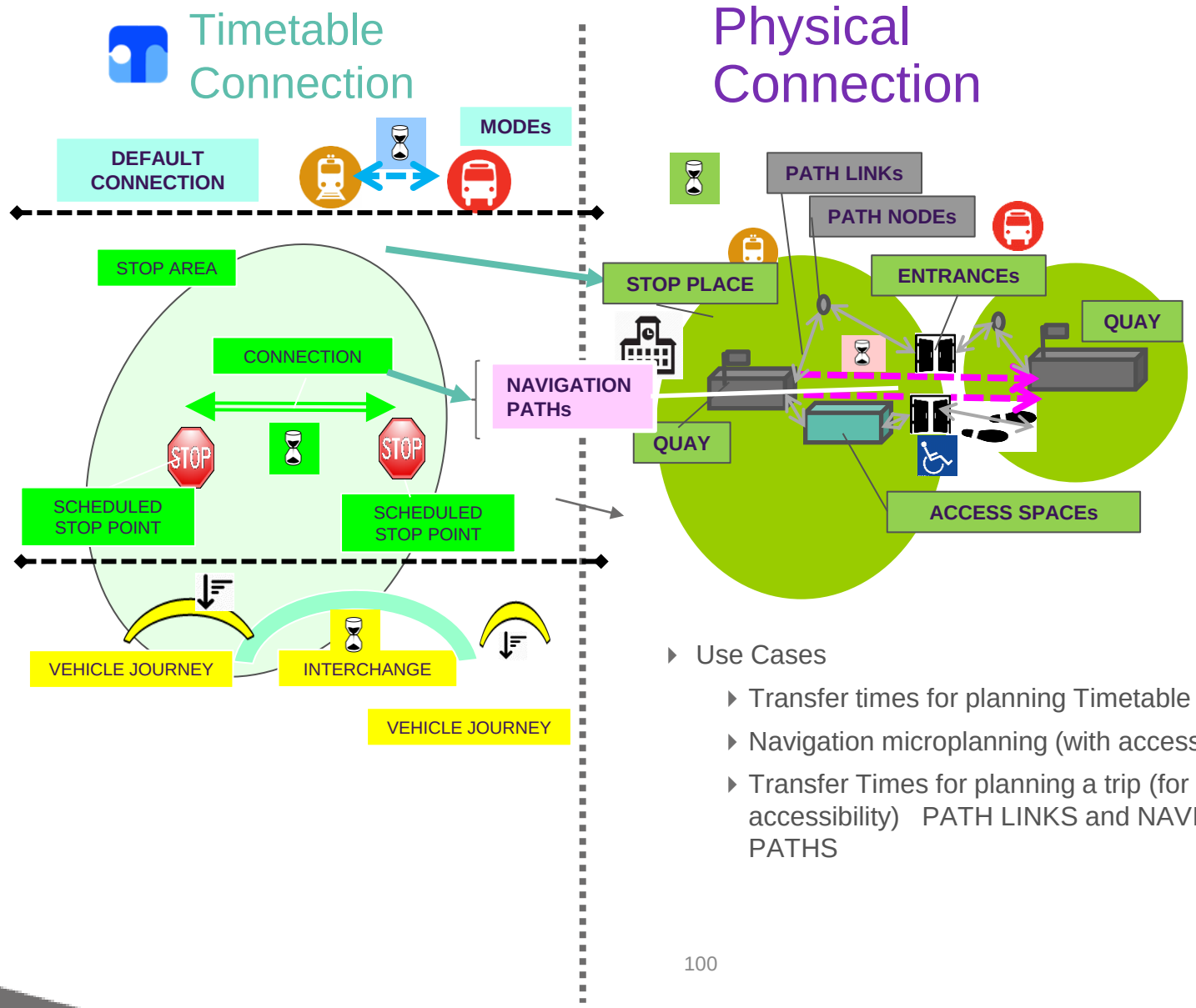
MAPPING:
(5)
GTFS TRANSFERS
→
NETEX CONNECTION + INTERCHANGE RULE

Connections & Interchanges in the timetable

- Transmodel/NeTEx separate out general vs specific transfers
  - STOP AREA - possibility of transfer between all contained STOP POINTs in area.
  - CONNECTION - possibility of transfer between two specific STOP POINTs.
  - SERVICE JOURNEY PATTERN INTERCHANGE two patterns intended to allow transfers at a CONNECTION..
  - SERVICE JOURNEY INTERCHANGE - Specific transfer between two journeys at a CONNECTION.
  - INTERCHANGE RULE – allows more complex rules, e.g., transfers in a specific direction for a specific line



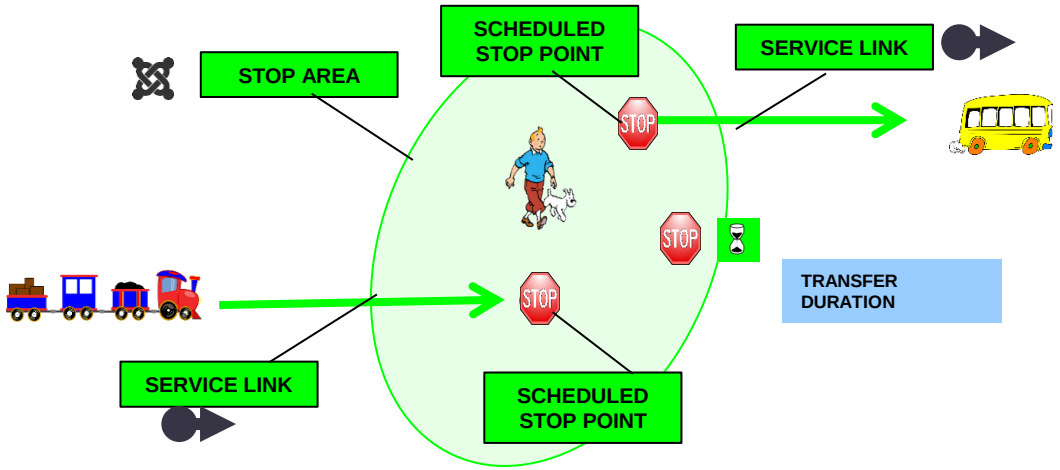
Timetabled versus physical connection times



- Use Cases
  - Transfer times for planning Timetable
  - Navigation microplanning (with accessibility)
  - Transfer Times for planning a trip (for given accessibility) PATH LINKS and NAVIGATION PATHS

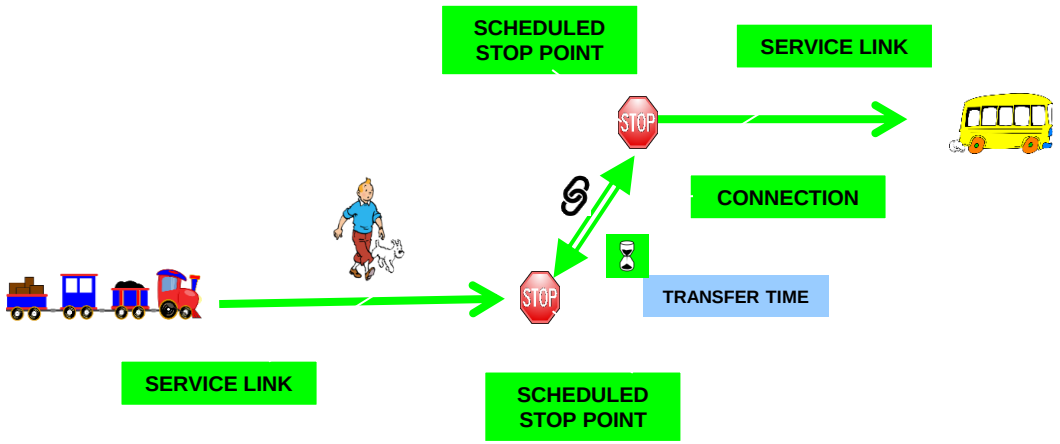
Transport Interchanges - Proximity

- Possibility of transfer between any nearby STOP POINTs within a STOP AREA
- General transfer duration for transfers with the STOP AREA



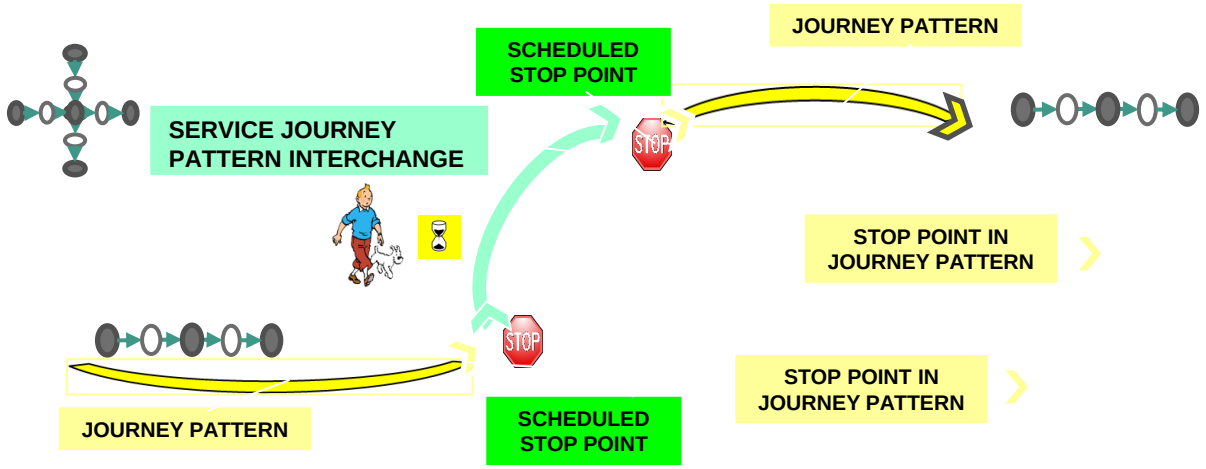
1. Transport Interchanges – explicit Connection

- Possibility of transfer between two specific STOP POINTs
- Specific transfer duration for CONNECTION.



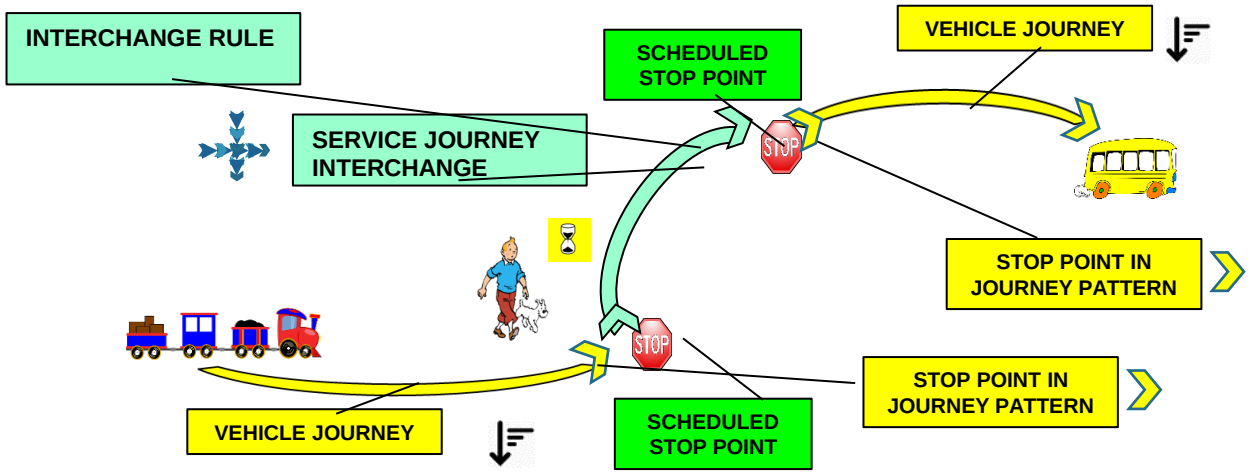
2. Transport Interchanges – between specific JOURNEY PATTERNS

- General vs Specific
  - SERVICE JOURNEY PATTERN INTERCHANGE = possible transfer between two specific scheduled POINTS IN JOURNEY PATTERN at specific SCHEDULED STOP POINTS
    - Any journey following pattern may interchange with journeys on other pattern



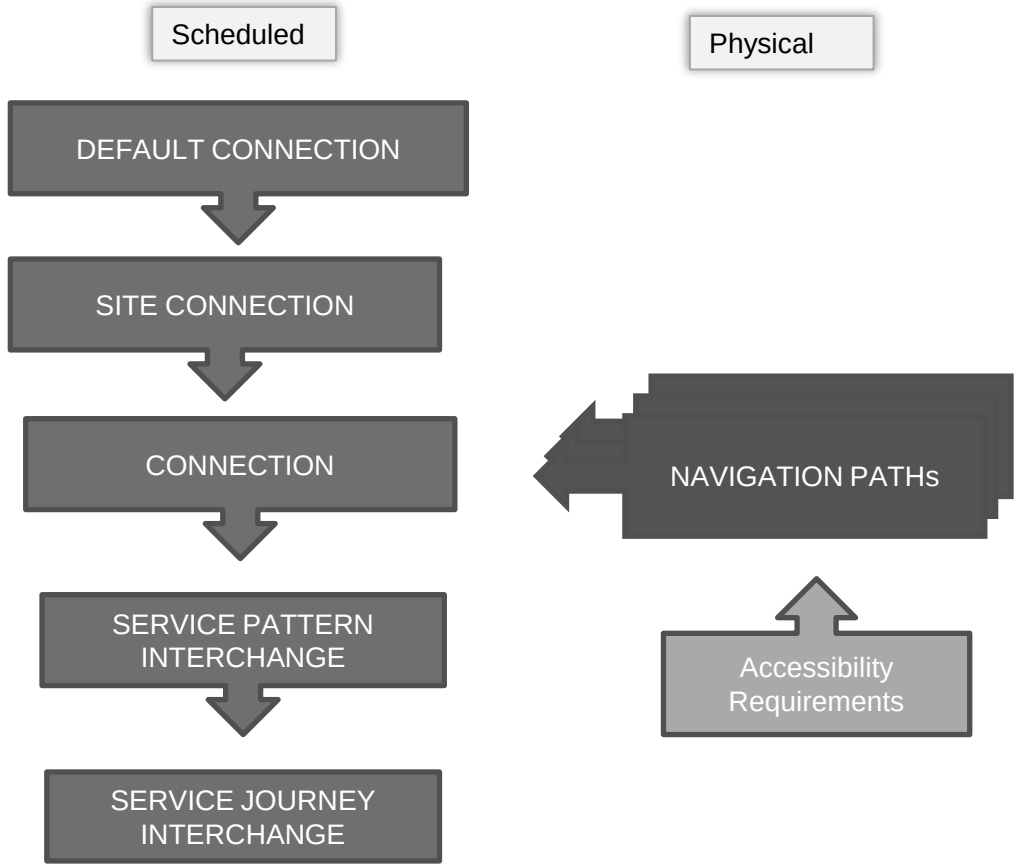
3. Transport Interchanges – between specific Journeys

- General vs Specific
  - SERVICE JOURNEY INTERCHANGE = possible transfer between two specific scheduled VEHICLE JOURNEYs at specific SCHEDULED STOP POINTS
    - May be managed (“Guaranteed”)
    - May be on same or different vehicles
  - INTERCHANGE RULE – Complex parameters – e.g., transfer eastbound on weekdays



NeTEx /Transmodel Transfer times

- **Transfer timings for scheduling may be specified at different levels**
  1. Countrywide defaults for mode & operator
     - DEFAULT CONNECTION
  2. Site defaults for mode & operator
     - SITE CONNECTION
  3. Specific stop pairs
     - CONNECTION
  4. Interchange between two services over a CONNECTION
     - SERVICE PATTERN INTERCHANGE
  5. Interchange between specific journeys
     - SERVICE JOURNEY INTERCHANGE
- **Transfer timings between stop pairs for specific accessibility needs may be specified on NAVIGATION PATH.**



GTFS

Mapping Overview: GTFS Transfer

- Key Equivalences
  - GTFS Transfer = TM CONNECTION + TRANSFER DURATION + INTERCHANGE RULE
- TM also allows for defaults
- GTFS stops conflates physical and logical stop concepts
  - Generic Mode / DEFAULT CONNECTION
  - Generic Mode / CONNECTION

GTFS Transfers Mapping Overview

GTFS

NeTEx
Network Timetable Exchange

GTFS transfers record ➔

Simple CONNECTION possible between two stops

- transfer (CONNECTION)

Excluded generic CONNECTION

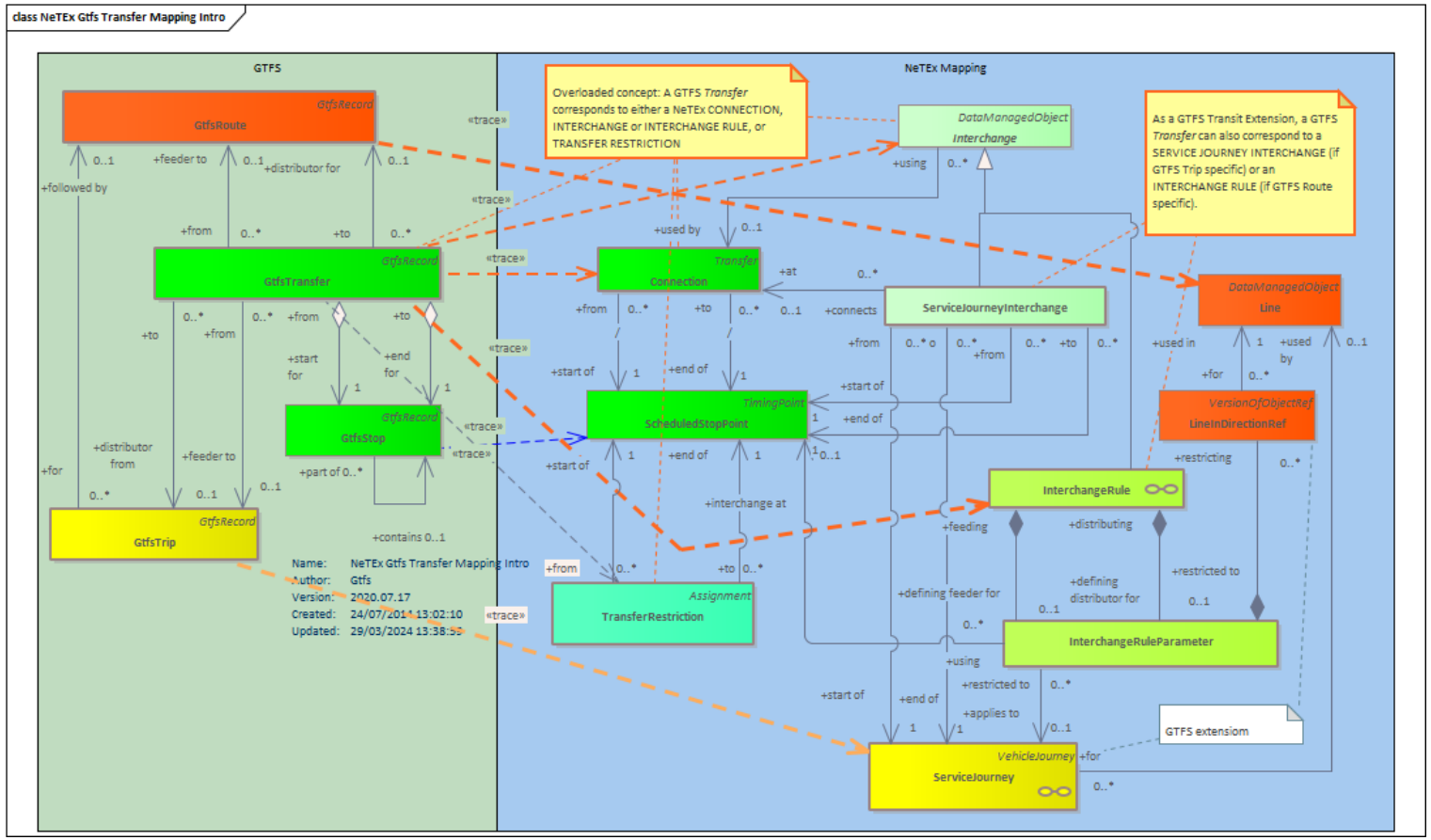
- transfer (CONNECTION + TRANSFER RESTRICTION)

Specific LINE interchange

- transfer (CONNECTION + INTERCHANGE RULE

Specific JOURNEY interchange

- transfer (CONNECTION + INTERCHANGE RULE + SERVICE JOURNEY INTERCHANGE



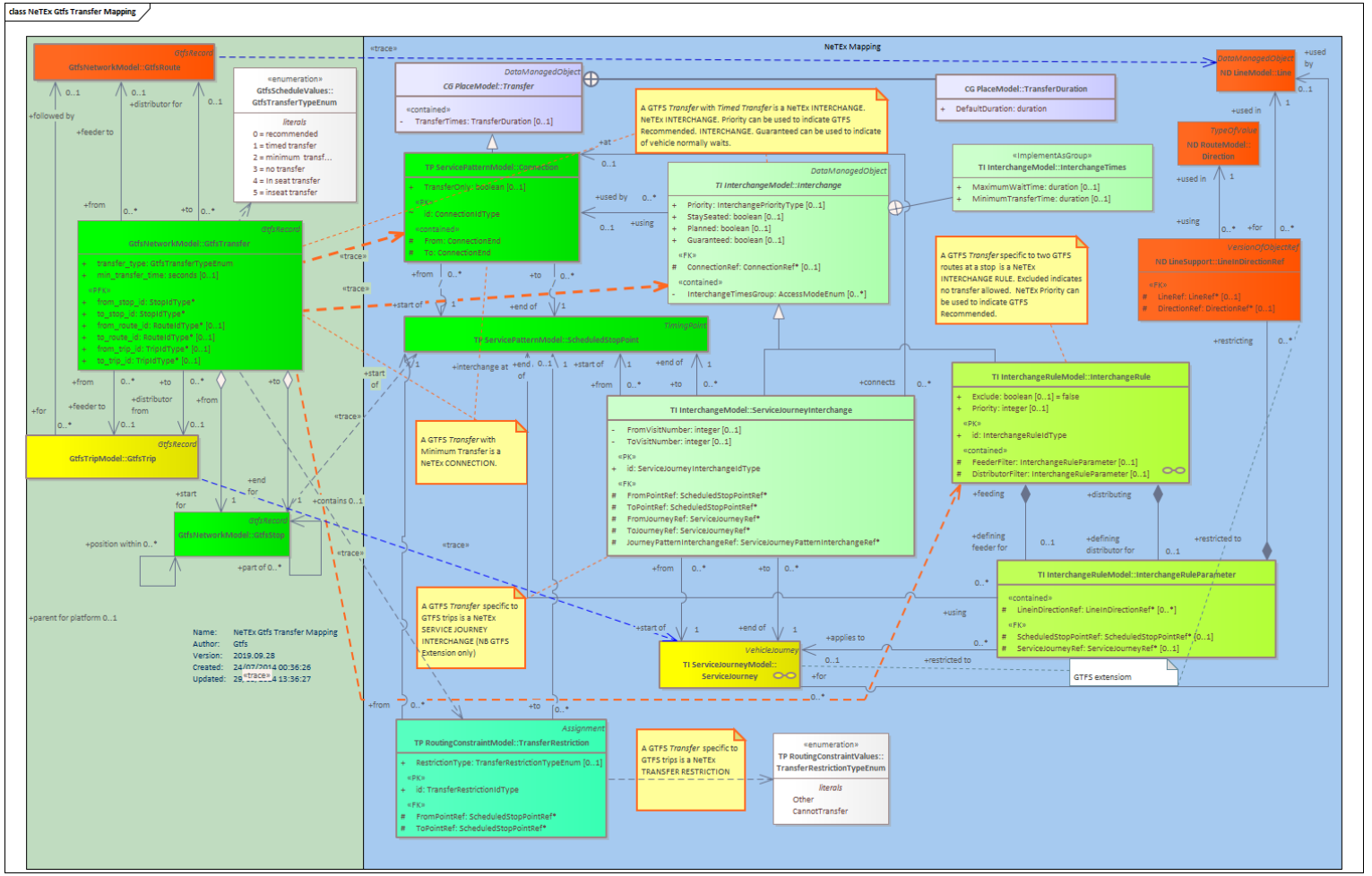
GTFS Transfer Mapping Detail ed attrfibutess -

GTFS

NeTEx
Network Timetable Exchange

Network

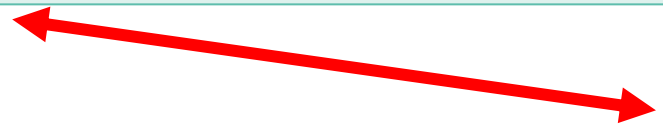
- **Gtfs Transfer ➔**
- NeTEx CONNECTION + INTERCHANGE RULE (



An Example mapping - GTFS transfers to NeTEx CONNECTION _ TRANSFER RESTRICTION

GTFS *CSV*

```
from_stop_id,to_stop_id, transfer_type,min_transfer_time,
NADAV,BOONDOCK,0,360
```



NeTEx Network Timetable Exchange


```
<Connection version="any" id="NADAV+BOONDOCK">
   <TransferDuration>
      <DefaultDuration>PT6M</DefaultDuration>
   </TransferDuration>
   <From>
      <ScheduledStopPointRef ref="NADAV"/>
   </From>
   <To>
      <ScheduledStopPointRef ref="BOONDOCK"/>
   </To>
</Connection>

<TransferRestriction order="1" version="any" id="NADAV+BOONDOCK">
   <Name>No Transfer</Name>
   <RestrictionType>cannotTransfer</RestrictionType>
   <FromPointRef ref="NADAV"/>
   <ToPointRef ref="BOONDOCK"/>
</TransferRestriction>
```

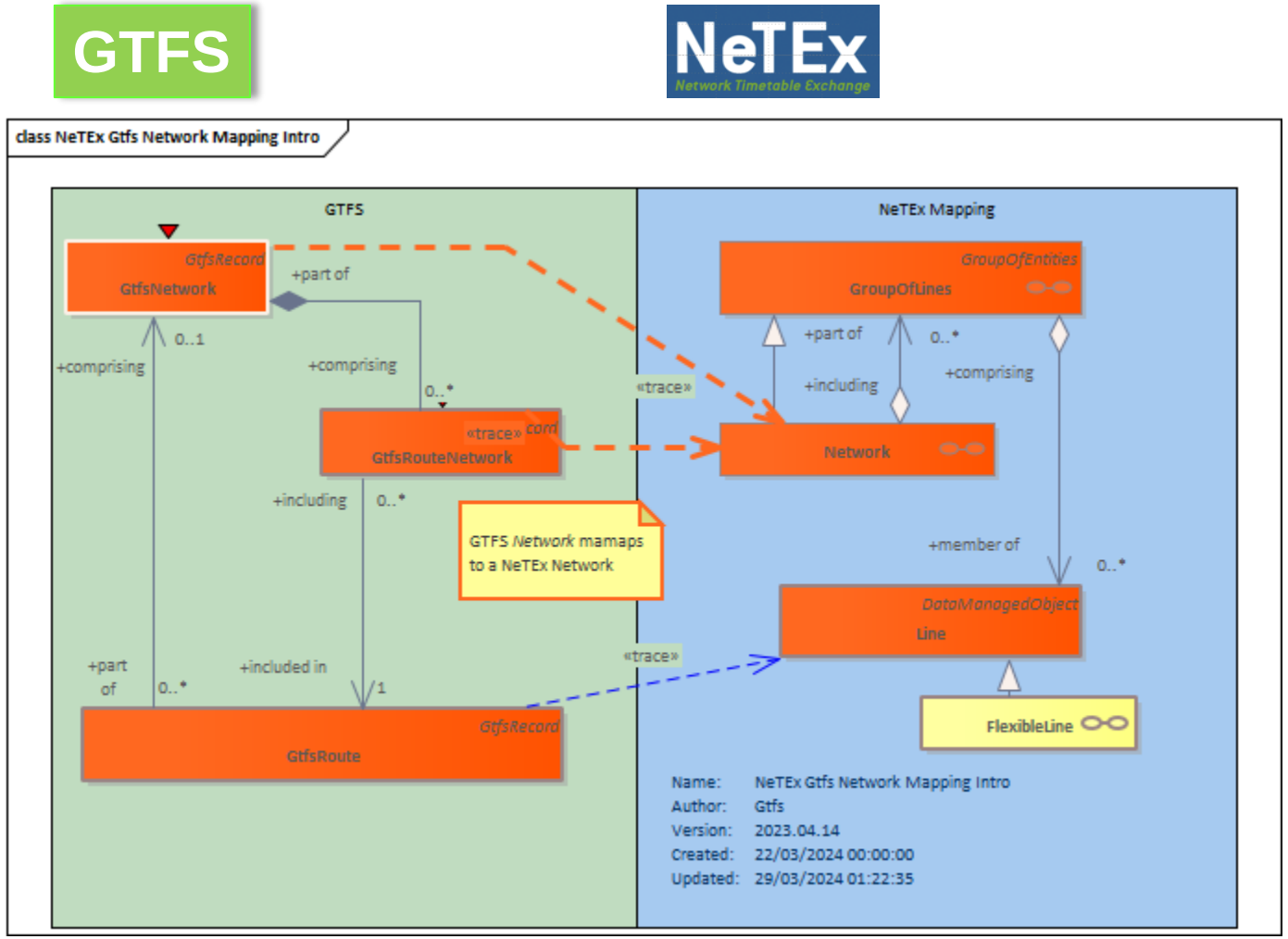
MAPPING:
(6)
GTFS NETWORK
→
NETEX NETWORK

GTFS Network Mapping Overview

Network

- **Gtfs network record ➔**
  - NeTEx NETWORK

- **Gtfs route_network record ➔**
  - NeTEx NETWORK list of member LINEss

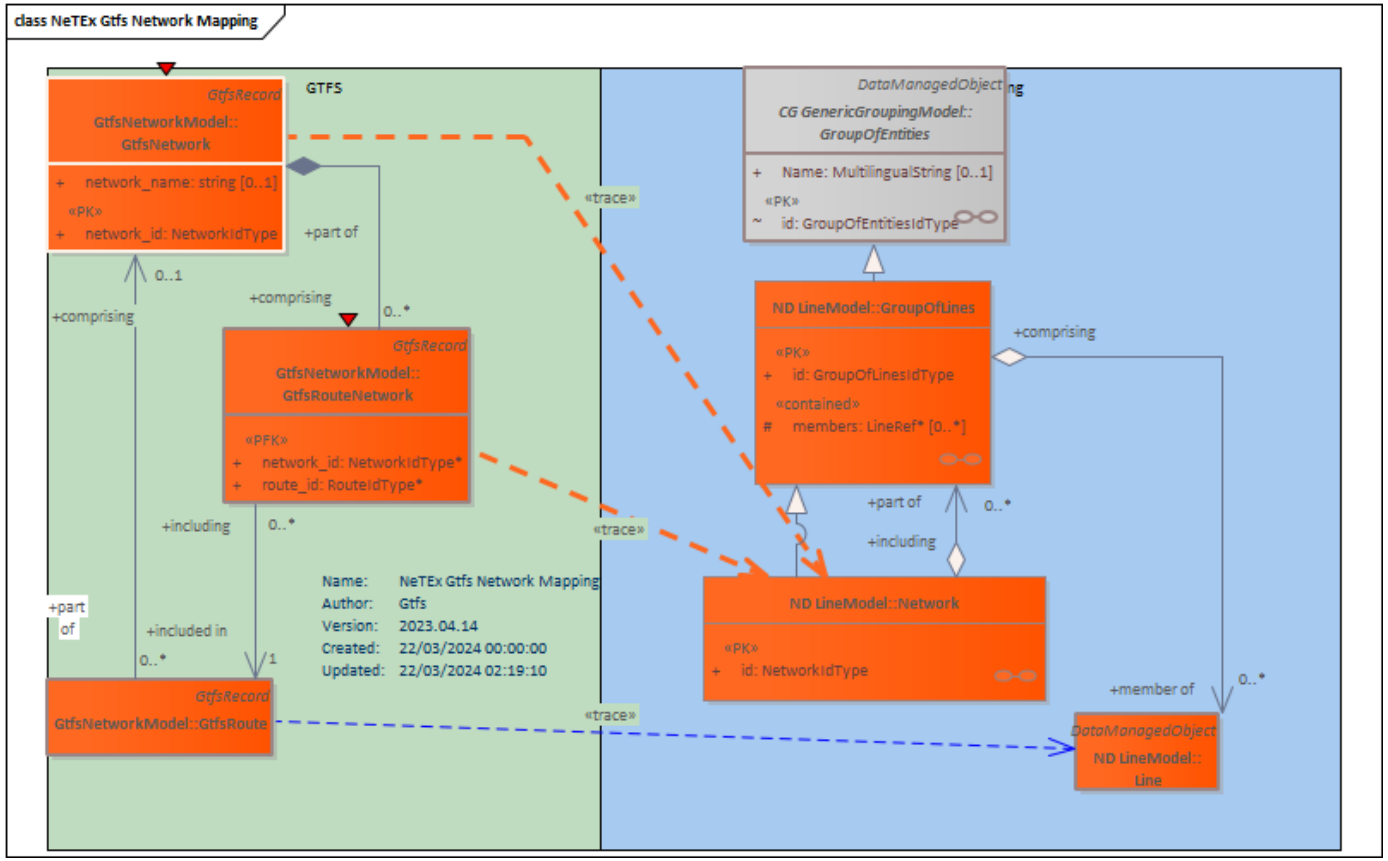


GTFS Network Mapping Details

Network

- **Gtfs network record ➔**
  - NeTEx NETWORK

- **Gtfs ruote_network record ➔**
  - NeTEx NETWORK list of member LINEs



MAPPING:
(7)
GTFS AREA
→
NETEX NETWORK

GTFS Area Mapping Overview

Gtfs area record ➔

Fares

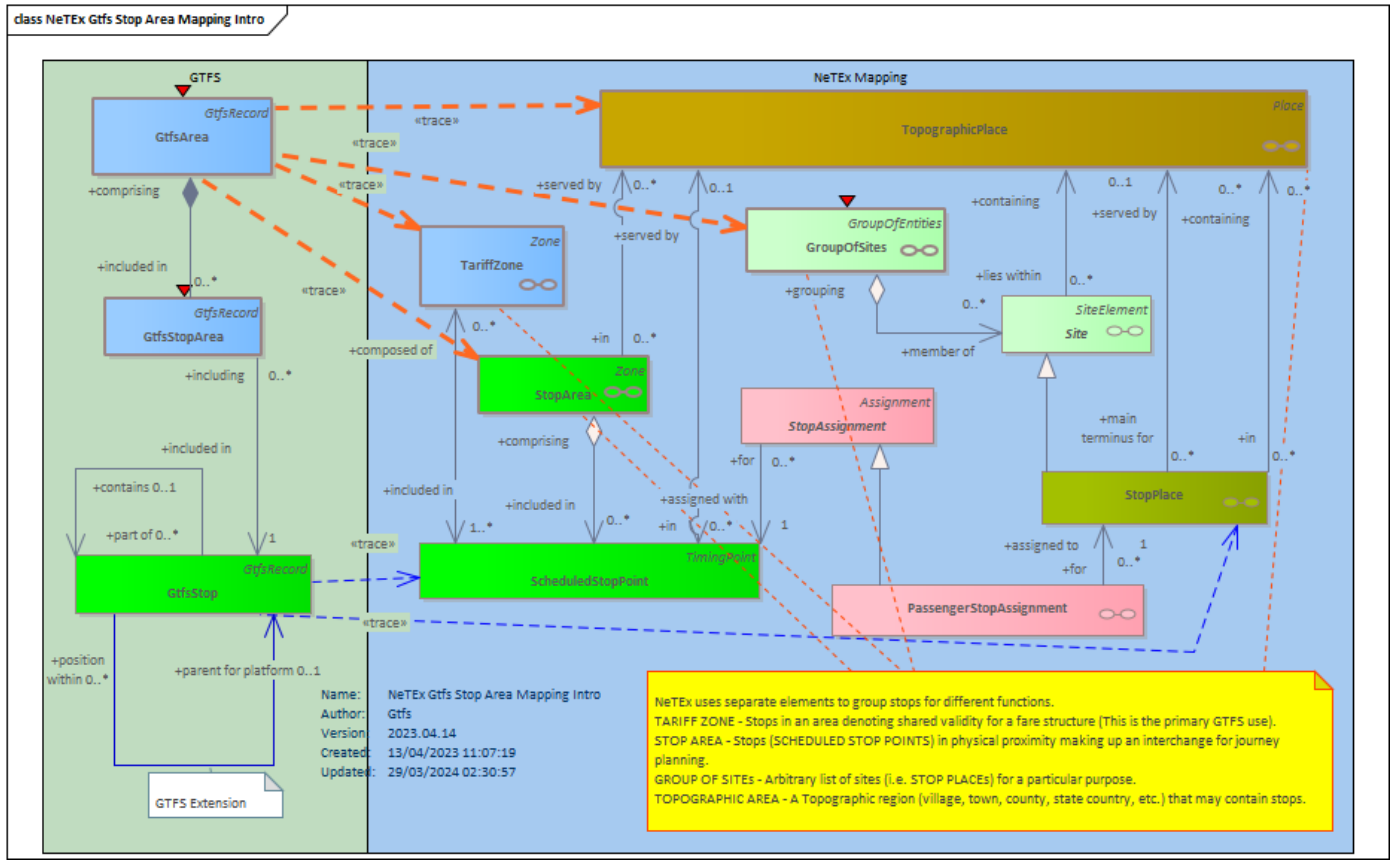
- NeTEx TARIFF ZONE

Interchange

- NeTEx STOP AREA

Locality, region

- NeTEx TOPOGRAPHIC AREA



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GTFS Area Mapping Details

GTFS

NeTEx
Network Timetable Exchange

Gtfs area record ➔

Mapping depends on function

Fares

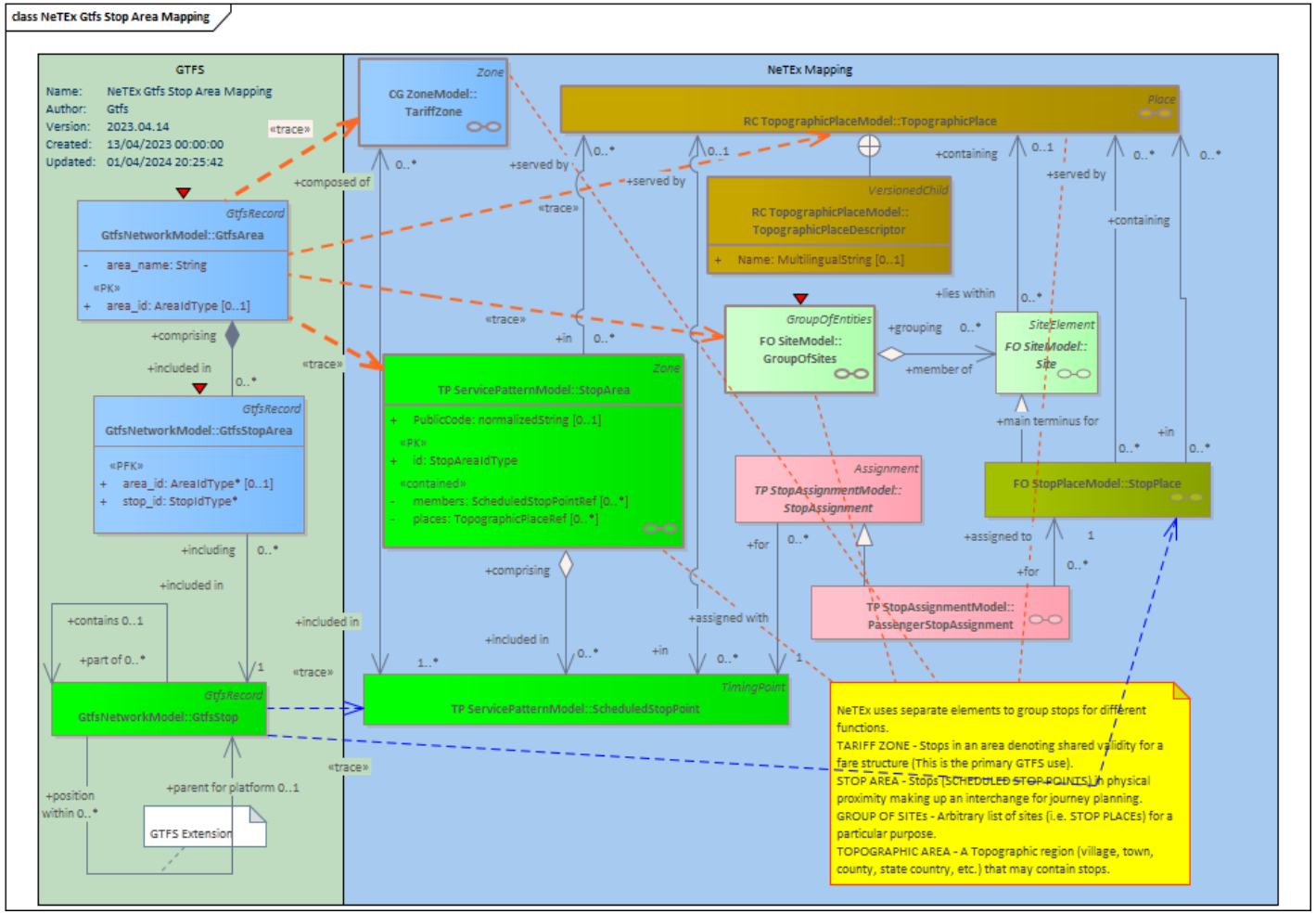
- NeTEx TARIFF ZONE

Interchange

- NeTEx STOP AREA

Locality, region

- NeTEx TOPOGRAPHIC AREA



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MAPPING:
(8)
GTFS ROUTE
→
NETEX LINE

GTFS

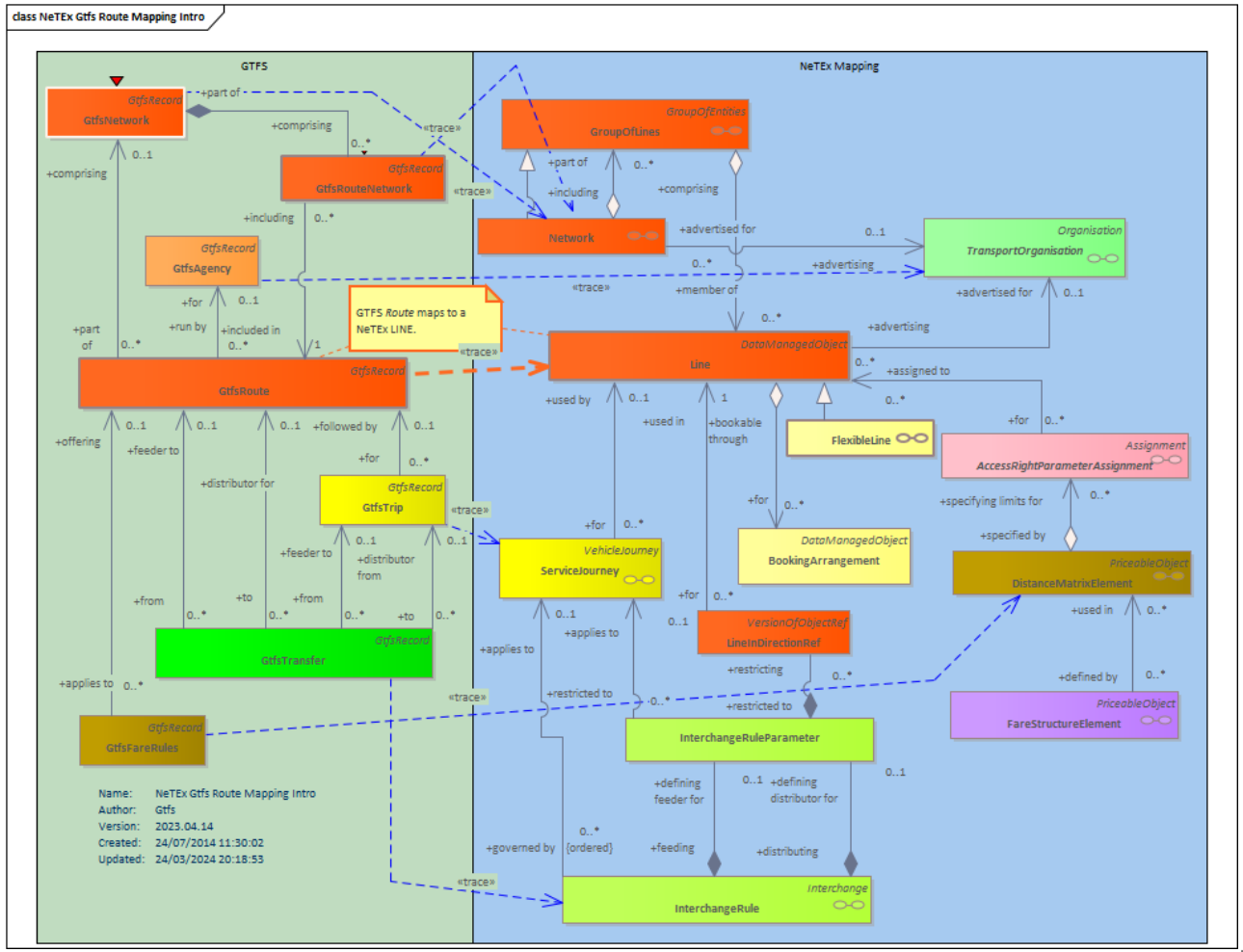
Mapping Overview: GTFS Route

- GTFS does not include a reusable ROUTE layer of links, nodes, etc – GTFS “route” is just the equivalent of a named Transmodel LINE, with an associated GTFS shape record for a a spatial PROJECTION (ie not a separate NeTEX ROUTE)
- Key Equivalences
  - GTFS Route = TM LINE
  - GTFS Type of Route = TM MODE
  - GTFS Extensions Type of route also gives a TM SUBMODE
- Route Sort Order
  - GTFS Route Sort Order attribute = TM extension: e.g. key value on a GROUP OF LINES /LINE

GTFS Routes Mapping Overview

Network

- **Gtfs routes record ➔**
  - NeTEx LINE



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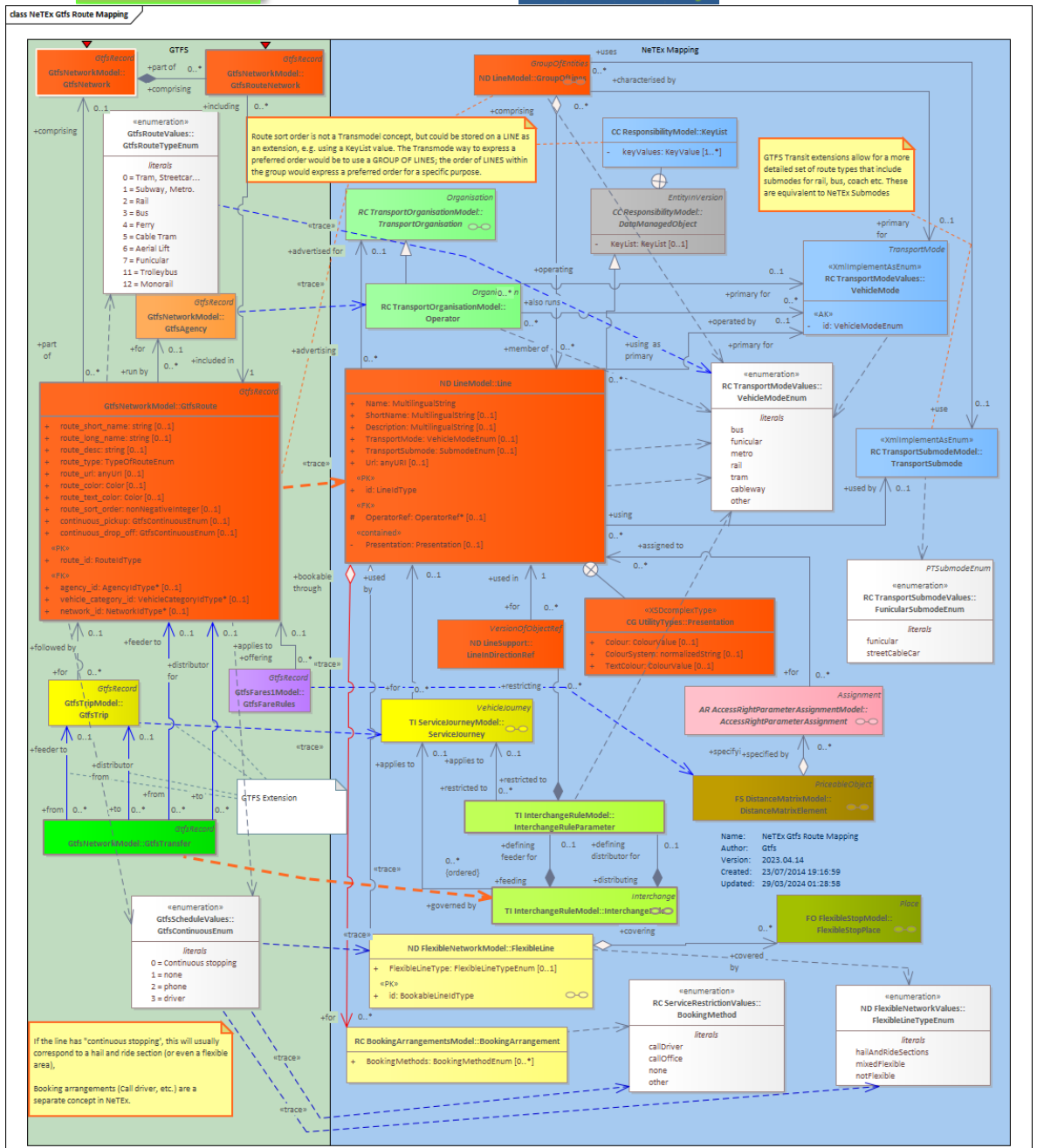
GTFS Routes Mapping - Details

Network

- **Gtfs Routes record**
  - ➔ NeTEx LINE
- GTFS Route Type → VehicleMode

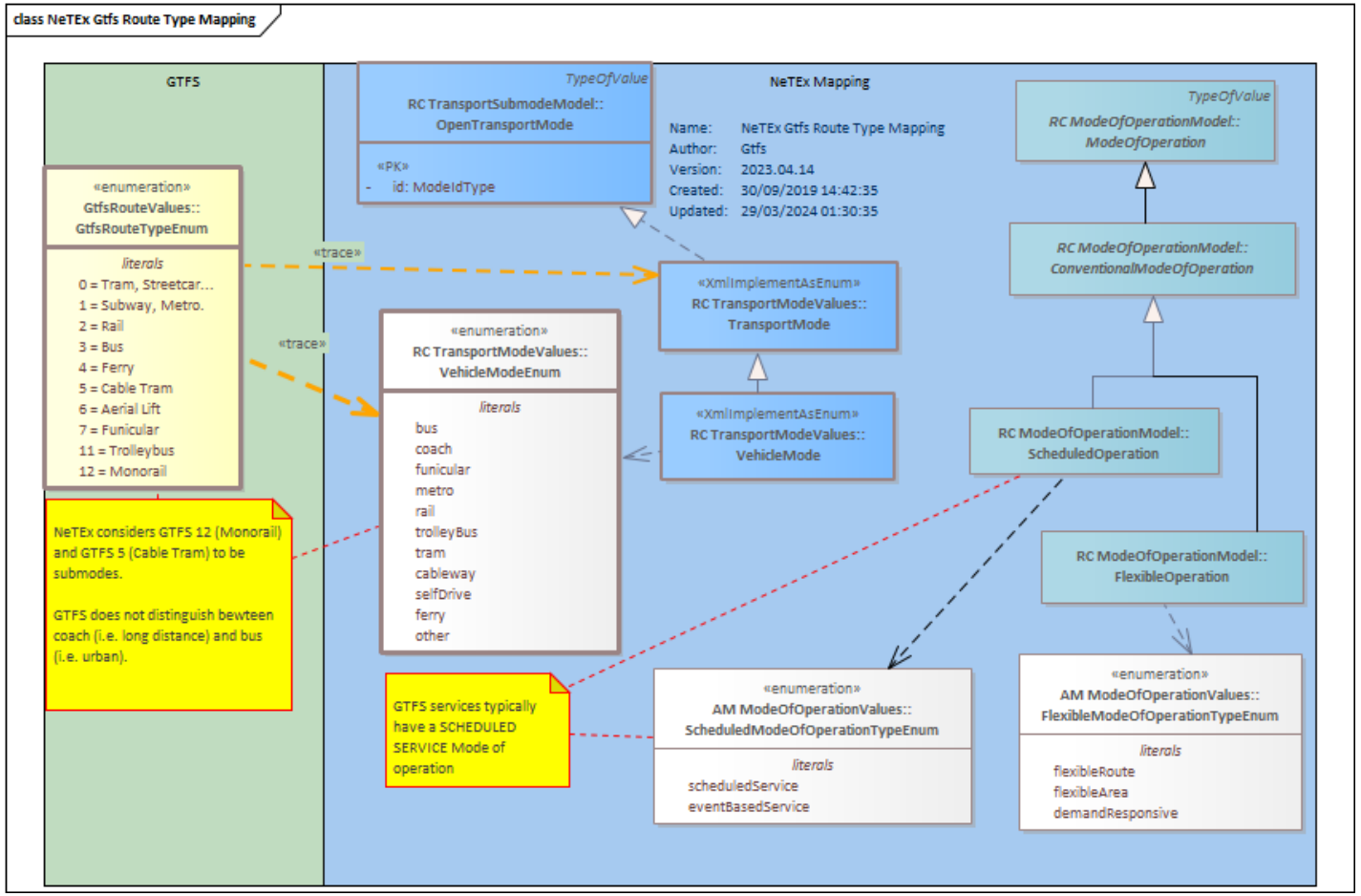
- NB GTFS extensions allows for submodes



GTFS Route Type Mapping Overview

Network

- **Gtfs RouteType enumeration ➔**
  - NeTEx VEHICLE MODE



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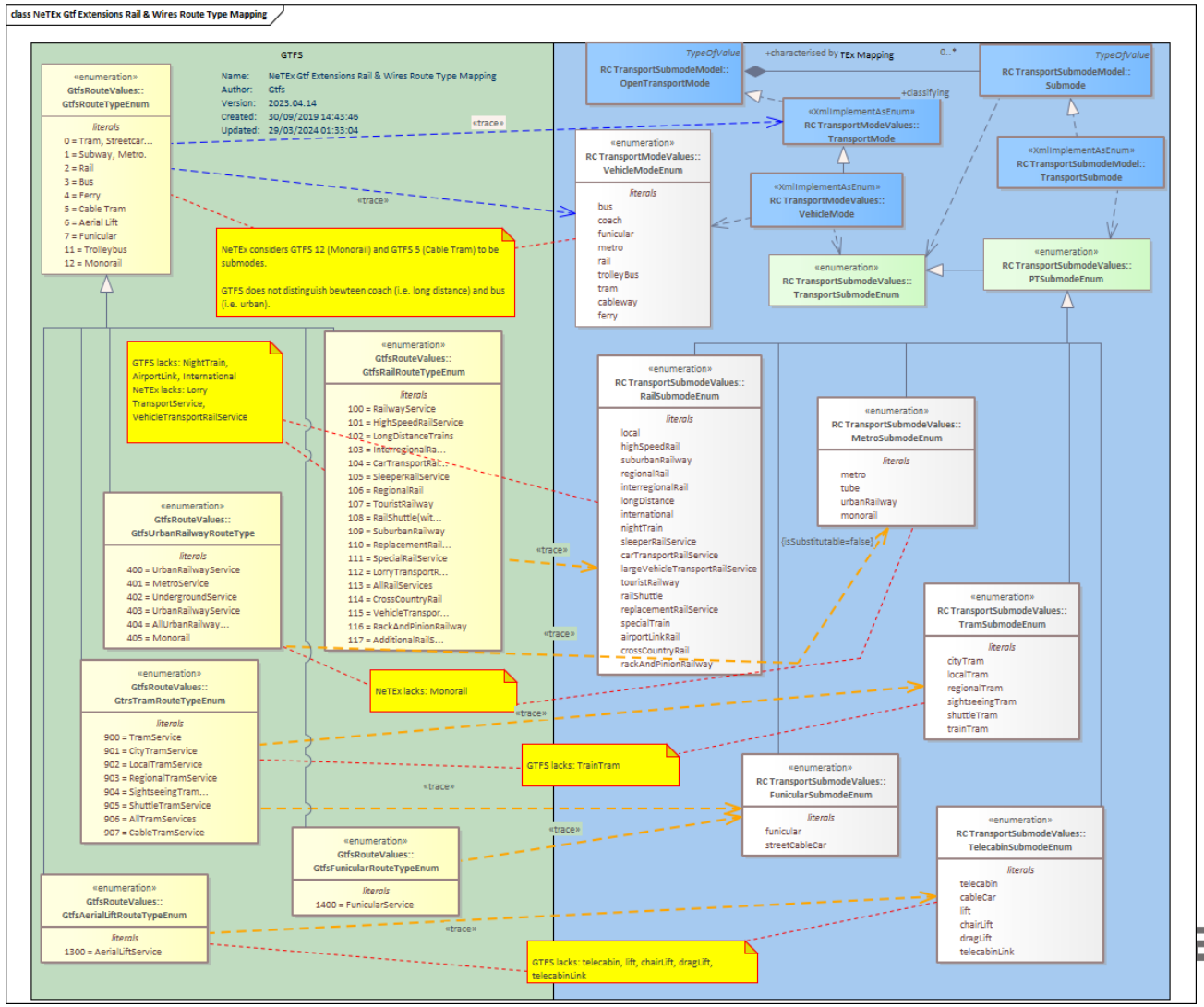
GTFS Extensions
Route Type Mapping Details – Rail modes

Network

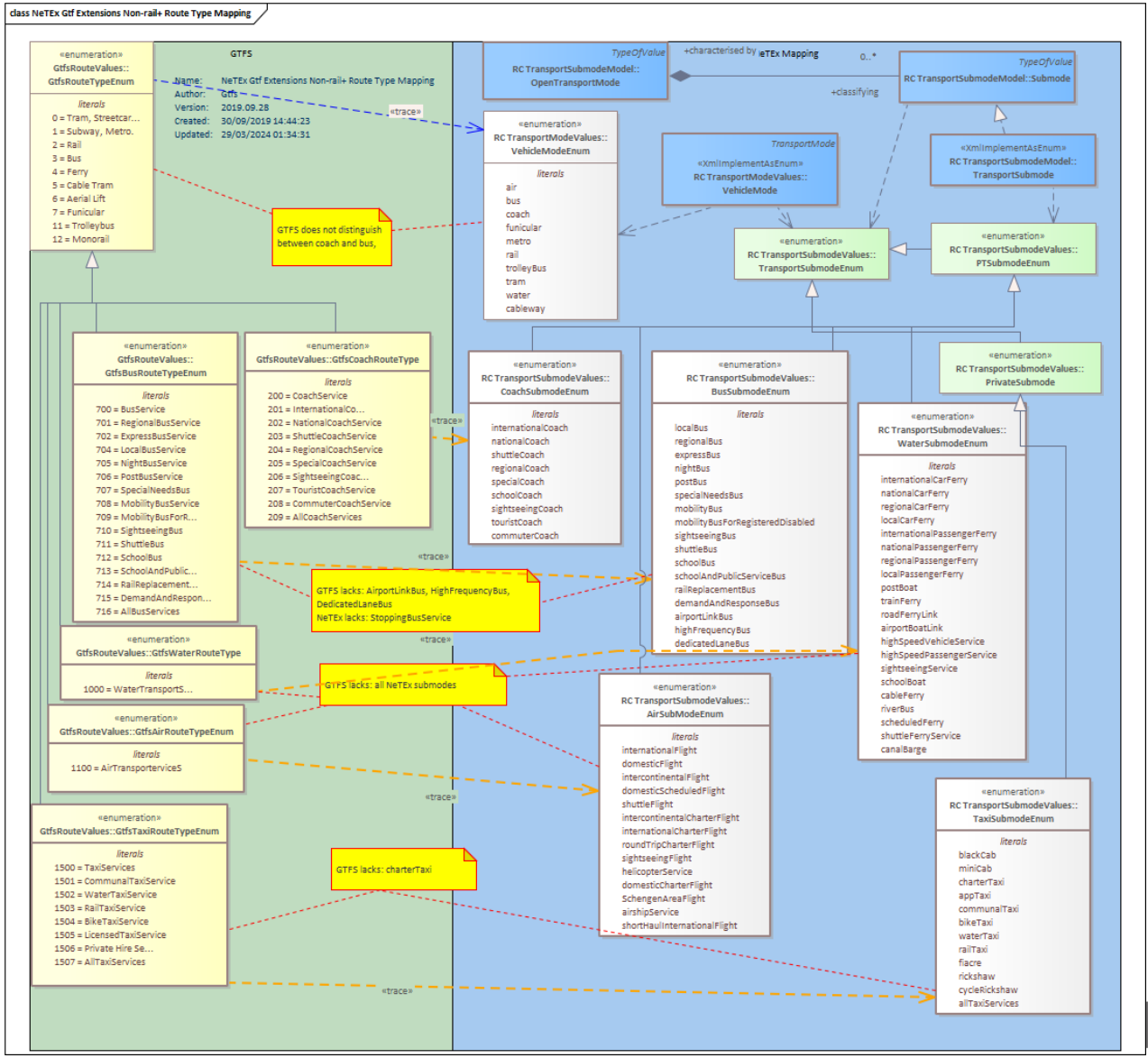
- **Gtfs RouteType enumeration** ➔
- -->NeTEx Transport SUbMode MODE



GTFS Extensions Route Type Mapping Details – Non rail modes

Network

- **Gtfs routeType enumeration** ➔
  - NeTEx Transport SUbMode MODE

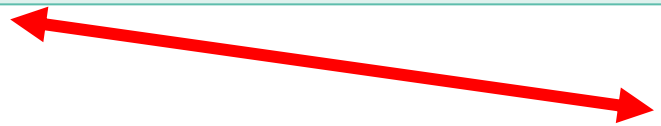


An Example mapping - GTFS route to NeTEx LINE

GTFS

CSV

routes.txt route_id,agency_id,route_short_name,route_long_name,route_desc,route_type,route_url,route_color,route_text_color
AB,DTA,10,Airport - Bullfrog,,3,http://www.demoagency.org/ab,00FFFF,00FFFF



NeTEx Network Timetable Exchange


```
<Line version="any" id="AB">
   <Name>Airport - Bullfrog</Name>
   <Description>From Airport to Bullfrog</Description>
   <TransportMode>bus</TransportMode>
   <Url>http://www.demoagency.org/ab</Url>
   <PublicCode>10</PublicCode>
   <AuthorityRef version="any" ref="DTA"/>
   <Presentation>
      <Colour>00FFFF</Colour>
      <TextColour>00FFFF</TextColour>
   </Presentation>
</Line>
```

Mapping:
(9)
GTFS Service
(Gtfs Calendar + GtfsCalendarDate)
→
NeTEx DAY TYPE ASSIGNMENT + DAY TYPE

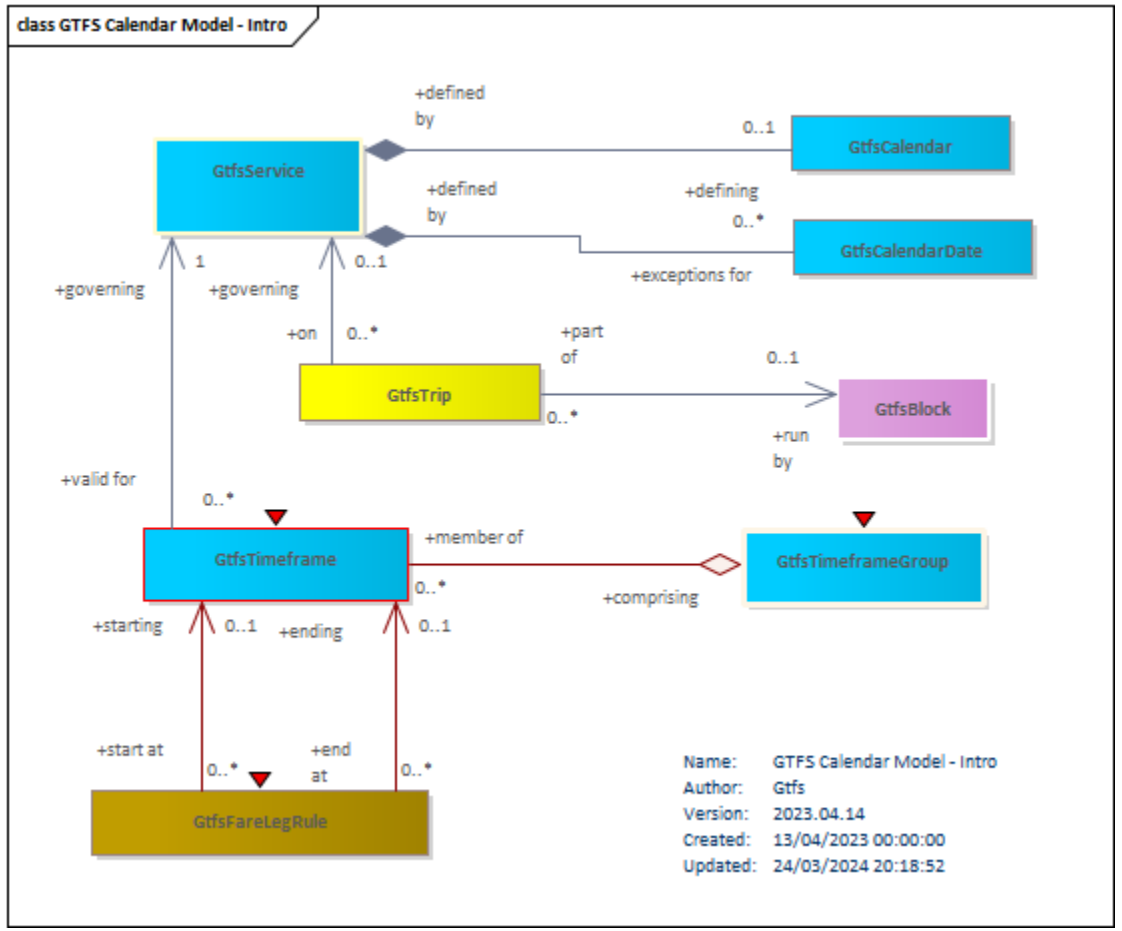
GTFS Service Calendar - Overview

GTFS

GTFS service used to set date conditions on trips and fares

Referenced by GTFS calendar and calendar_date

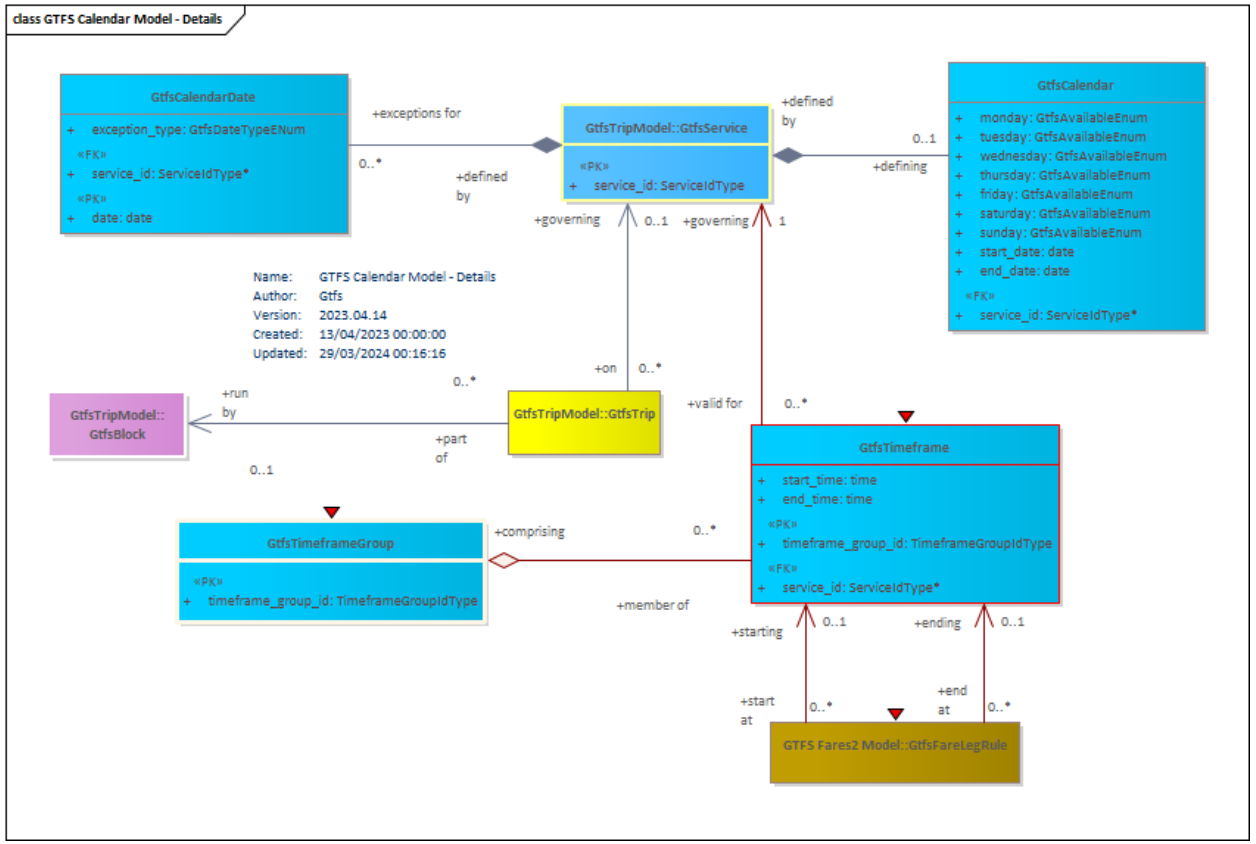
- NB No actual service record



GTFS Service Calendar - Details

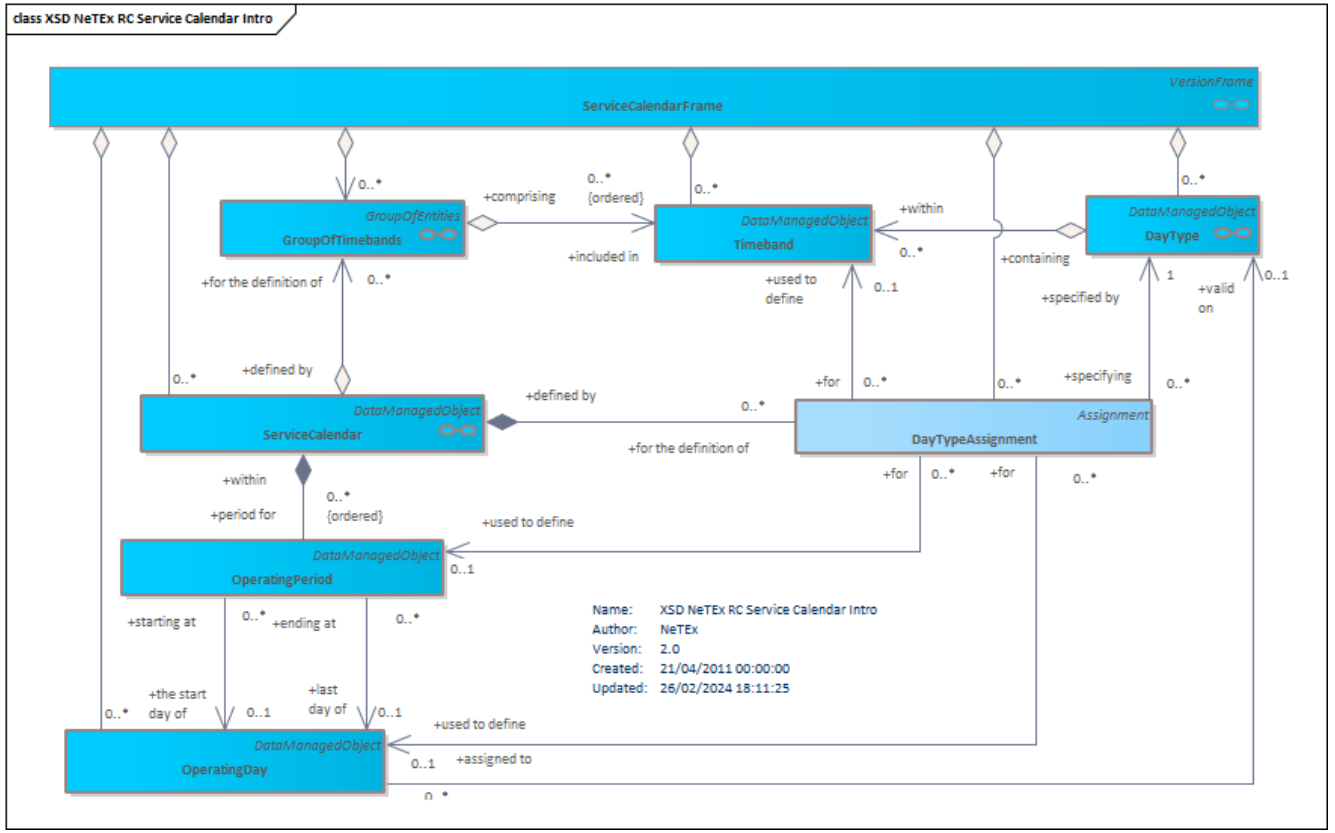
GTFS

Used to set date conditions on trips and fares

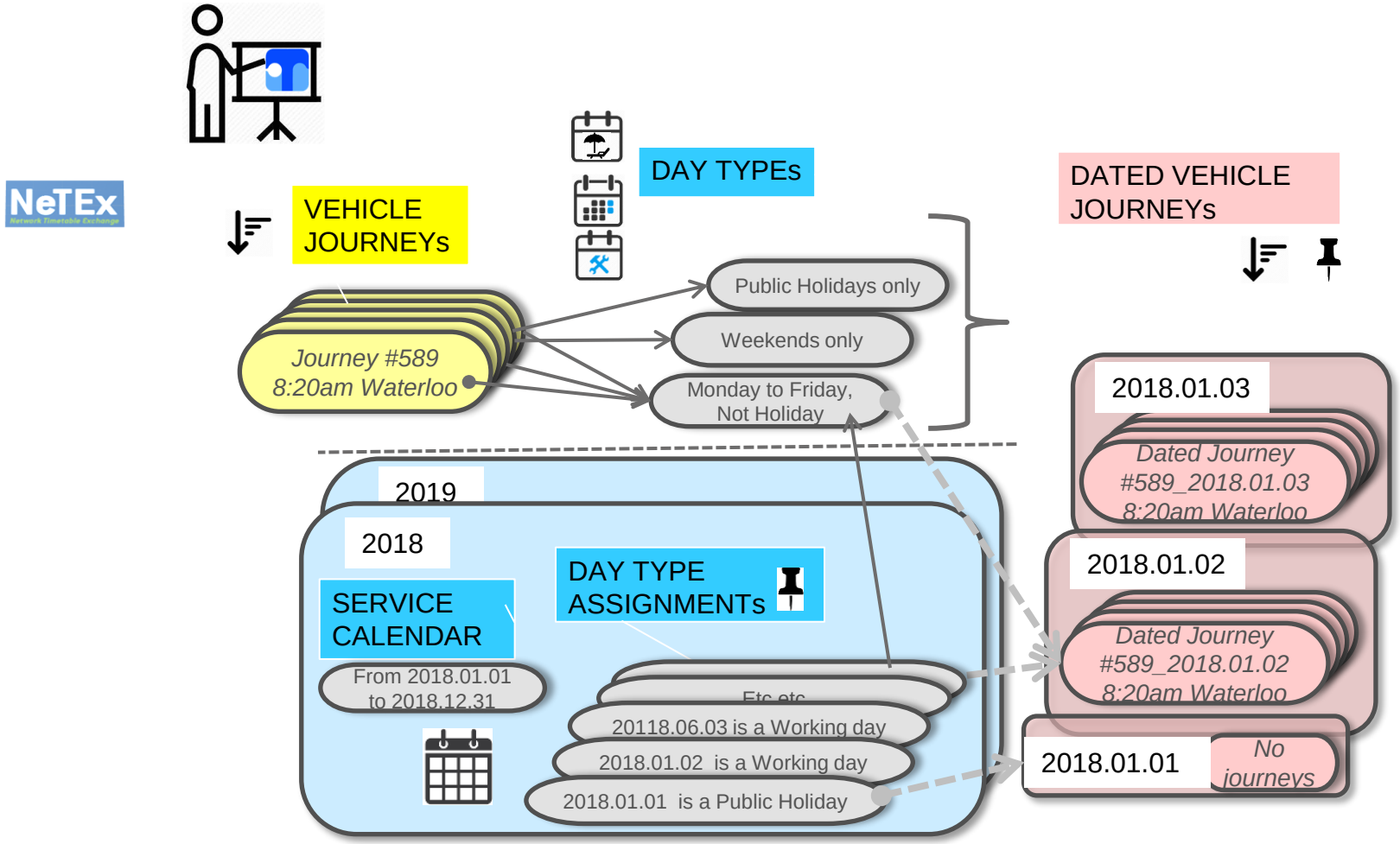


Transmodel/ NeTEx Service Calendar

Transmodel SERVICE CALENDAR separates DAY TYPE from dated OPERATING DAYs and/or OPERATING PERIODs



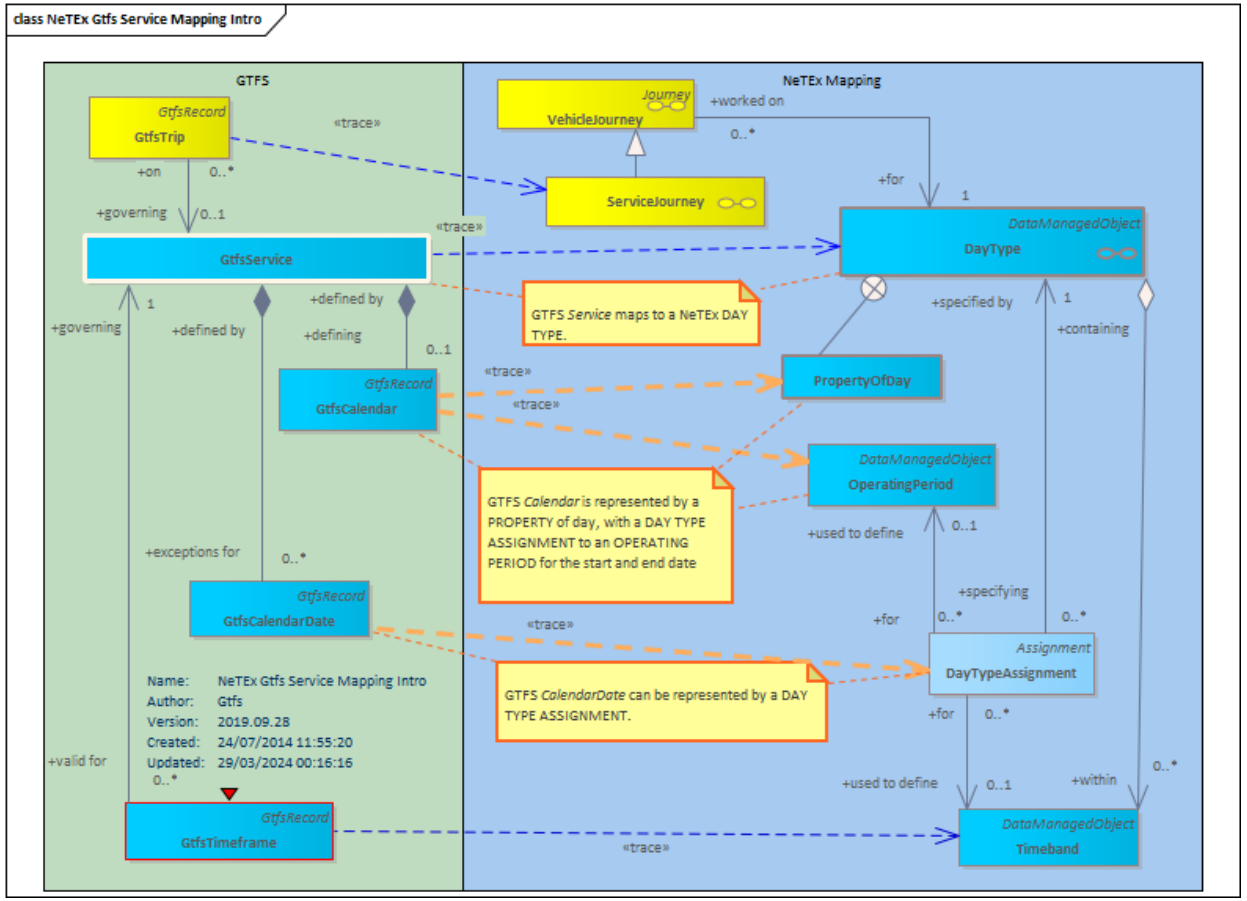
Dated and undated journeys



GTFS Calendar Mapping Overview

Service Calendar

- **Gtfs service [implied] record)➔**
  - ❑ DAY TYPE
- **Gtfs calendar record ➔**
  - ❑ PROPERTY OF DAY+ OPERATING PERIOD
- **Gtfs calendar_date record ➔**
  - ❑ DAY TYPE + DAY TYPE ASSIGNMENT
- **Gtfs timeframe record ➔**
  - ❑ TIMEBAND



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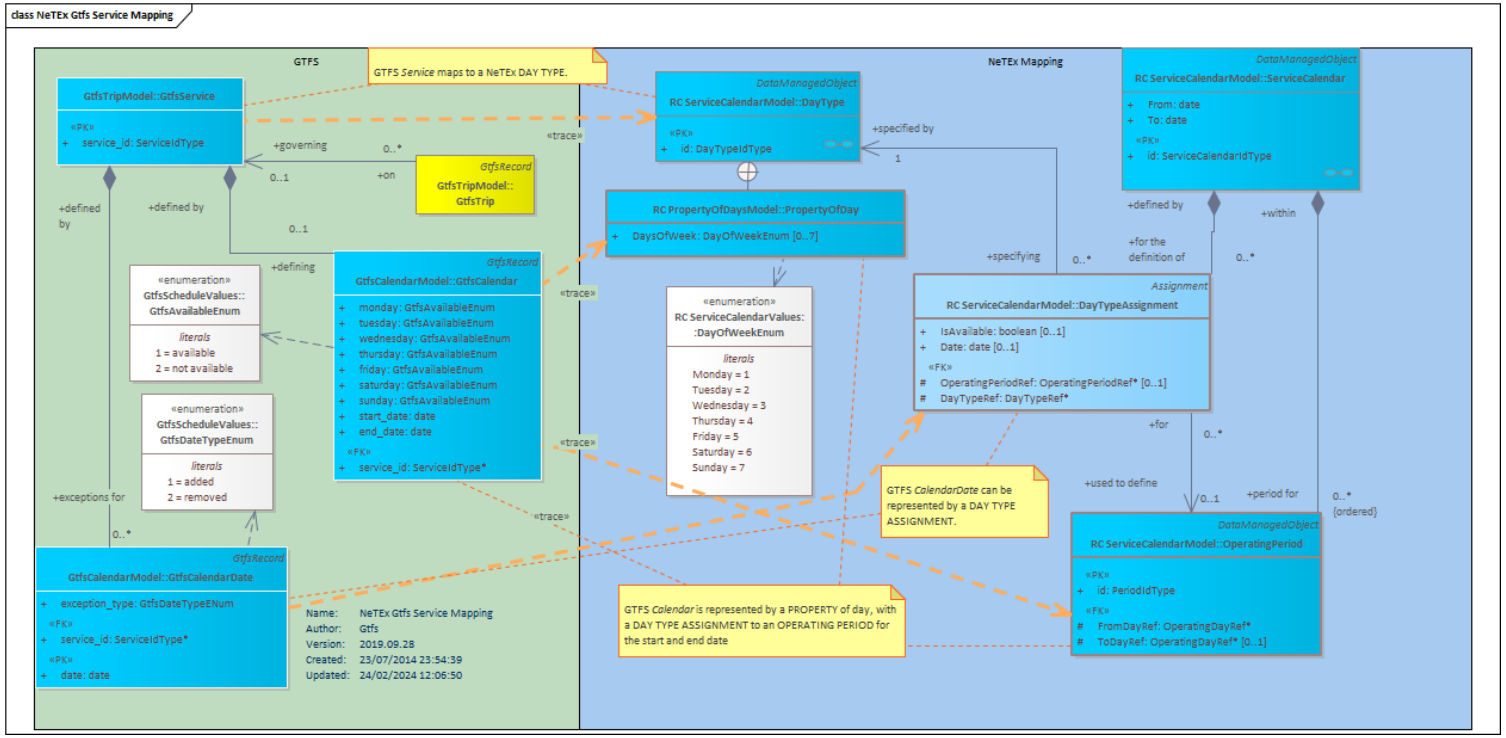
GTFS Calendar Mapping - Details

GTFS

NeTEx Network Timetable Exchange

Service Calendar

- **Gtfs service [(mplied record) ➔**
  - DAY TYPE
- **Gtfs calendar record ➔**
  - PROPERTY OF DAY+ OPERATING PERIOD
- **Gtfs calendar_date record ➔**
  - DAY TYPE + DAY TYPE ASSIGNMENT
- **Gtfs calendar_date record ➔**
  - DAY TYPE + DAY TYPE



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datapt

June 24

An Example mapping - GTFS calendar to NeTEx LINE

GTFS

```
service_id,monday,tuesday,wednesday,thursday,friday,saturday,sunday,start_date,end_date
FULLW,1,1,1,1,1,1,1,20070101,20101231
```

NeTEx Network Timetable Exchange

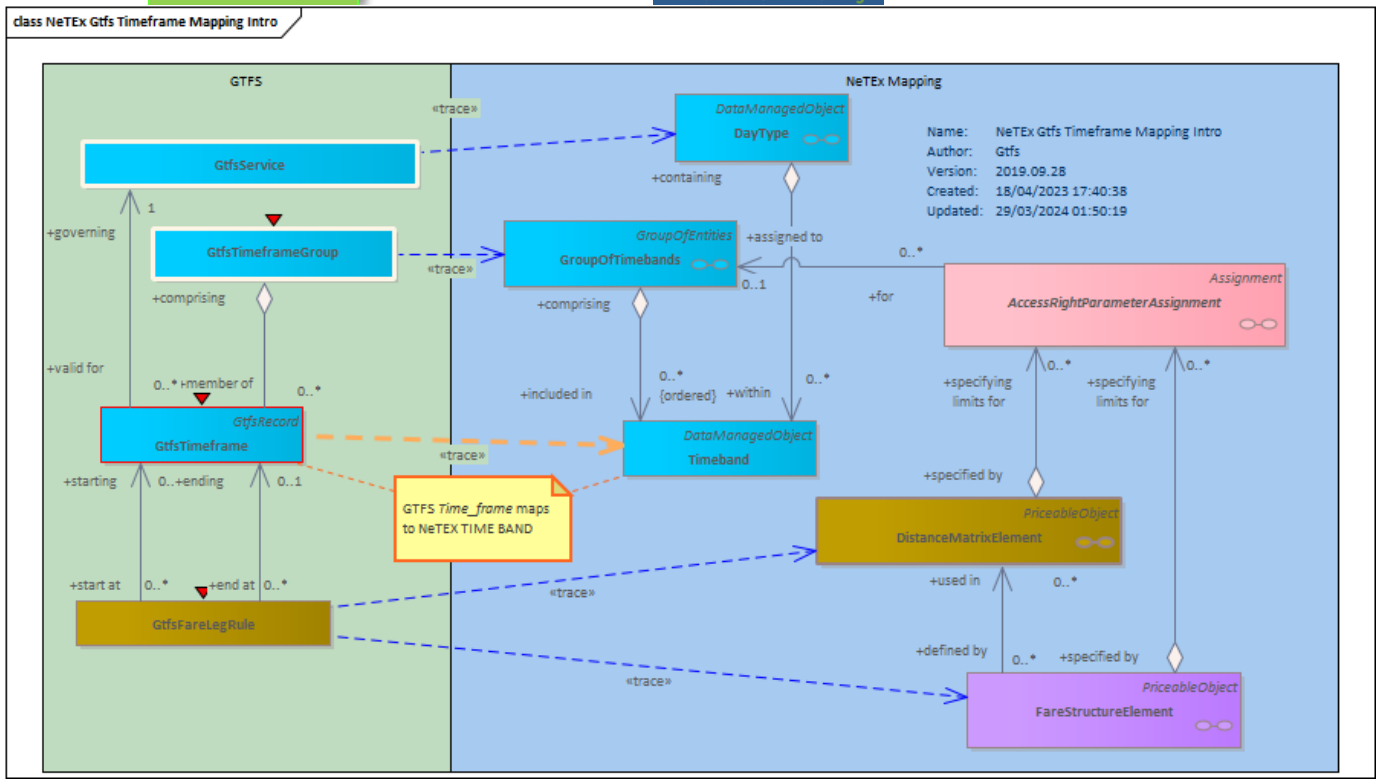

```
<ServiceCalendar version="any" id=":FULLW">
    <FromDate>2007-01-01</FromDate>
    <ToDate>2010-12-31</ToDate>
 <dayTypes>
    <DayType version="any" id=":FULLW">
      <Name>Weekdays</Name>
      <properties>
        <PropertyOfDay>
          <DaysOfWeek>Monday Tuesday Wednesday Thursday Friday</DaysOfWeek>
        </PropertyOfDay>
      </properties>
    </DayType>
 </dayTypes>
</ServiceCalendar>
```

MAPPING
(10)
GTFS SERVICE
(GTFS TIMEFRAME)
→
NETEX TIME BAND

GTFS Timeframe Mapping Overview

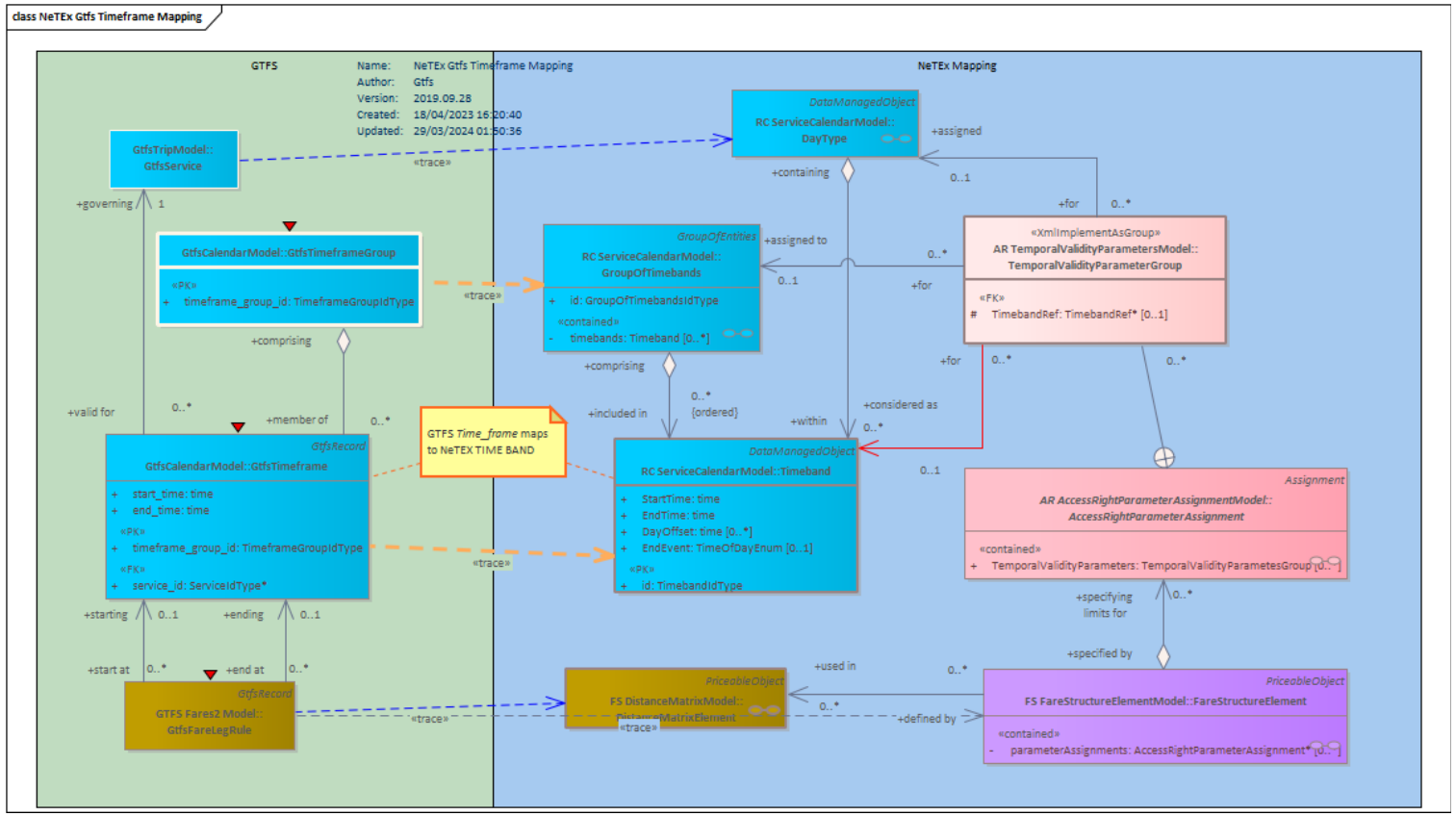
Used to specified allowed times of travel for GTFS fares2

- **GTFS timeframe_group [implied] record ➔**
- NeTEx GROUP OF TIMEBANDS
- **Gtfs Timeframe record ➔**
- NeTEx TIMEBAND



GTFS Timeframe Mapping Details

- **GTFS Timeframe record**
- NeTEx TIMEBAND



MAPPING:
(11)
GTFS TRIP
→
NETEX SERVICE JOURNEY

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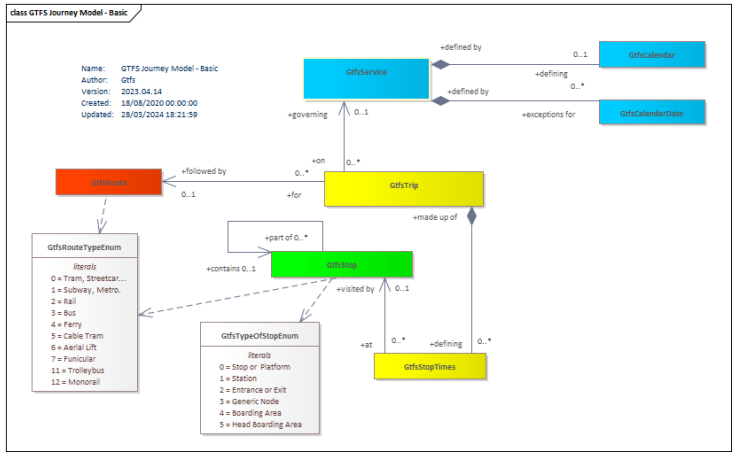
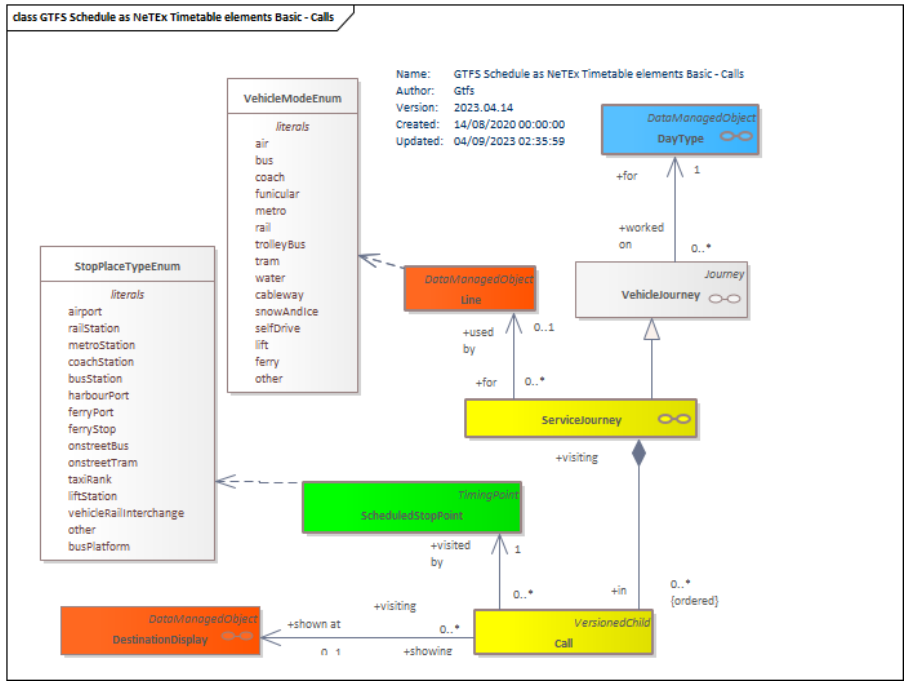
Mapping GTFS Trips to NeTEx Journeys – The basics

Easy!

- You say *route*, we say LINE…
- You say *trip*, we say VEHICLE JOURNEY...
- You say *stop_times*, we say CALL…
- You say *headsign* ,we say DESTINATION DISPLAY





GTFS

NeTEx
Network Timetable Exchange

datagpt

Mapping Overview:
GTFS Trip, GTFS Stop_Times

GTFS

- NB Terminology VEHICLE JOURNEY (=GTFS Trip)
- GTFS Doesn't separate dated / undated journey concepts
  - All journeys
  - Key Equivalences
  - GTFS Trip = SERVICE JOURNEY / TEMPLATE SERVICE JOURNEY
  - GTFS ***stop***s = CALL (View of POINT IN JOURNEY PATTERN + TIMETABLED PASSING TIMEs + DESTINATION DISPLAY)
  - GTFS Frequency = JOURNEY FREQUENCY GROUP (HEADWAY JOURNEY GROUP or RYTHMICAL FREQUENCY
- GTFS ***stop_times*** corresponds to a view (CALL) that combines PASSING TIMES, DESTINATION DISPLAYS, etc
  - Times or Frequencies repeated on each journey
  - Destination displays, etc, repeated on each journey.
  - Shape plot is for whole journey
- GTFS Can alternatively map direct to POINT

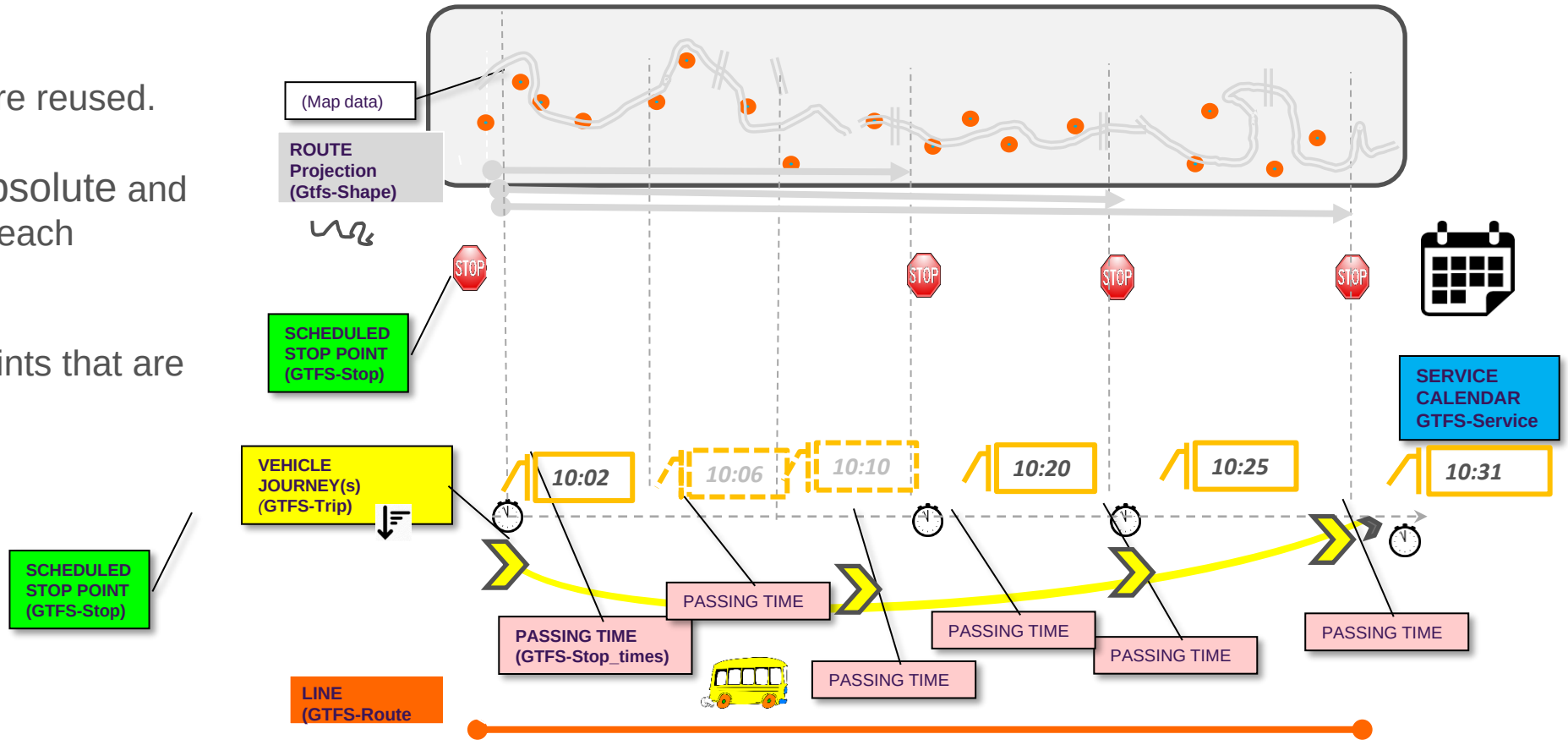
GTFS

A VEHICLE JOURNEY (Gtfs-Trip) is for a LINE

Only stops are reused.

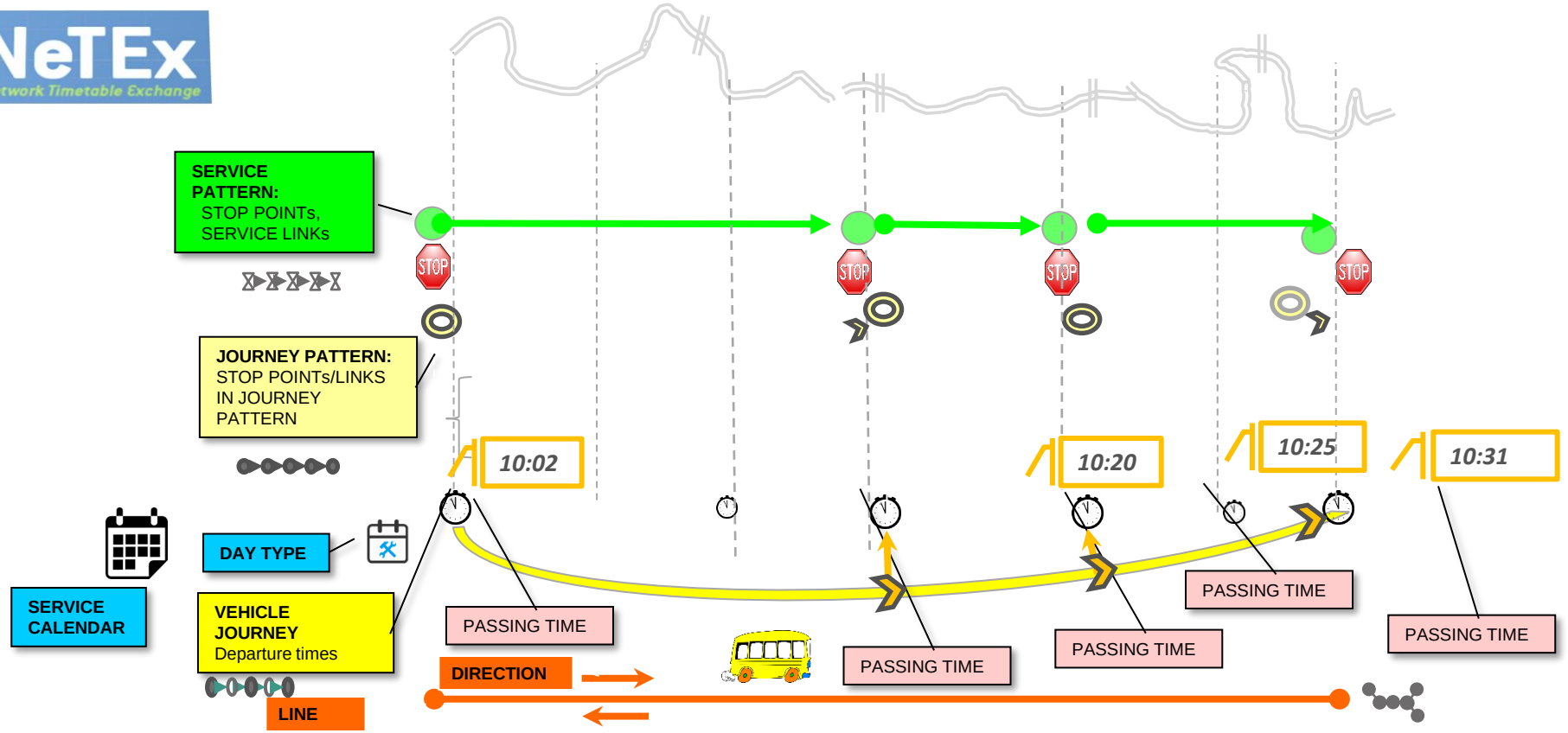
Times are absolute and repeated on each journey.

No timing points that are not stops.

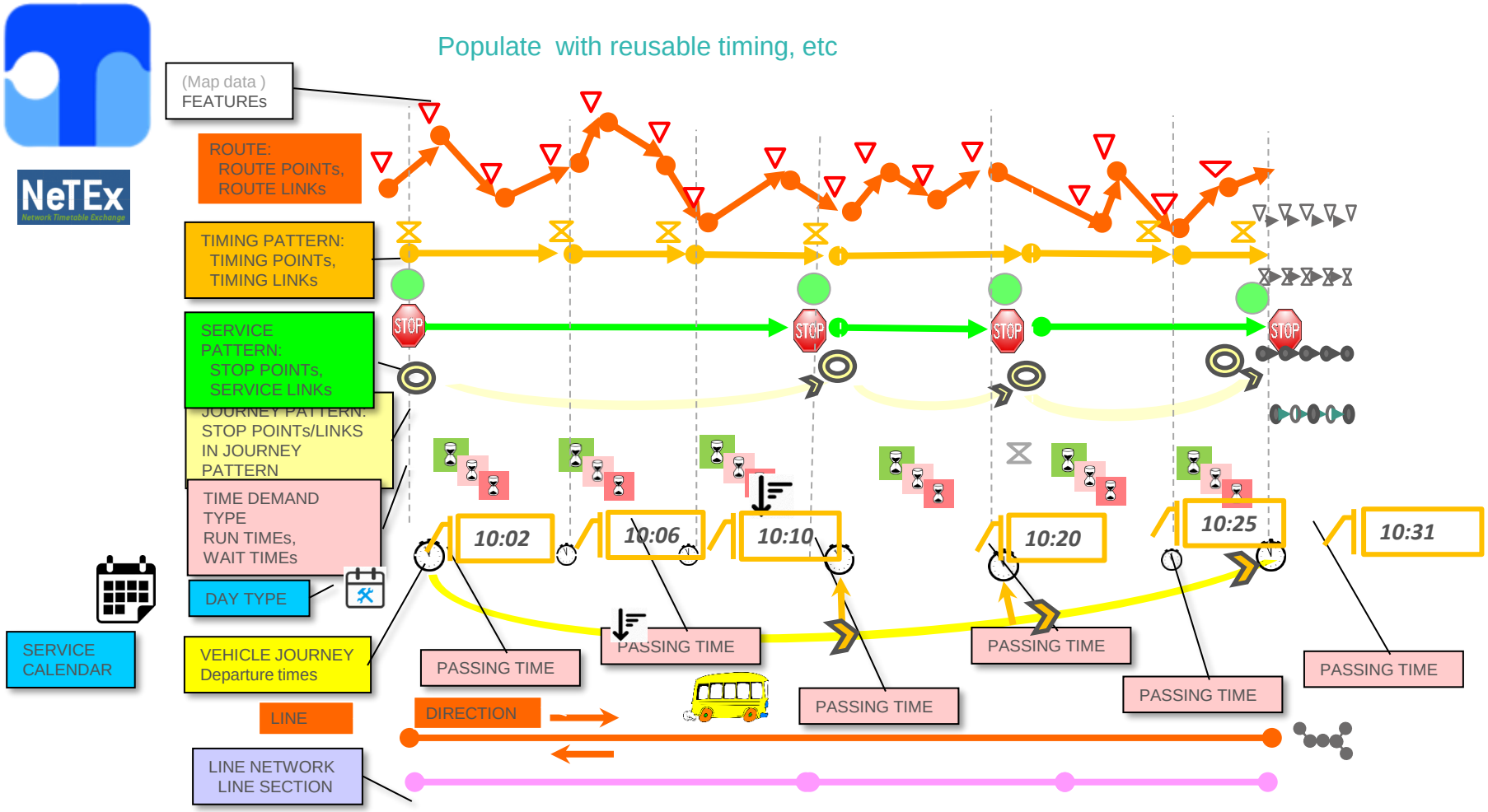


TM Minimal: A VEHICLE JOURNEY follows a JOURNEY PATTERN, for a SERVICE PATTERN, along a ROUTE for specified PASSING TIMES

Populate document with just stops, journeys and fully resolved passing times

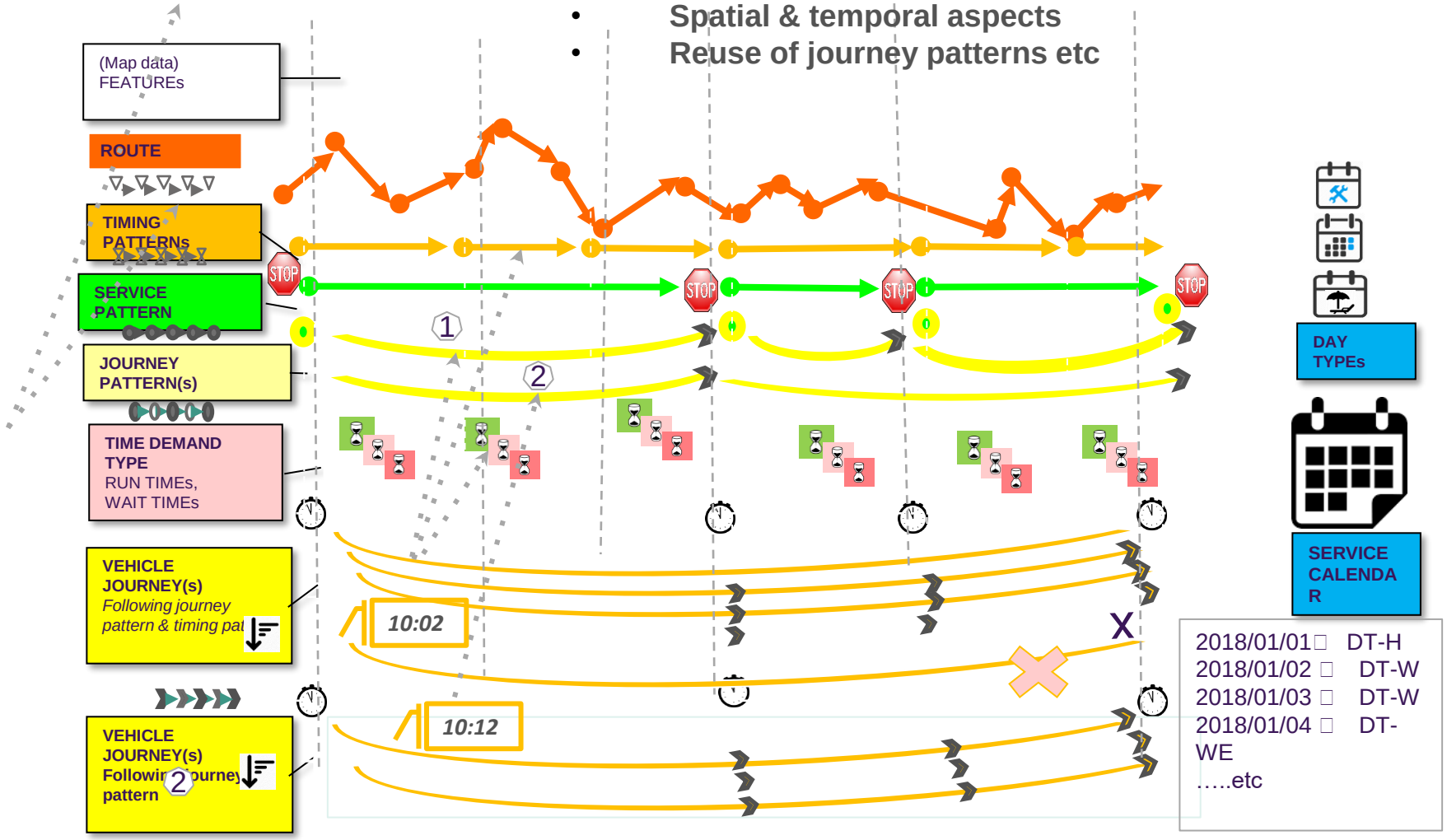


TM Full Model: A VEHICLE JOURNEY follows a JOURNEY PATTERN, to a TIMING PATTERN, over a SERVICE PATTERN, along a ROUTE during a TIME DEMAND TYPE



JTM reuse: journeys can be specified completely just by indicating a Joueney pattern and a START Time

- Separate levels of abstraction for each concept
- Spatial & temporal aspects
- Reuse of journey patterns etc

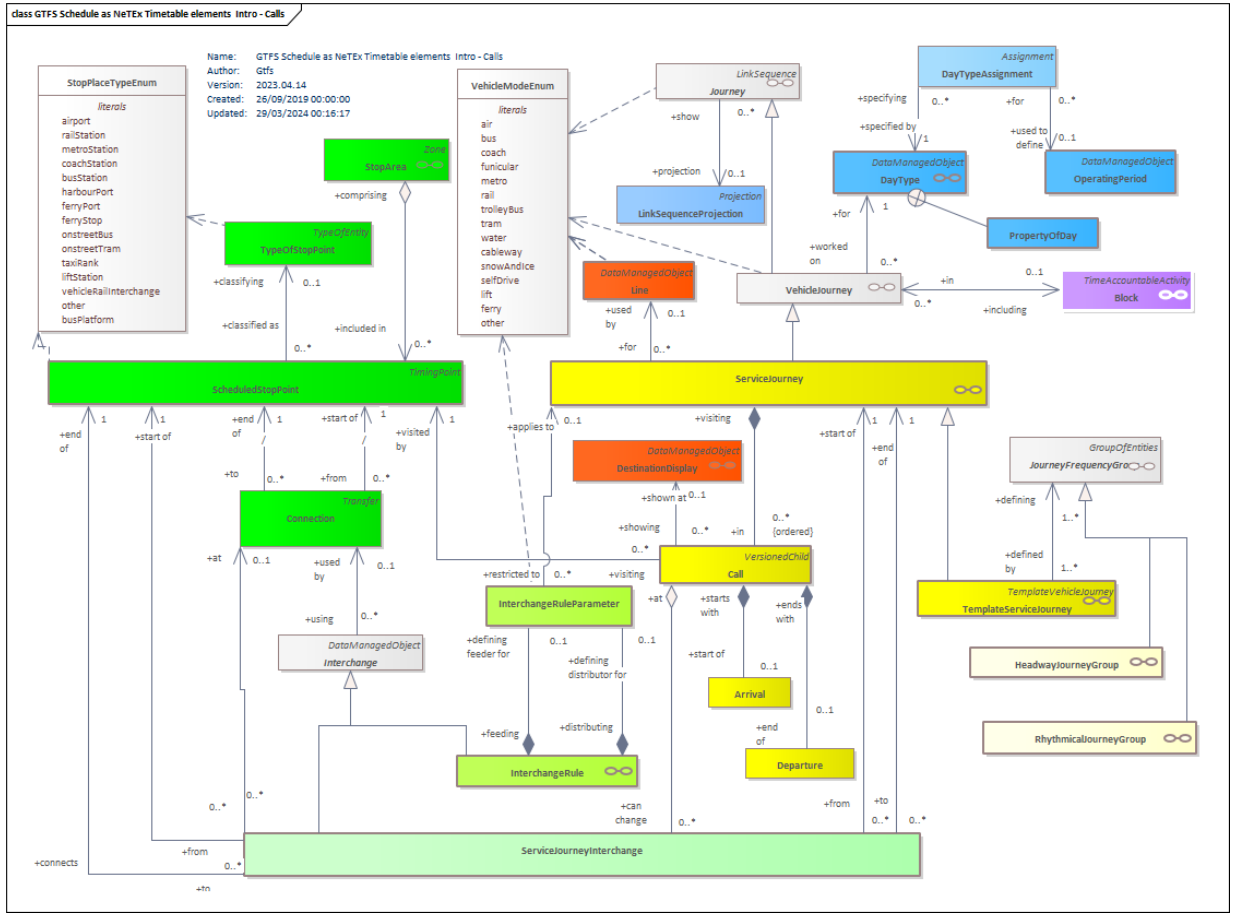


NeTEx elements equivalent to GTFS Trip record – #1 using CALL - Overview

Using NeTEX CALLs

- **trip** ➔
  - SERVICE JOURNEY
- **trip + frequency**
  - ➔ TEMPLATE SERVICE JOURNEY + HEADY FREQUENCY GROUP
- **stop times** ➔ CALL

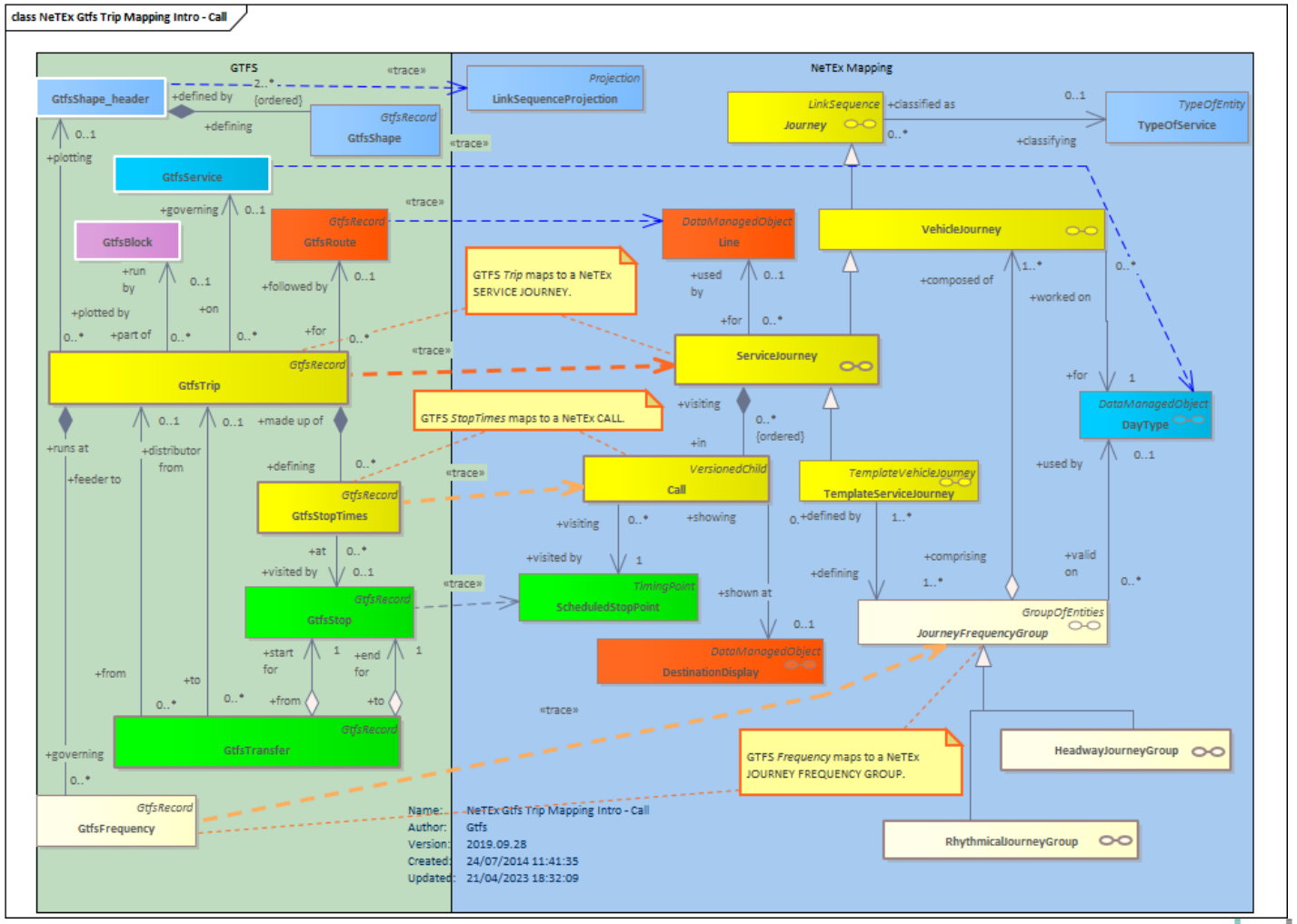
- **calendar** ➔
  - DAY TYPE
- **transfer** ➔
  - CONNECTION
  - SERVICE JOURNEY INTERCHANGE
  - INTERCHANGE RULE



GTFS Trips MAPPING #1 – Using CALLS Intro

GTFS

NeTEx Network Timetable Exchange



Timetable

GTFS trips record ➔

- NeTEx SERVICE JOURNEY

GTFS stop times ➔

- NeTEx CALL + DESTINATION DISPLAY

- If times given as frequencies, use TEMPLATE SERVICE JOURNEY

GTFS Trips MAPPING #1 using CALLs - details

GTFS

NeTEx Network Timetable Exchange

Timetable

GTFS trip record ➔

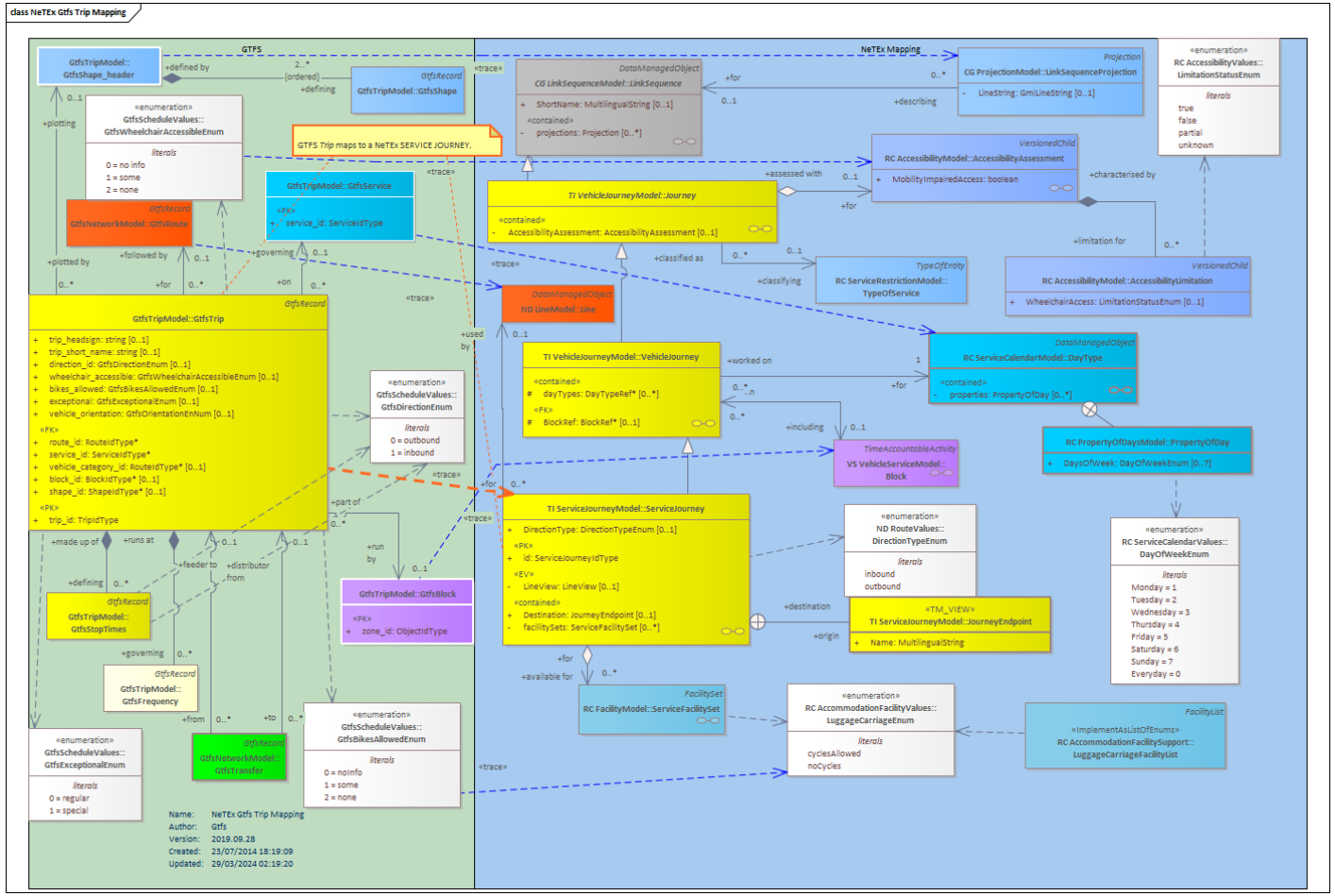
- NeTEx SERVICE JOURNEY + ACCESSIBILITY ASSESSMENT

Plot

GTFS shape record ➔

- NeTEx SERVICE JOURNEY.lineString

- Or use LINK SEQUENCE PROJECTION



GTFS stop times MAPPING #1 using CALLs - details

GTFS

NeTEx
Network Timetable Exchange

Timetable

GRFS trip record ➔

○ NeTEx SERVICE JOURNEY

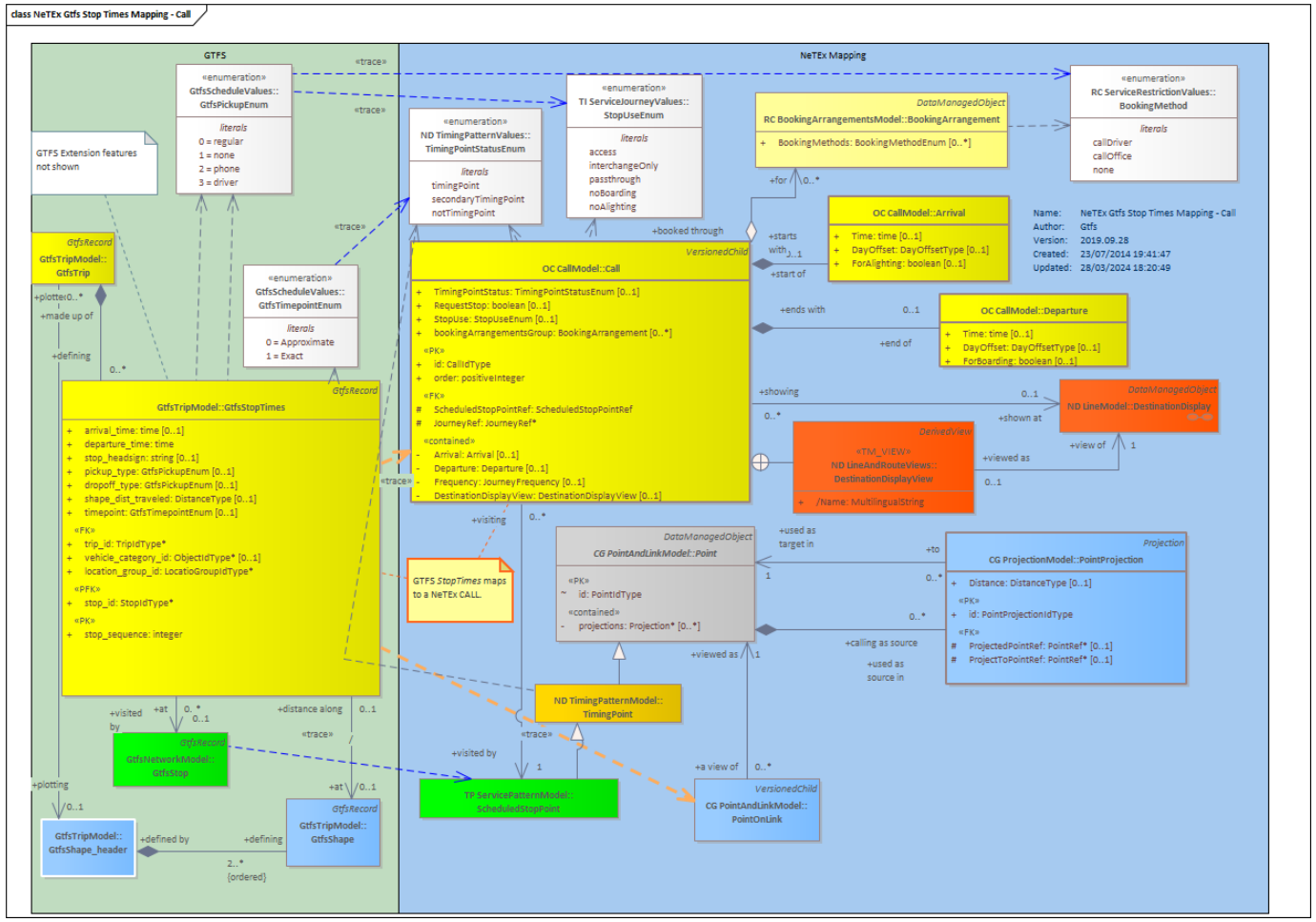
GTFS stop times ➔

- NeTEx CALL + ARRIVAL _ DEPARTURE + DESTINATION DISPLAY

Track to stop

GTFS shape➔

- NeTEx CALL + ARRIVAL _ DEPARTURE + DESTINATION DISPLAY



GTFS Frequencies Mapping - Details

Timetable /Schedule

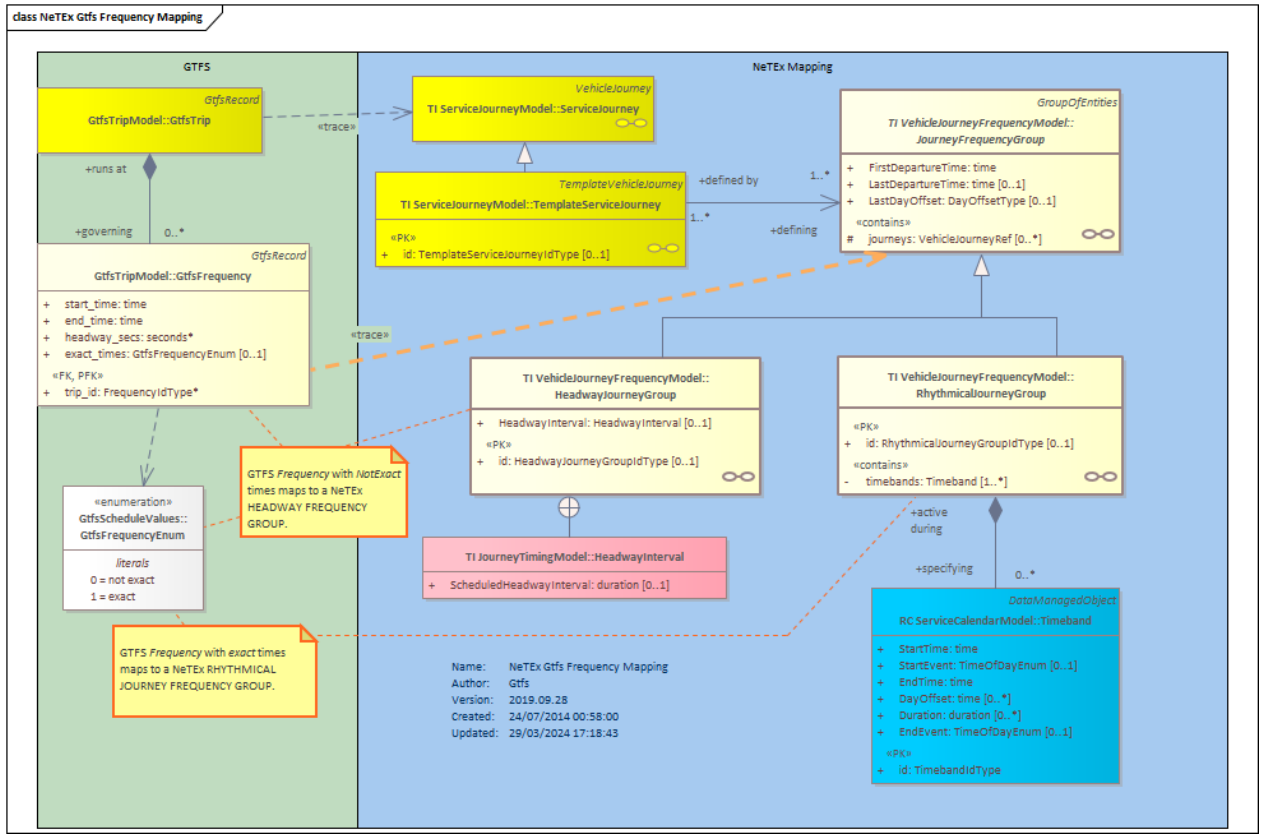
- **Gtfs trips record** ➔
  - NeTEx TEMPLATE SERVICE JOURNEY + JOURNEY FREQUENCY GROUP

Interval based frequencies

- **Gtfs Frequencies record** ➔
  - NeTEx SERVICE HEADWAY JOURNEY GROUP + HEADWAY INTERVAL

Minutes past hour frequencies

- **Gtfs Frequencies record** ➔
  - NeTEx SERVICE RHYTHMICAL JOURNEY GROUP + TIME BANDs



An Example mapping - GTFS frequency to NeTEx HEADWAY

```
trip_id,start_time,end_time,headway_secs,exact_times
CITY2,6:00:00,7:59:59,1800,0
CITY2,8:00:00,9:59:59,600,0
CITY2,10:00:00,15:59:59,1800,0
CITY2,16:00:00,18:59:59,600,0
```

GTFS

CSV

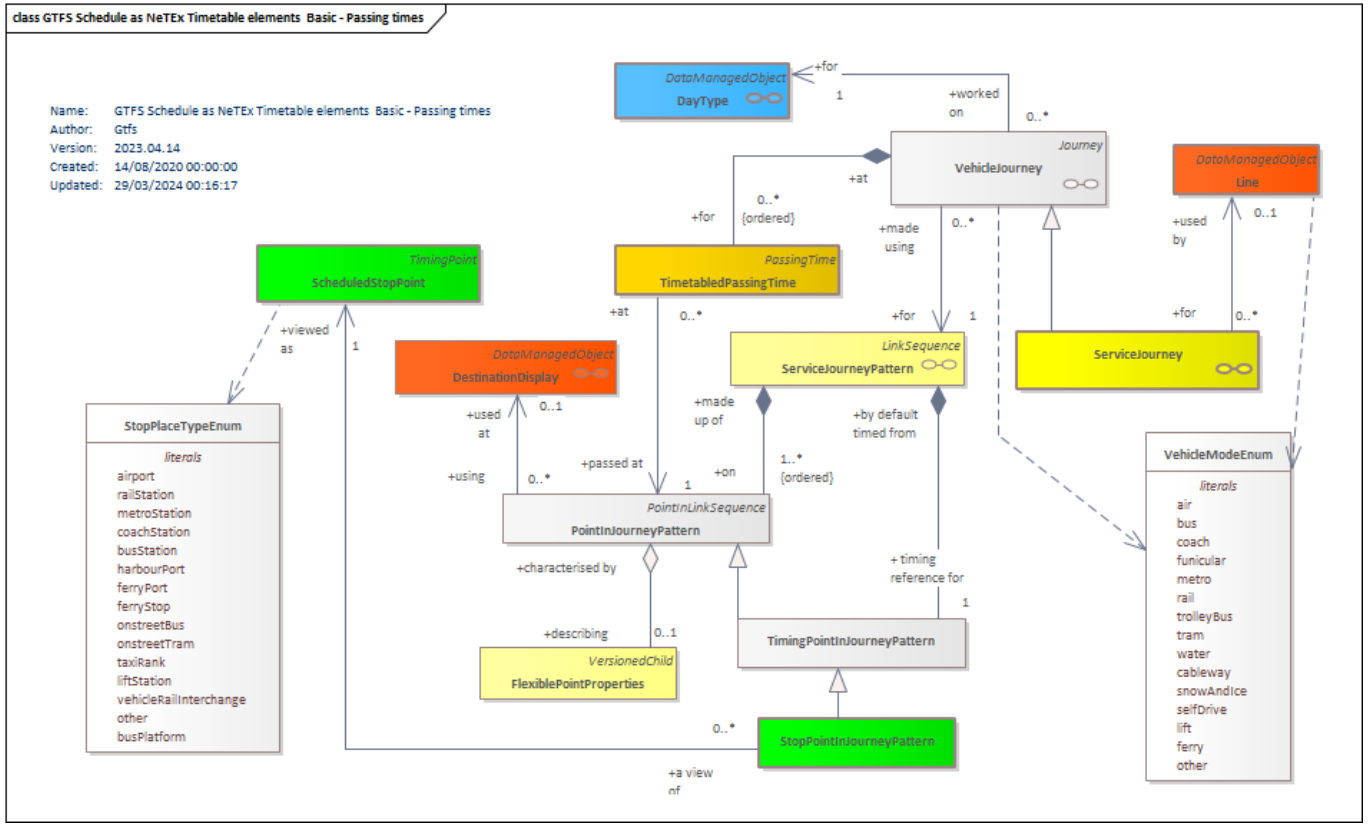
NeTEx Network Timetable Exchange


```
<TemplateServiceJourney version="any" id="mygtfsxm:CITY2">
   <DepartureTime>06:00:00</DepartureTime>
   <frequencyGroups>
      <HeadwayJourneyGroup version="any" id="mygtfsxm:CITY2-06:00:00">
         <FirstDepartureTime>06:00:00</FirstDepartureTime>
         <LastDepartureTime>07:59:59</LastDepartureTime>
         <ScheduledHeadwayInterval>PT30M</ScheduledHeadwayInterval>
      </HeadwayJourneyGroup>
      <HeadwayJourneyGroup version="any" id="mygtfsxm:CITY2-08:00:00">
         <FirstDepartureTime>08:00:00</FirstDepartureTime>
         <LastDepartureTime>09:59:59</LastDepartureTime>
         <ScheduledHeadwayInterval>PT10M</ScheduledHeadwayInterval>
      </HeadwayJourneyGroup>
      <HeadwayJourneyGroup version="any" id="mygtfsxm:CITY2-10:00:00">
         <FirstDepartureTime>10:00:00</FirstDepartureTime>
         <LastDepartureTime>15:59:59</LastDepartureTime>
         <ScheduledHeadwayInterval>PT30M</ScheduledHeadwayInterval>
      </HeadwayJourneyGroup>
      <HeadwayJourneyGroup version="any" id="mygtfsxm:CITY2-16:00:00">
         <FirstDepartureTime>16:00:00</FirstDepartureTime>
         <LastDepartureTime>18:59:59</LastDepartureTime>
         <ScheduledHeadwayInterval>PT10M</ScheduledHeadwayInterval>
      </HeadwayJourneyGroup>
   </frequencyGroups>
</TemplateServiceJourney>
```

NeTEx elements equivalent to GTFS Trips record - #2 POINT IN PATTERN - Basic

Using NeTEx POINTS IN PATTERN and PASSING TIMES

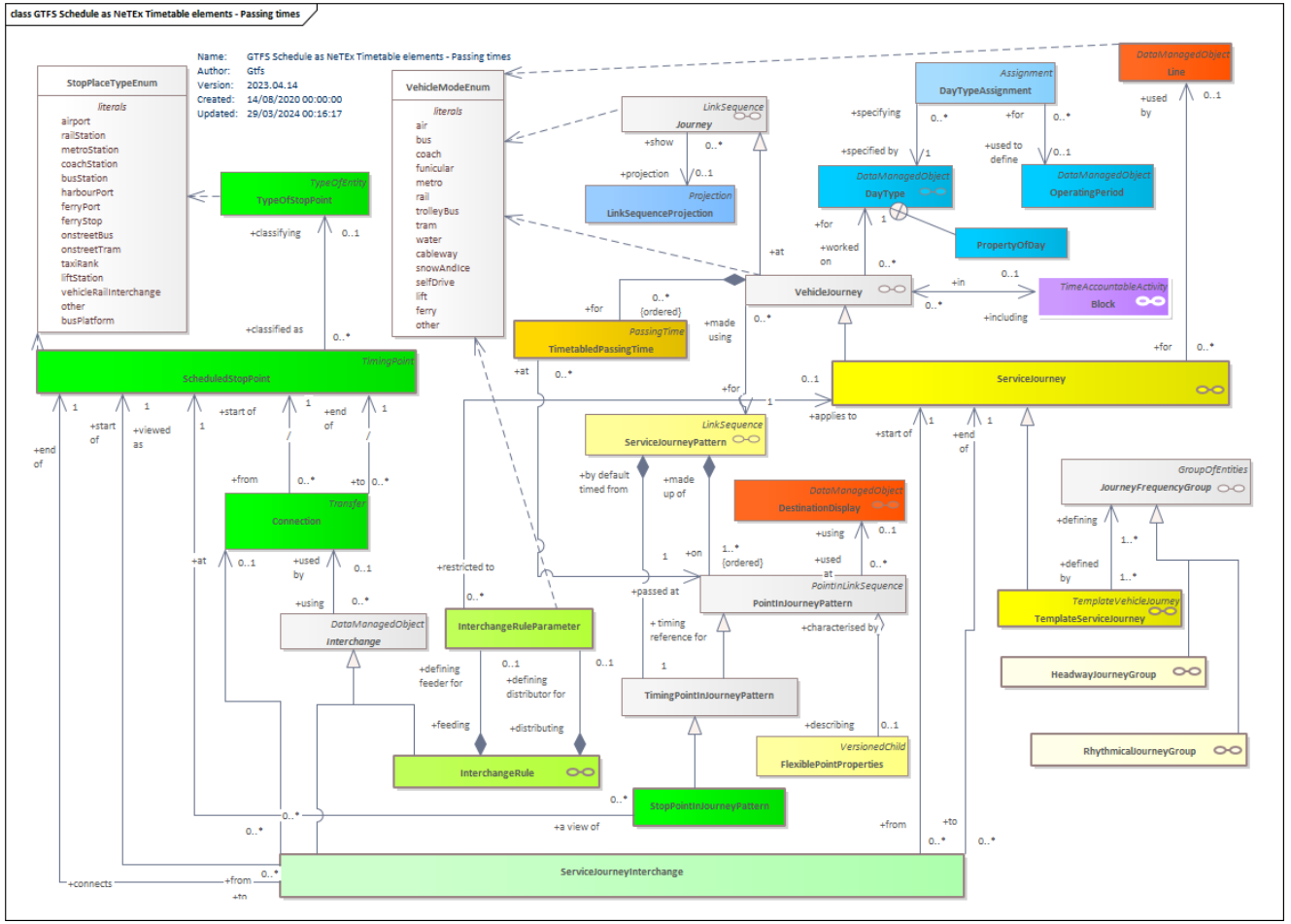
- trip ➔
  - SERVICE JOURNEY
  - stop times ➔
  - POINT IN PATTERN + TIMETABLED PASSING TIME
- calendar ➔
  - DAY TYPE



NeTEx elements equivalent to GTFS Trips record - #2 POINT IN PATTERN - Overview

Using NeTEX POINTS in PATTERN

- **trip** ➔
  - SERVICE JOURNEY
- **trip + frequency** ➔
  - TEMPLATE SERVICE JOURNEY + HEADY FREQUENCY GROUP
- **stop_times** ➔
  - POINT IN PATTERN + TIMETABLED PASSING TIME
- **calendar** ➔
  - DAY TYPE
- **transfer** ➔
  - CONNECTION
  - SERVICE JOURNEY INTERCHANGE
  - INTERCHANGE RULE



GTFS Trips MAPPING #2 using POINTS IN PATTERN - Overview

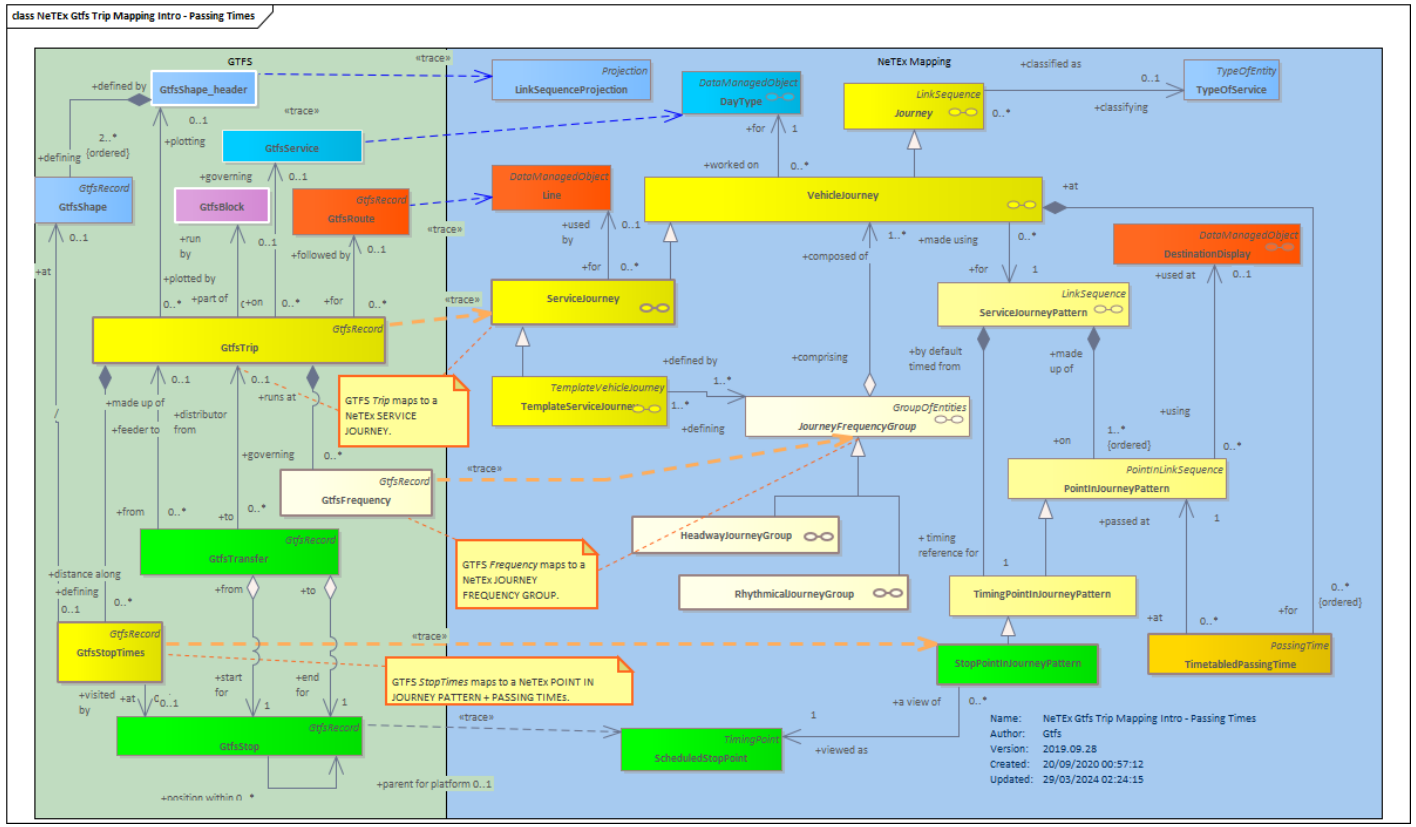
Timetable

GTFS trips record ➔

- NeTEx SERVICE JOURNEY

GTFS stop times ➔

- NeTEx POINT IN PATTERN + TIMETABLED PASSING TIME + DESTINATION DISPLAY

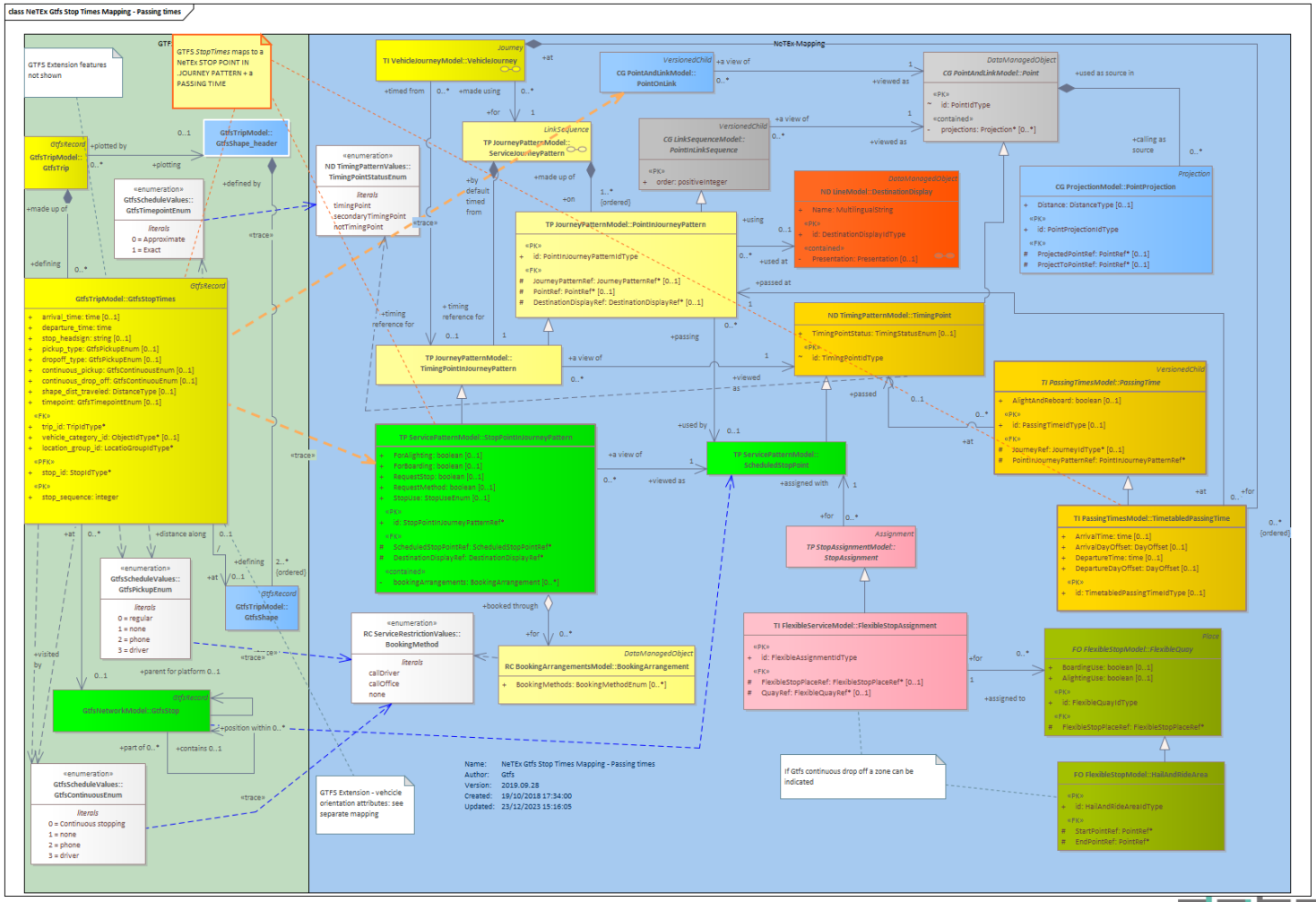


GTFS TripsMAPPING #2 using POINTS IN PATTERN - details

Timetable

Gtfs Trips

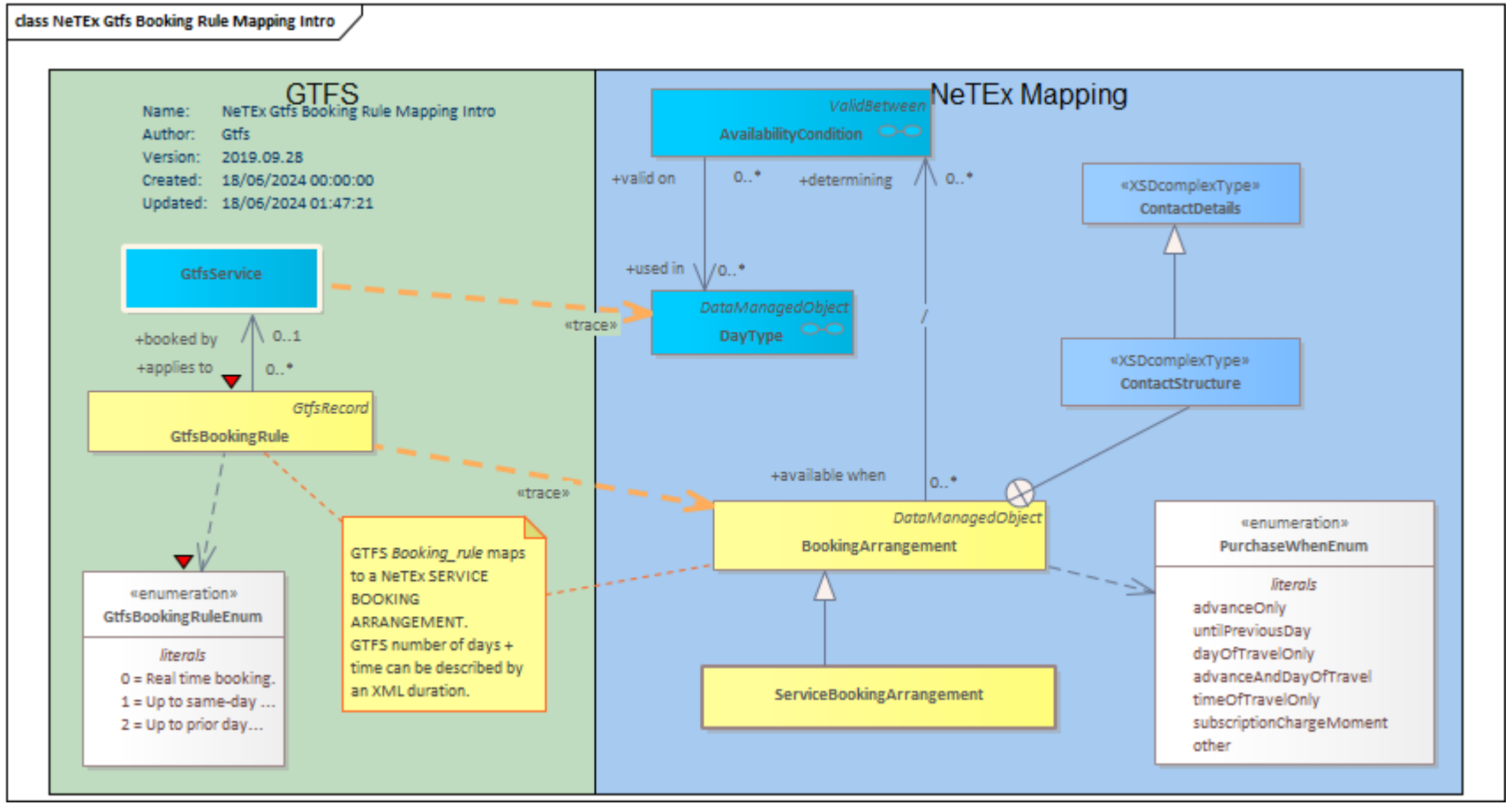
➔ NeTEx SERVICE JOURNEY + POINT IN PATTERN + TIMETABLED PASSING TIME



MAPPING:
(12)
GTFS BOOKING_RULE
→
NETEX BOOKING ARRANGEMENTS

GTFS Booking_rule Mapping - Overview

GTFS booking_rule_record
➔
NeTEx BOOKING ARRANGEMENTS

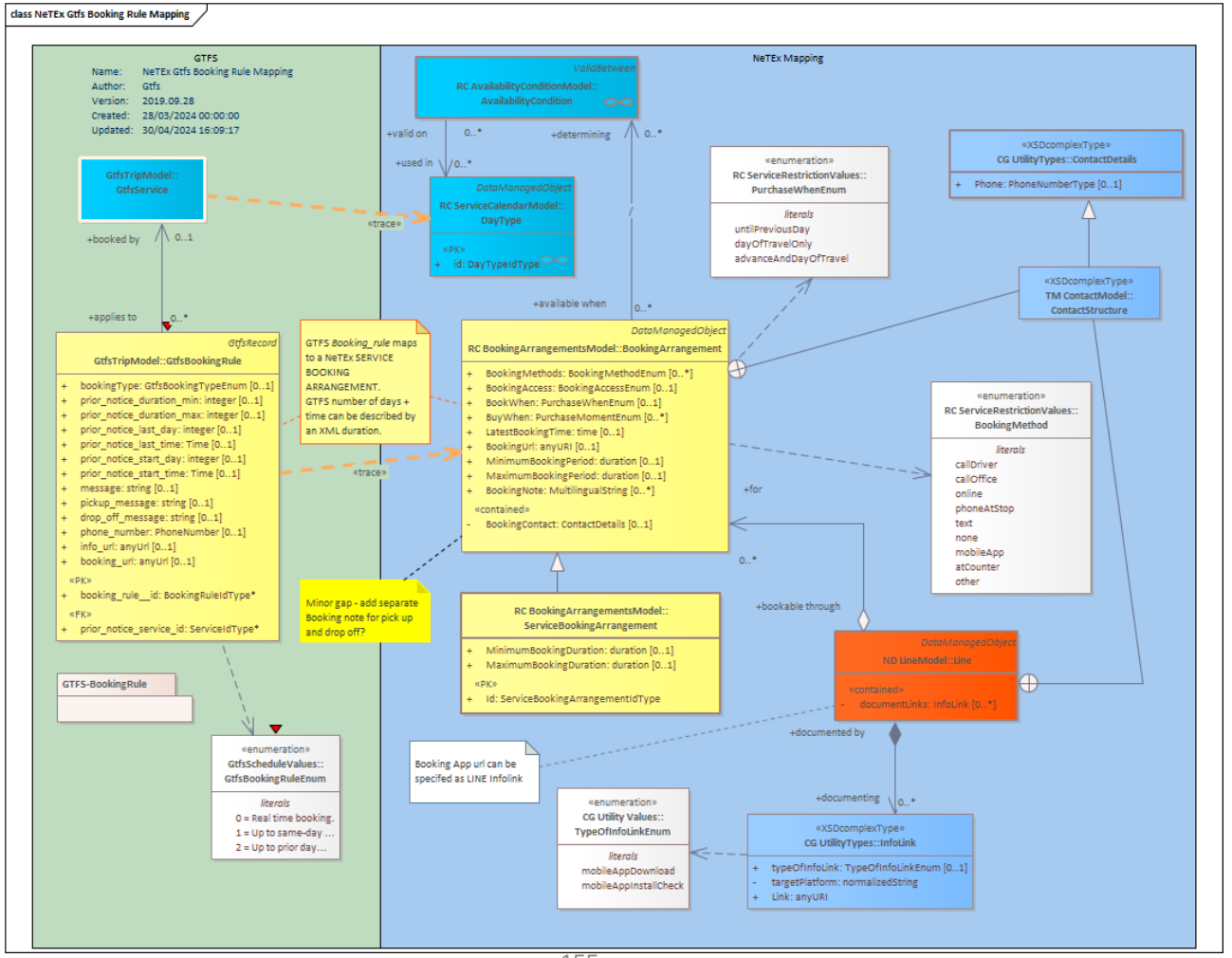


GTFS Booking_rule Mapping - Details

GTFS booking_rule_record

➔

NeTEx BOOKING ARRANGEMENTS



MAPPING:
(13)
GTFS SHAPES
→
NETEX ROUTE LINK + POINT ON LINK

Mapping Overview: Plotting a route GTFS shape

- Different mappings possible
  - Route
- Simple (Single LINK for whole ROUTE)
  - Each GTFS Shape record = NeTEx ROUTE POINT
  - GTFS shape (overall) = ROUTE LINK + PROJECTION to VEHICLE JOURNEY (or just use NeTEX SErviceJounrey.LineSTring
  - GTFS stop_times record = NeTEx POINT ON LINK
- Extended (Explicit LINKs between each point on JOURNEY PATTERN)
  - Create ROUTE POINT for each GTFS stop _times record
  - Create ROUTE LINK between each one, allocate distance from FS stop _times record. Make any intermediate points either additional ROUTE POINTs + POINT IN JOURNEY

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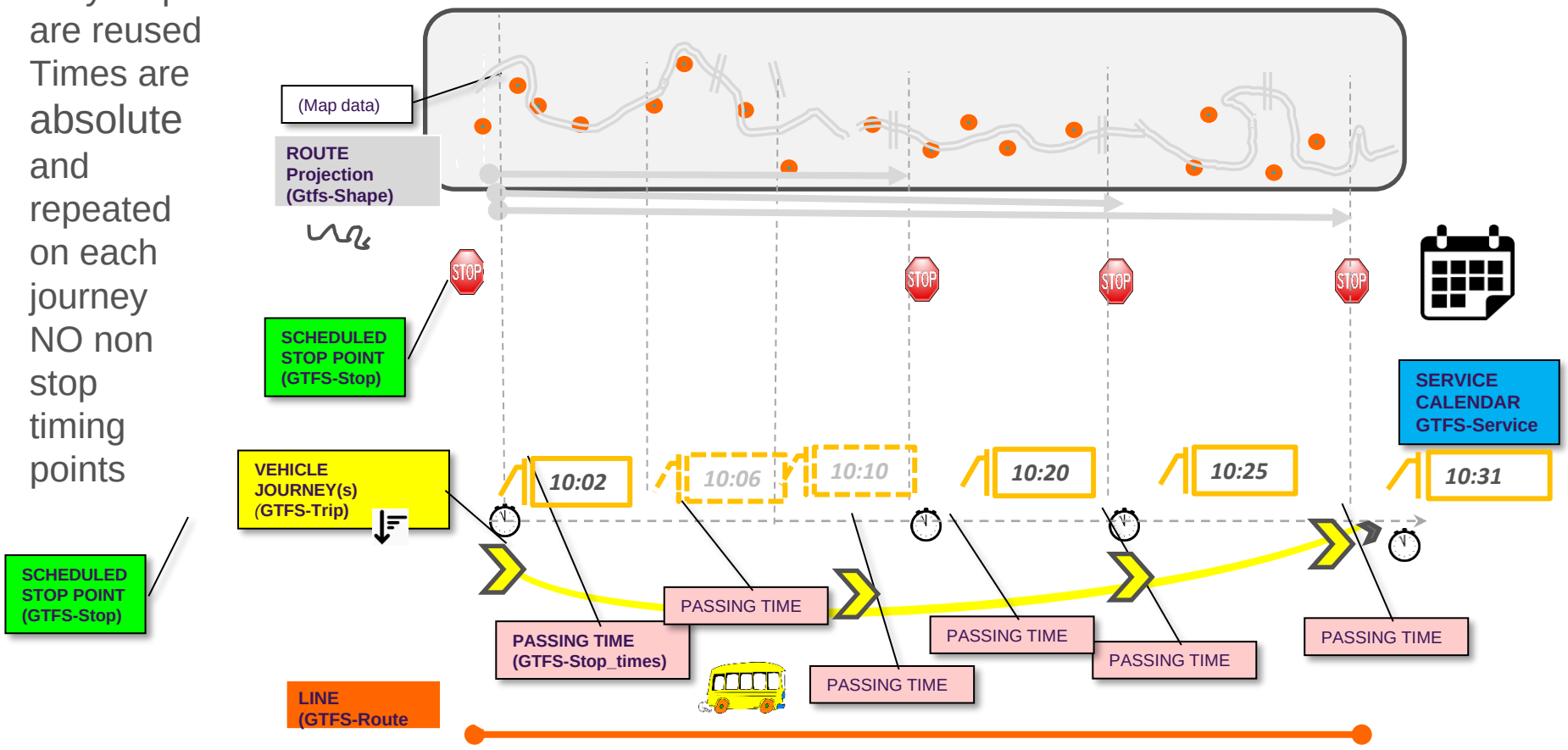
GTFS

A VEHICLE JOURNEY (GTFS-Trip) is for a LINE

Only stops are reused
Times are absolute and repeated on each journey
NO non stop timing points



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GTFS Shapes record Mapping - #1 Basic

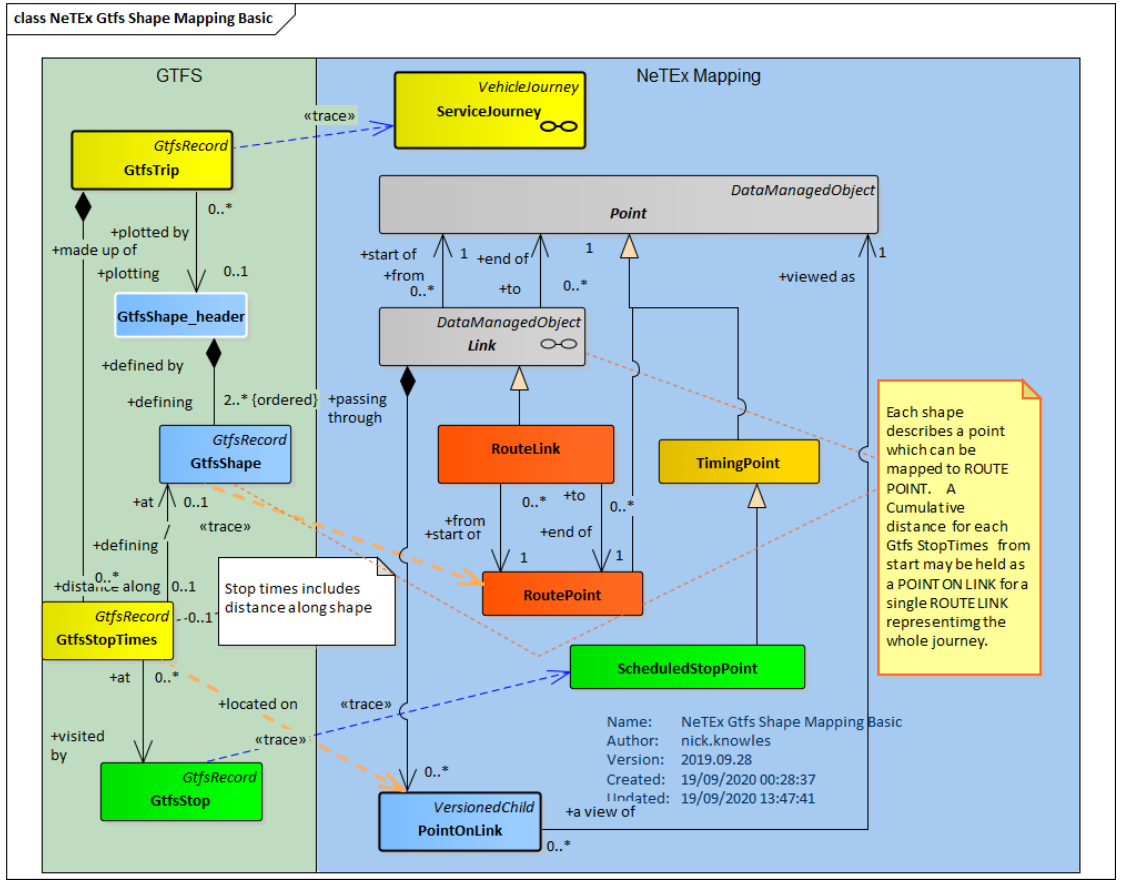
GTFS

NeTEx
Network Timetable Exchange

Route projection

- **Gtfs shape record ➔**
  - ROUTE POINT
- **Gtfs stop_times record➔**
  - POINT ON LINK with distance from start.
  - Define a single ROUTE LINK for journey. Place points on link.

Note however that Netex also supports a simple GML *Lineshape* representation of the plot of a link



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An Example mapping - GTFS trip and shape to NeTEx LINE

GTFS

CSV

```
trip_Id,arrival_time,departure_time,stop_Id,stop_sequence,stop_headsign,pickup_type,drop_off_type,shape_dist_traveled
BFC1,8:20:00,8:20:00,BULLFROG,1
BFC1,9:20:00,9:20:00,FUR_CREEK_RES,2
shape_id,shape_pt_lat,shape_pt_lon,shape_pt_sequence,shape_dist_traveled
AB2o,53.00, 1.00,1,100
AB2o,53.10, 1.10,2,120
AB2o,53.20, 1.20,3,130
```

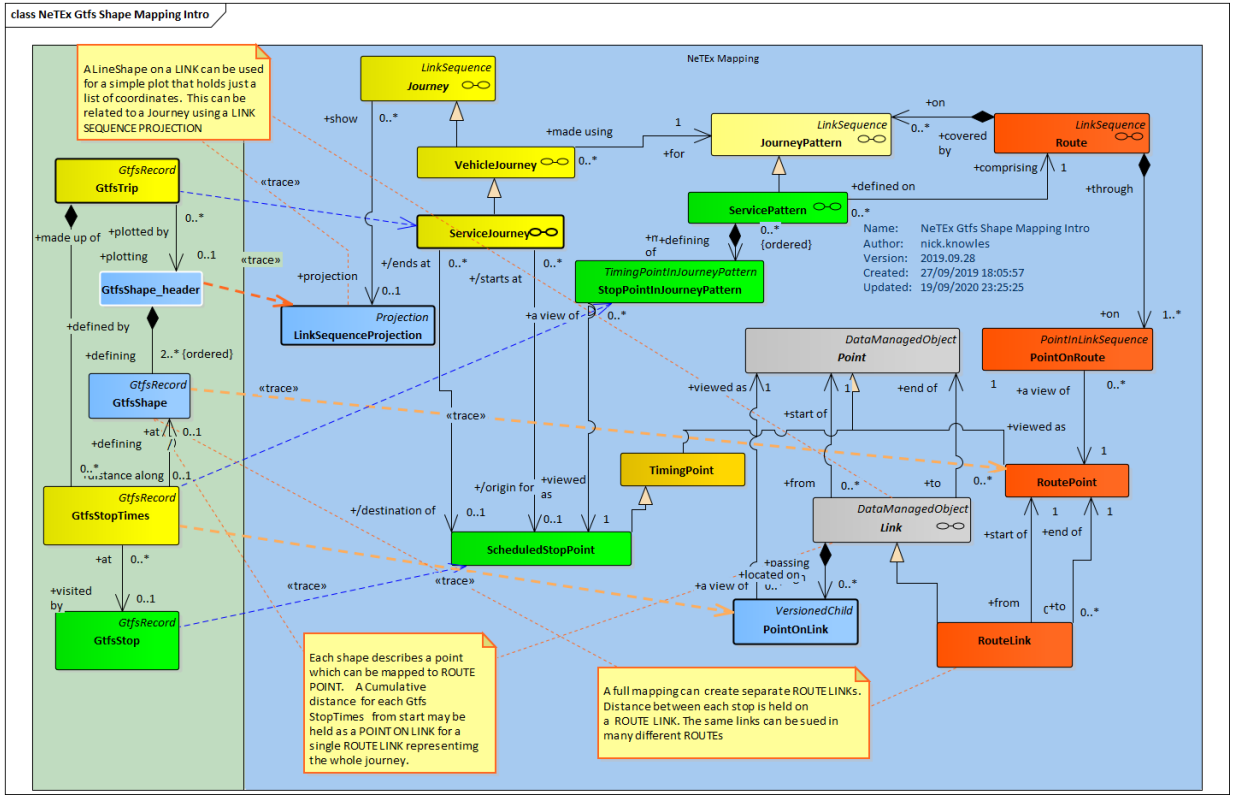
NeTEx
Network Timetable Exchange

```
<ServiceJourney version="any" id="BFC1">
   <validityConditions>
      <AvailabilityConditionRef version="any" ref="FULLW-2007-06-04"/>
   </validityConditions>
   <LinkSequenceProjection version="any" id="BFC1">
      <gml:LineString srsName="WGS84" gml:id="BFC1">
         <gml:pos>53.00 1.00</gml:pos>
         <gml:pos>53.10  1.10</gml:pos>
         <gml:pos>53.20  1.20</gml:pos>
      </gml:LineString>
   </LinkSequenceProjection>
   <DepartureTime>08:20:00</DepartureTime>
   <dayTypes>
      <DayTypeRef version="any" ref="FULLW"/>
   </dayTypes>
   <BlockRef ref="Block:1"/>
   <LineRef version="any" ref="BFC"/>
   <JourneyPatternView>
      <DestinationDisplayView>
         <Name>to Furnace Creek Resort</Name>
      </DestinationDisplayView>
   </JourneyPatternView>
   <calls> …
    </calls>
</ServiceJourney>
```

GTFS Shapes record Mapping - #2 EXTENDED

Route projection

- **Gtfs shape record ➔**
  - ROUTE POINT
- **Gtfs shape record ➔**
  - POINT ON LINK with distance from start.
  - Define a single ROUTE LINK



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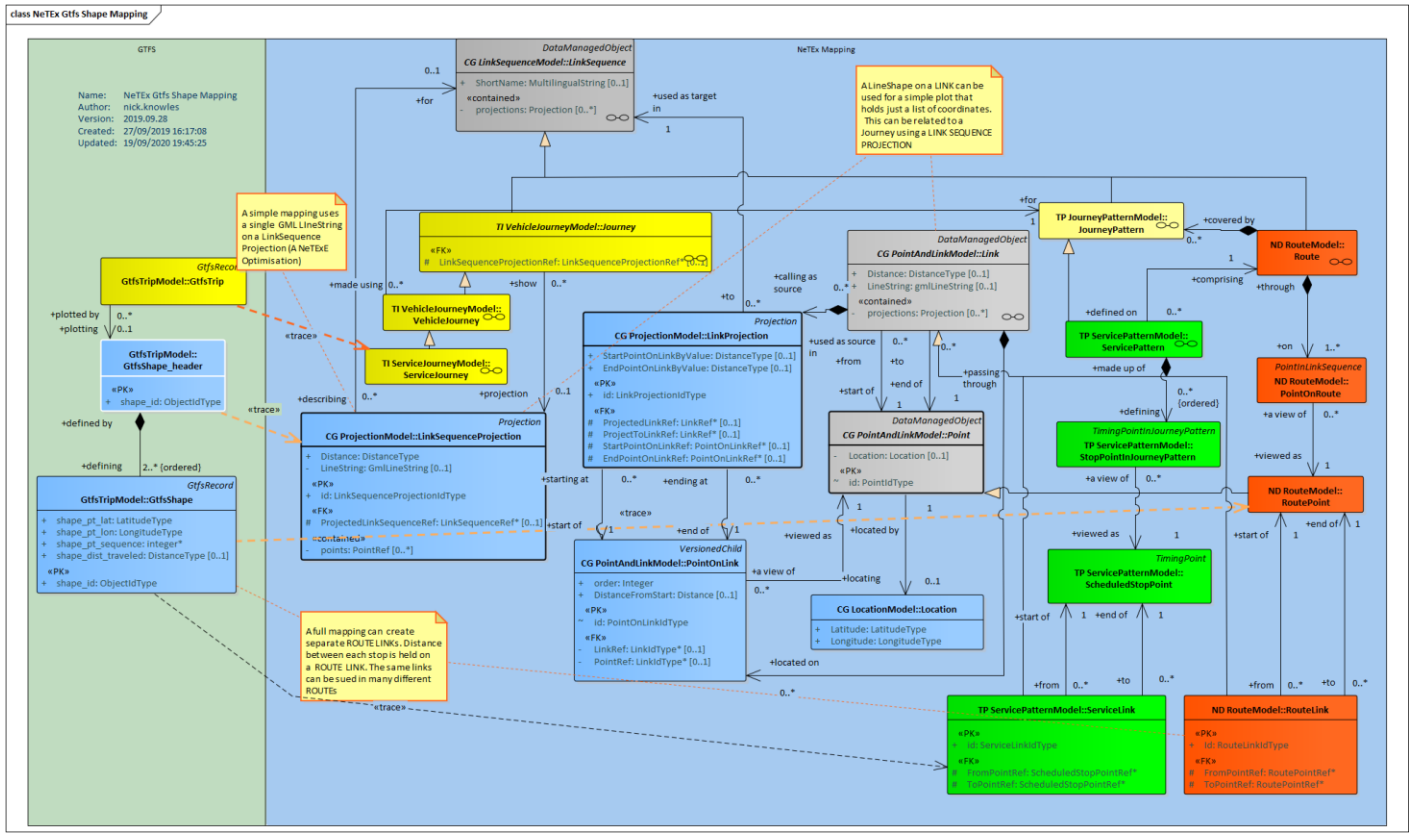
GTFS Shapes Mapping - Details

GTFS

NeTEx Network Timetable Exchange

- **Gtfs shape record ➔**
  - ROUTE POINT
- **Gtfs shape record ➔**
  - POINT ON LINK with distance from start.
  - Define a single ROUTE LINK



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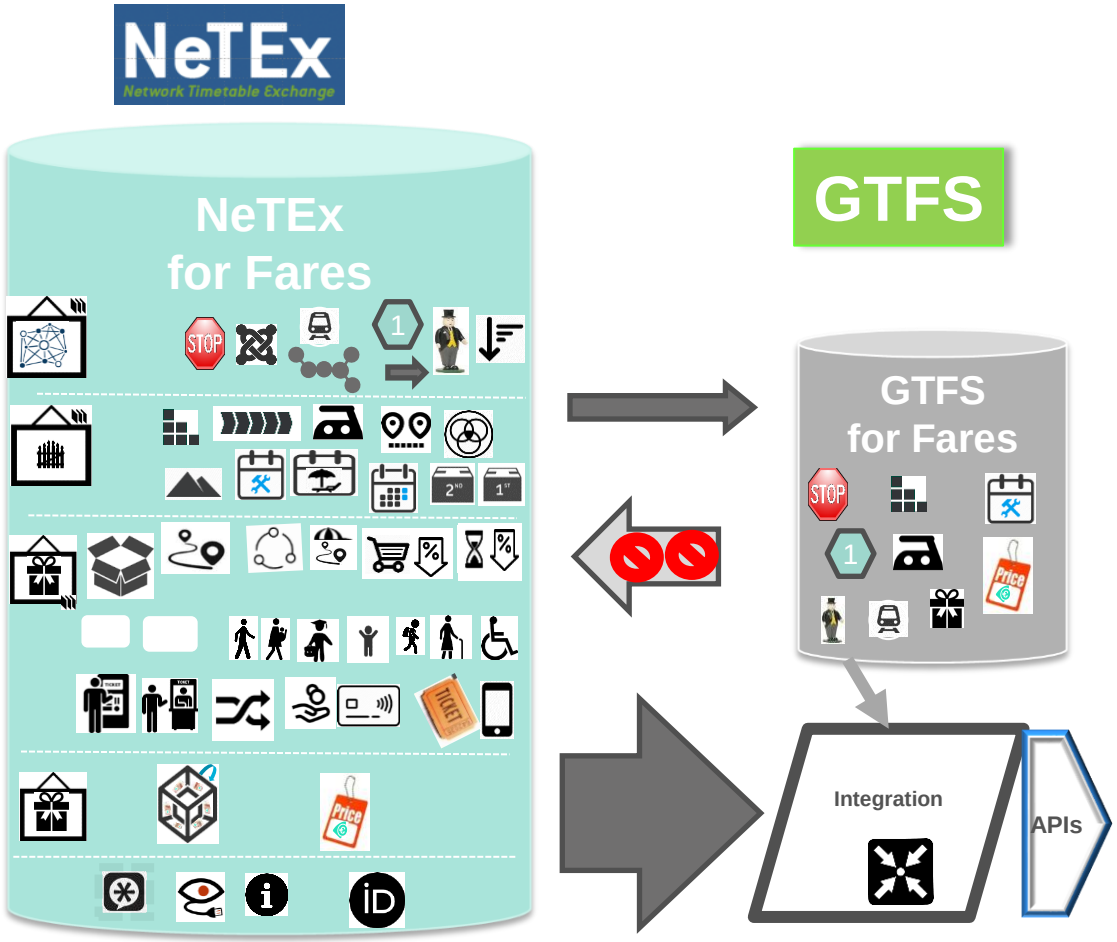
MAPPING:
(14)
GTFS FARE_RULES
→
NETEX, RESPONSIBILITY SET

NeTEx & GTFS Interoperation – Fares & Prices

- GTFS is very basic subset of fare data
  - Flat & P2P structures
  - Simple absolute prices
  - Minimal “product” definition
- Round trip is very, very “Lossy”



Mapping Overview: GTFS Fares

- GTFS Basic Fare model covers prices for basic P2P, Z2Z and flat fares
  - Complex fare structures and products not covered
    - Eg no distance based, no series, no user types etc
- Gtfs is a simple model – does not cover many aspects of fares
  - No support for Fare products and conditions
    - E.g. user types
  - Fixed, absolute prices (not derived, dynamic etc)
  - Overloaded records – different meaning in different contexts
  - Very limited description of sales channels
    - media, purchase method, fulfilment etc
- Transmodel/ Netex
    - Rich fare model
    - Separates concerns: Taiff structure:; product structure; prices, etc etc

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Mapping Overview: GTFS Fare_Rules

GTFS

NeTEx
Network Timetable Exchange

- Key Equivalences
  - GTFS fare_rules = TM DISTANCE MATRIX ELEMENT
    - “origin/destination” (**Point to Point** and **Zone to Zone** fares)
  - GTFS fare_rules = TM FARE STRUCTURE ELEMENT / FARE STRUCTURE ELEMENT IN SEQUENCE
    - (“contains”) = sequence of named zones
  - GTFS fare_Attributes = TM FARE PRICE + PURCHASE METHOD

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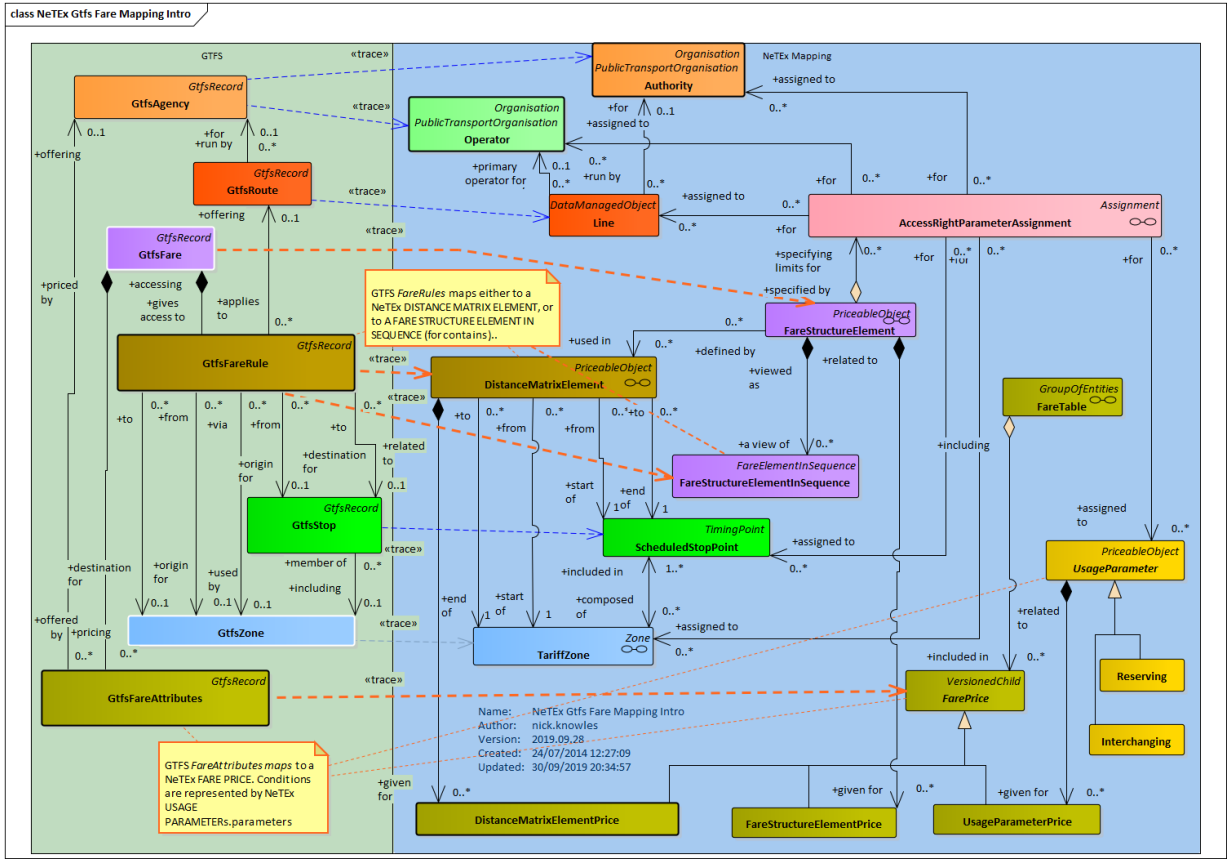
GTFS Fare Rules Mapping - Overview

GTFS

NeTEx
Network Timetable Exchange

Tariff Structure

- **GTFS fare_rule record ➔**
  - NeTEx DISTANCE MATRIX ELEMENT
  - + ACCESS RIGHT PARAETER ASSIGNMENT to a LINE



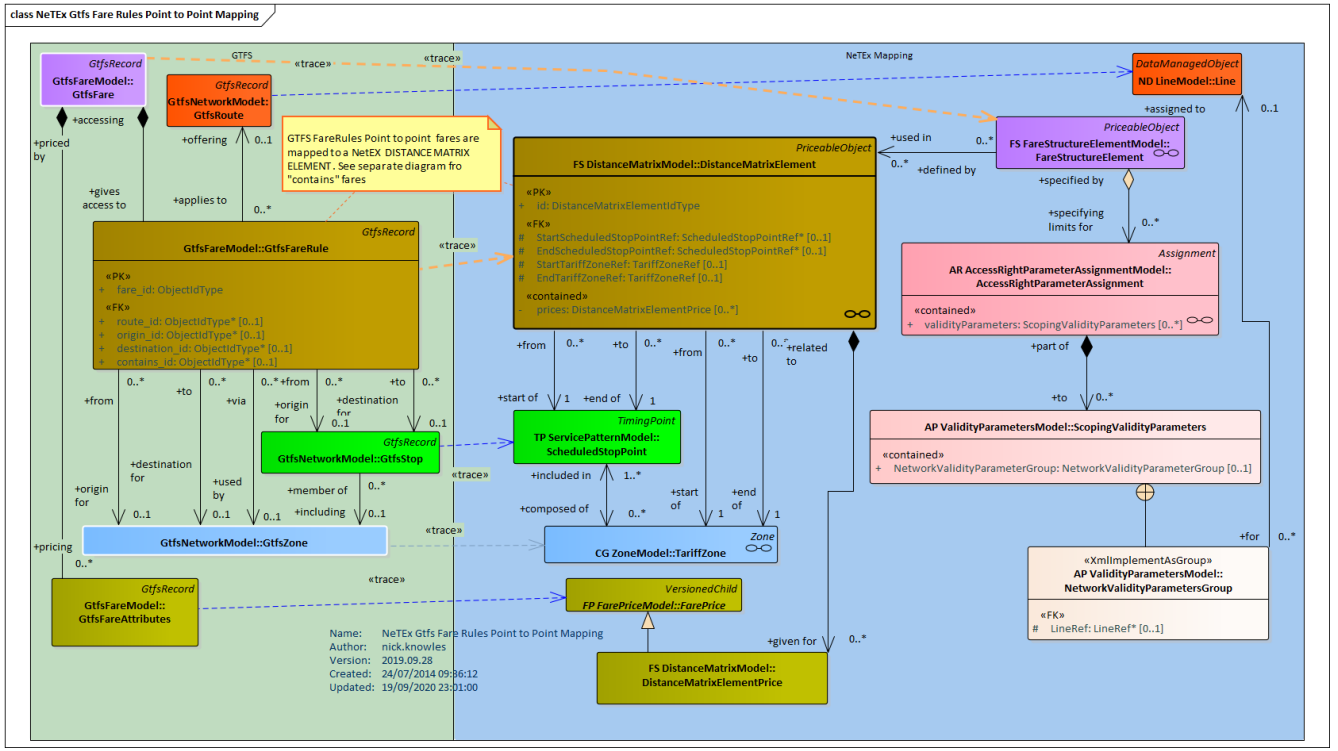
GTFS Fares1 fare_rules Mapping – P2P Tariff Details

GTFS

NeTEx
Network Timetable Exchange

Responsibilities

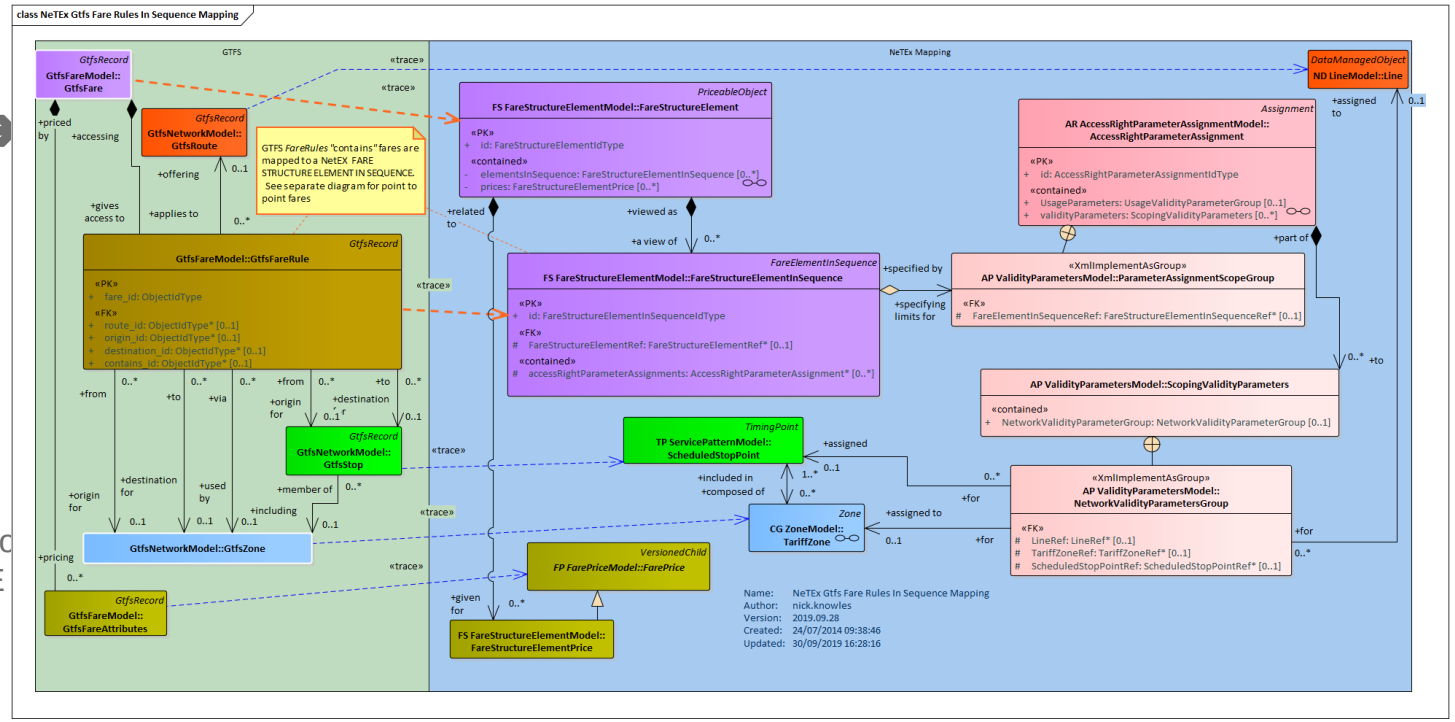
- **GTFS fare_rules record** (Origin/destination)
- ➔ NeTEX DISTANCE MATRIX ELEMENT
  - ❑ Point to point
  - ❑ Zone to zone



GTFS Fares1 Fare_rules Mapping – Element in Sequence Details

Tariff Structure

- GTFS fare_rules record (contains) ➔
  - FARE STRUCTURE ELEMENT IN SEQUENCE
    - Specifed SCHEDULED STOP POINT o TARIFF ZONE



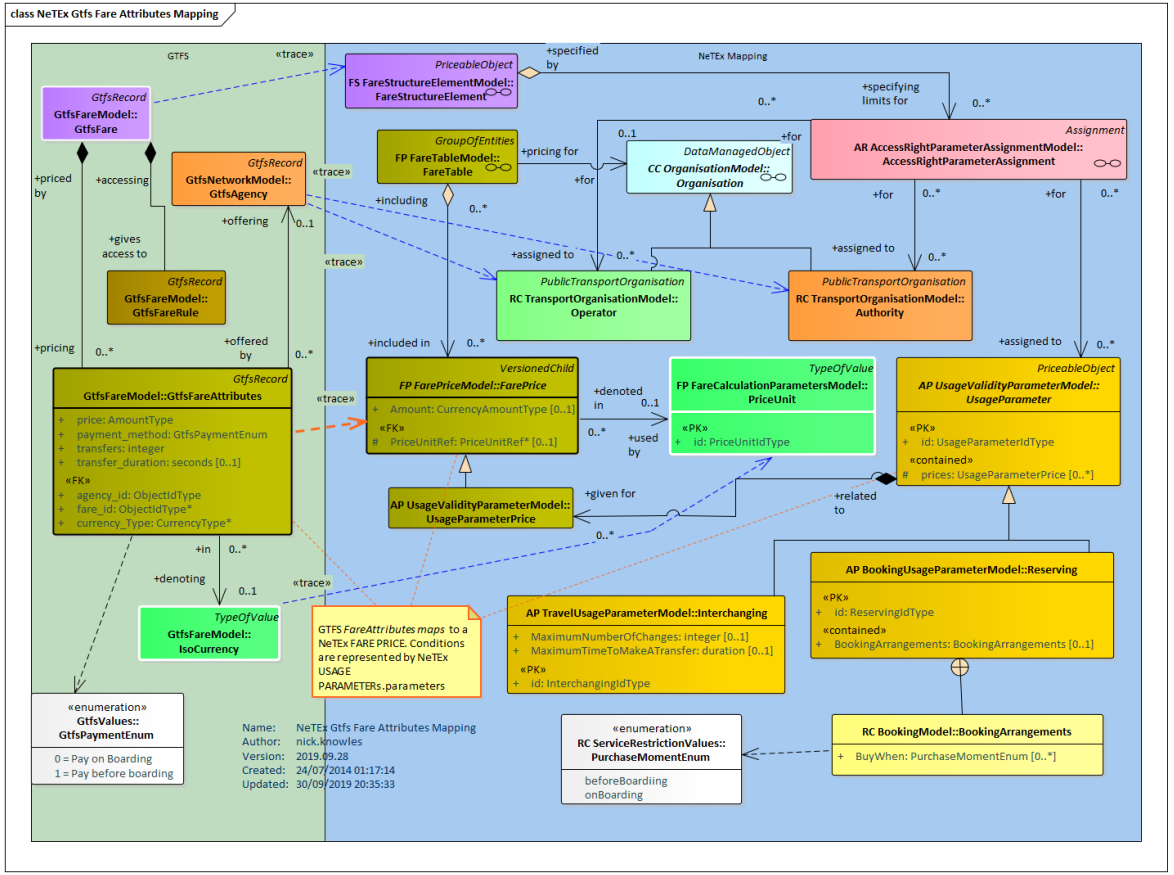
GTFS Fares 1 Fare_attributes Mapping

GTFS

NeTEx
Network Timetable Exchange

Tariff Structure

- **GTFS Fare ➔**
  - FARE STRUCTURE ELEMENT
- **GTFS Fare_attributes record ➔**
  - FARE PRICE
  - + USAGE PARAMETERs: INTERCHANGING and /or RESERVING



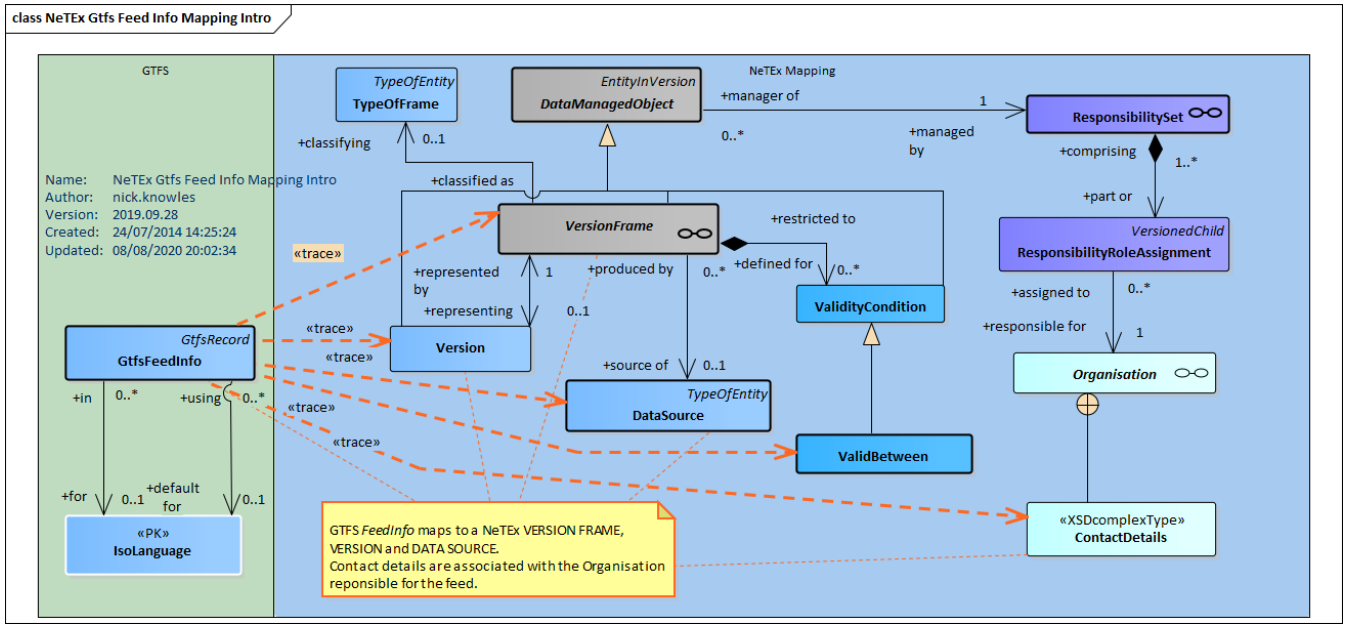
MAPPING:
(15)
GTFS FEED_INFO
→
NETEX DATA SOURCE, RESPONSIBILITY SET + DAY TYPE

GTFS Feed Info Mapping - Overview

Validity and contact details

Data is place in a NeTEx VERSION FRAME with a common validity condition

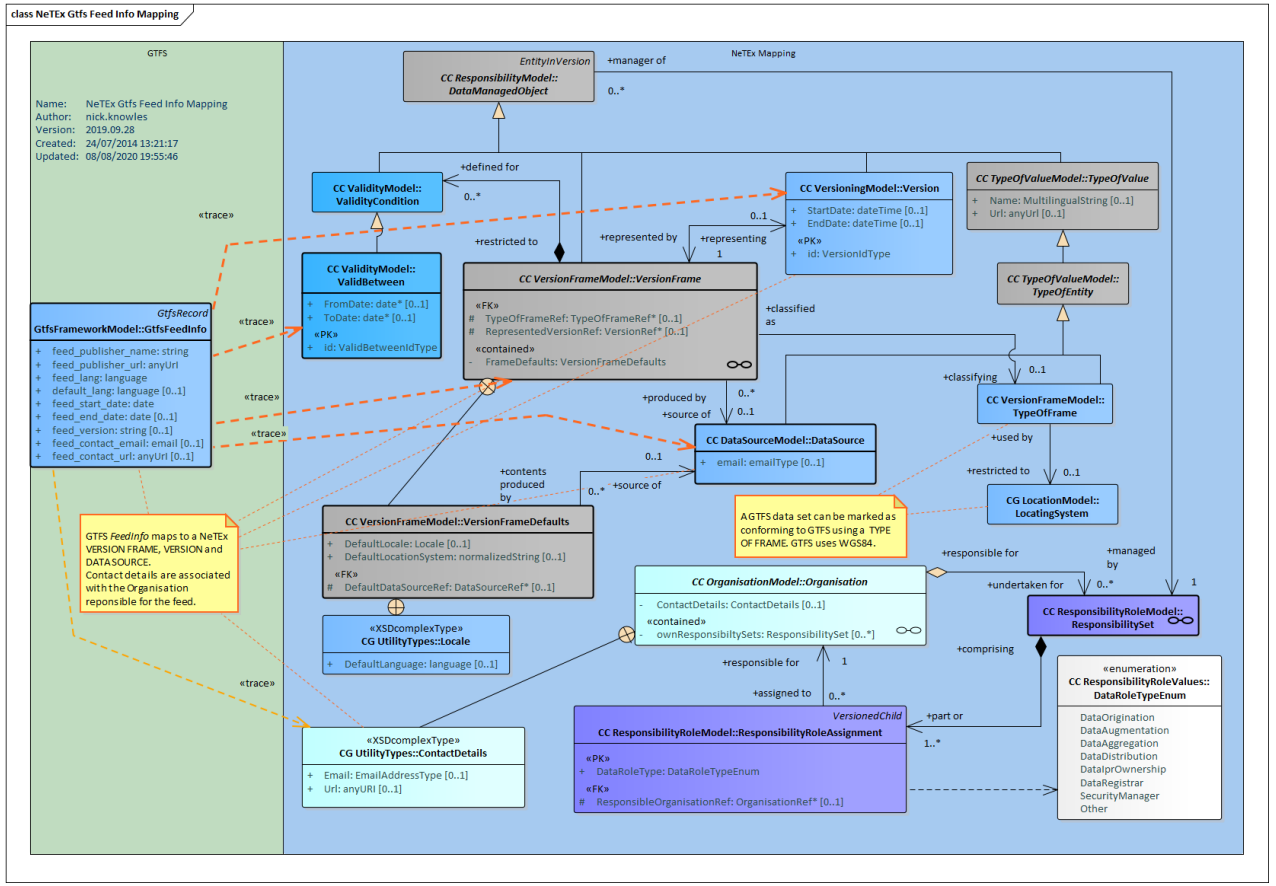
- **GTFS Feed_info record ➔**
  - NeTEx DATA SOURCE
  - NeTEx VERSION FRAME + VALIDITY CONDITION
  - RESPONSIBILITY SET – assigns contact details to an OPERATOR or OTHER ORGANISATION



GTFS Feed_info Mapping – With attributes

Transmodel / NeTEX separtaes concerns of DATA SOURCE, RESPONSIBILITY and VERSION/VALIDITY

- **GTFS Feed_info record ➔**
  - NeTEx DATA SOURCE
  - NeTEx VERSION FRAME + VALIDITY CONDITION
  - RESPONSIBILITY SET – assigns contact details to an OPERATOR or OTHER ORGANISATION



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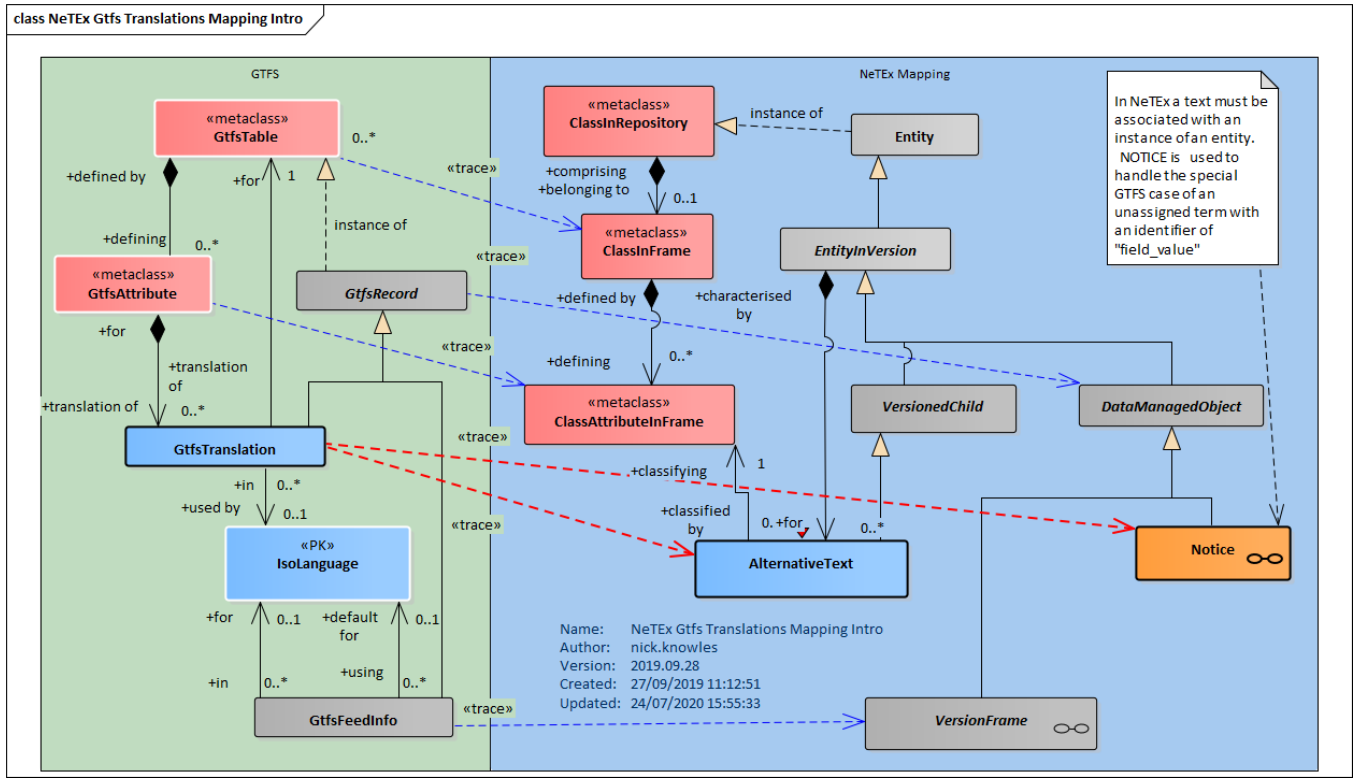
MAPPING:
(16)
GTFS TRANSLATIONS
→
NETEX ALTERNATIVE TEXT

GTFS Translations Mapping - Overview

Translations

- **GTFS Translations record (with named GTFS record) ➔**
  - NeTEx ALTERNATIVE TEXT
- **GTFS Translations record (unassigned) ➔**
  - NeTEx NOTICE

- NB more complex process to determine keys for GTFS child entities



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GTFS Translations Mapping - - Details

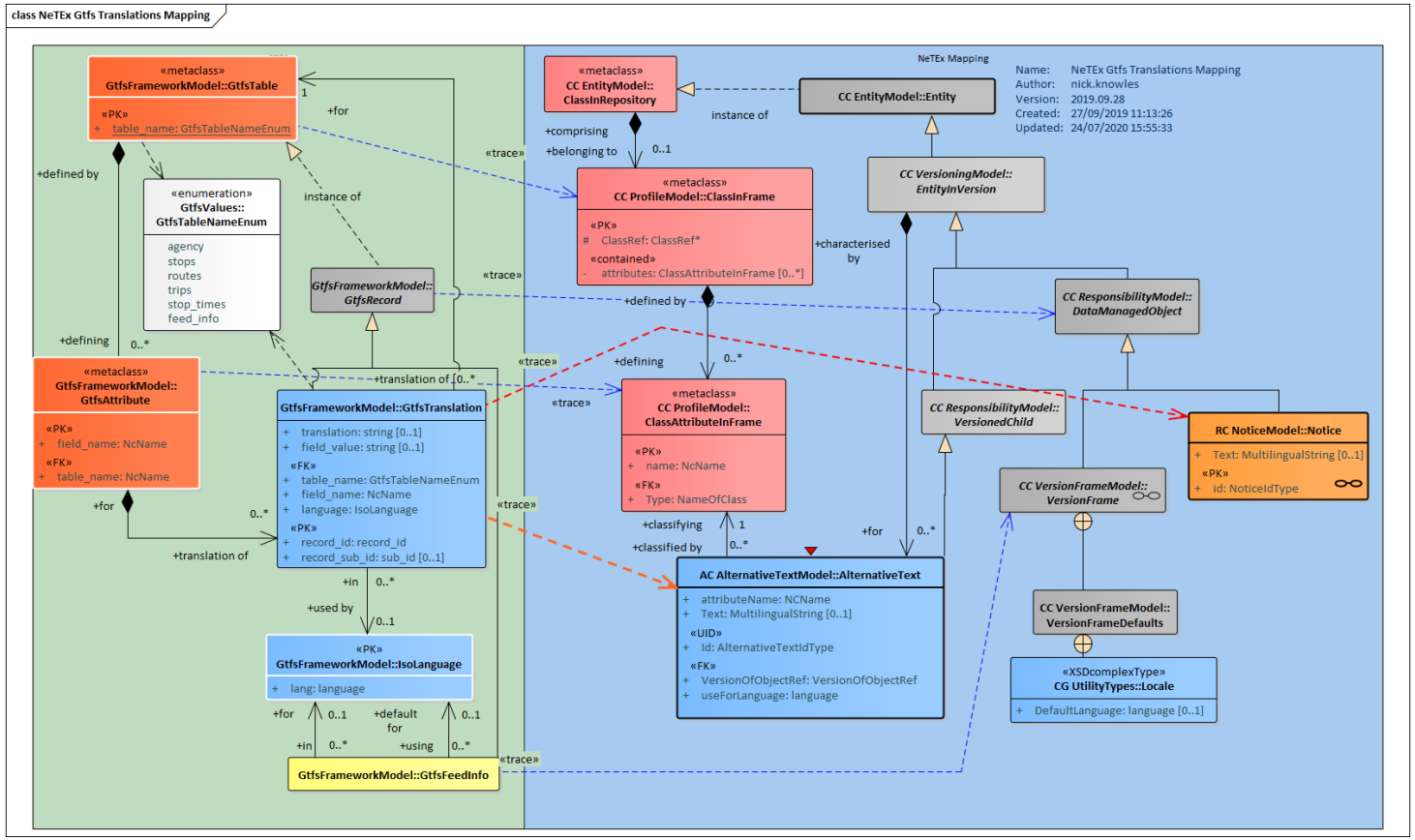
Translations & Notices

GTFS Translations record (with named GTFS record) ➔

- NeTEx ALTERNATIVE TEXT

GTFS Translations record (unassigned) ➔

- NeTEx NOTICE



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MAPPING:
(17)
GTFS ATTRIBUTIONS
→
NETEX, RESPONSIBILITY SET

GTFS Attribution

- GTFS indicates contact details for fixed roles for
  - GTFS Agency (Whole data set?)
  - Specific Gtfs Route
  - Specific Gtfs Trip

Transmodel has general purpose mechanism to assign roles – a RESPONSIBILITY SET can be assigned to a frame ro any individual entity.

- Assigns a specified ROLE to an ORGANISATION
- CONTACT DETAILS apply to ORGANISATION

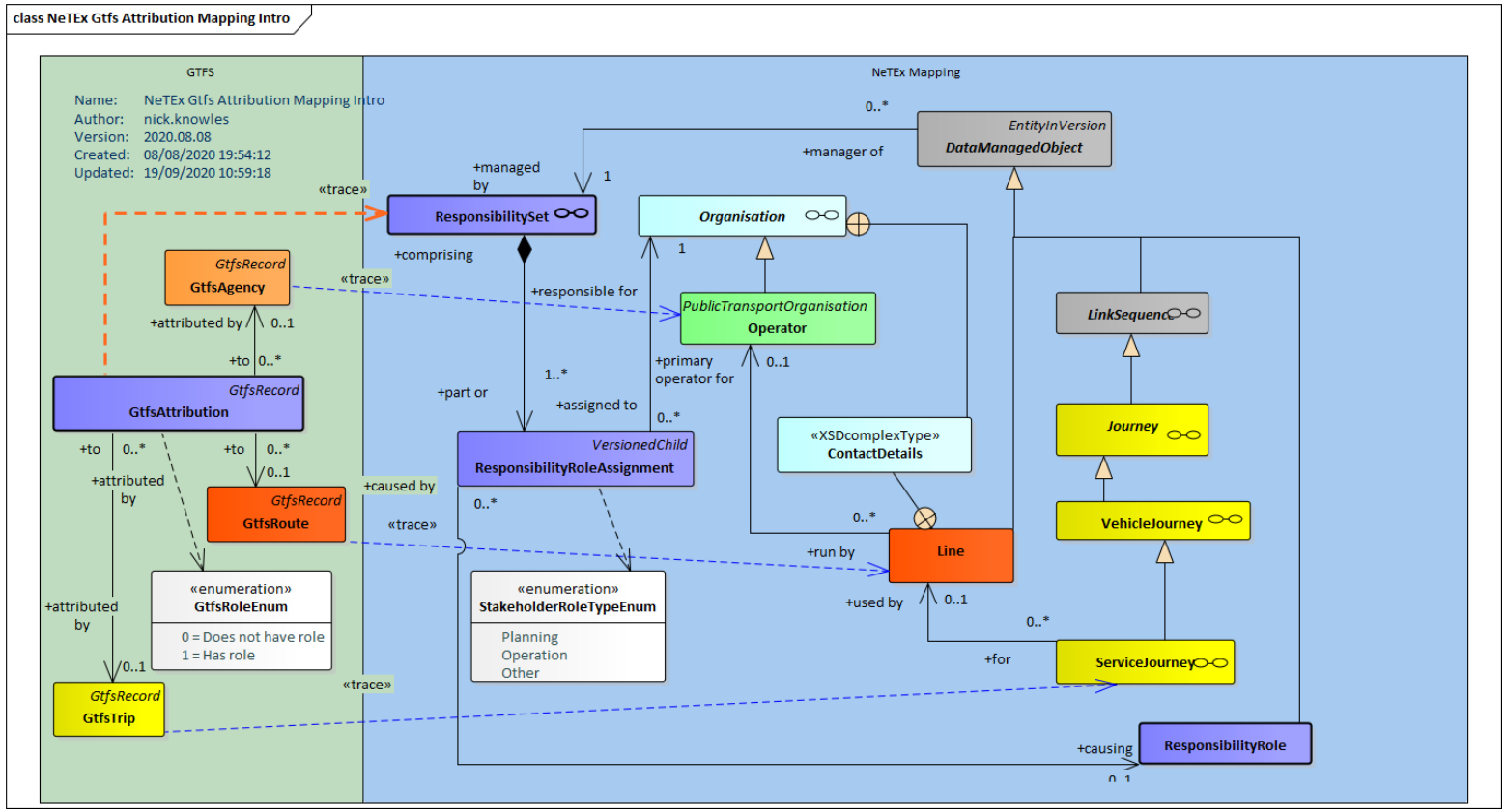
GTFS Attributions Mapping - Overview

GTFS

NeTEx
Network Timetable Exchange

Responsibilities

- **GTFS attributions record ➔**
  - NeTEx RESPONSIBILITY SET – assigns contact details to an OPERATOR or OTHER ORGANISATION
  - (May need to create dummy organisation)
  - NeTEx operate delegates a responsibility to exclude



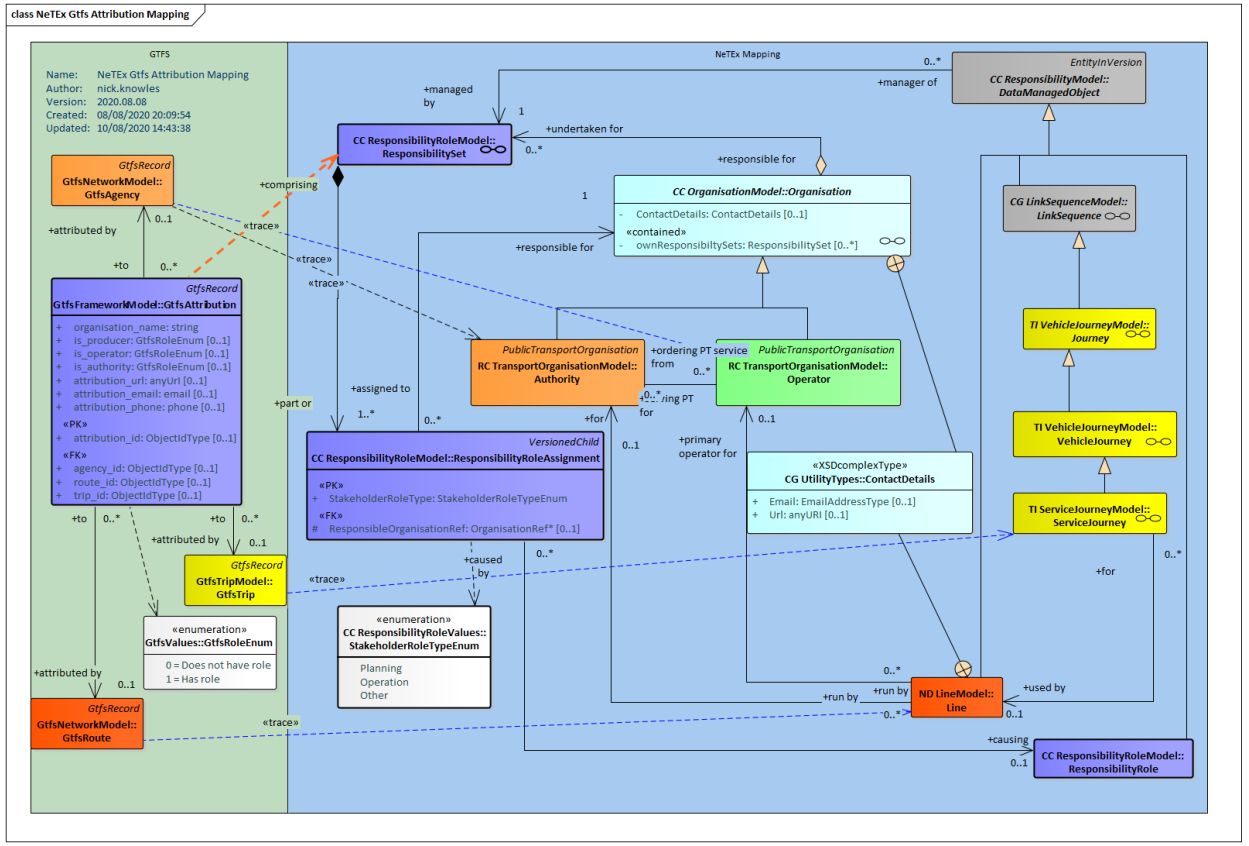
GTFS Attributions Mapping - Details

GTFS

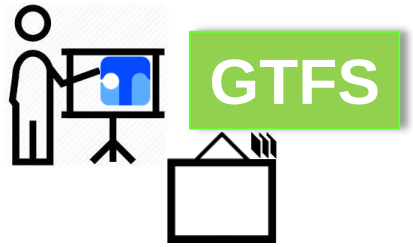
NeTEx
Network Timetable Exchange

Responsibilities

- **Gtfs Attributions record ➔**
  - NeTEx RESPONSIBILITY SET – assigns contact details to an OPERATOR or OTHER ORGANISATION
  - (May need to create dummy organisation)
  - NeTEx operate delegates a responsibility to exclude it



MAPPING
(19)
FURTHER
TECHNICAL POINTS



Mapping Overview: GTFS Feed

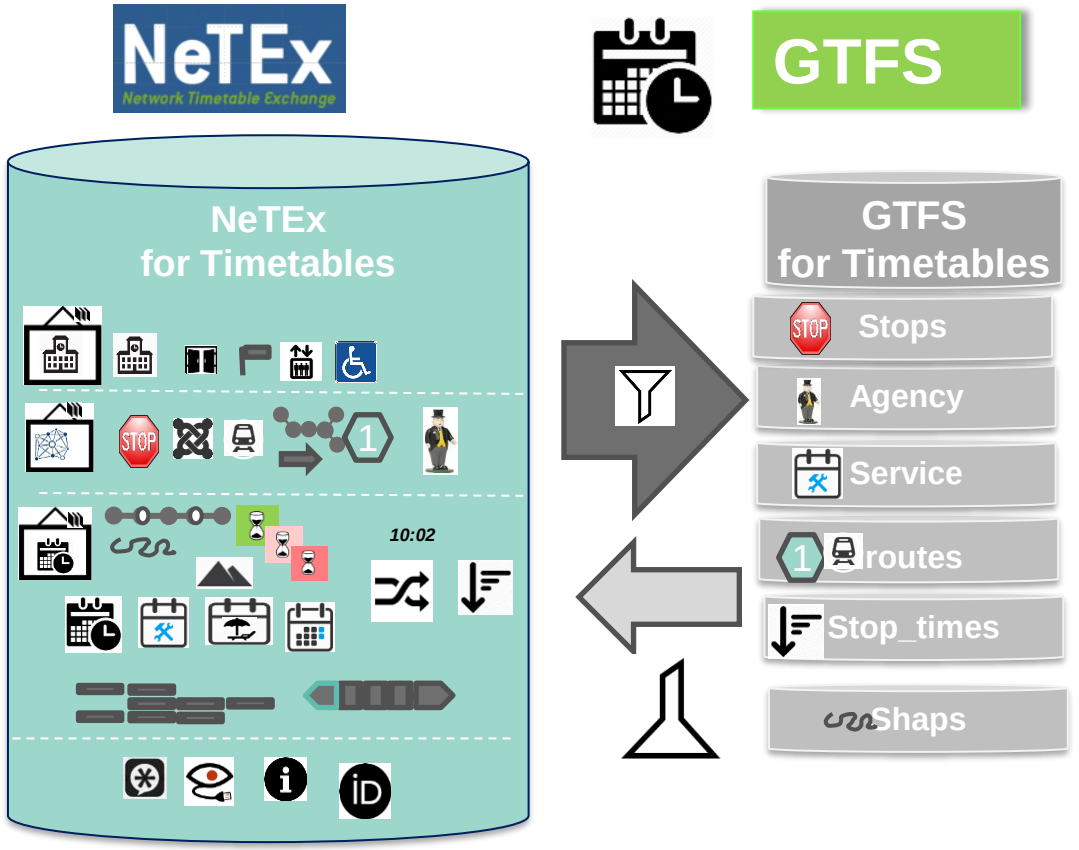
- Key Equivalences
  - GTFS Zip file = XML Document
  - GTFS csv record file = Single XML Element
  - GTFS Feed = TM VERSION FRAME + VERSION + VALIDITY CONDITION

- NeTEx intended for many use cases & workflows
  - Stops are not specific

Open Data is Good!
NeTEx & GTFS Interoperation - Timetables

GTFS is useful subset of timetable data for trip planners

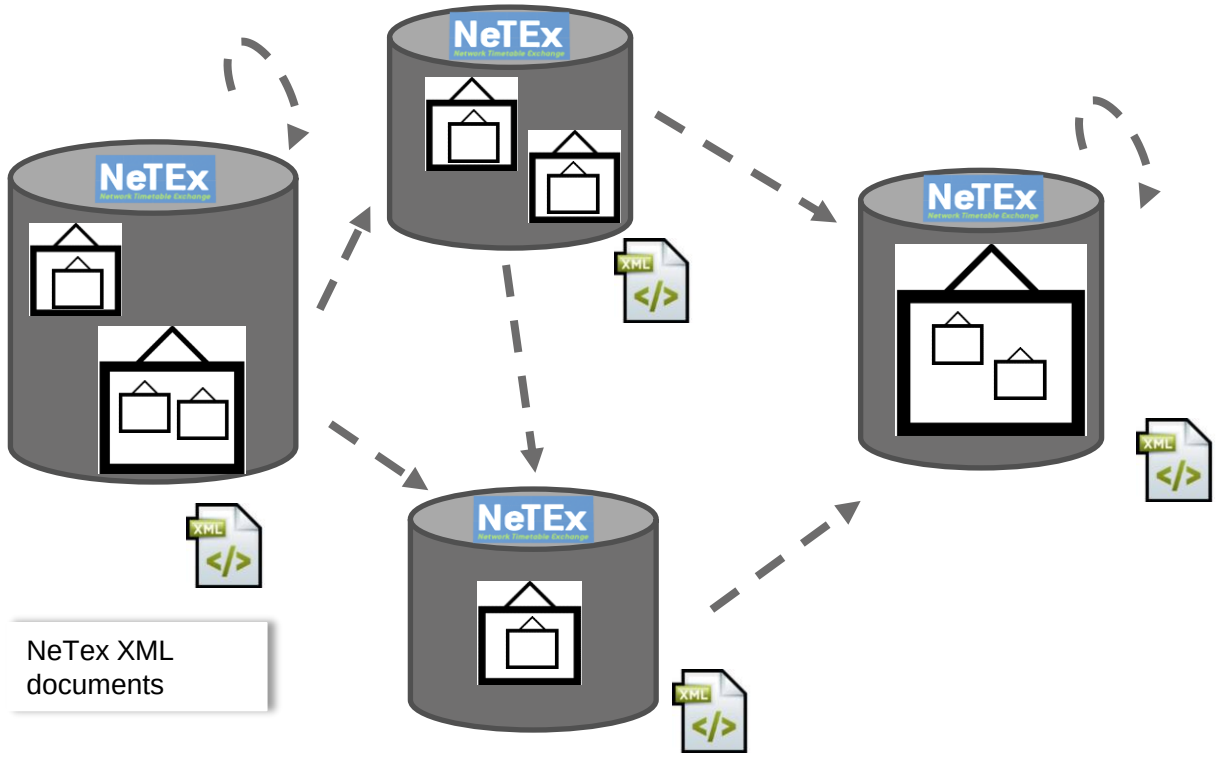
- Does not have underlying reusable elements to build data sets
  - e.g. journey patterns, routes.
    - Simple view for consuming system: Layers & times at stop resolved to single sequence
- Does not cover complex aspects
  - e.g. grouping, connections, join/spilt, makeup, etc
- Does not cover some operational data



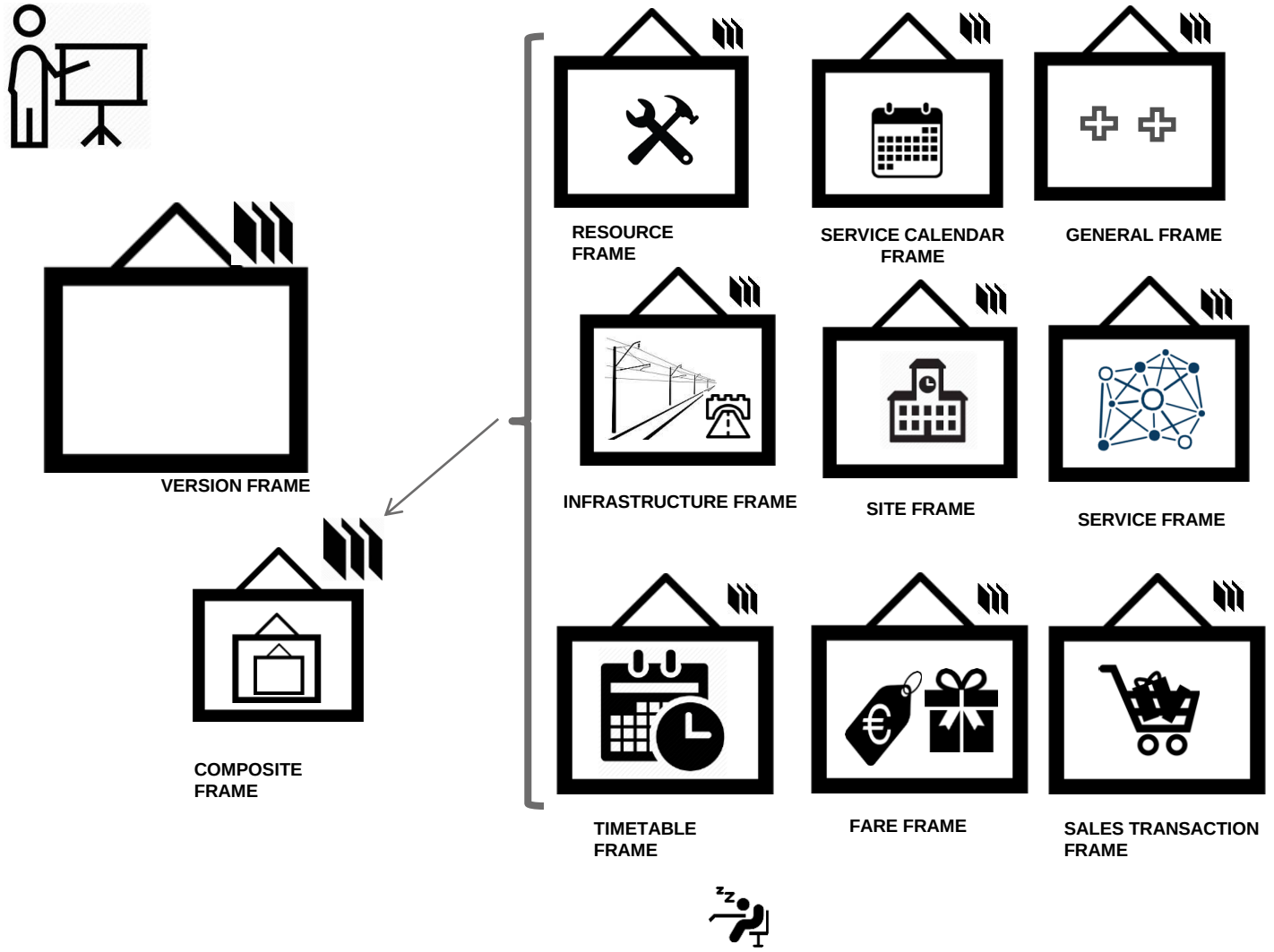
Round trip is "lossy"

- ❑ NeTEx to GTFS: OK
- ❑ GTFS to NeTEx: limited function

Modularised documents ; references may be internal or external



Version Frames



Using extensions for attributes not yet in NeTEx

GTFS

CSV

```
agency_id,agency_name,agency_url,agency_timezone,agency_lang,agency_phone,agency_fare_url
10000,Transport For Ireland,http://transportforireland.ie,Irish Standard Time,en,1-800-300-604,http://transportforireland.ie/fares
```

NeTEx Network Timetable Exchange


```
<Operator version="any" id="10000">
   <keyList>
      <KeyValue typeOfKey="gtfs">
         <Key>gtfs_agency_fare_url</Key>
         <Value>http:// transportforireland.ie/fares</Value>
      </KeyValue>
   </keyList>
   <Name>Transport For Ireland</Name>
   <Locale>
      <TimeZone>Irish Standard Time</TimeZone>
      <DefaultLanguage>en</DefaultLanguage>
   </Locale>
   <ContactDetails>
      <Phone>1800 300 604</Phone>
      <Url>http://www.transportforireland.ie</Url>
   </ContactDetails>
</Operator>
```

Identifiers

GTFS

- GTFS – Central registrar of Agencies,
  - single codespace for agency code
    Elements are Unique within s GTFS zip
  - GTFS allocates agency (ie operator) codes

NeTEx
Network Timetable Exchange

- NeTEX Peer to peer, multiple codespace
  - IANA Domains used to ensure CODESPACEs are unique
  - Can have Multiple CODESPACEs in data set, e.g., National stop codes, and operator codes, Operator timetables.
  - Default CODESPACE for a given version frame
  - Allows integration of multiple data sets in same frame.

Dates and times

GTFS

- GTFS
  - Time – allows unlimited hours e.g. 28:00
  - Dates are in current time zones
  - Time zones may be given for Gtfs Agency

NeTEx
Network Timetable Exchange

- NeTEx
  - Time: Uses XML times (00:00:00 – 24:00:00) with integer day offset for times that are later than 24:00
  - Times are usually relative to Operational day.
  - Date Time : uses UTC
  - Timezone may be given on Locale (OPERATOR, STOP etc)