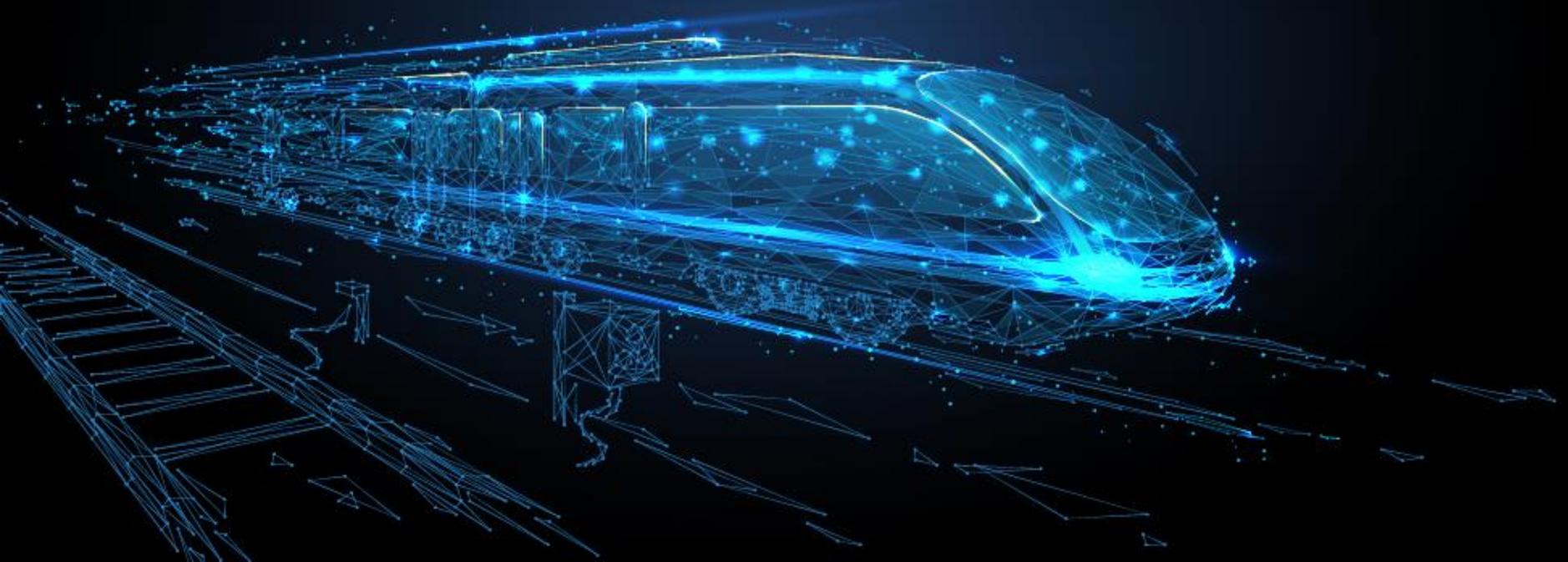
INTERNATIONAL UNION
OF RAILWAYS

DIGITAL MODELLING INITIATIVES FOR THE OPERATIONAL RAILWAY



Webinar

June 30, 2021

Opening remarks

François Davenne

Director General, UIC

Programme

Opening Remarks (François Davenne, UIC Director General)

Session 1 (11.00-12.30)

RailSystemModel
- RailSystemModel fundamentals
- What's new in RSM1.2?
- Example of projects in relation to RailSystemModel

OntoRail
- What is OntoRail?
- What are ontologies?
- OntoRail fundamentals

Session 2 (13.30-15.30)

Perspectives
- RailSystemModel & OntoRail as enablers of the Conceptual Data Model (UIC)
- Digital Twin at SNCF (Gilles Dessagne, SNCF Réseau)
- RSM in support of FRMCS (UIC)
- Signalling data preparation with RailSystemModel and EULYNX (Dr. Bob Janssen, EULYNX information modeller)

Next Steps

Closing Remarks (Pierre-Etienne Gautier, SNCF Réseau)


RSM®
Rail System MODEL

Rail System Model: RSM fundamentals

What is RSM ?

A conceptual and implementable model of the railway system…

- “One concept, one class” – SOLID design principles
- Project-independent, not limited to specific “use cases”

A set of UML packages and class diagrams…

- UML most widespread
- Suitable for code (Java, C#...) and scheme (XSD…) generation

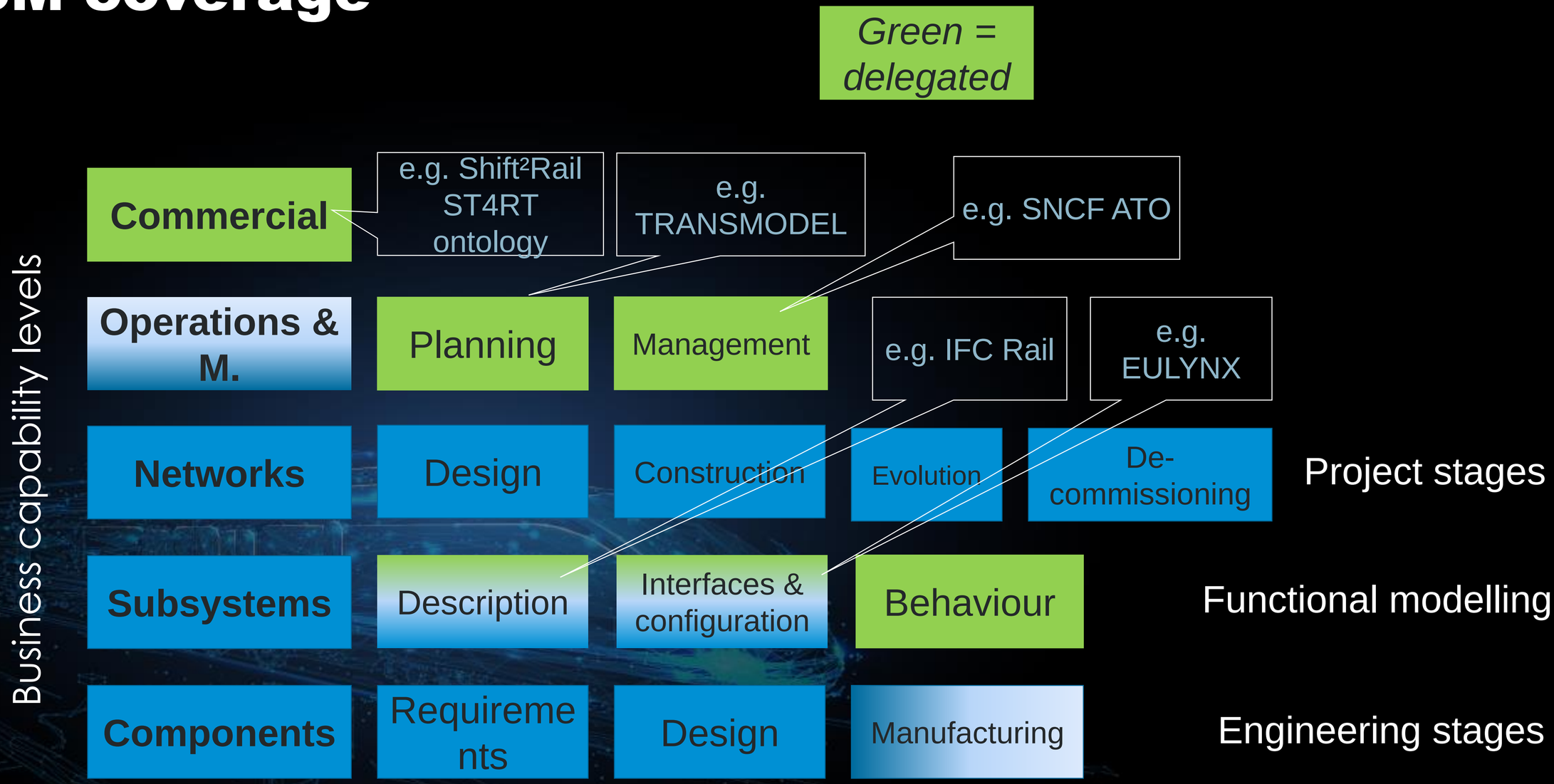
An ontology in Ontorail…

- “True image” UML to OWL extraction
- For model linking and information exchange

An International Railway Standard by UIC.

- RTM 1.1 : IRS 30100
- RSM: 1.2
  - Live documentation on rsm.uic.org
  - Later published as eIRS

RSM coverage

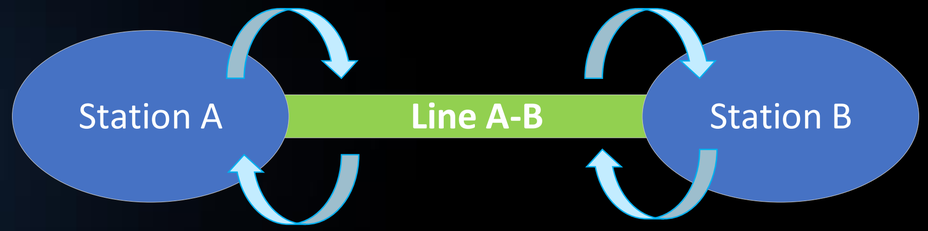


Topology: Kernel of RSM

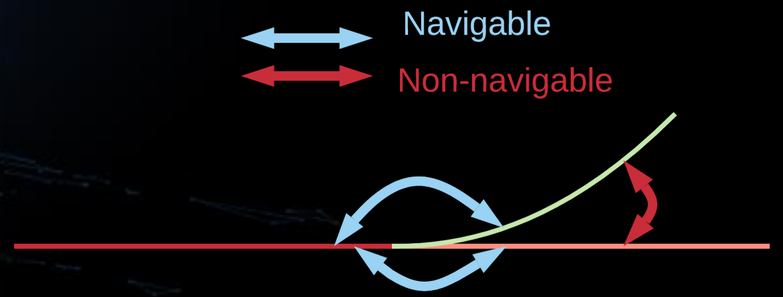
Topology answers the question “**what railway net element is connected to what other net element**”,
using one formal representation, regardless of **scale** or **level of detail**.

Net elements can correspond to lines, or tracks, or stations…
Topology relations are explicit and allow correct pathfinding.

MACRO level: stations and line have bi-directionally navigable relations



MICRO level: topological (track) segments relations may be navigable or not



RSM 1.2 highlights

Package overview

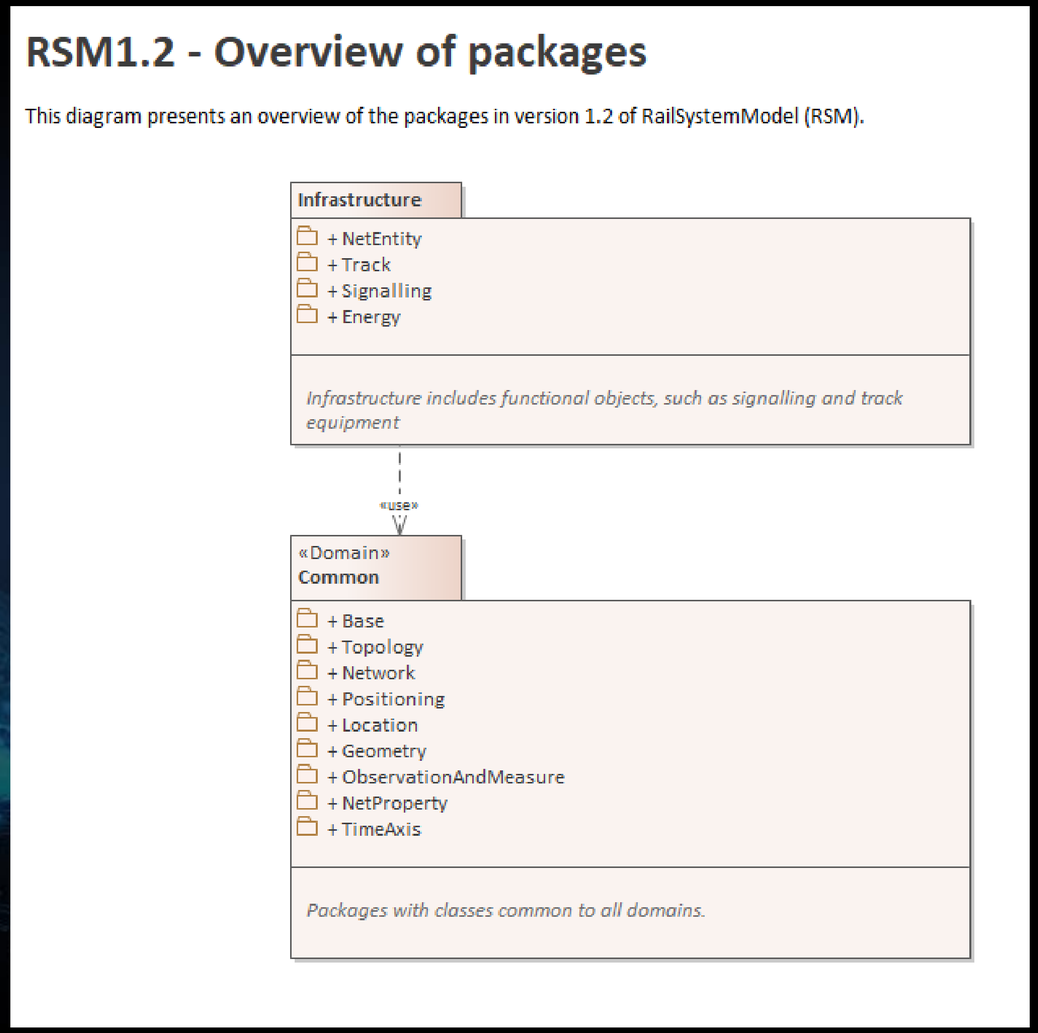
Infrastructure

Sorted by subsystem, broken down into Net Entities

Currently:

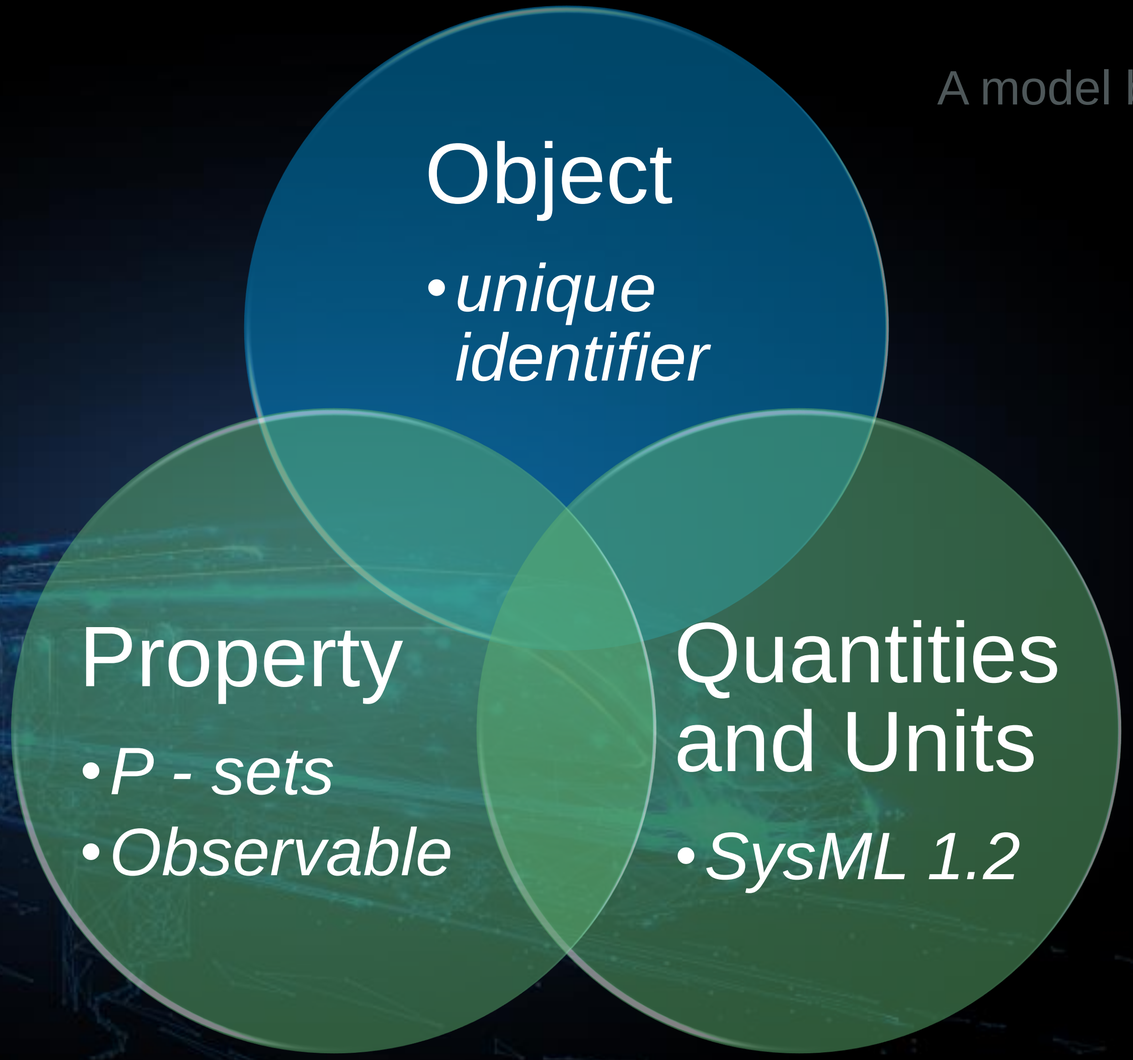
- Track
- Signalling
- Energy

Common

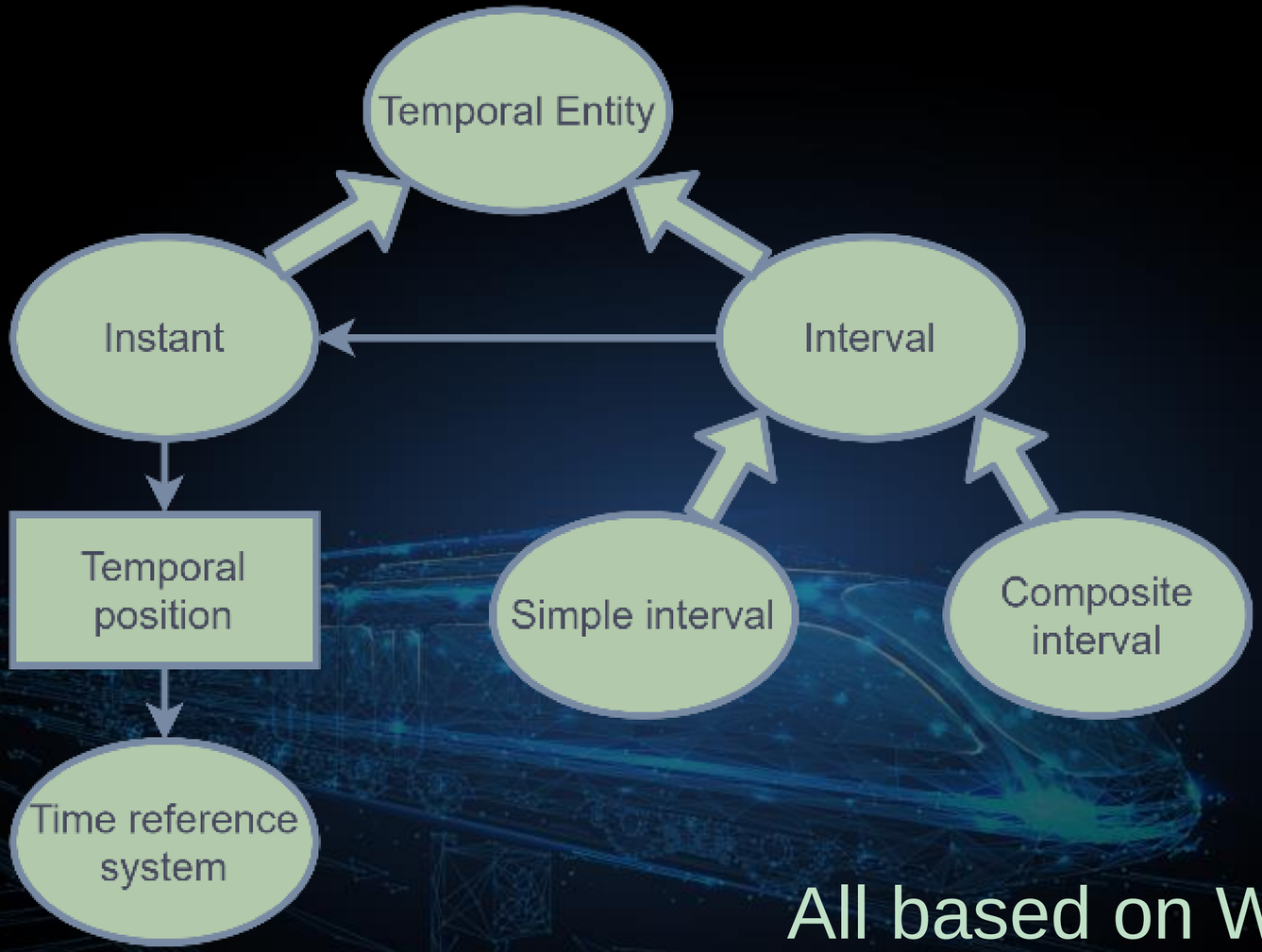


Base package : new responsibilities

A model by engineers, for all professionals

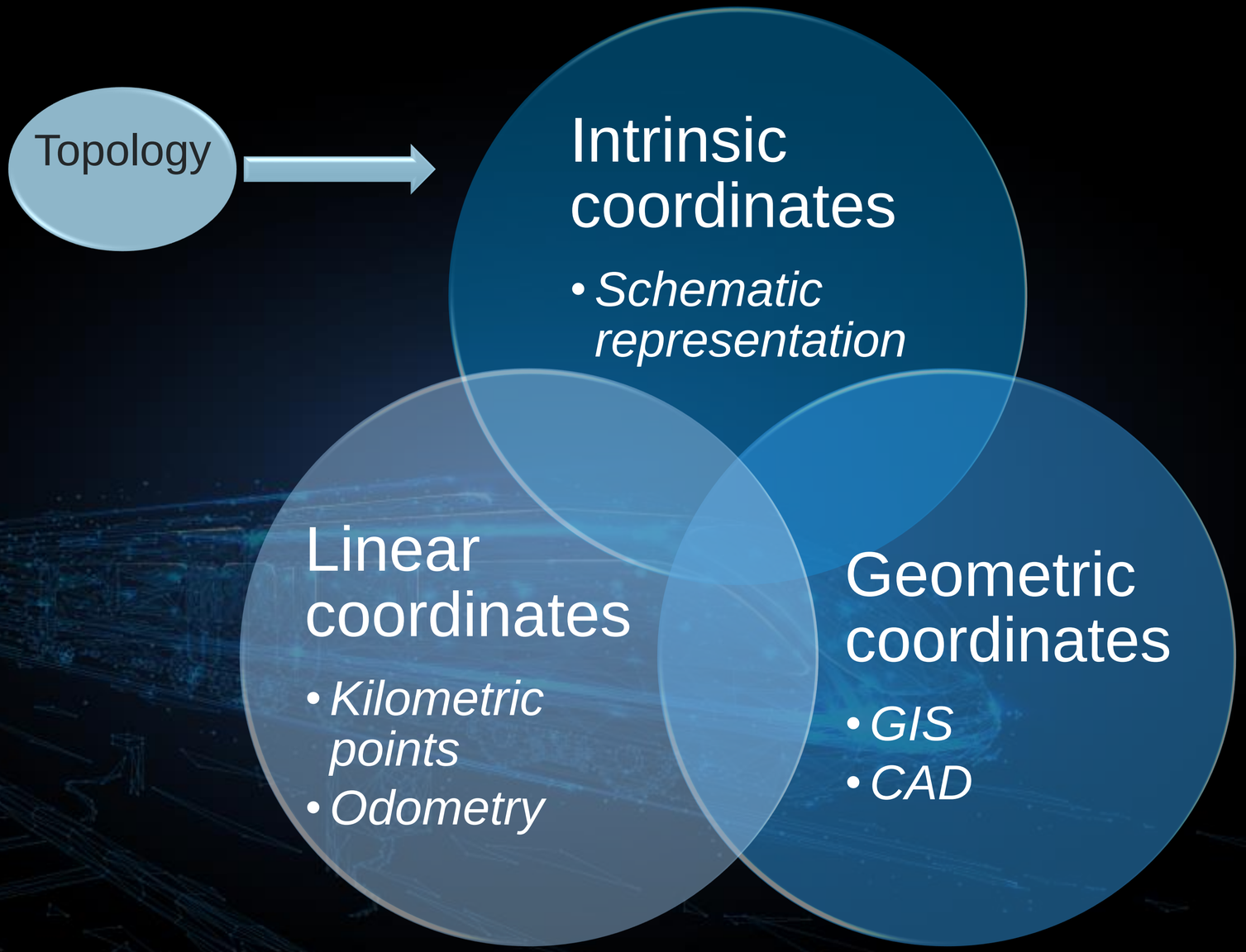


Time Axis : instants, intervals, calendars



All based on W3C / OGC time ontology
https://www.w3.org/TR/owl-time/

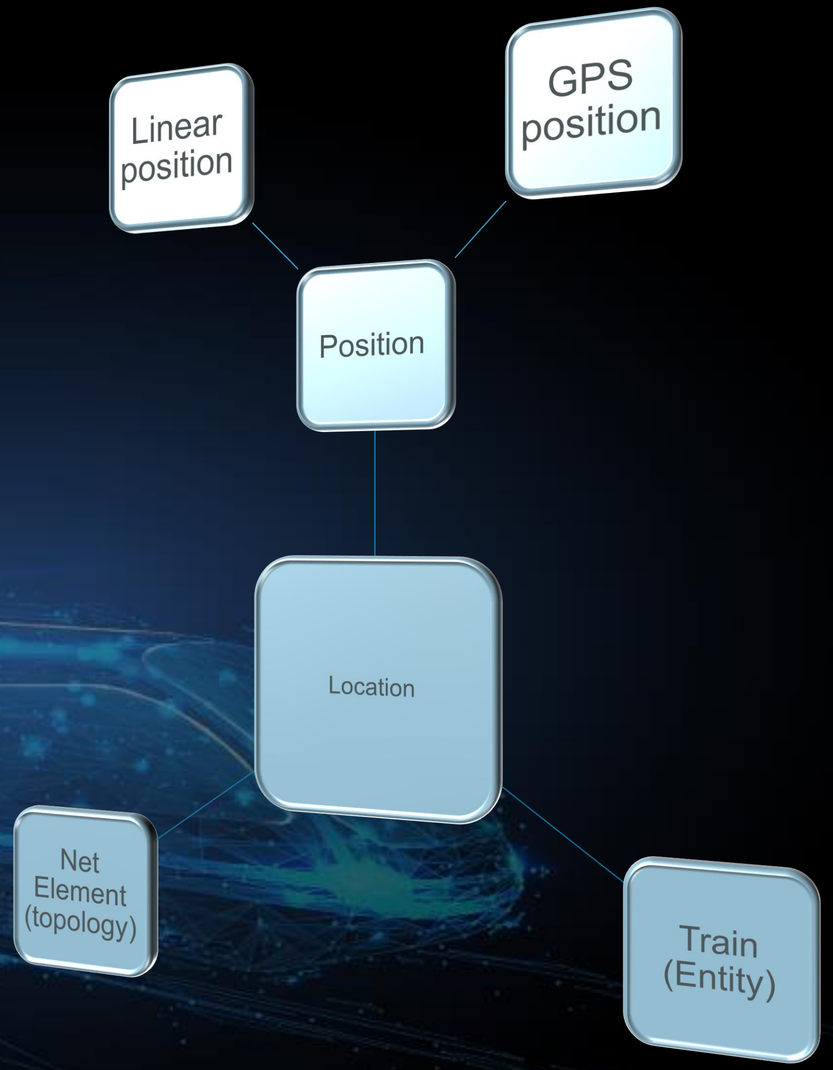
Positioning : OGC concepts adapted to railways



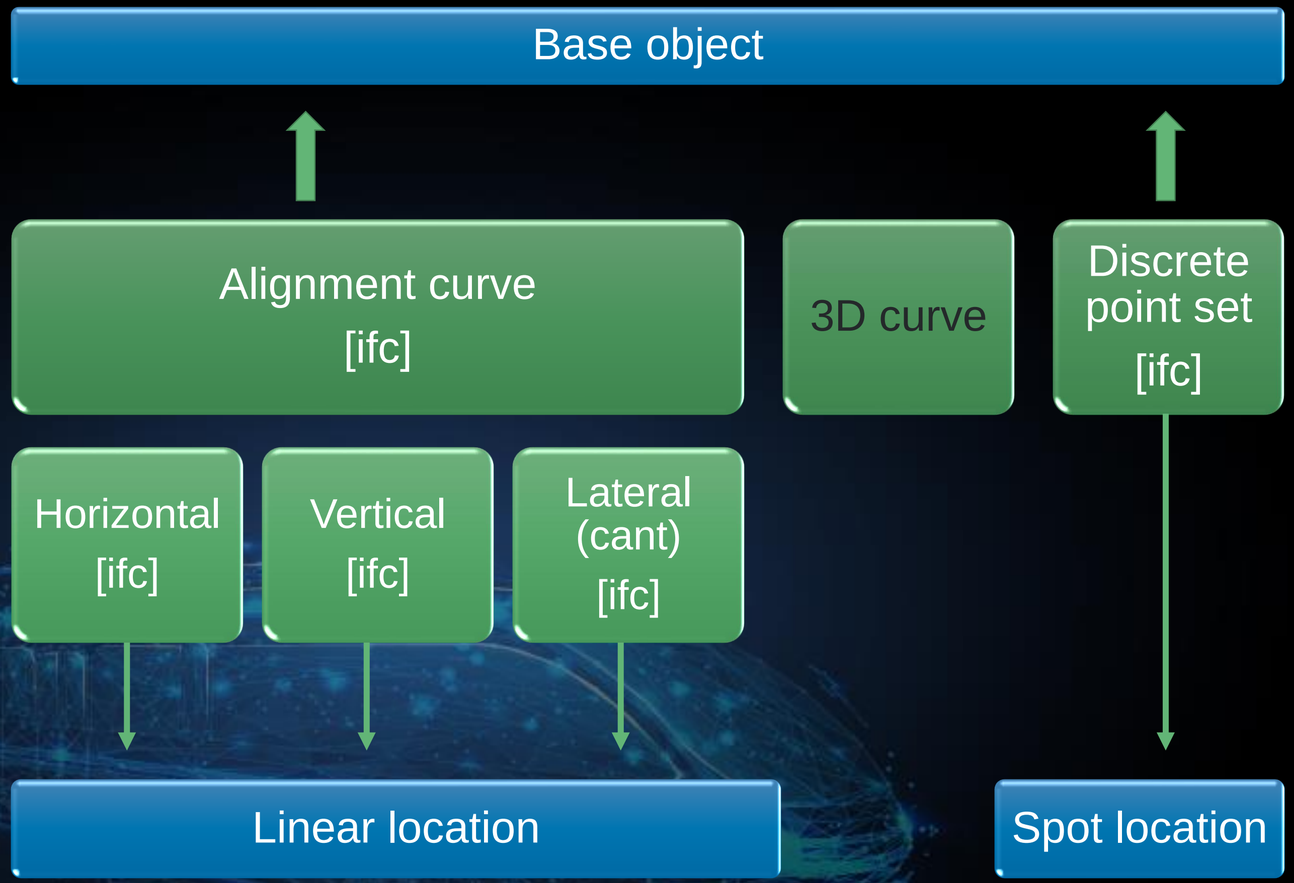
Location : simplified

Sample use case:
“where is my train?”

“Location” pulls the information together.



Geometry : cooperating with bSI - IFC Rail project

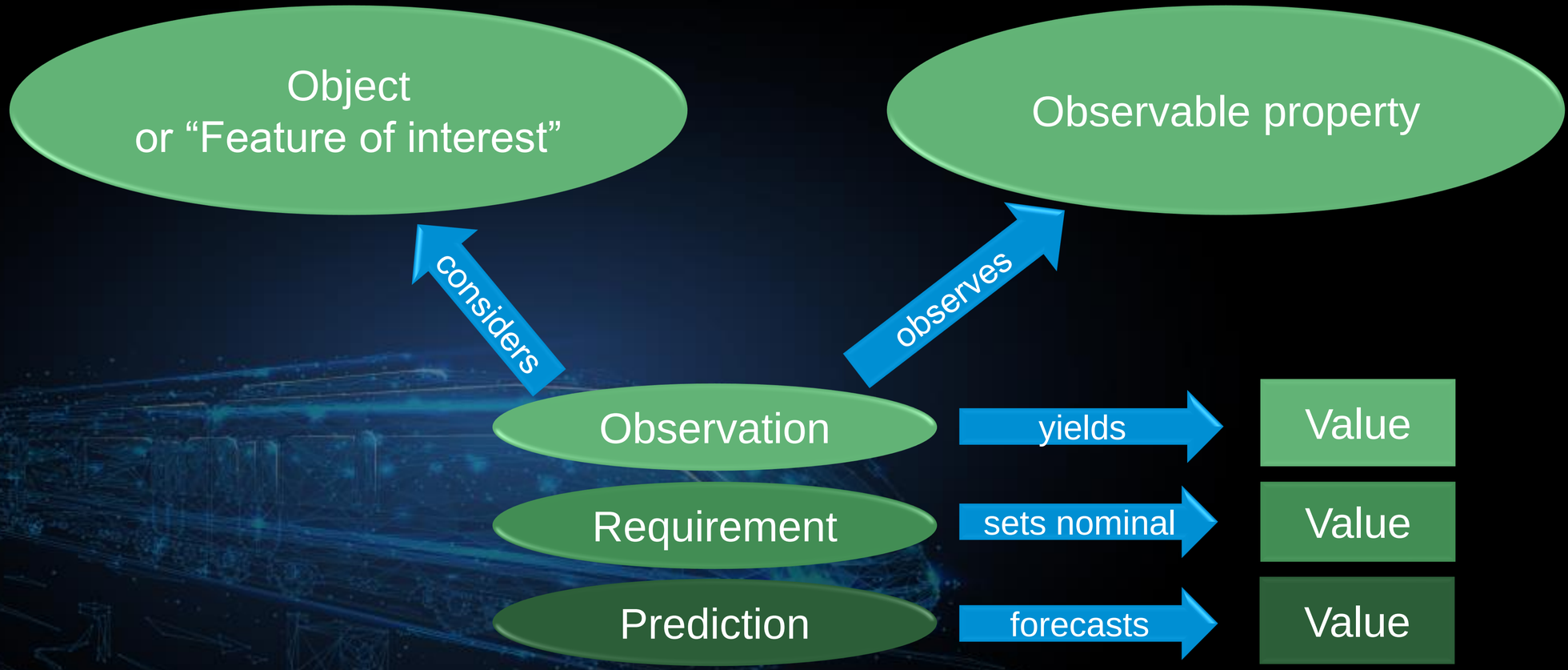


Geometry rests on classes defined by buildingSMART International, for the purpose of IFC (Industry Foundation Classes) and extended with railway-specific notions (cant / inclination).

bSI classes themselves inspired by OGC.

3D-curves added: not widely used, but futureproof.

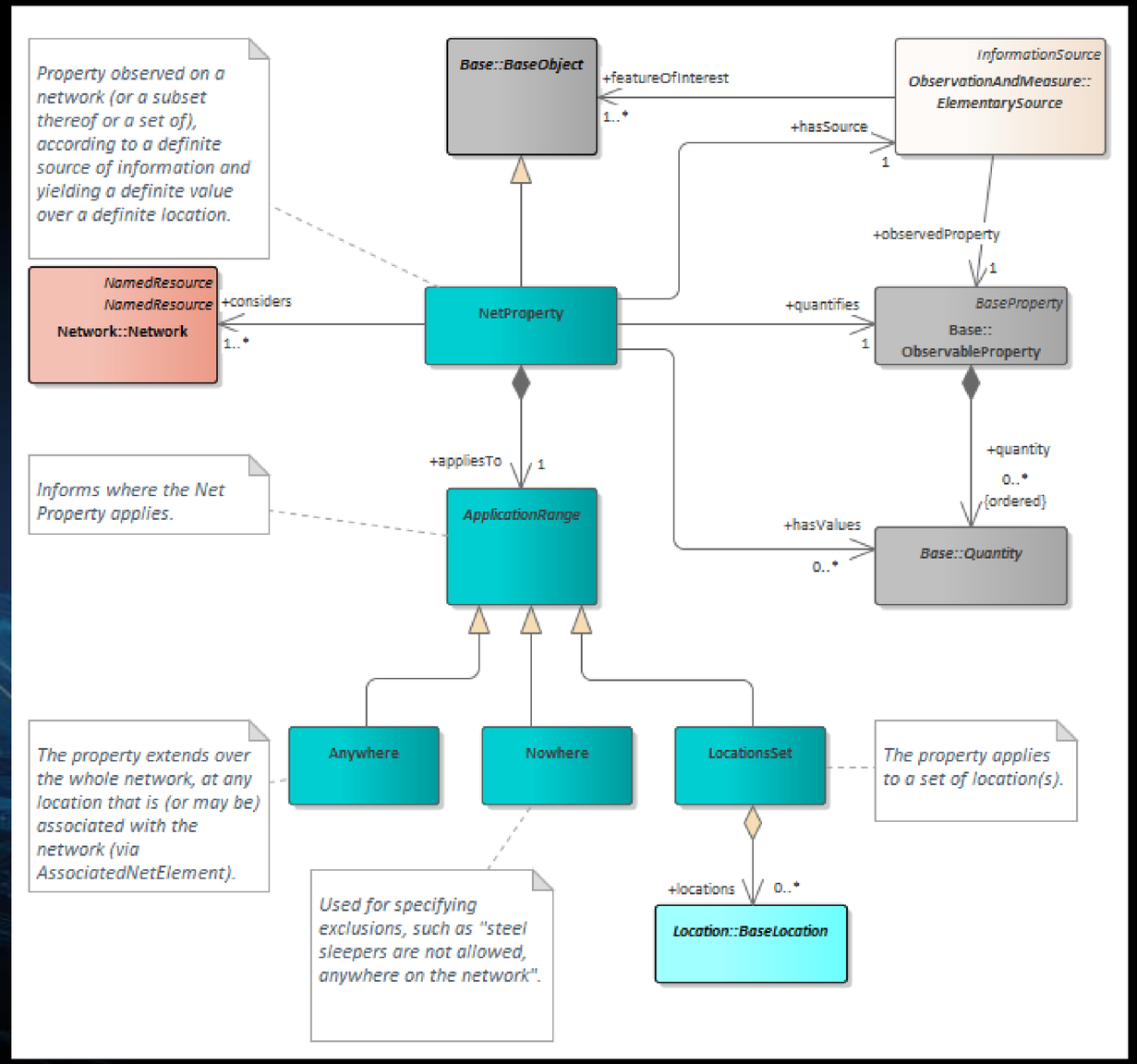
Observation and Measure : ready for IOT and predictive maintenance



Package rests on ontology SOSA / SSN, jointly developed by W3C and OGC
(Sensors, observation, actuation and sampling / Semantic sensor network)
Requirement and Prediction added: a use case examined with buildingSMART Intl. (IFC Rail project).

Net Property : a bird's eye view on the network

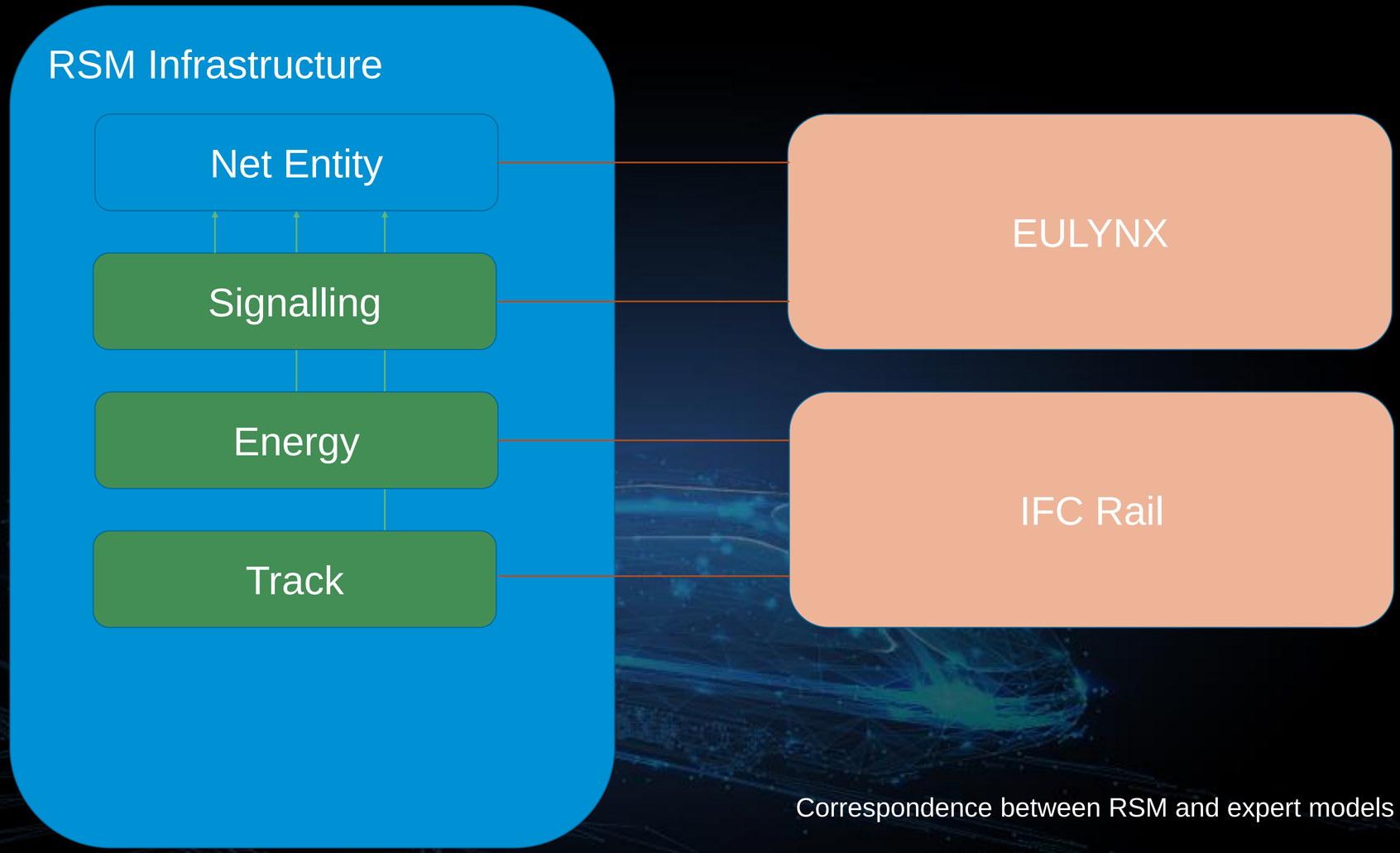
- "Net property" or "Line property" observes atomic data (property values) and sums them up over arbitrary "networks" (sets of net elements or net entities)
- "Net property" or "Line property" values are derived (and distinct) from observed or nominal values
- E.g. "760mm" and "600mm" can be summed up into "narrow gauge"
- Can yield property values for RINF



Package results from cooperation with

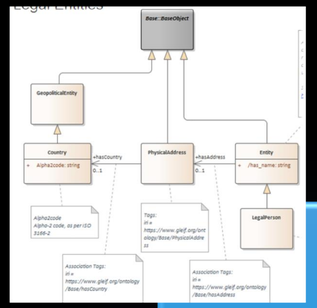
bSI / IFC Rail

Track, Signalling, Energy



Correspondence between RSM and expert models was established.

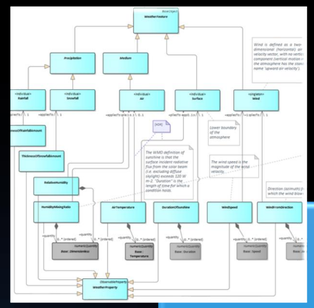
Environment: we (railways) are not alone



Legal Entities

- Legal person
- Country…

Based on GLEIF ontology and ISO20275



Weather

- Phenomena: Wind, rainfall…
- Properties: speed, thickness…

Based on Climate & Forecast (CF) terminology and ontologies

Whenever possible, RSM extensions are based on **available industry standards** (text, models, ontologies)

RSM at use in projects

EULYNX DataPrep (current)

See EULYNX presentation:

Signalling data preparation with RailSystemModel and EULYNX

SIA (H2020): predictive maintenance

General goal

- Develop 4 ready-to-use new services to provide prognosis of health status of the railway's most cost-intensive assets, at the points of interaction between the vehicle and the infrastructure (wheelset / rail, pantograph / catenary)

Specific goal

- UML model and XSD generation to support data exchange from sensors to diagnosis centres

Achievement

- Model federation: RSM basis + railML3 parts (subsystems)

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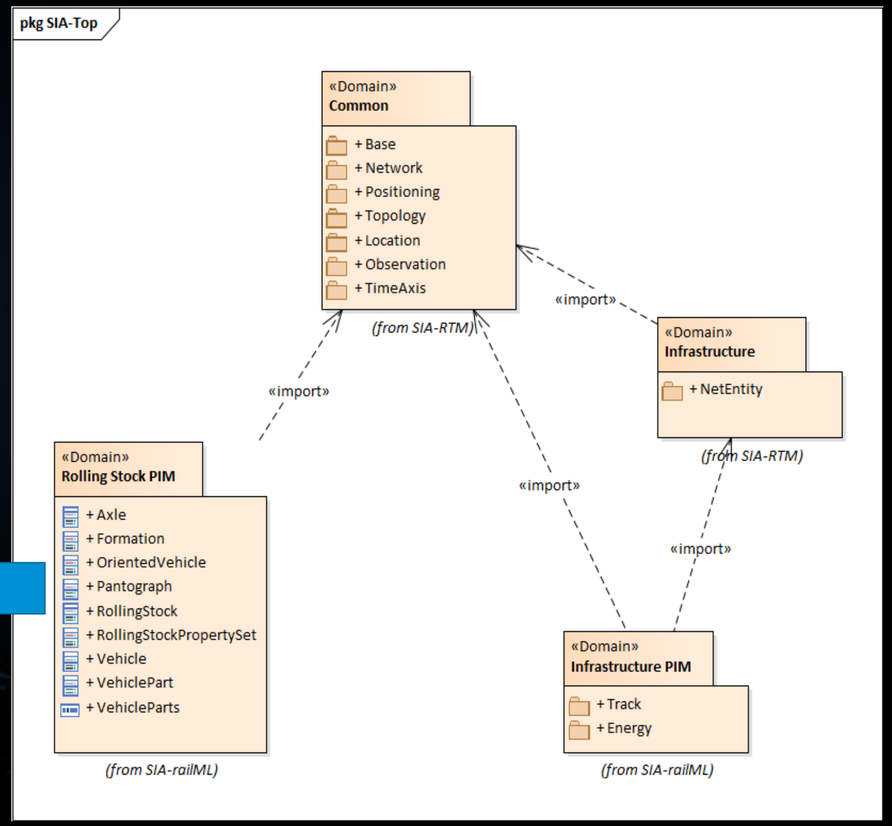


OPTIMA (Shift²Rail open call): Traffic Management System

The power of a conceptual model (Python implementation) at the service of a data model

OSM geometry → RSM network instantiation (Python) → KML export → Display in Google Earth

JSON export

```
_Sidecar
  py/object                          RSM12beta.Common.XTN_Base.Sidecar
  sID                                10
  _Name                              Test Ventimiglia-Albenga import from osm file, sidecar
  _resources
    DualGraph
    Geometric positioning system WGS84 (epsg:4326)
    Grid reference system ETRS89 LAEA Europe (epsg:3035)
    LRS
      Riferimento_lineare_binario_Nord
        py/object                    RSM12beta.Common.XTN_Positioning.LinearLocationBasedLRS
        sID                          1765
        _Name                        Riferimento_lineare_binario_Nord
        hasLinearReferencingMethod   relative
        startMeasure                 0
        endMeasure                   null
        anchors
          py/object                  RSM12beta.Common.RSM_Positioning.AnchorPoint
          sID                        1779
          _Name                      kp2
          _measure
            py/object                RSM12beta.Common.RSM_Base.Length
            q_kind
            unit
            Value                    2000
          _measureToNext
            py/object                RSM12beta.Common.RSM_Base.Length
            q_kind
            unit
            Value                    1005.0
```

Linear referencing, regenerated

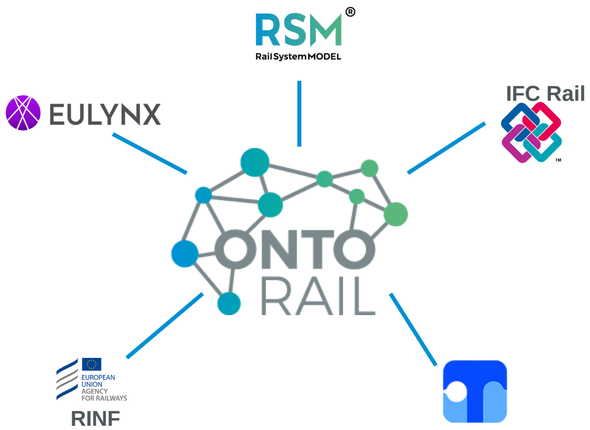

ONTO
RAIL

What is OntoRail?

ONTO RAIL

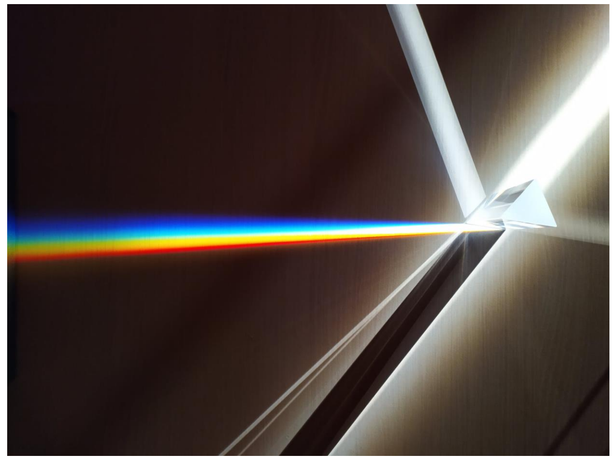
An Encyclopedia

to consolidate and enrich Railways Systems Modelling knowledge



A Tool for Building Consensus

to promote and facilitate convergence and federation between models



A knowledge engine, powered by Ontologies

What are Ontologies?

Ontologies are formal representations of knowledge, built on a consensus on domain knowledge and on a shared and precise vocabulary to qualify relations between concepts.

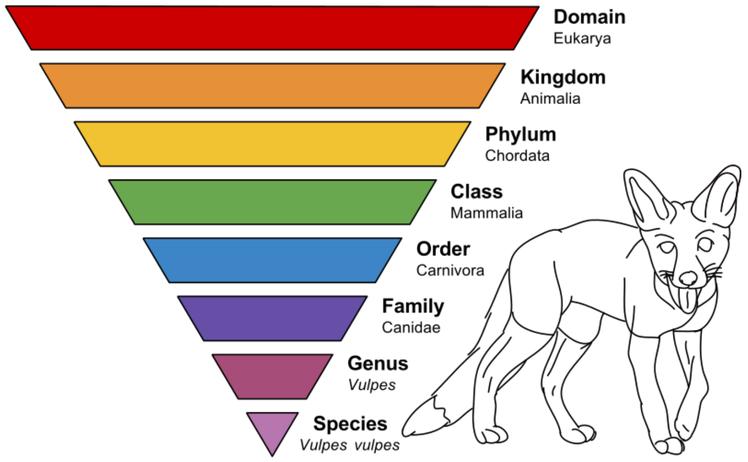


Image source: Taxonomic Rank Graph.svg by Annina Breen [CC-BY-SA]

Additional statements about the subjects:

BT	broader term
NT	narrower term (inverse of BT)
SN	scope note
USE	use
UF	used for (inverse of USE)
TT	top term
RT	related term

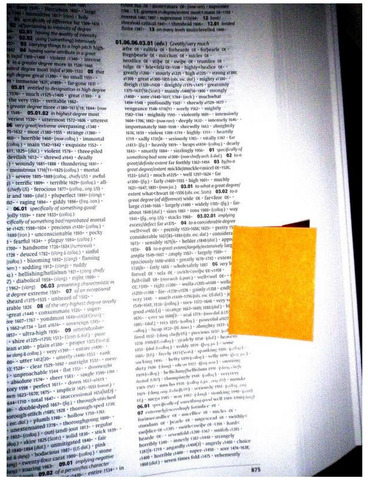


Image source: Very, Oxford Historical Thesaurus, the office, Hackney, London, UK by Cory Doctorow [CC-BY-SA

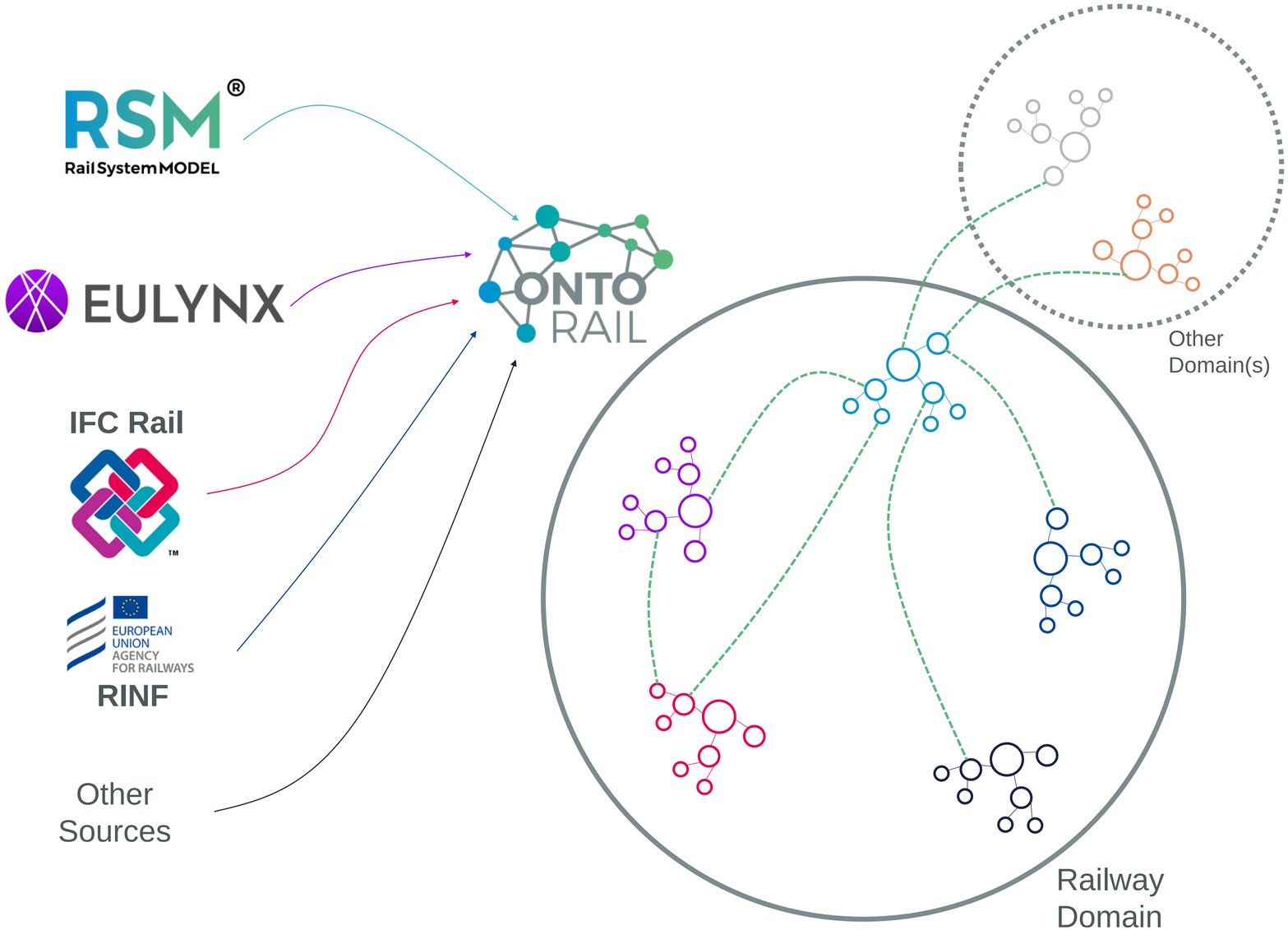
Taxonomy

Subject-based classification
Hierarchical organization (parent / child)

Thesaurus

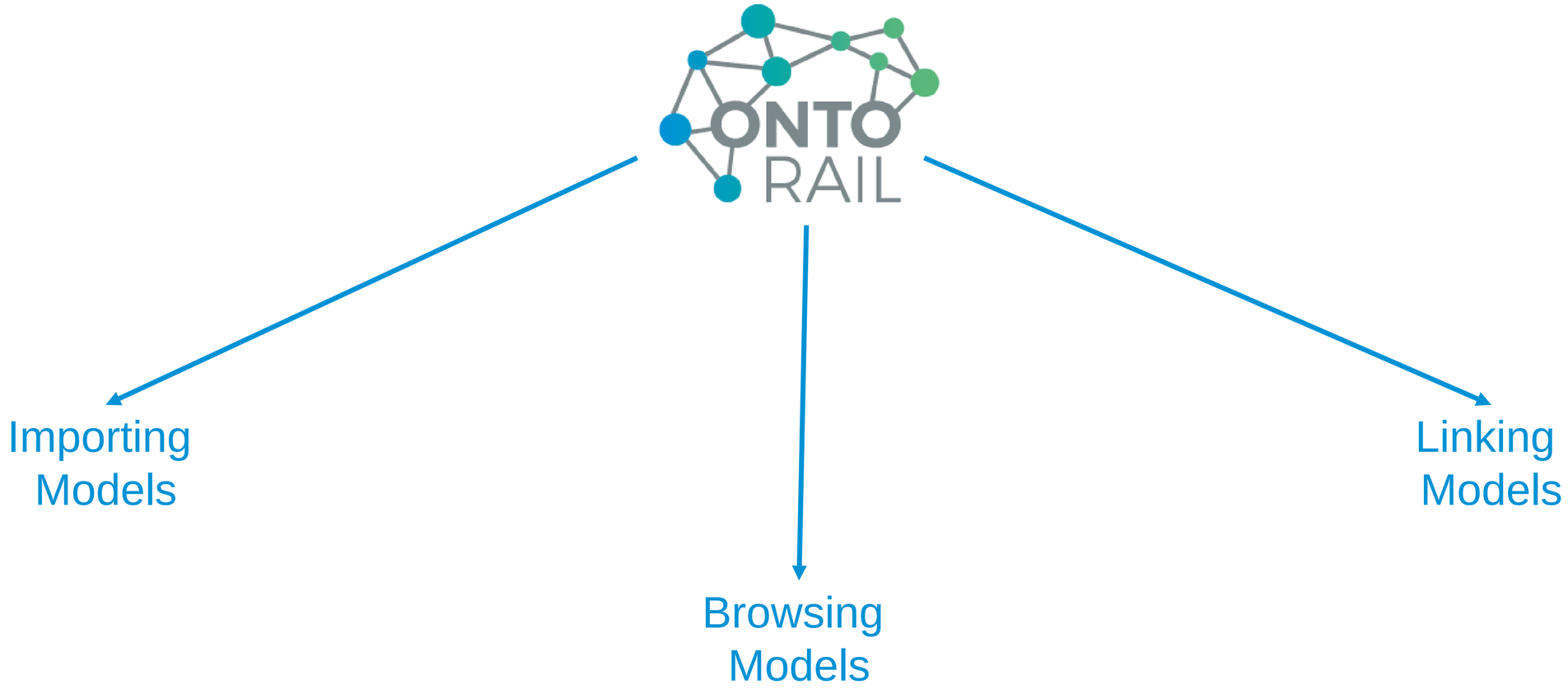
Extends taxonomies
Additional statements (BT, NT, SN, …)

OntoRail Fundamentals



- Filtering
- Querying
- Linking

OntoRail Fundamentals



OntoRail application homepage

[OntoRail]

Non sécurisé | app.ontorail.org:5000/ontorail

Mettre à jour

OntoRail Aggregated Ontology

ONTO RAIL

Login

» **Source Ontologies:**

[EULYNX]

EULYNX standardises the interfaces between the interlocking at the core of the signalling system and all peripheral subsystems, ranging from light signal to traffic control system.

- 174 Packages
- 4806 Classes
- 2518 Properties
- 165 Enumerations
- 12 DataTypes

Tree Browser | Graph

[RSM 1.2 beta]

RailSystemModel (RSM) provides a structural backbone model to foster digital continuity across railway domains and business processes. RSM cooperates with Expert Projects in their respective domains (for example Eulynx for signaling, IfcRail for BIM process, ...).

- 18 Packages
- 143 Classes
- 158 Properties
- 8 Enumerations
- 2 DataTypes

Tree Browser | Graph

[Transmodel (SNAP)]

Transmodel model of the European ITS Directive.

- 5 Packages
- 256 Classes
- 170 Object Properties
- 64 Data Properties
- 3 DataTypes

Tree Browser | Graph

[IFC Rail]

IFC Rail aims at delivering open standards and extending the current buildingSMART shema to fit the needs of the Rail industry.

- 267 Packages
- 1454 Classes
- 1540 Properties
- 242 Enumerations
- 249 DataTypes

Tree Browser | Graph

[ERA 1.2.1]

Vocabulary defined by the European Union Agency for Railways to describe the concepts and relationships related to the European railway infrastructure and the vehicles authorized to operate over it.

- 13 Classes
- 50 Object Properties
- 91 Data Properties
- 0 DataTypes

Tree Browser | Graph

[Transmodel (v6.56)]

CEN European Reference Data Model for Public Transport Information Transmodel provides an abstract model of common public transport concepts and data structures that can be used to build many different kinds of public transport information system, including timetabling, fares, operational management, real time data, journey planning etc.

- 316 Packages
- 1093 Classes
- 4086 Properties
- 3 Enumerations
- 1045 DataTypes

Tree Browser | Graph

Establish a relation between entities:

» » "Ontorail Relations" forum

Entity1... | >> ontorail:hasSource >> | Entity2...

Add Relation

Comment: You can attach a comment here...

Creator: DG • 28-Jun-2021

Status: Under Review

Web Application available at http://app.ontorail.org:5000/ontorail

June 28th 2021, 16:01:05.

OntoRail: consolidate & federate

Imported models to consolidate railway knowledge

» **Source Ontologies:**

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Tree Browser | Graph

volumetry of the imported model

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Tree Browser | Graph

Establish a relation between entities:

» » "Ontorail Relations" forum

rsm12beta:("RouteBody") >> ontorail:hasSource >> rsm12beta:("RouteBody")

rsm:EAID_FDE74596_9FE8_4169_AEAA_A39E0093EBEF rsm:EAID_FDE74596_9FE8_4169_AEAA_A39E0093EBEF

Add Relation

Comment: *You can attach a comment here...*

Creator: DG • 28-Jun-2021

Status: Under Review

Establishing relations between entities to federate models

A unified interface to explore source models

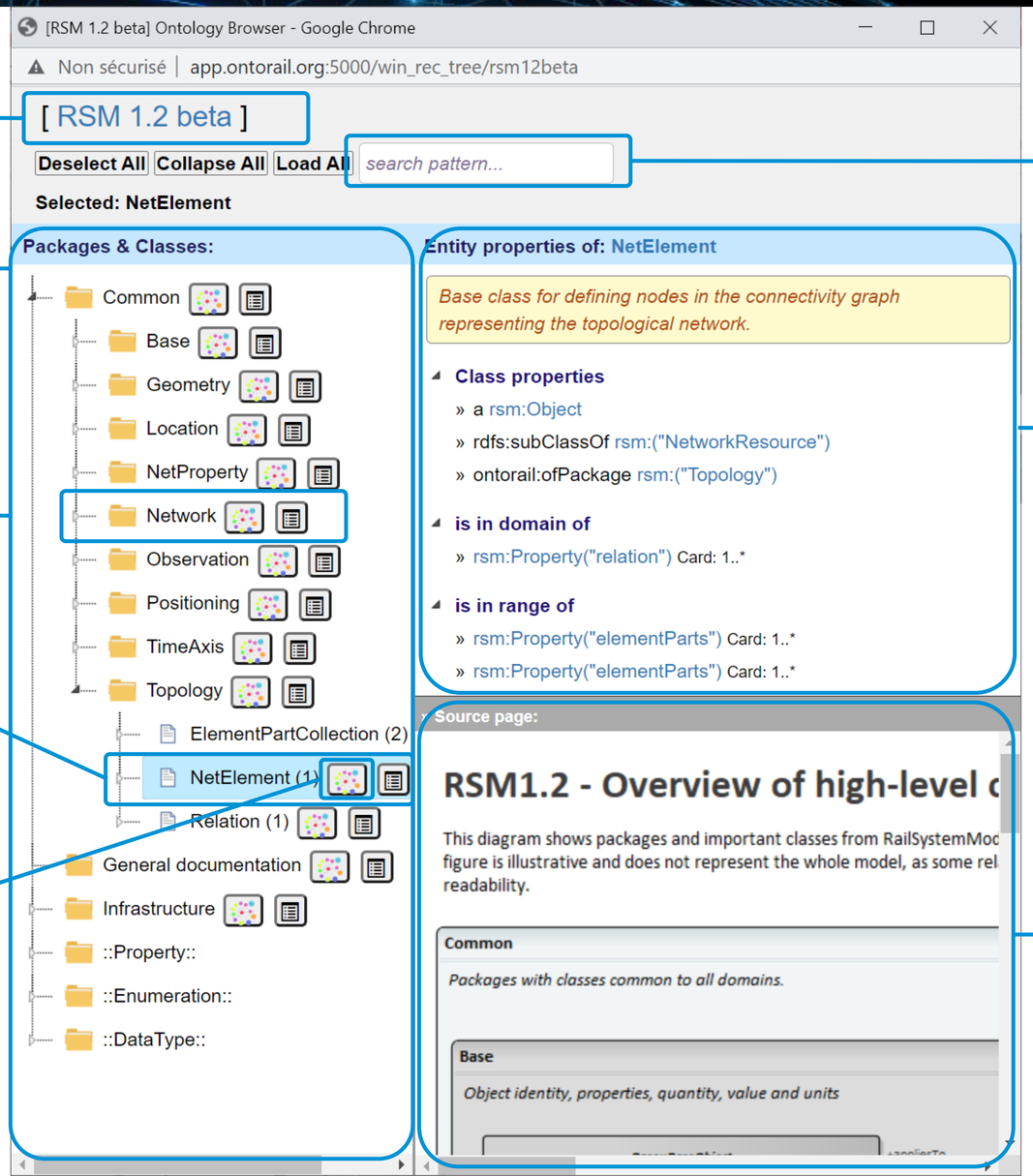
Link to official documentation page

Tree view of the model packaging structure

Individual package

Individual class

Class in context



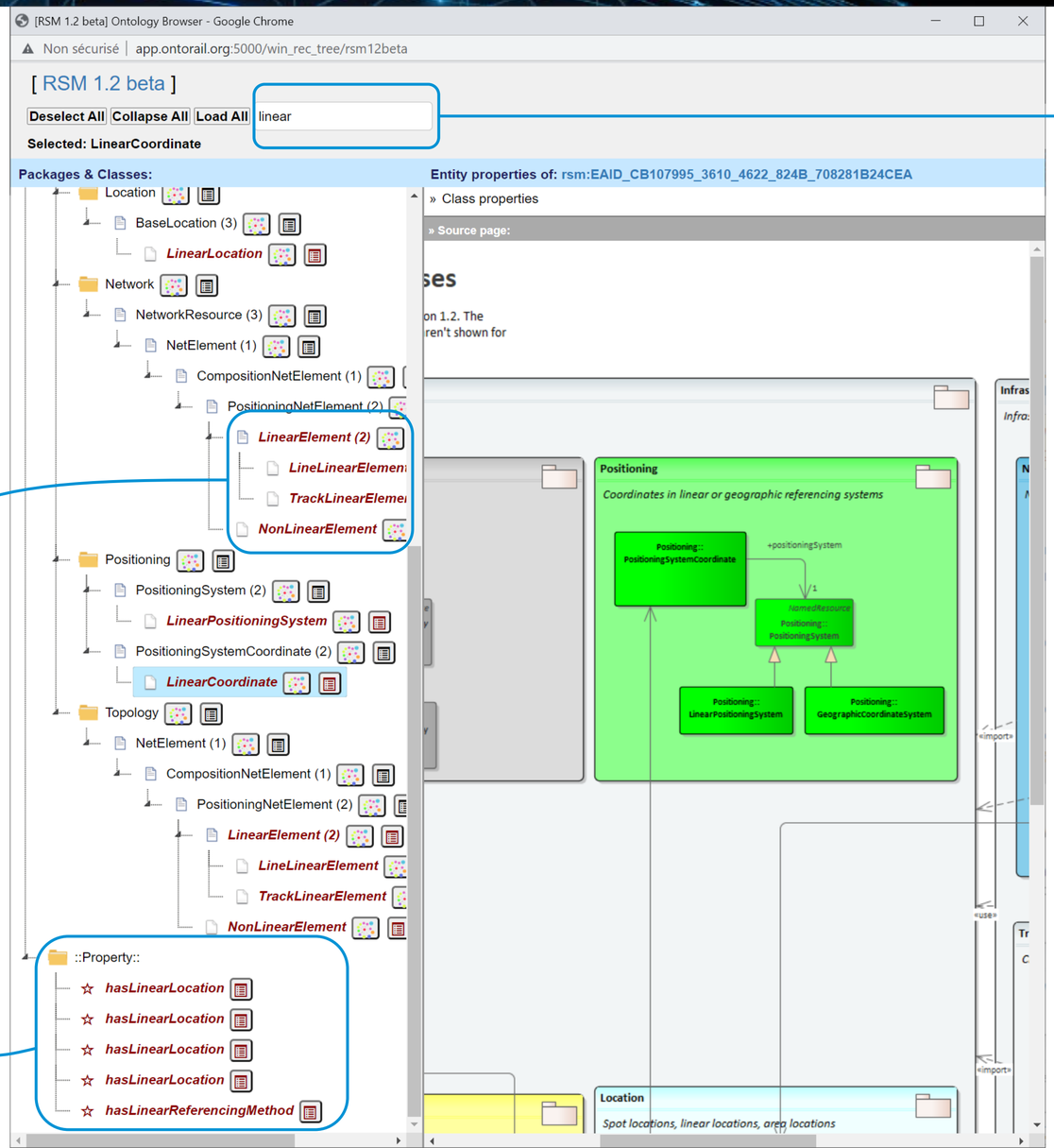
Searching through a model

Object Properties

Object Documentation

A rich, hyperlinked & unified browsing of source models

Searching through a model

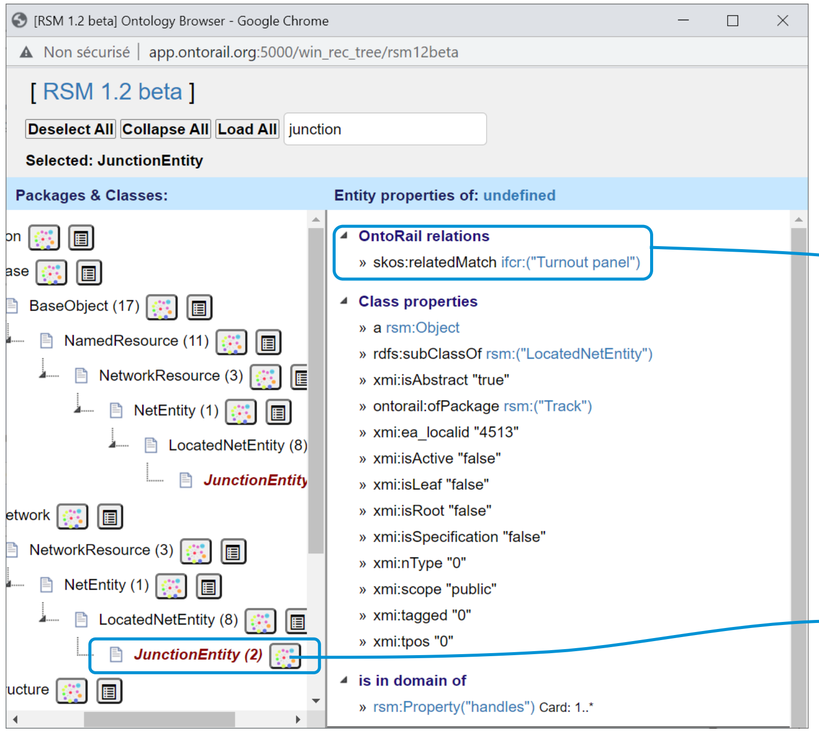


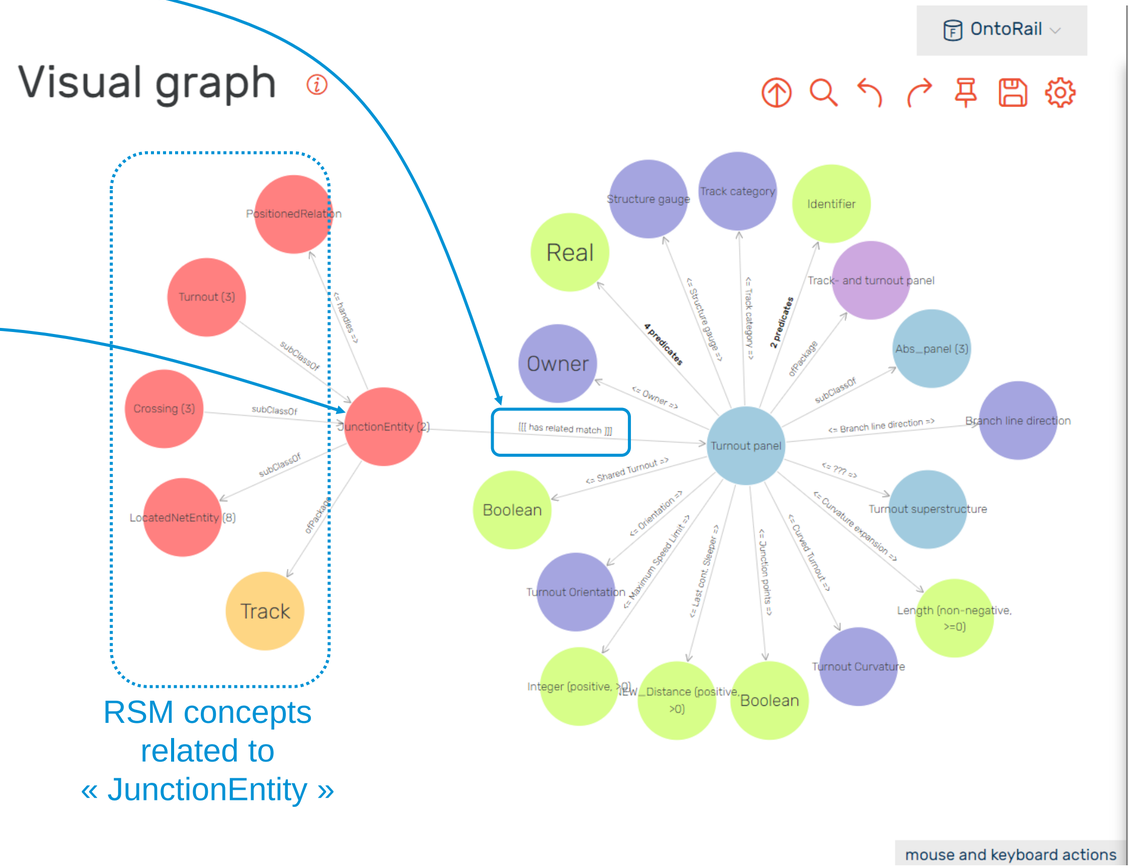
Search box
with regex support

Dynamic filtering
through the model
(classes, properties, …)

Search functionality
for quick insights into
the contents of a
model

Graph view

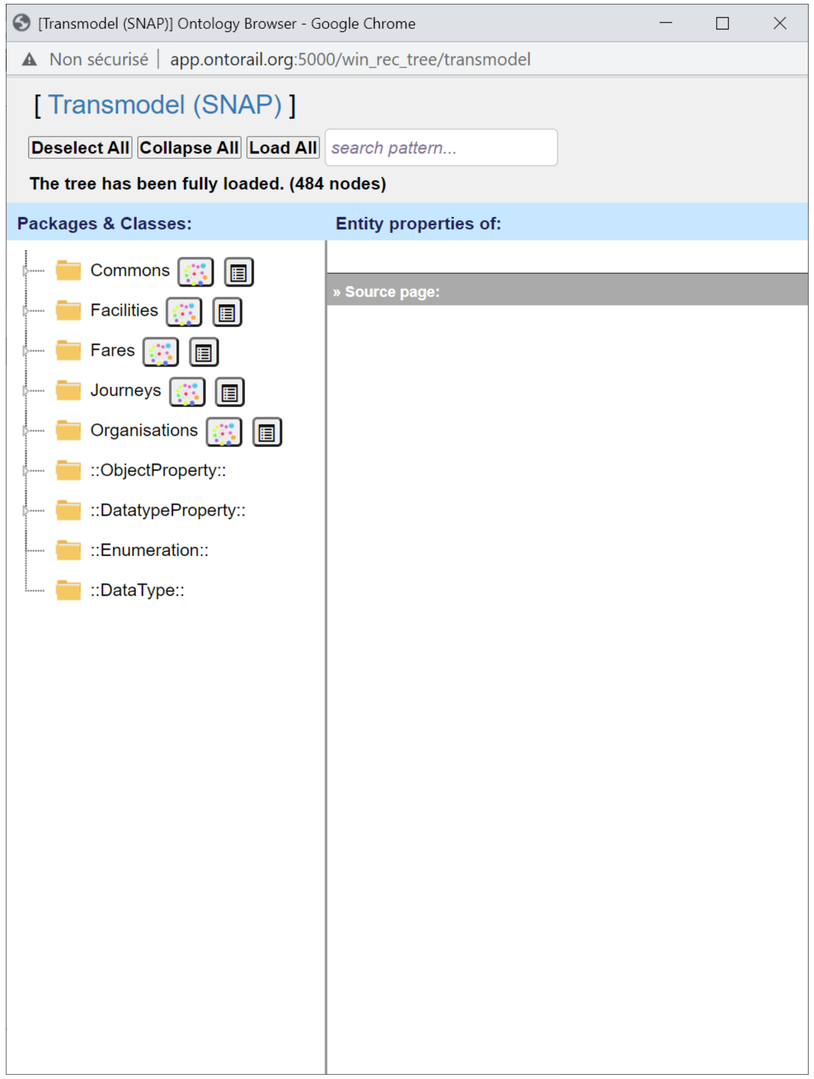




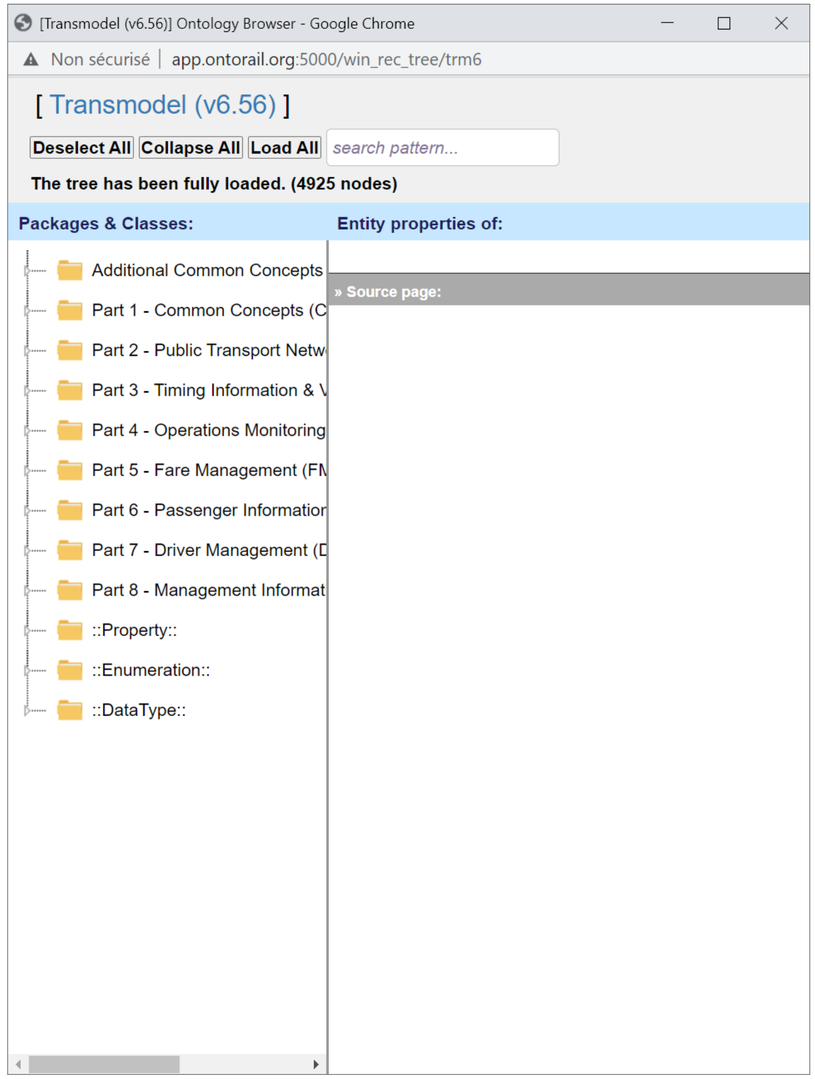
RSM concepts related to « JunctionEntity »

Seeing objects in context of their model and in relation to other models

Supporting two versions of a model
Example of Transmodel (SNAP) vs Transmodel v6.56

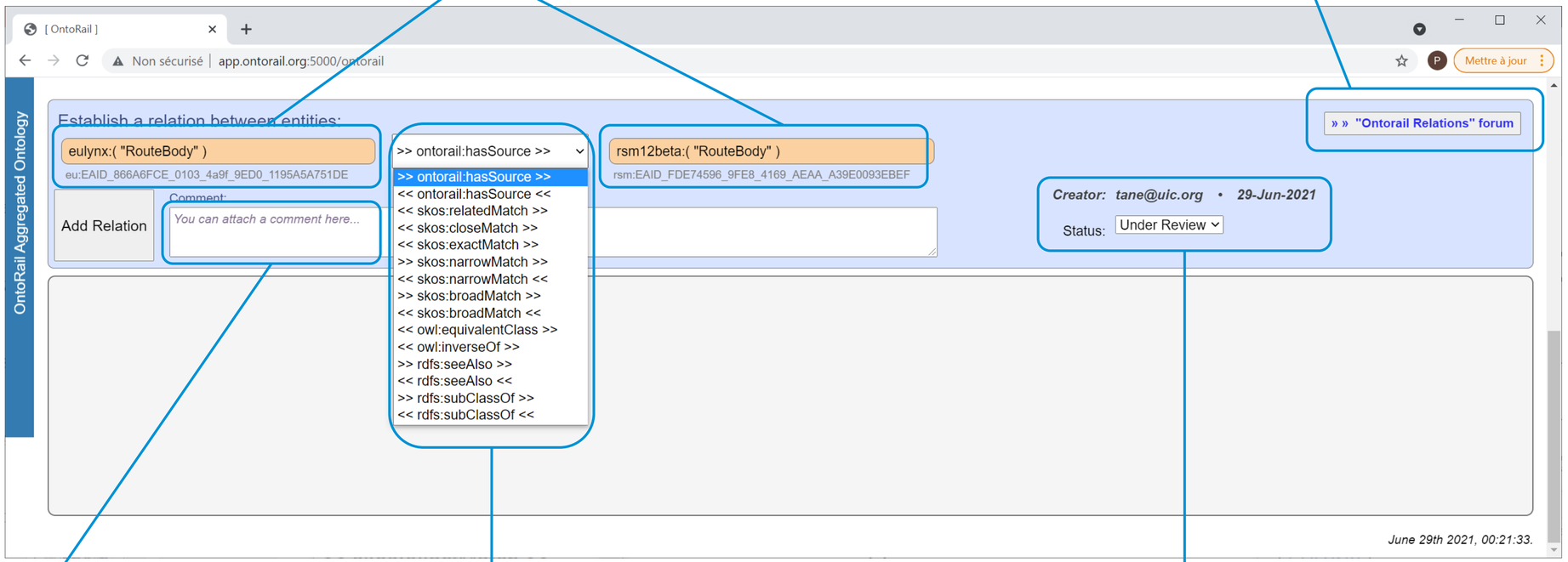


Supporting two models to accompany lifecycle of models



Establishing relations between models

Qualified relations between models to foster convergence and federation



Entities identified for a relation proposal

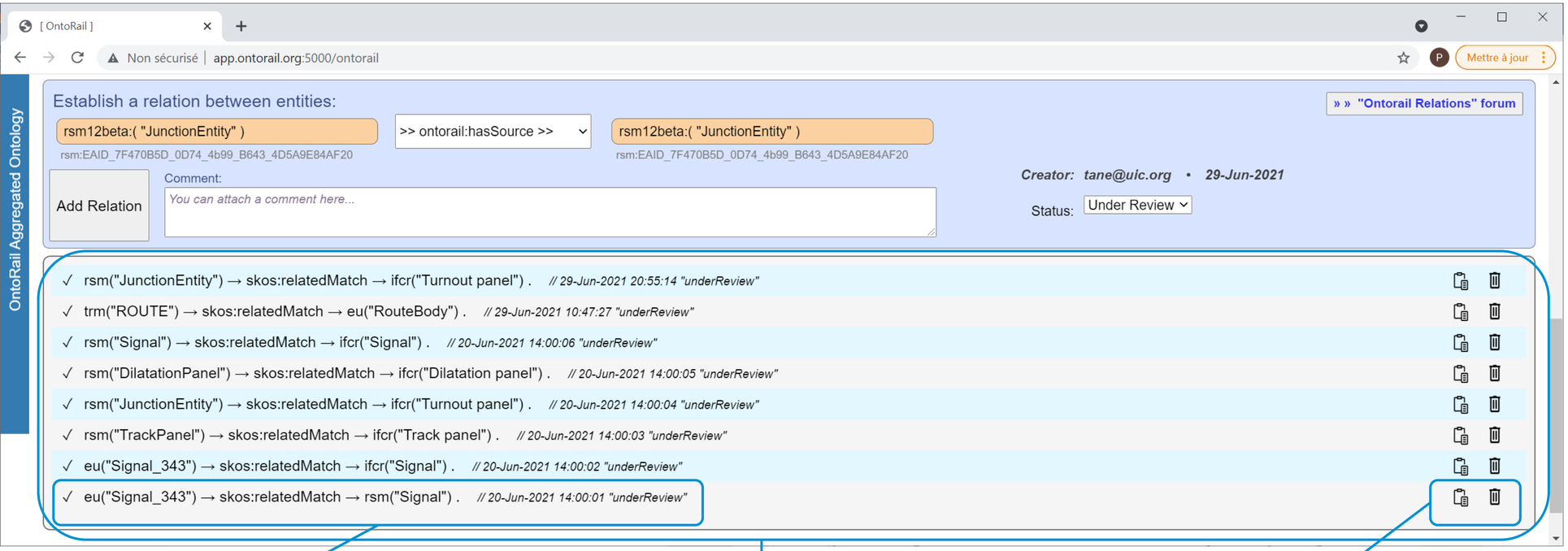
Forum to establish consensus on the proposed relation

Freeform comment for context

Formal vocabulary to qualify the relation (issued from ontologies)

Traceability on the initiator, timestamp of the proposal and initial status

View and manage proposed relations



Summary of proposed relation (additional information when hovering with a mouse)

Most recent proposed relations

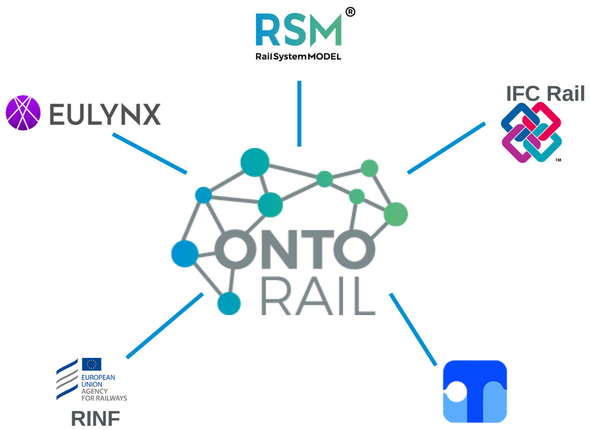
Convenience functions

View & manage proposed relations

OntoRail, in summary

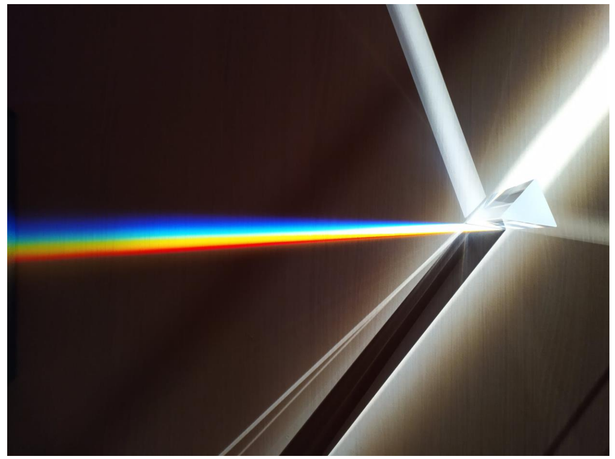
An Encyclopedia

to consolidate and enrich Railways Systems Modelling knowledge



A Tool for Building Consensus

to promote and facilitate convergence and federation between models



A knowledge engine, powered by Ontologies

Perspectives

Perspectives

RailSystemModel & OntoRail as enablers of the Linx4Rail Conceptual Data Model

LinX4Rail, a Shift²Rail project (1)

LinX4Rail

« The railway sector is currently acting **in a fragmented way and in silos** corresponding most often

- to physical or functional subsystems or use cases,
- the different owners/managers of the overall infrastructure
- at regional/national level,
- without global extensive view or full control of the global system involved by rail operations.

With the progress of digitization, analogue devices based on relays were progressively substituted by digital ones

What is missing is an efficient, automated and standardized way for these integrated and interplaying systems to act as one ecosystem: sharing, integrating, identifying, correlating and exploiting the right data at the right time. »

***LinX4Rail**, System architecture and Conceptual Data Model for railway, common data dictionary and global system modelling specifications,* December 6, 2019

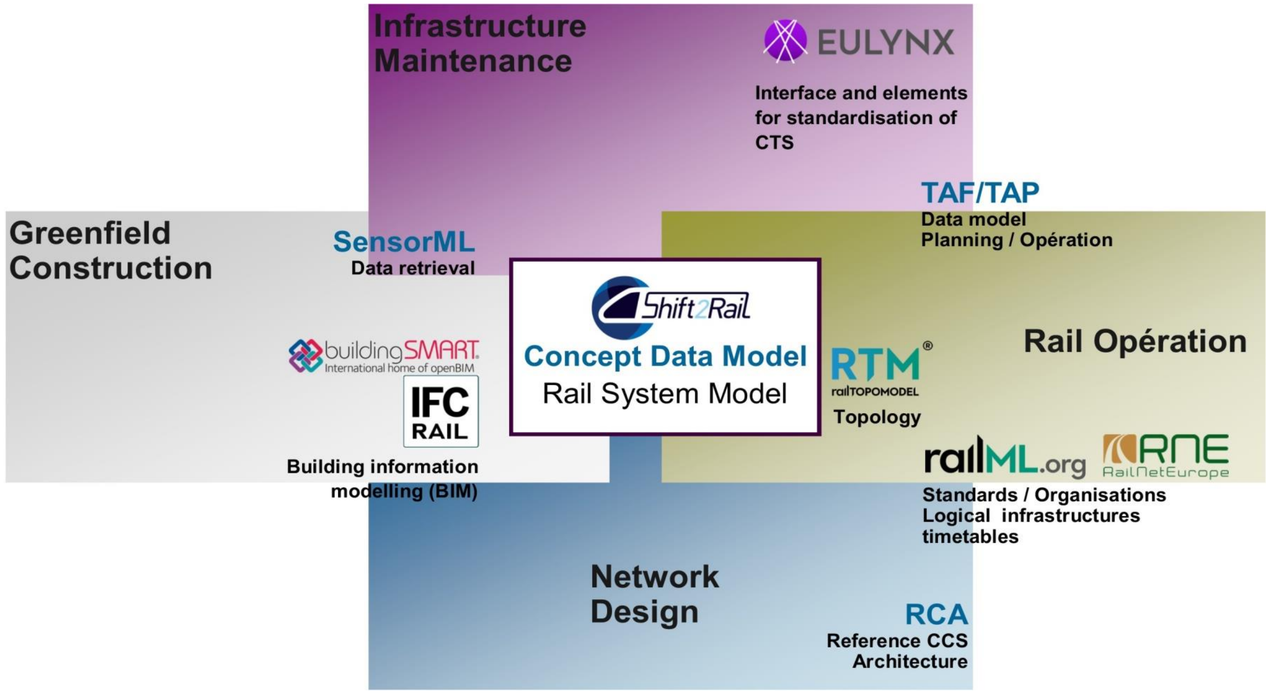
Project funded under the Shift2Rail Joint Undertaking Grant Agreement n° 881826

LinX4Rail, a Shift²Rail project (2)

LinX4Rail

« Only the adoption of a standardized, modular, and interoperable architecture approach, reviewed and shared by the entire sector, can enable streamlined implementation of these new concepts **at affordable costs for the sector whilst ensuring a realistic transition from legacy systems.** »

***LinX4Rail**, System architecture and Conceptual Data Model for railway, common data dictionary and global system modelling specifications,*
December 6, 2019



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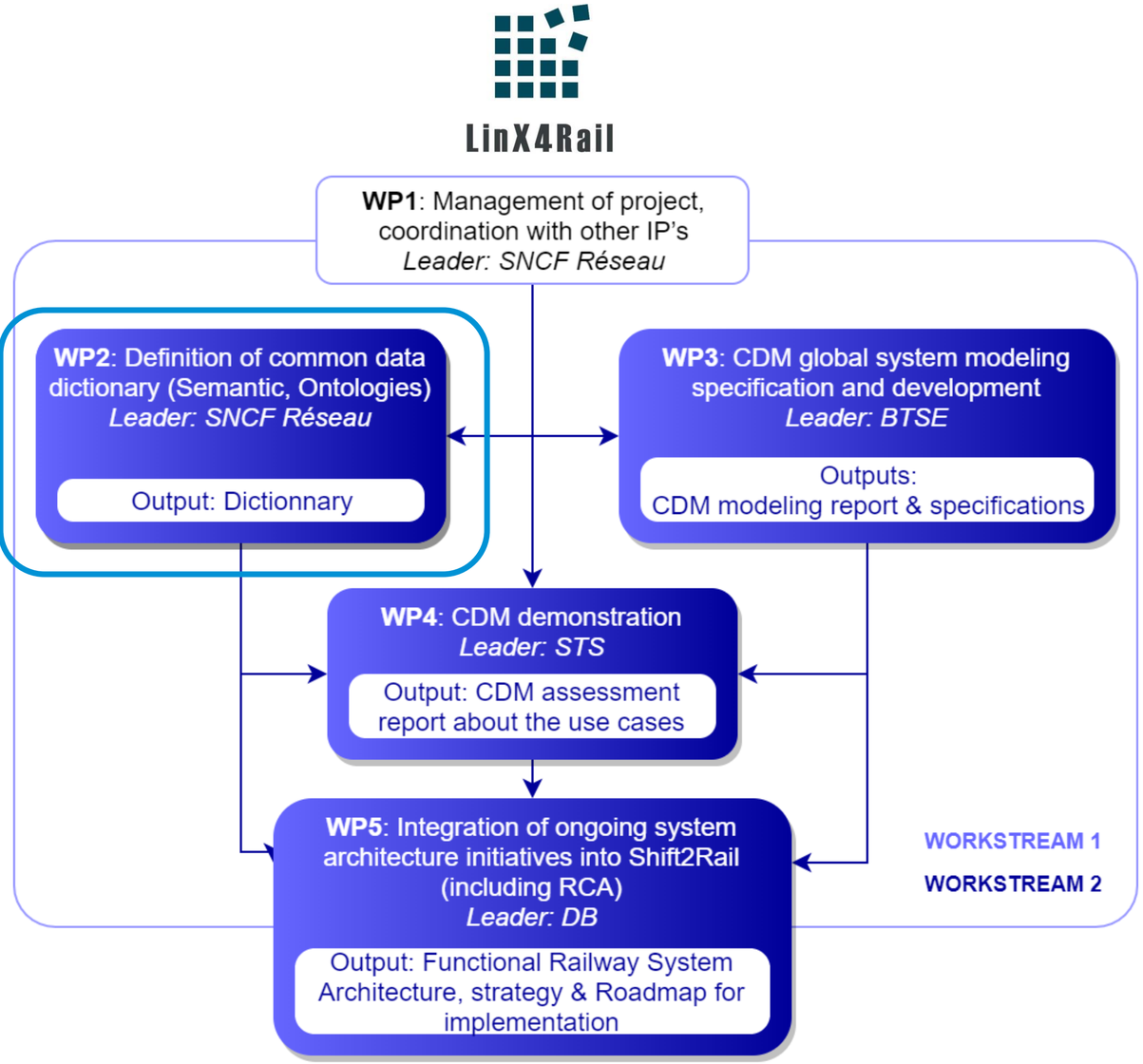
LinX4Rail, a Shift²Rail project (3)

Use of OntoRail knowledge engine for LinX4Rail purposes



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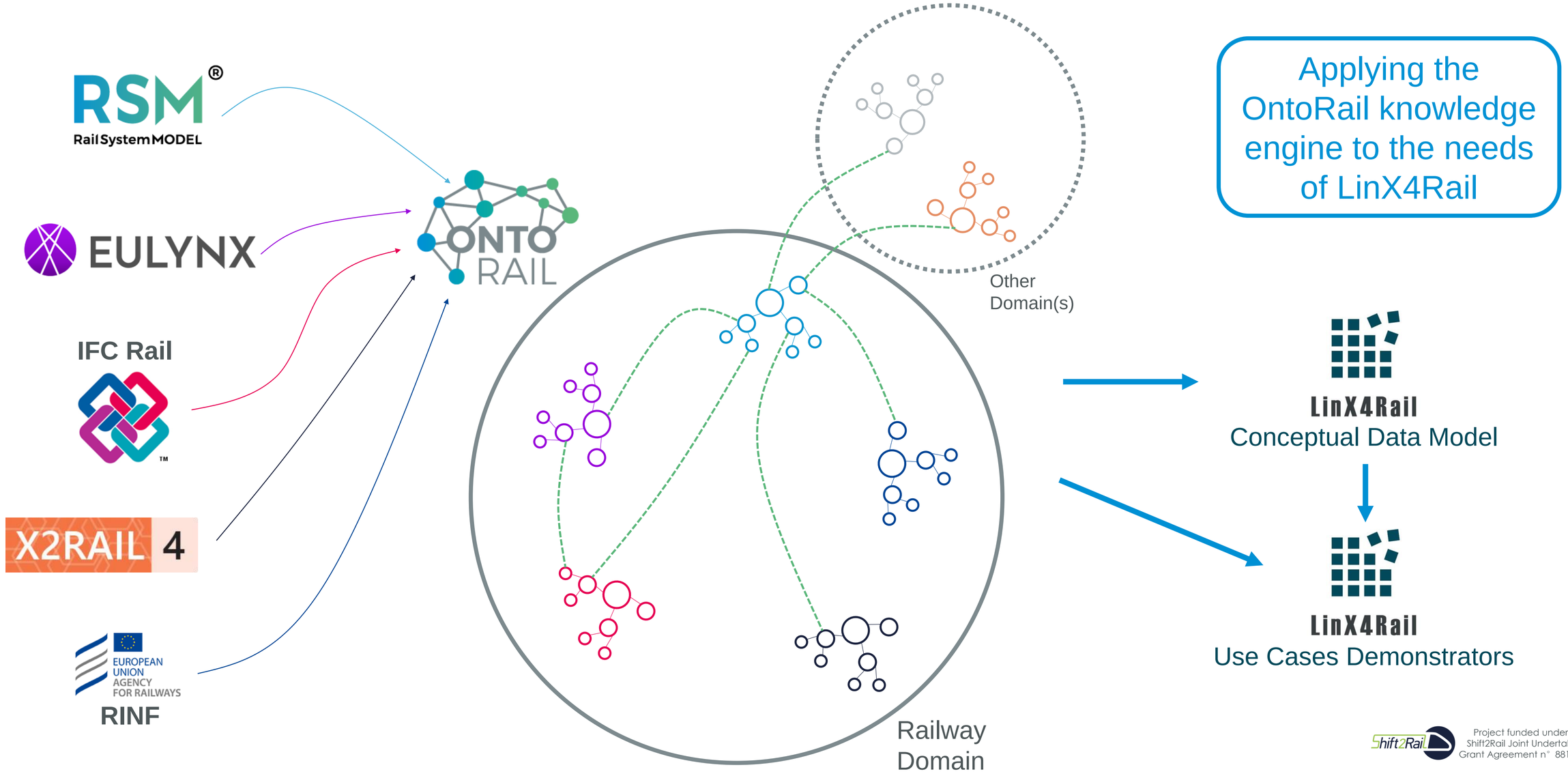
From source models to L4R Conceptual Data Model



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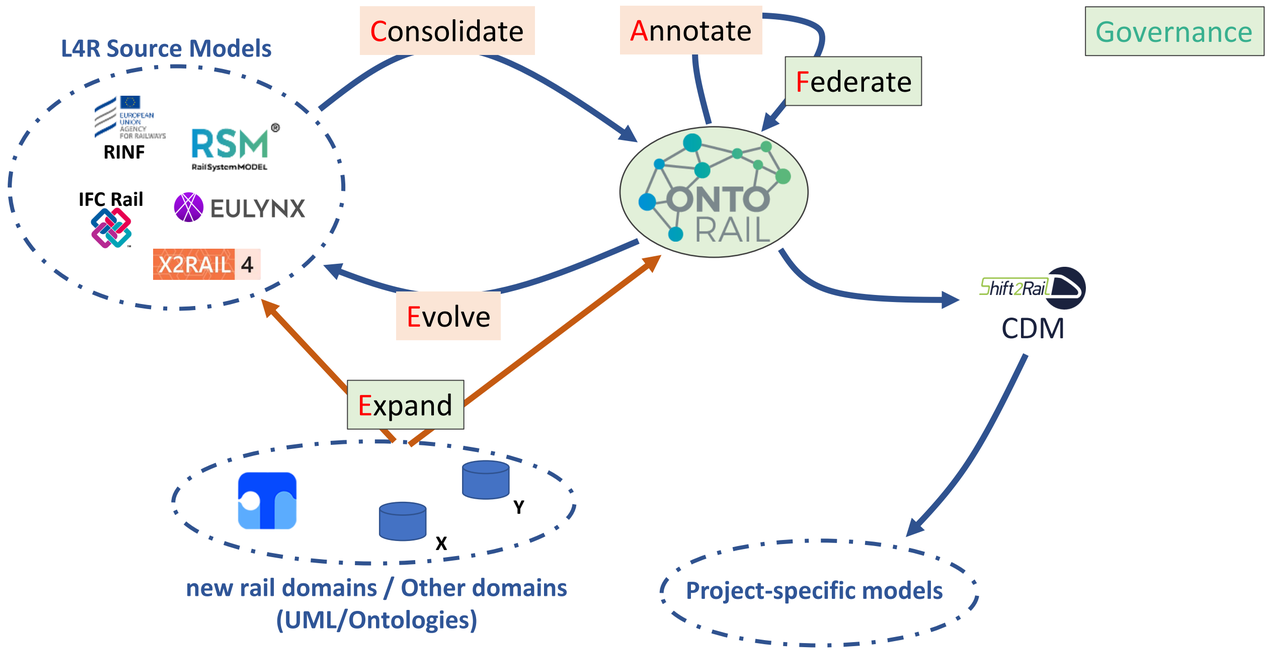
Using OntoRail within L4R

Consolidate railway domain knowledge

Annotate by establishing relations between concepts, enriched with semantic

Federate models by facilitating establishing a consensus on domains of authorities

Evolve source models by tagging / **E**xpand railway domain coverage



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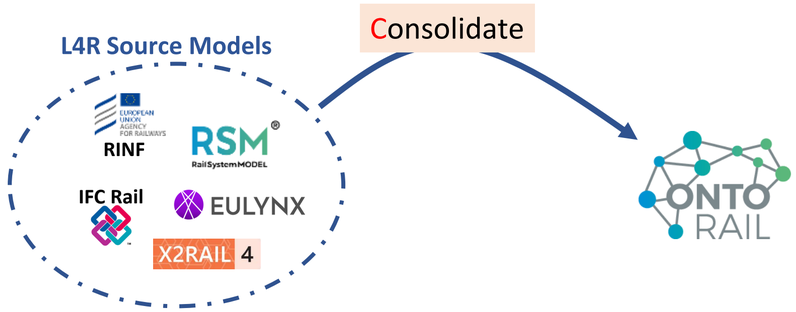
Using OntoRail within L4R: Consolidate



Importing
Versioning

Source Models are subject to evolution / expansion

- Need to automate importation process
  - Need to validate with source projects owners the faithfulness of the importation
- Need to support multiple versions

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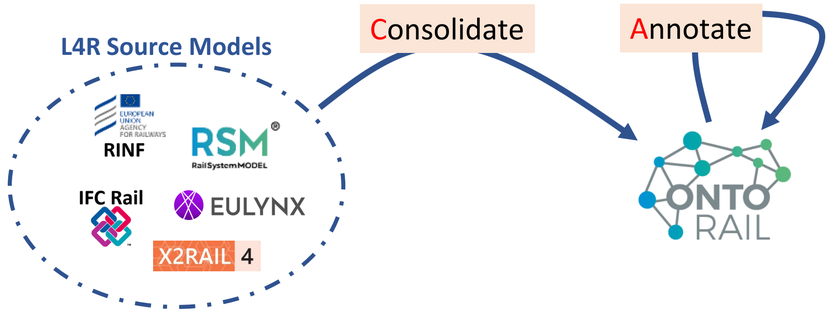
Using OntoRail within L4R: Annotate



Semantic Annotation
Domain Expertise

Source Models may have overlap, commonalities, existing collaborations…

- Need to identify & qualify relations between the concepts of different models
- Domain Expertise required to support the annotation process

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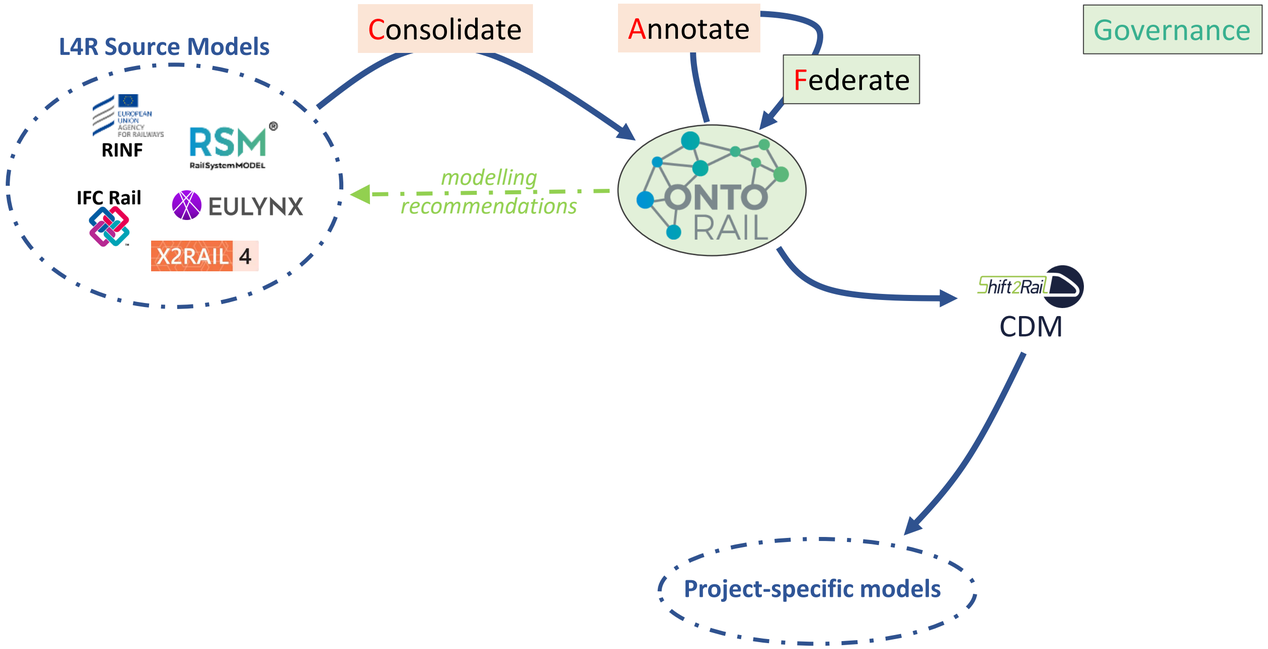
Using OntoRail within L4R: Federate



Governance

Federation will involve

- Building consensus on relations between models
- Identifying modelling recommendations to reflect & facilitate federation
- Identification of potential for additional modelling domains

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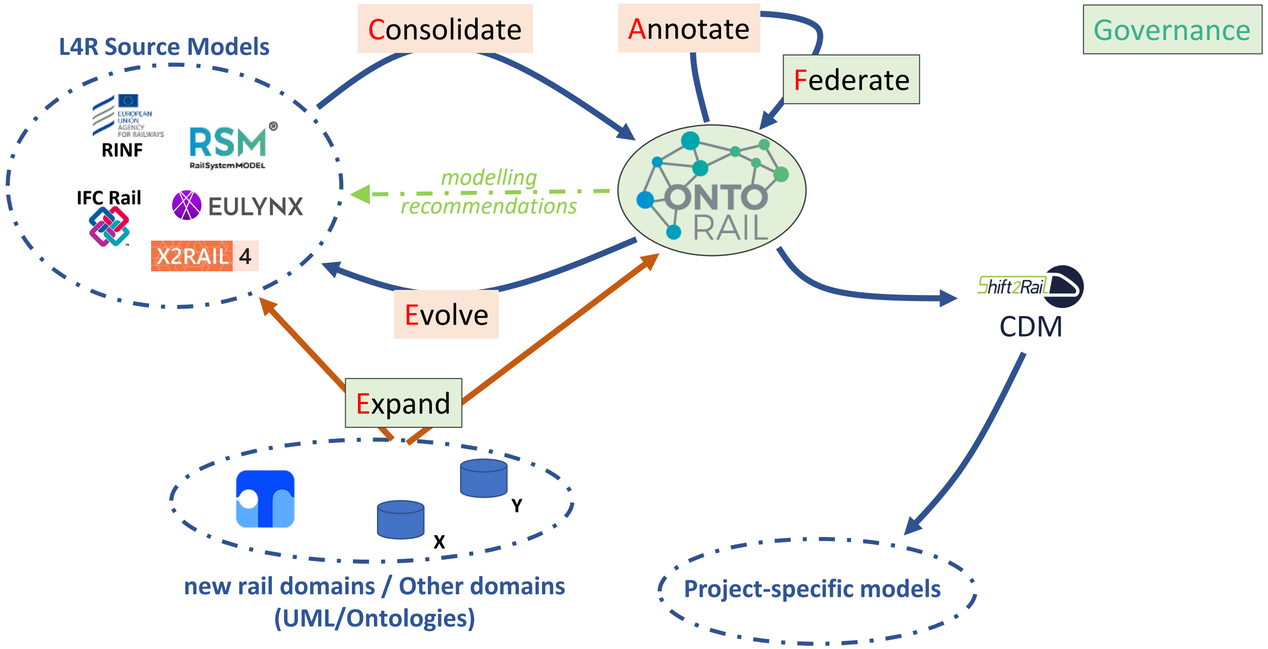
Using OntoRail within L4R: Evolve and Expand



Feedback loop
Collaboration
Independance

Source Models are subject to evolution / expansion

- Identify new rail domains to cover in model(s)
- Identify potential links with other domains

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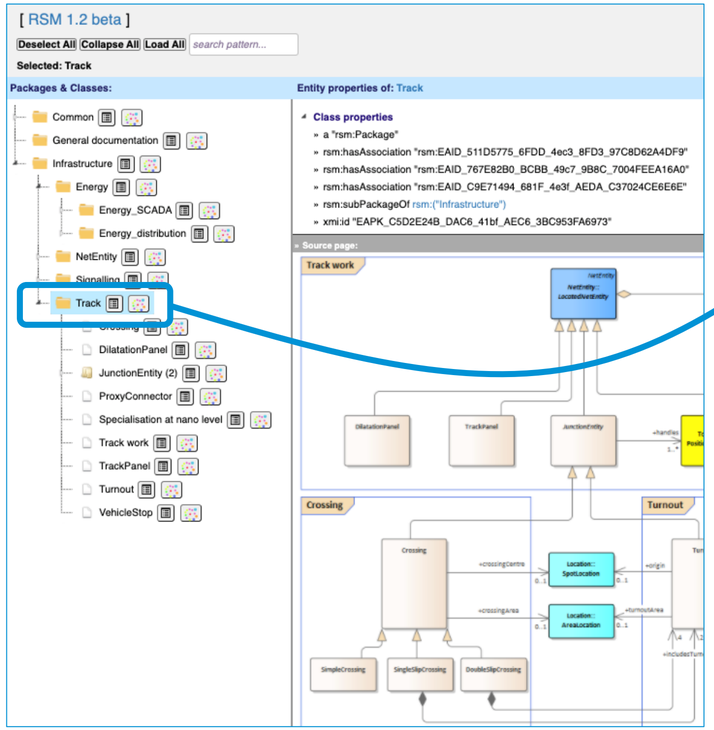
I am a... Source...
I want to... Verify Import Faithfulness

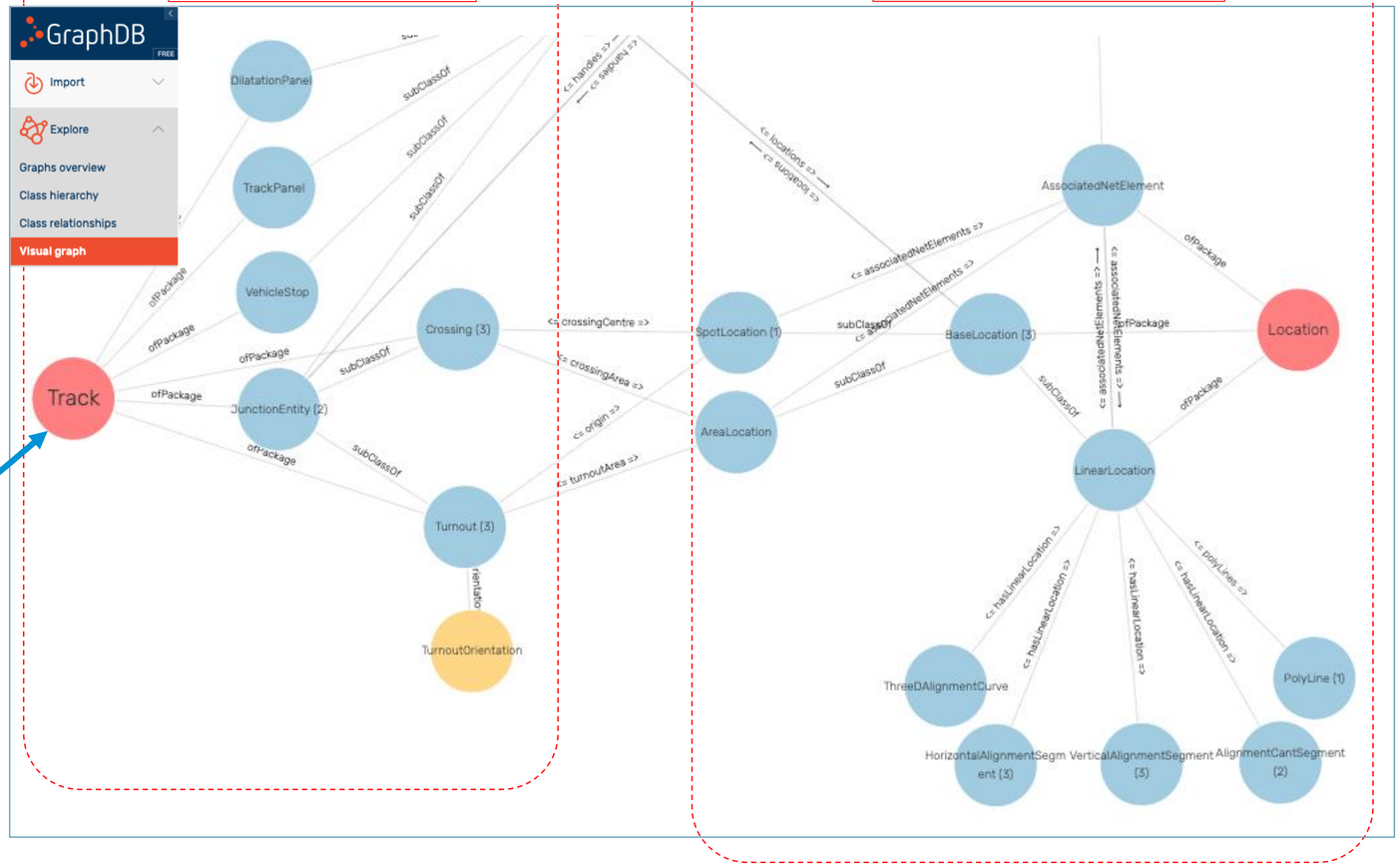
Verify Import Faithfulness

The graph view is complementary to UML and allows easy navigation in, and between, packages



RSM
"Track" Package

RSM
"Location" Package



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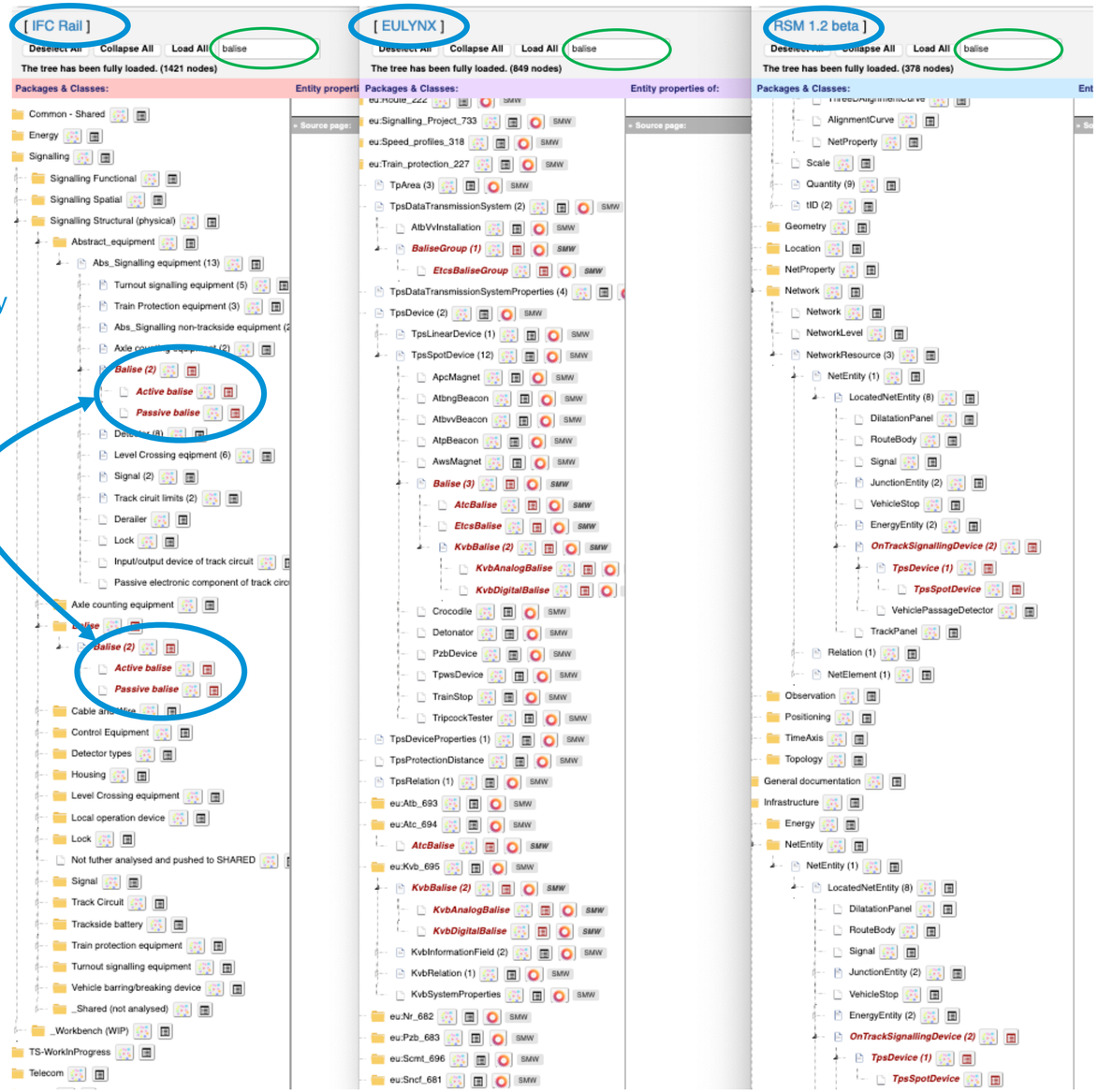
I am a... User of Models...
I want to... Browse

Explore the richness of source models

Source models each model their area of expertise from a certain angle. Some particular use cases may require modelling coming from these different perspectives, potentially at different stages in a project lifecycle.

Search functionality is essential for identifying in multiple sources the potential classes to fit particular Use Cases.

* The tree representation might display a same class at different positions, while graph representation will show multiple links



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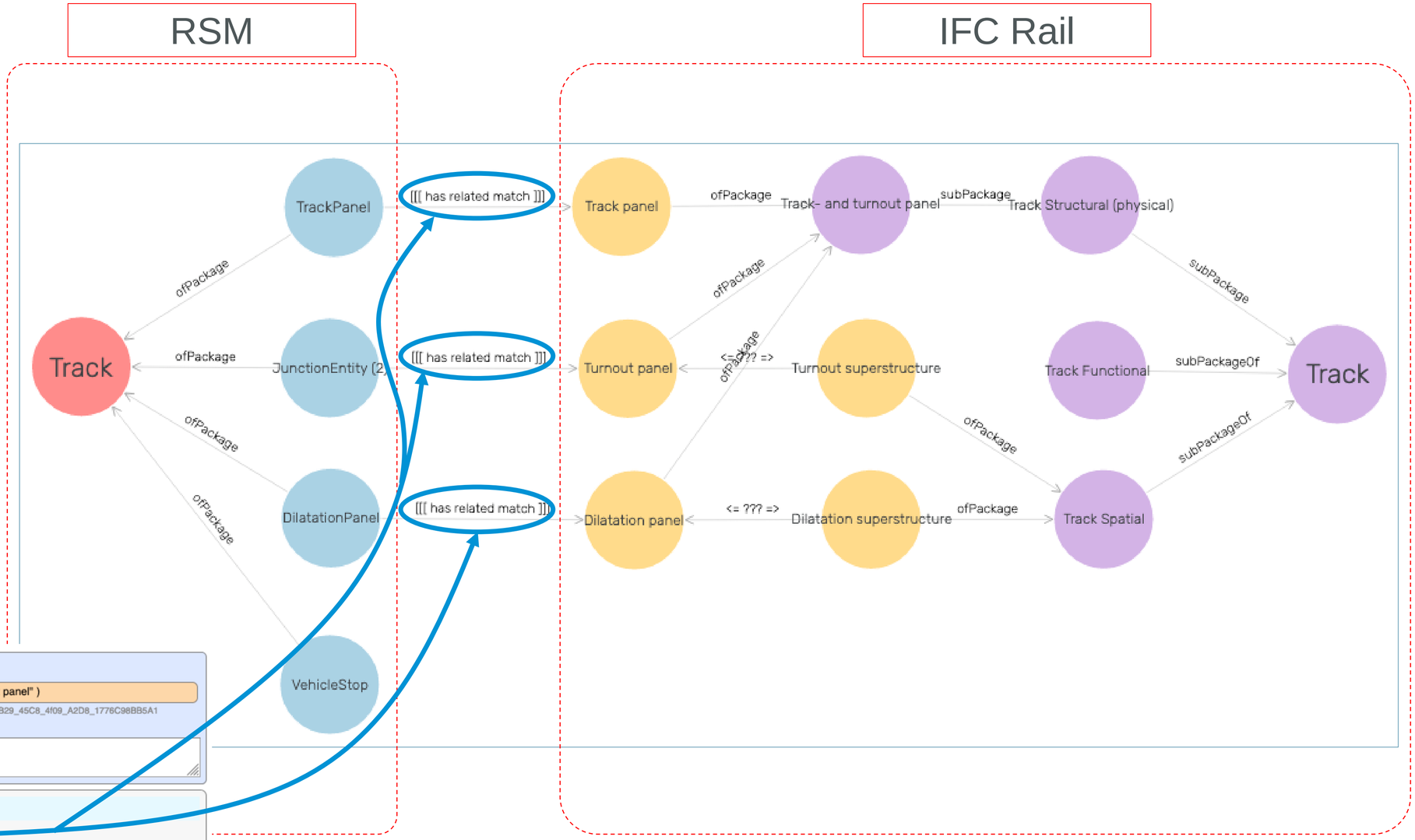
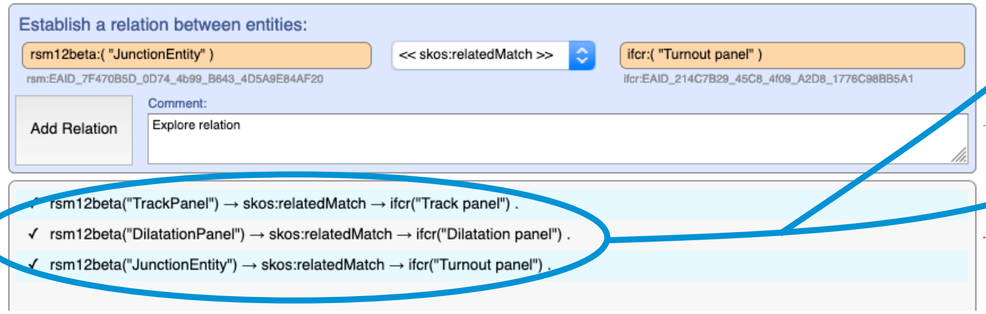
I am a... Domain Expert...
I want to... assert a candidate link between concepts

Propose a candidate relation

OntoRail allows to:

- Search and select relevant classes to be linked
- Create a link (with multiple types of proposed relations within a controlled vocabulary)
- Qualify the candidate link
- View the models jointed by the proposed relation





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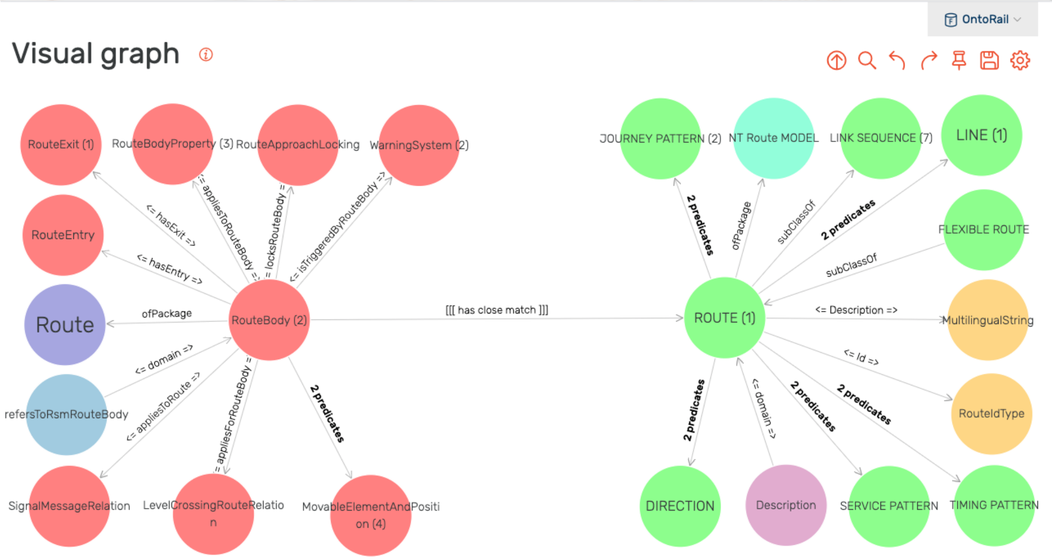
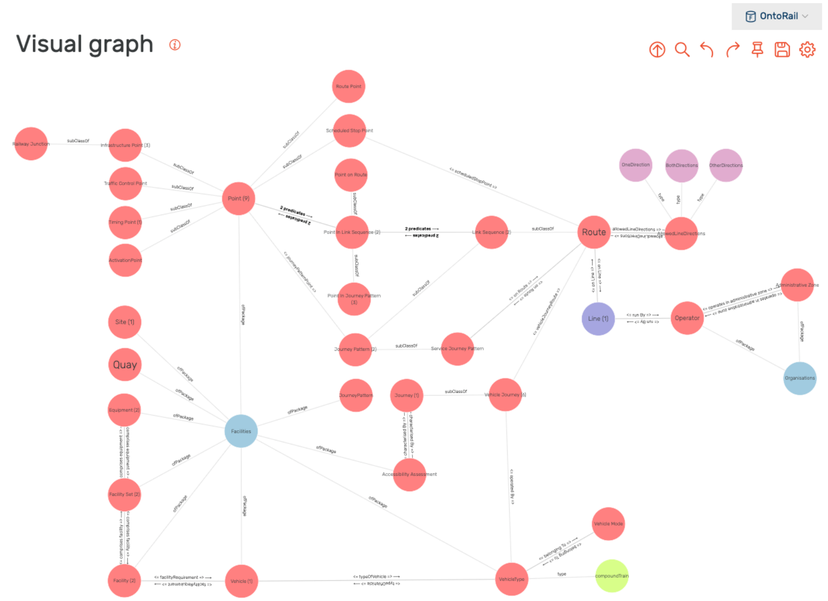
I am a... Group of Domain Expert...
I want to... federate the concept of Route

Foster a discussion around the federation of a Concept

- Domain Experts can propose relations between concepts within the consolidated knowledge graph
  - Proposals are annotated with relevant metadata (author, timestamp, comment, status, …)
- Discussion on the proposed relation take place in an external forum allowing historical tracking of subsequent discussions between domain experts.
- Eventually, consensus can be reached as to whether the proposed relation is accepted or rejected after discussion.
- Discussion may also entail actions on source models (tagging, …), on CDM (superclass, …) or on the OntoRail knowledge engine (new proposals, …).





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Perspectives

Digital Twin at SNCF, the importance of a common digital model for operation

Gilles Dessagne

Responsable Division Urbanisme DSI/CSI/URB, SNCF Réseau

Perspectives

RSM in support of FRMCS

RSM in support of FRMCS?

GSM-R railways

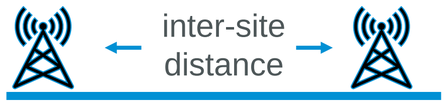
1998

2025

FRMCS
Future Railway Mobile Communication System

900 MHz spectrum

GSM-R



900 MHz & 1900 MHz spectrum

Reuse of 900 MHz Infrastructure?

Simulating reuse of 900 MHz infrastructure

RSM® Rail System MODEL

Topology

Kellojen siirto by Tuomas Puikkonen [CC-BY]

Traffic Management System

FRMCS Future Railway Mobile Communication System

Telecom Traffic Model

Telecom needs projected on topology

Topology & Radio Sites

Radio Pathloss (Observation, Specification & Prediction)

FRMCS Future Railway Mobile Communication System

Telecom Propagation Model Radio Performance

Telecom predictions at 900 MHz & 1900 MHz

Perspectives

Signalling data preparation with RailSystemModel and EULYNX

Dr. Bob Janssen
EULYNX information modeller

Next Steps

RSM Futures

Structure

- Generic separation functional / structural / physical objects

Substance

- Project phasing
- Rolling stock
- Operations
- Telecom (FRMCS, …)

Links

- RINF
- Transmodel ?

Documentation

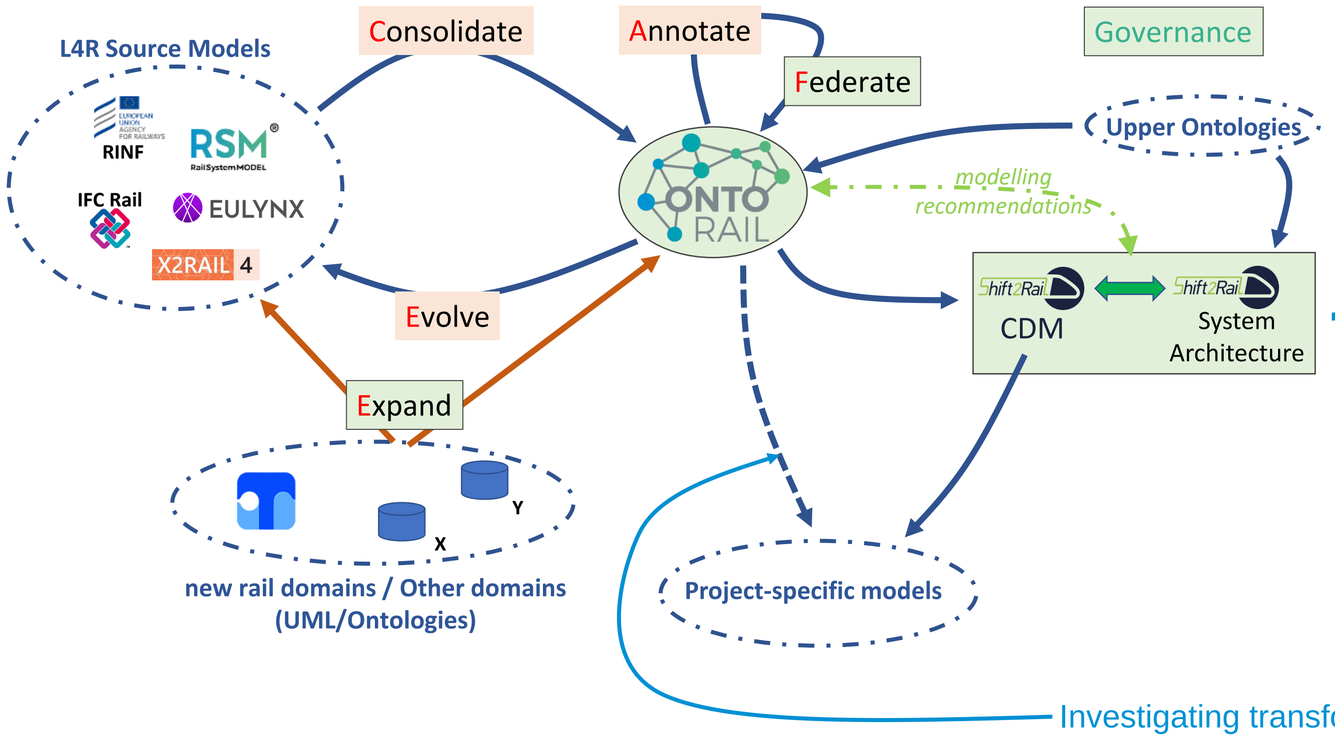
- Ontorail ontologies

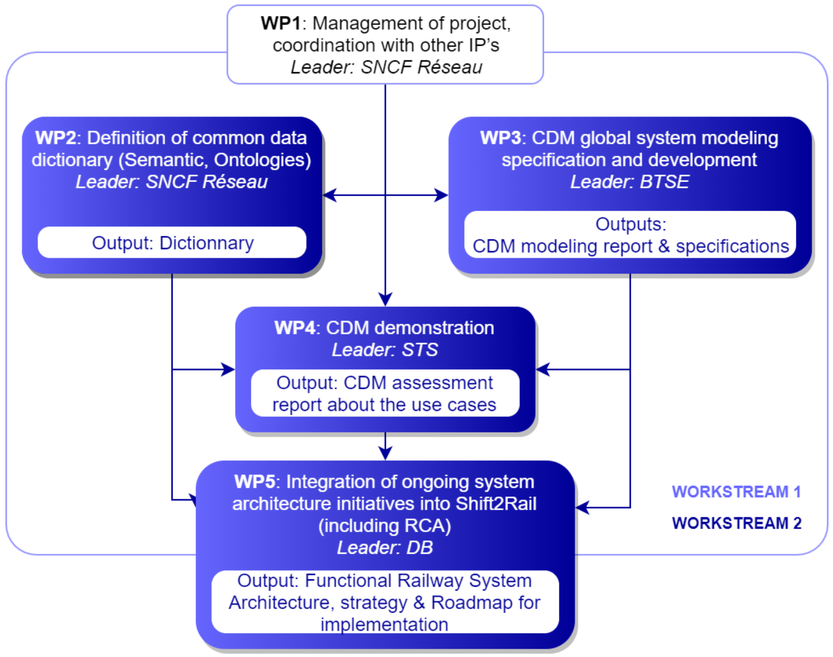
Tools

- Live Model (IT code)
- Sample networks

Towards CCS+ with RSM

LinX4Rail: Dictionary, Conceptual Data Model … and System Architecture





Investigating transformation from ontologies to project-specific models

OntoRail knowledge engine powering the Dictionary as an input to L4R Conceptual Data Model and System Architecture

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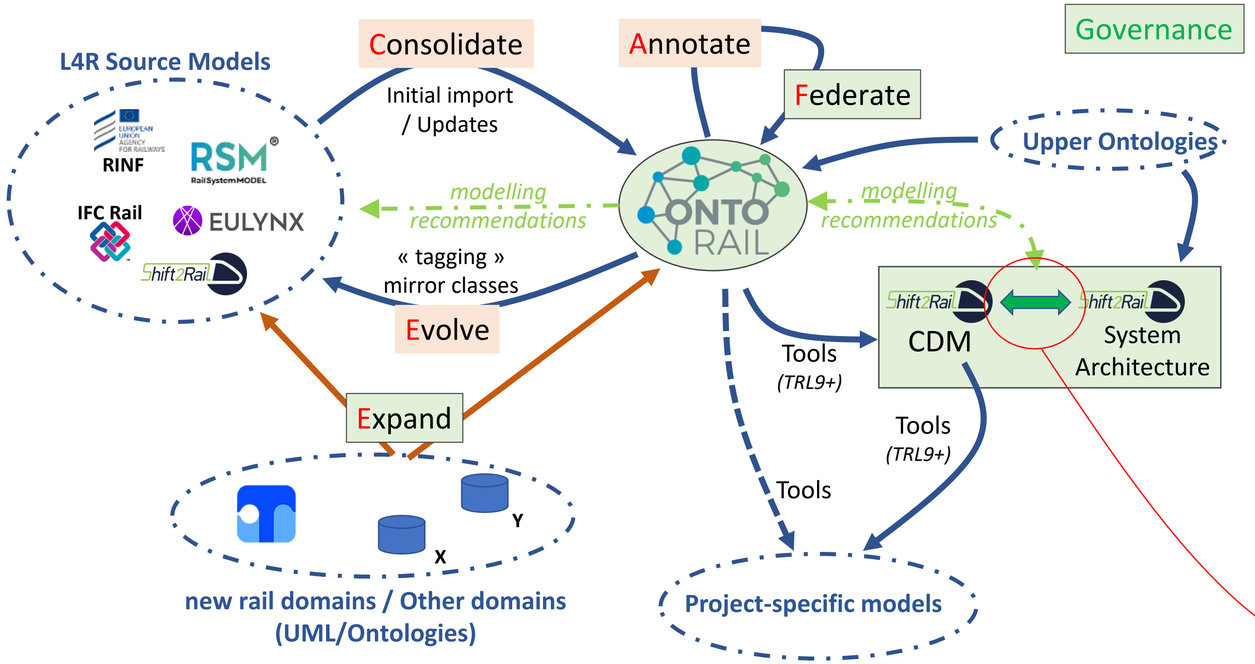
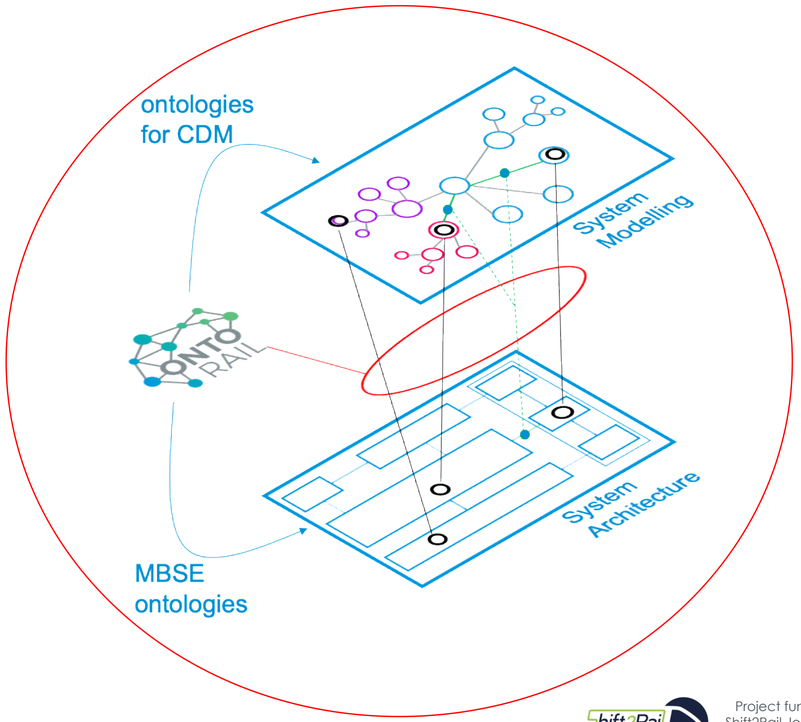
Weaving System Architecture & System Modelling





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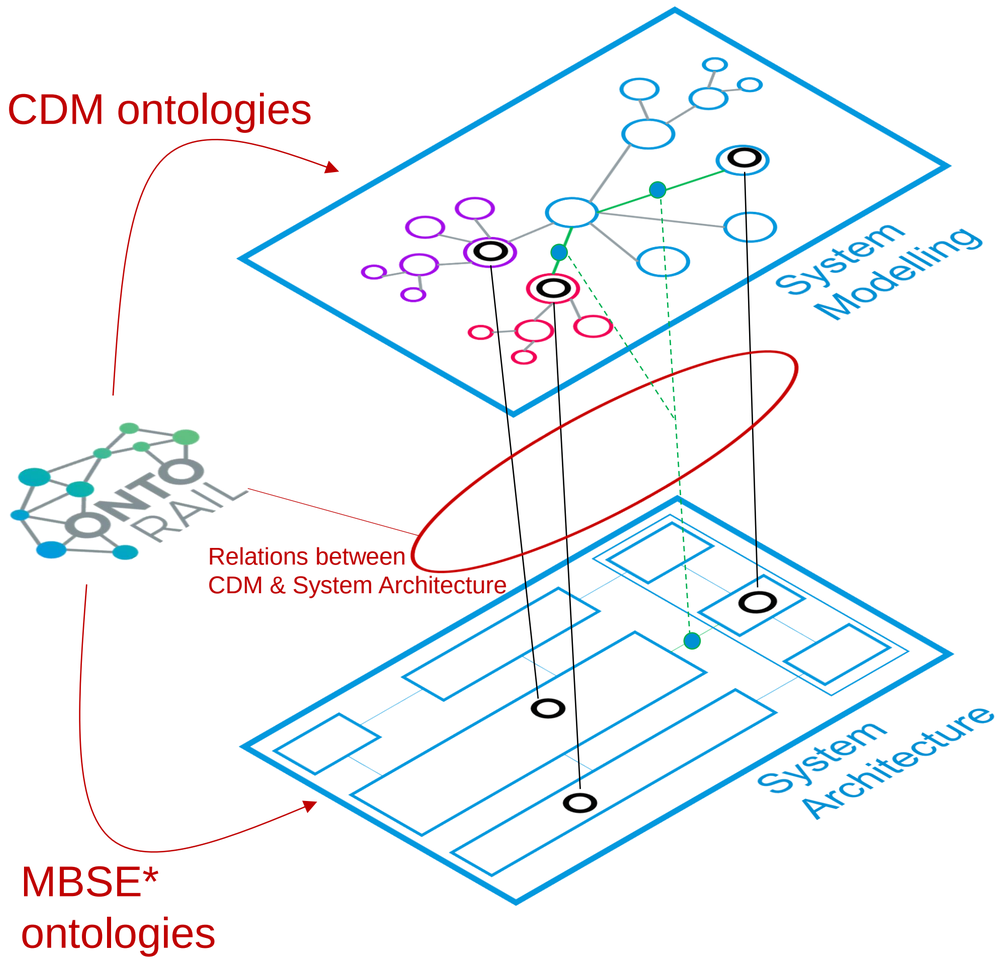
Weaving System Architecture & System Modelling … with Ontologies



System Architecture and Data Modelling represent different aspects of the railway system, intrinsically linked

OntoRail is engaged in building CDM while federating multiple source models

We propose to include System Architecture as an additional source model, and link it with CDM concepts/Packages/functions…

Semantic continuity across architecture & CDM, a key building block of the Digital Twin

*MBSE: Model Based System Engineering

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Resources

RSM®
Rail System MODEL

https://rsm.uic.org

https://gitlab.com/rail.system.model/rtm

ONTO RAIL

https://ontorail.org/ (website)

http://app.ontorail.org:5000/ontorail (the web application)

Source code will be published at a later stage

Closing remarks

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LinX4Rail & LinX4Rail2 (Shift2Rail) coordinator
RSF Sector Chair of the Railway Digital Modelling, UIC