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Towards Telematics Ontology

Ghislain ATEMEZING| 12-06-2025 | RDF 2025

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Content of TAF TSI

TAF TSI

Railway Undertaking - Infrastructure Manager communication

Railway Undertaking:
- Path Request
- Train Preparation
- Train Running Forecast
- Service Disruption Information
- Train Location
- Interchange Reporting
- Data Exchange for Quality Improvement

Infrastr. Manager:
- Path Request
- Train Preparation
- Train Running Forecast
- Service Disruption Information
- Train Location
- Interchange Reporting
- Data Exchange for Quality Improvement

Railway Undertaking function

Same as "Railway Undertaking - Infrastructure Manager communication"

+

- Consignment Note data
- Shipment Estimated Time of Interchange / Arrival
- Wagon Movement

Wagon keeper function

Rolling Stock Reference Databases

Common TAF TSI elements

TAF TSI published on EU Journal: COMMISSION REGULATION (EU) No 1305/2014

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Content of TAP TSI

TAP TSI

Railway Undertaking - Infrastructure Manager communication

Railway Undertaking:
- Path Request
- Train Preparation
- Train Running Forecast
- Service Disruption Information

Infrastr. Manager:
Path Request
- Train Preparation
- Train Running Forecast
- Service Disruption Information

Railway Undertaking function

- Provide timetable data
- Provide tariff data
- Provide reservation interface
- Provide ticketing functions

Ticket vendor function

- Use reservation interface
- Use ticketing functions

TAP TSI published on EU Journal: COMMISSION REGULATION (EU) No 454/2011

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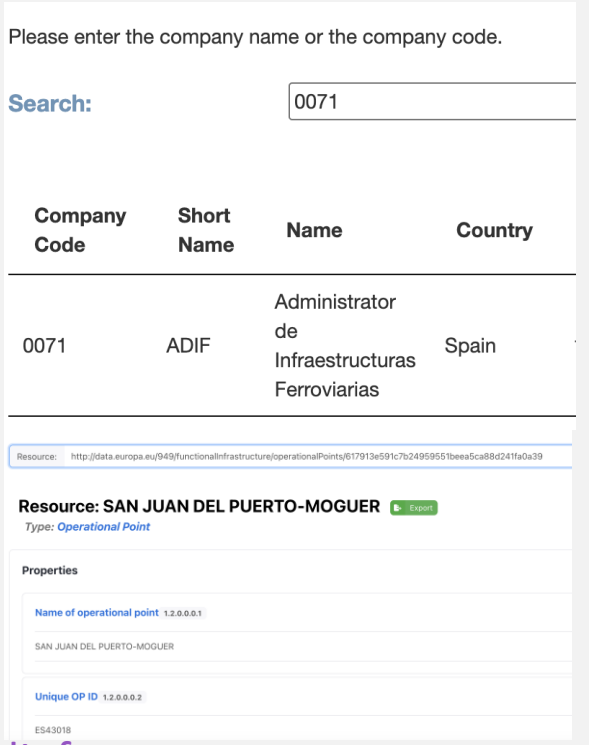
Train Ready Message (TAF TSI)

<ns1:TrainReadyMessage xmlns:ns1="http://www.era.europa.eu/schemes/TAFTSI/3.4" xmlns:xsi="http://www.w3.org/20

```
<ns1:TrainReadyMessage xmlns:ns1="http://www.era.europa.eu/schemes/TAFTSI/3.4"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.era.europa.eu/schemes/TAFTSI/3.4
    file:///C:/Users/vargami/OneDrive%20-%20European%20Union%20Agency%20for%20Railways%20
    (ERA)/Desktop/Telematics/Compliance%20mapping/IRAIL/Renfe/ConsignmentOrderMessage/XSD%203.4.0/taf_cat_complete.xsd">
    <ns1:MessageHeader>
        <ns1:MessageReference>
            <ns1:MessageType>3006</ns1:MessageType>
            <ns1:MessageTypeVersion>2.2.2</ns1:MessageTypeVersion>
            <ns1:MessageIdentifier
                xmlns="http://taf-jsg
                .info/schemes">2c525ccf-9253-11ee-83e9-005056911639</ns1:MessageIdentifier>
            <ns1:MessageDateTime
                xmlns="http://taf-jsg.info/schemes">2023-12-04T04:14:01
                .868+01:00</ns1:MessageDateTime>
        </ns1:MessageReference>
        <ns1:Sender>2171</ns1:Sender>
        <ns1:Recipient>0071</ns1:Recipient>
    </ns1:MessageHeader>
    <ns1:MessageStatus>1</ns1:MessageStatus>
    <ns1:OperationalTrainNumberIdentifier>
        <ns1:OperationalTrainNumber>43018</ns1:OperationalTrainNumber>
        <ns1:ScheduledTimeAtHandover>2023-12-04T04:30:00</ns1:ScheduledTimeAtHandover>
    </ns1:OperationalTrainNumberIdentifier>
    <ns1:TrainLocation>
        <ns1:CountryCodeISO>ES</ns1:CountryCodeISO>
        <ns1:LocationPrimaryCode>43023</ns1:LocationPrimaryCode>
    </ns1:TrainLocation>
    <ns1:TrainReadyStatus>
        <ns1:TrainReady>1</ns1:TrainReady>
    </ns1:TrainReadyStatus>
</ns1:TrainReadyMessage>
```

- How can I know the sender "2171" ?
- Who is the recipient "0071" ?
- Where is this train located in RINF ?



https://teleref.era.europa.eu/

http://data.europa.eu/949/functionalInfrastructure/operationalPoints/617913e591c

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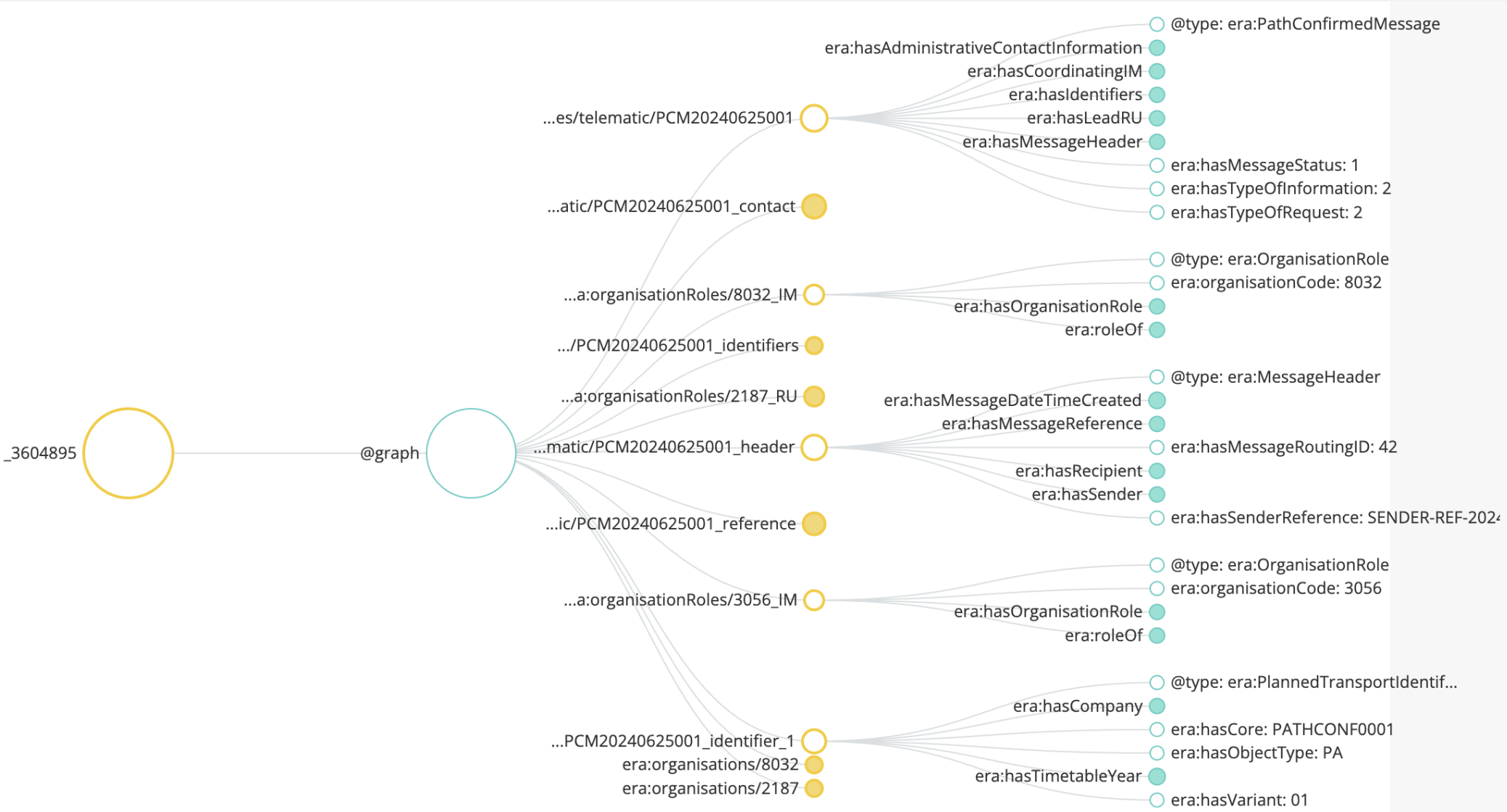
Ideal scenario - interconnected concepts



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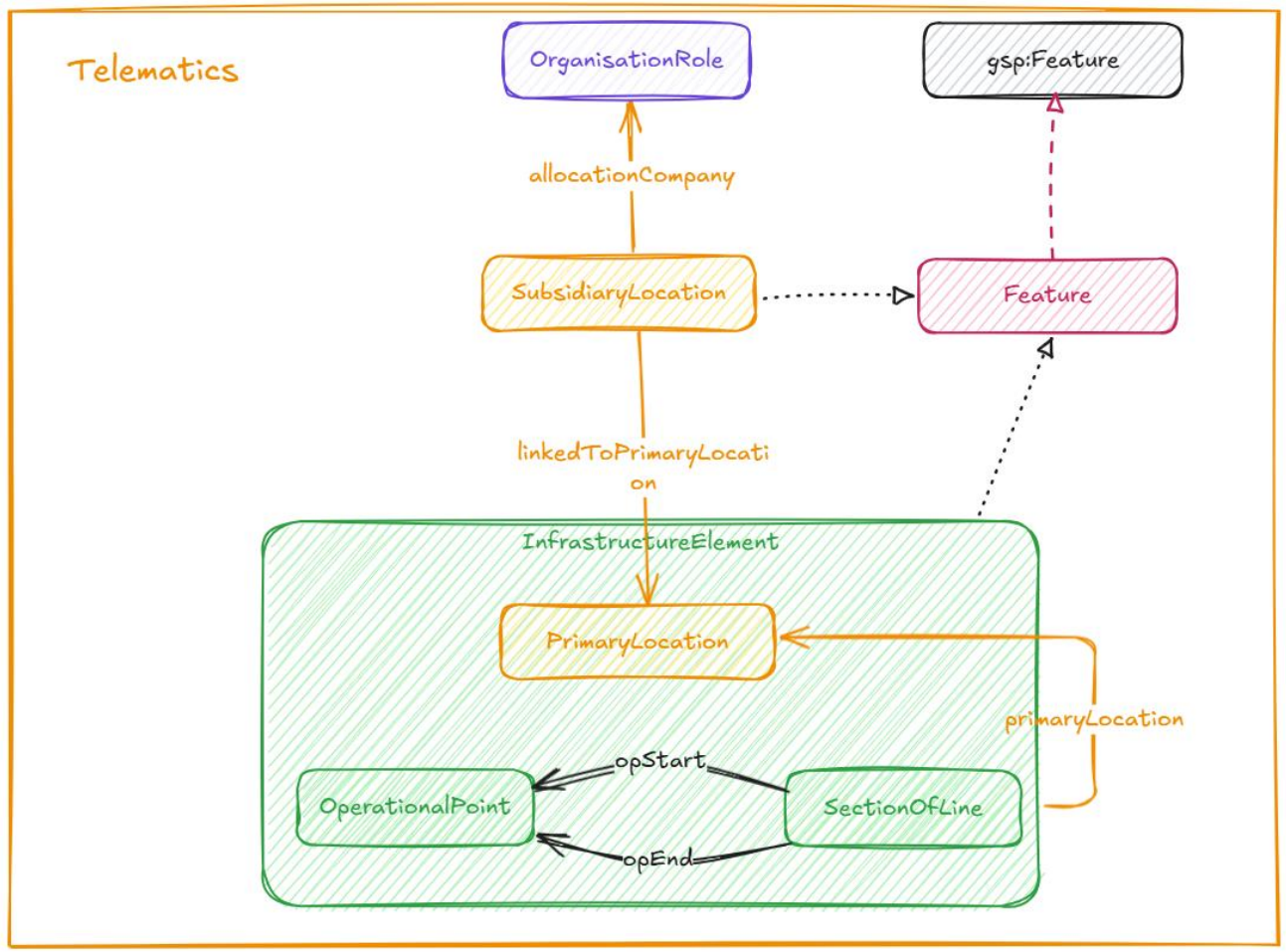
Extend ERA ontology to Telematics



Primary Location [C]

Primary Location is a place used by IM to define a path for a train in TAF/TAP TSI framework/messages. This location is a rail point inside the rail network where train starts, ends, stops, or runs through or change line. This location must be managed by an Infrastructure Manager (IM) identified by company code.

Primary locations are identified by single and unique Primary Location codes. Primary location code is allocated based on processes defined by national entity. Primary location codes are used in any kind of TAF/TAP communication.

See: Handbook 9.3.3 / page 60

IRI: *http://data.europa.eu/949/PrimaryLocation*

Has Properties

- Container handling flag
- Freight flag
- Handover point flag
- Primary location code
- Primary location name

Validation

Validation Rules:

- Primary Location Shape

Additional Information

Example:

Primary locations are for example: stations, yards, halts, handover points, border points, open access terminals.

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How do we integrate telematics domain?

XSD Schemas Input
- Taf_cat XSD
- NeTEx XSD
- Passengers reservation XSD (TAP B5)
- TAP TSI - ELECTRONIC RESERVATION OF ASSISTANCE FOR PERSONS WITH REDUCED MOBILITY (TAP B10)

XSD2RDF Conversion
- Automatic converter to OWL, SHACL and SKOS
- Mapping rules

Semantic artifact validation
- Unit tests
- Sample message generation

Telematics onto integration
- Semantic alignment
- Constraints fusion

ERA ontology updates
- CCM Onto
- Major release

GitLab CI Template for Multiple XSD Sources

This GitLab CI configuration has been restructured to handle 4 different XSD source folders **by type rather than by XSD source** for better maintainability and overview.

XSD Source Folders

The pipeline processes the following XSD sources:

1. **NETEX** (`xsd-source/netex/`)
   - Main file: `NeTEx_publication.xsd`
   - Complex structure with multiple subdirectories
2. **TAF** (`xsd-source/taf/`)
   - Main file: `taf_cat_complete_fixed.xsd`
   - Contains catalog complete definitions
3. **TAP-B5** (`xsd-source/tap-b5/`)
   - Multiple XSD files (processed as batch)
   - Passenger reservation and booking schemas
4. **TAP-B10** (`xsd-source/tap-b10/`)
   - Main file: `TAP_TSI_b.10.xsd`
   - Single file processing

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Sample mapping rule -

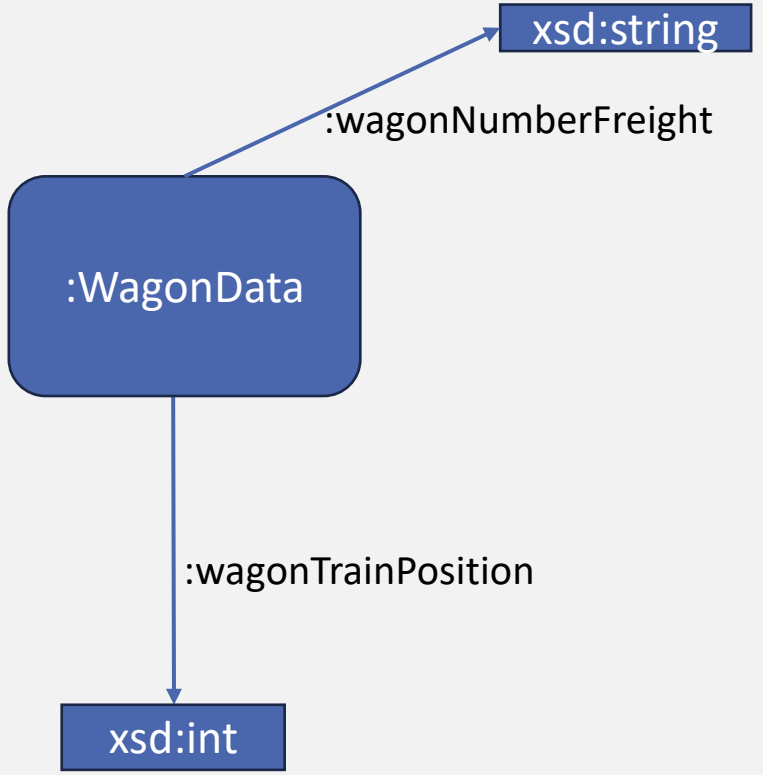
```
<xsd:element name="WagonNumberFreight"
type="xsd:string">
 <xsd:annotation>
 <xsd:documentation>Freight wagon
number</xsd:documentation>
 </xsd:annotation>
 </xsd:element>
 <xsd:element name="WagonTrainPosition"
type="xsd:int">
 <xsd:annotation>
 <xsd:documentation>Position of wagon in
train</xsd:documentation>
 </xsd:annotation>
 </xsd:element>
<xsd:element name="WagonData">
 <xsd:annotation>
 <xsd:documentation>Wagon relevant data for
the wagons within a running
train</xsd:documentation>
 </xsd:annotation>
 <xsd:complexType>
 <xsd:sequence>
 <xsd:element ref="WagonNumberFreight"/>
 <xsd:element ref="WagonTrainPosition"/>
 </xsd:sequence>
 </xsd:complexType>
</xsd:element>
```

```
:wagonNumberFreight a owl:DatatypeProperty;

 rdfs:label "Wagon Number Freight"@en ;
 rdfs:comment "Freight wagon number"@en ;
 rdfs:domain :WagonData ;
 rdfs:range xsd:string .

:wagonTrainPosition a owl:DatatypeProperty;
rdfs:label "Wagon Train Position"@en ;
 rdfs:comment "Position of wagon in train"@en ;
 rdfs:domain :WagonData ;
 rdfs:range xsd:int .

:WagonData a owl:Class ;
 rdfs:label "Wagon Data"@en ;
 rdfs:comment "Wagon relevant data for the wagons
within a running train"@en .
```



Mixed content complex types map to SHACL shapes allowing both text and elements with OWL classes using RDFS annotations for text content.

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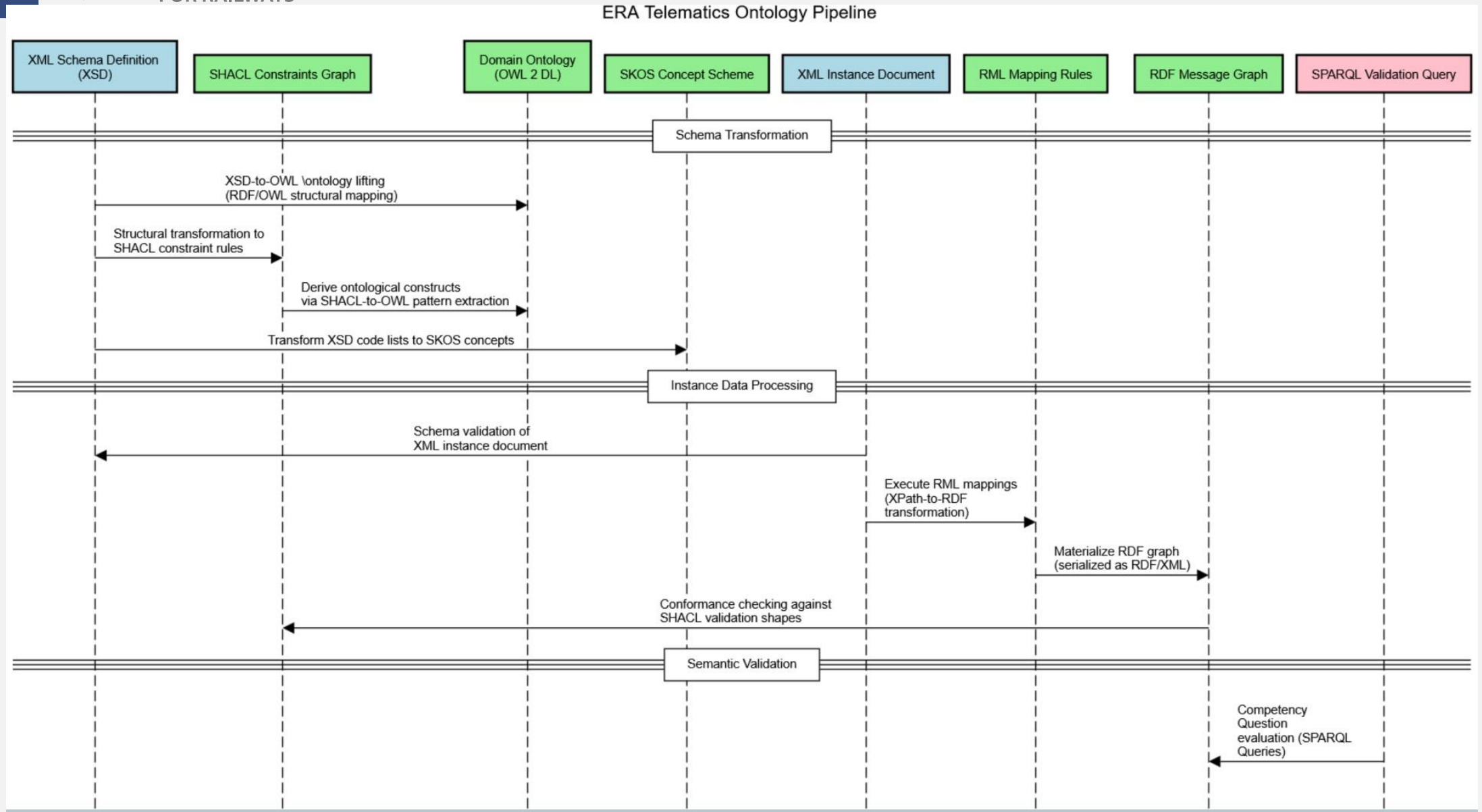
XSD2OWL – XML2RDF



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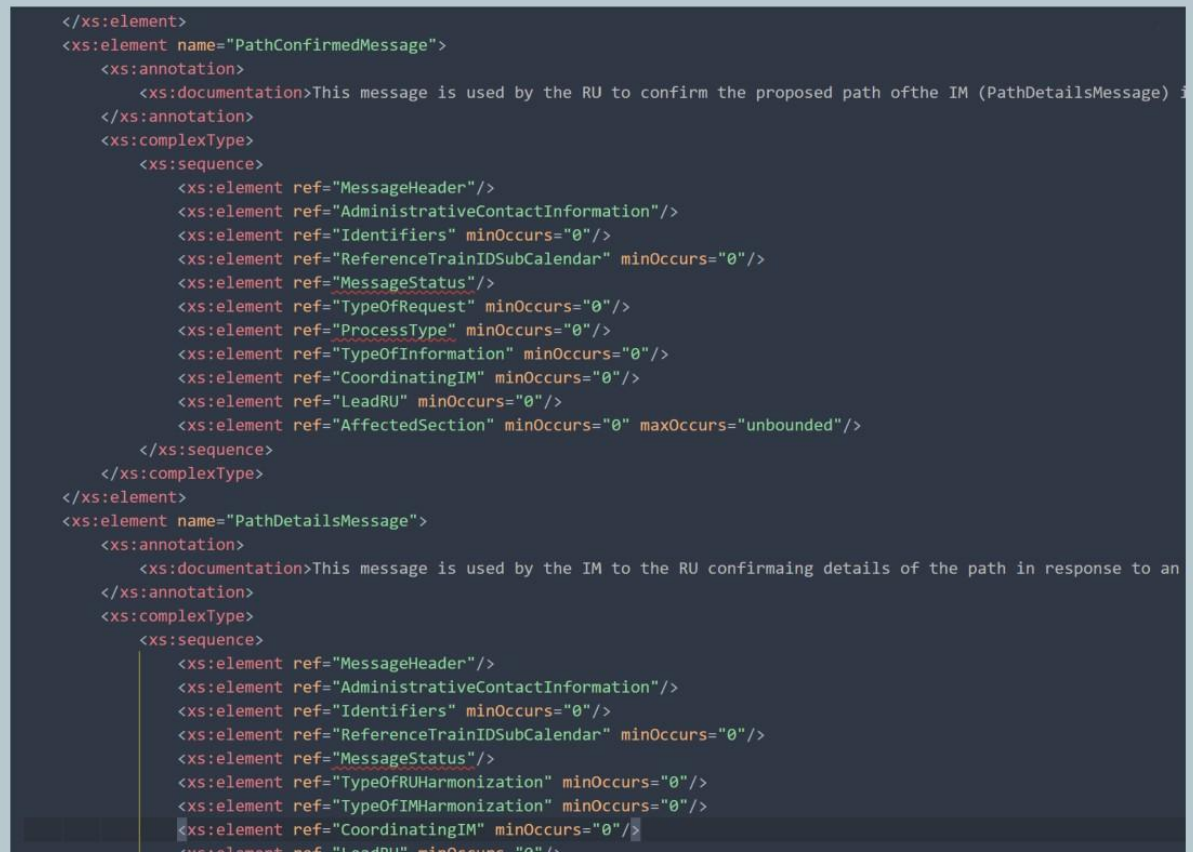
XSD – « Source of Truth »

XML Schema Definition (XSD)

The XML Schema Definition (XSD) serves as the blueprint that describes the structure and constraints of XML messages used by ERA within TAF TSI. This schema ensures that XML documents are valid and follow specified rules, forming the foundation for the subsequent transformation processes.



```
</xs:element>
<xs:element name="PathConfirmedMessage">
    <xs:annotation>
        <xs:documentation>This message is used by the RU to confirm the proposed path ofthe IM (PathDetailsMessage) i
    </xs:annotation>
    <xs:complexType>
        <xs:sequence>
            <xs:element ref="MessageHeader"/>
            <xs:element ref="AdministrativeContactInformation"/>
            <xs:element ref="Identifiers" minOccurs="0"/>
            <xs:element ref="ReferenceTrainIDSubCalendar" minOccurs="0"/>
            <xs:element ref="MessageStatus"/>
            <xs:element ref="TypeOfRequest" minOccurs="0"/>
            <xs:element ref="ProcessType" minOccurs="0"/>
            <xs:element ref="TypeOfInformation" minOccurs="0"/>
            <xs:element ref="CoordinatingIM" minOccurs="0"/>
            <xs:element ref="LeadRU" minOccurs="0"/>
            <xs:element ref="AffectedSection" minOccurs="0" maxOccurs="unbounded"/>
        </xs:sequence>
    </xs:complexType>
</xs:element>
<xs:element name="PathDetailsMessage">
    <xs:annotation>
        <xs:documentation>This message is used by the IM to the RU confirmaing details of the path in response to an
    </xs:annotation>
    <xs:complexType>
        <xs:sequence>
            <xs:element ref="MessageHeader"/>
            <xs:element ref="AdministrativeContactInformation"/>
            <xs:element ref="Identifiers" minOccurs="0"/>
            <xs:element ref="ReferenceTrainIDSubCalendar" minOccurs="0"/>
            <xs:element ref="MessageStatus"/>
            <xs:element ref="TypeOfRUHarmonization" minOccurs="0"/>
            <xs:element ref="TypeOfIMHarmonization" minOccurs="0"/>
            <xs:element ref="CoordinatingIM" minOccurs="0"/>
```

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Mapping to OWL (Ontology)

Transformation to OWL Classes and Properties

The transformation process converts the SHACL shapes into OWL classes and properties, establishing a structural framework for semantic web applications. This would enhance interoperability, allowing for richer data exchange and queries across systems.

```
###  http://data.europa.eu/949/PathCanceledMessage
:PathCanceledMessage rdf:type owl:Class ;
                     rdfs:comment """Path Canceled message according to Short Term Path Request
        specification (WG5)""" ;
                     rdfs:label "PathCanceledMessage" .


###  http://data.europa.eu/949/PathConfirmedMessage
:PathConfirmedMessage rdf:type owl:Class ;
                      rdfs:comment """This message is used by the RU to confirm the proposed path ofthe IM
        (PathDetailsMessage) in response to an RUs Original Request""" ;
                      rdfs:label "PathConfirmedMessage" .


###  http://data.europa.eu/949/PathDetailsMessage
:PathDetailsMessage rdf:type owl:Class ;
                    rdfs:comment """This message is used by the IM to the RU confirmaing details of the
        path in response to an RU request""" ;
                    rdfs:label "PathDetailsMessage" .
```

```
###  http://data.europa.eu/949/hasAdditionalCharges
:hasAdditionalCharges rdf:type owl:ObjectProperty ;
                      rdfs:domain [ rdf:type owl:Class ;
                                    owl:unionOf ( :ChargingSections
                                                  :PrepaymentInstructions
                                                )
                                  ] ;
                      rdfs:range :AdditionalCharges ;
                      rdfs:label "has AdditionalCharges" .


###  http://data.europa.eu/949/hasAdministrativeContactInformation
:hasAdministrativeContactInformation rdf:type owl:ObjectProperty ;
                                     rdfs:domain [ rdf:type owl:Class ;
                                                   owl:unionOf ( :Customers
                                                                 :ErrorMessage
                                                                 :LoadingFacility
                                                                 :PathCanceledMessage
                                                                 :PathConfirmedMessage
                                                                 :PathDetailsMessage
                                                                 :PathDetailsRefusedMessage
                                                                 :PathNotAvailableMessage
                                                                 :PathRequestMessage
                                                               )
```

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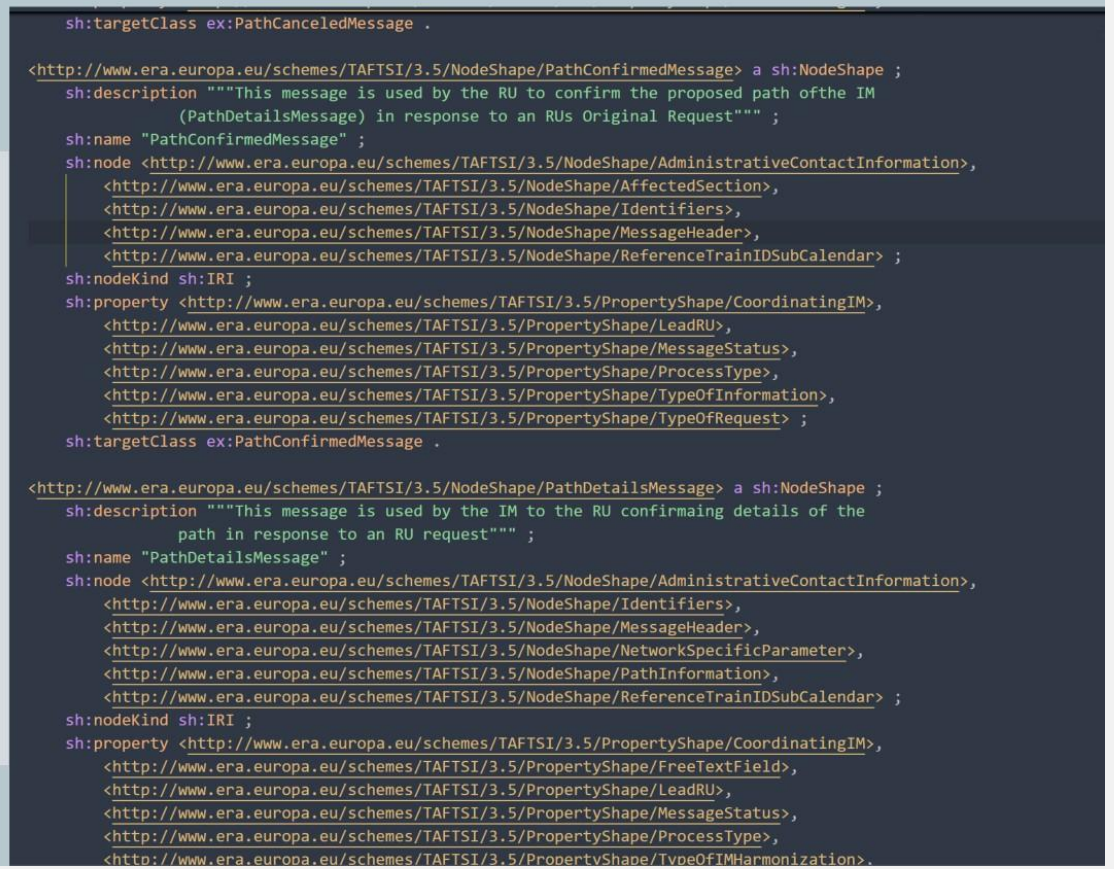
Generation of shape constraints

Generation of SHACL Constraint Rules

SHACL (Shapes Constraint Language) constraint rules are generated from the XSD to detail structural constraints on the RDF data. These rules allow for validation of data instances against the defined constraints, ensuring data integrity and compliance with the structured ontology.



```
    sh:targetClass ex:PathCanceledMessage .

<http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/PathConfirmedMessage> a sh:NodeShape ;
    sh:description """This message is used by the RU to confirm the proposed path ofthe IM
              (PathDetailsMessage) in response to an RUs Original Request""" ;
    sh:name "PathConfirmedMessage" ;
    sh:node <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/AdministrativeContactInformation>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/AffectedSection>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/Identifiers>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/MessageHeader>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/ReferenceTrainIDSubCalendar> ;
    sh:nodeKind sh:IRI ;
    sh:property <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/CoordinatingIM>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/LeadRU>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/MessageStatus>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/ProcessType>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/TypeOfInformation>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/TypeOfRequest> ;
    sh:targetClass ex:PathConfirmedMessage .

<http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/PathDetailsMessage> a sh:NodeShape ;
    sh:description """This message is used by the IM to the RU confirmaing details of the
             path in response to an RU request""" ;
    sh:name "PathDetailsMessage" ;
    sh:node <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/AdministrativeContactInformation>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/Identifiers>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/MessageHeader>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/NetworkSpecificParameter>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/PathInformation>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/NodeShape/ReferenceTrainIDSubCalendar> ;
    sh:nodeKind sh:IRI ;
    sh:property <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/CoordinatingIM>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/FreeTextField>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/LeadRU>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/MessageStatus>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/ProcessType>,
        <http://www.era.europa.eu/schemes/TAFTSI/3.5/PropertyShape/TypeOfIMHarmonization>,
```

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Extraction of SKOS Concepts

Conversion of XSD Code Lists to SKOS Concepts

XSD code lists are transformed into SKOS (Simple Knowledge Organization System) concepts, facilitating better representation and standardization of vocabularies. This conversion ensures that terminologies are harmonized across different datasets, enhancing data sharing and interoperability.

```
era-consignment-order-type:ECN a skos:Concept;
   skos:inScheme era-consignment-order-type:;
   skos:topConceptOf era-consignment-order-type:;
   skos:notation "ECN"^^xsd:token;
   skos:prefLabel "ECN: Electronic consignment note. MessageType will be sent up to the inter
   .

era-consignment-order-type:NACK a skos:Concept;
   skos:inScheme era-consignment-order-type:;
   skos:topConceptOf era-consignment-order-type:;
   skos:notation "NACK"^^xsd:token;
   skos:prefLabel "NotAcknowledged. Message is only sent out by the CDS, in case an ECN is re
   .

era-consignment-order-type:PRN a skos:Concept;
   skos:inScheme era-consignment-order-type:;
   skos:topConceptOf era-consignment-order-type:;
   skos:notation "PRN"^^xsd:token;
   skos:prefLabel "At the beginning of an ECN transport the shipping carrier sends the prior
   .

era-consignment-order-type:INFE a skos:Concept;
   skos:inScheme era-consignment-order-type:;
   skos:topConceptOf era-consignment-order-type:;
   skos:notation "INFE"^^xsd:token;
   skos:prefLabel "Information ECN: This MessageType has only informative character and can b
   .

era-consignment-order-type:INFP a skos:Concept;
   skos:inScheme era-consignment-order-type:;
   skos:topConceptOf era-consignment-order-type:;
   skos:notation "INFP"^^xsd:token;
   skos:prefLabel "Information PCN: This MessageType has only informative character and may c
   .

era-consignment-order-type:CANCEL a skos:Concept;
```

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Evaluation & Validation

Evaluation of Competency Questions

Competency questions assess the ontology's ability to represent required knowledge accurately. These questions guide the validation process, ensuring that the RDF data aligns with the intended semantics and fulfills the information needs of stakeholders.

No	Competency Question	Expected Answer	Type of Message Covered
Q9		and coupling details).	
Q10	The train readiness details for a specific train located in "Valenciennes"	- The train ready status, - train delay and cause - and reason for not ready if applicable	Train Ready Message
Q11	List of reporting points agreed by RU and IM for a given train number on a given date	A reporting point is a start/end/intermediary PathPoint including 'Points of handover' and 'Points of interchange'. So a list of reporting points including identifiers and scheduling details (a given train number on a given date)	Path Request Message Path Details Message
Q12	How many IMs were contacted by a given RU for a path request?	A count of distinct IMs associated with the pathrequest, filtered by contacted by RU	Path Request Message Path Details Message
Q13	What are the intermediate points on a path for train number NNNN from "City1" to "City2"?	A list of intermediate points, with location and timing details.	Path Request Message Path Details Message
Q14	What is the estimated time of arrival (TETA) at a specified point on a path for train number NNNN?	The TETA at the given location for the given train	Train Running Information Train Running Forecast
Q15	What are the delays encountered by train number NNNN along its path?	A list of delay details at each PathPoint for the given train	Train Delay Cause Message Train Running Interruption message
Q16	What is the planned path for multiple freight trains originating from "Hamburg Maschen" on a given day?	A list of confirmed paths with departure and arrival details.	Path Request Message Path Details Message
Q17	What are the agreed reporting points with TETA values for train number NNNN?	A list of reporting points with TETA details.	Path Details Message
Q18	How many path requests were sent by a given RU to a specific IM and were confirmed without modifications on a given day?	A count of path requests confirmation messages fby a RU from an IM	Path Request Message Path Details Message
	How many path requests were sent by a given RU to a specific IM and a proposal with modifications was returned on a given day?	A count of path proposals from IM X related to path requests by RU Y	Path Request Message Path Details Message

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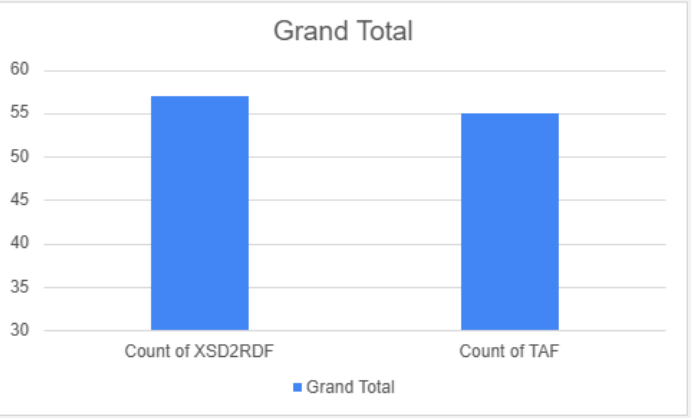
Current status – ERA Gitlab

- https://gitlab.com/era-europa-eu/public/interoperable-data-programme/era-ontology/era-telematics-ontology-pipeline
- https://gitlab.com/era-europa-eu/public/interoperable-data-programme/era-ontology/xsd2rdf



Telematics Ontology

license EUPL 1.2

This repository provides the automation for the publication of the ERA (European Union Agency for Railways) telematics ontology. It includes:

- The input XSD source file as well as a fixed version of it (see further)
- Scripts for further post-processing the RDF files after output by the `xsd2rdf` tool (XSD2RDF repository)
- Several example folders containing both xml and rdf messages as well as several transformation options
- A CI/CD pipeline for validation, transformation, documentation generation, and publishing

Please note that this repository is still a work in progress.

Automation

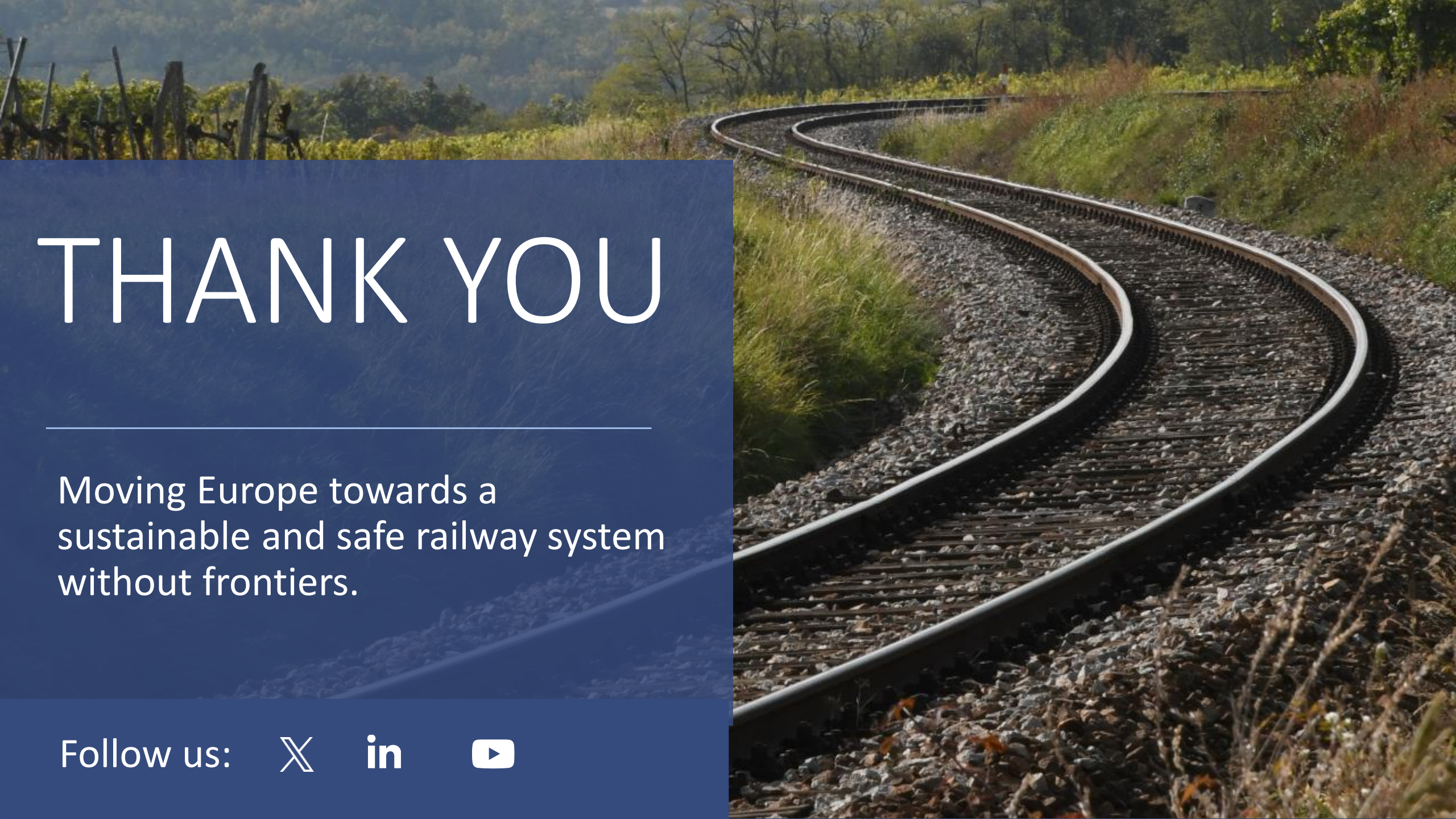
The telematics ontology is automatically generated in a two step process:

- conversion from the XSD schema using the `xsd2rdf` tool
- post-processing using the scripts defined in this repository

There is no manual curation performed.

Repository Structure

- `xsd-source/` — Source XSD files (including `taf_cat_complete.xsd` and `taf_cat_complete_fixed.xsd`).
- `post-processing/` — Python scripts for post-processing RDF/OWL files.
- `example-xml-messages/` — A wide variety of example XML messages. Their purpose is to serve as test



THANK YOU

Moving Europe towards a sustainable and safe railway system without frontiers.

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