DIGITAL MODELLING INITIATIVES FOR THE OPERATIONAL RAILWAY
Opening remarks

François Davenne
Director General, UIC
Programme

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

Opening Remarks (François Davenne, UIC Director General)

Closing Remarks (Pierre-Etienne Gautier, SNCF Réseau)
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

Operations & M.  
Commercial  
Networks  
Subsystems  
Components  
- Planning  
- Management  
- Design  
- Construction  
- Description  
- Interfaces & configuration  
- Requirements  
- Design  
- Manufacturing  
- Green = delegated  
- e.g. Shift²Rail ST4RT ontology  
- e.g. TRANSMODEL  
- e.g. SNCF ATO  
- e.g. IFC Rail  
- e.g. EULYNX  

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

Object
- unique identifier

Property
- P-sets
- Observable

Quantities and Units
- SysML 1.2

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

- Intrinsic coordinates
  - Schematic representation

- Linear coordinates
  - Kilometric points
  - Odometry

- Geometric coordinates
  - GIS
  - CAD

Topology
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
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)
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

Linear referencing, regenerated

JSON export
What is OntoRail?

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.

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

**Taxonomy**
Subject-based classification
Hierarchical organization (parent / child)

**Thesaurus**
Extends taxonomies
Additional statements (BT, NT, SN, …)
OntoRail Fundamentals

- Importing Models
- Browsing Models
- Linking Models
OntoRail application homepage

Web Application available at http://app.ontorail.org:5000/ontorail
OntoRail: consolidate & federate

**Source Ontologies:**

### [EULYNX]
EULYNX standardizes the interface between the interlocking of the core of the signaling system and all peripheral systems, ranging from light signal to traffic control system.
- 148 Packages
- 4095 Classes
- 2001 Properties
- 165 Enumerations
- 12 DataTypes

### [RSM 1.2 beta]
RSM (Railway System Model) provides a structural/functional model to foster digital connectivity across railway domains and business processes. RSM incorporates with other Projects in their respective domains (for example Euron for signaling, R(ail) for GSM process, etc).
- 18 Packages
- 145 Classes
- 140 Properties
- 8 Enumerations
- 2 DataTypes

### [Transmodel (SNAP)]
Transmodel model of the European ITX Directive.
- 6 Packages
- 298 Classes
- 175 Object Properties
- 64 Data Properties
- 3 DataTypes

### [IFC Rail]
IFC Rail aims at delivering open standards and extending the current buildingSMART IFC to fit the needs of the Rail Industry.
- 207 Packages
- 1468 Classes
- 1469 Properties
- 242 Enumerations
- 248 DataTypes

### [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 on it.
- 13 Classes
- 83 Object Properties
- 81 Data Properties
- 5 DataTypes

Imported models to consolidate railway knowledge

Establishing relations between entities to federate models

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
- A rich, hyperlinked & unified browsing of source models
- Object Documentation
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

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

RSM concepts related to « JunctionEntity »
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

Entities identified for a relation proposal

Forum to establish consensus on the proposed relation

Qualified relations between models to foster convergence and federation

Freeform comment for context

Formal vocabulary to qualify the relation (issued from ontologies)

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

Creator: tane@ielc.org · 29-Jun-2021
Status: Under Review
View and manage proposed relations

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

Most recent proposed relations

Convenience functions
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
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
LinX4Rail, a Shift²Rail project (2)

« 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
LinX4Rail, a Shift²Rail project (3)

WP1: Management of project, coordination with other IP’s
   Leader: SNCF Réseau

WP2: Definition of common data dictionary (Semantic, Ontologies)
   Leader: SNCF Réseau
   Output: Dictionary

WP3: CDM global system modeling specification and development
   Leader: BTSE
   Outputs:
   CDM modeling report & specifications

WP4: CDM demonstration
   Leader: STS
   Output: CDM assessment report about the use cases

WP5: Integration of ongoing system architecture initiatives into Shift2Rail
   (including RCA)
   Leader: DB
   Output: Functional Railway System Architecture, strategy & Roadmap for implementation

Use of OntoRail knowledge engine for LinX4Rail purposes
From source models to L4R Conceptual Data Model

Applying the OntoRail knowledge engine to the needs of LinX4Rail

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

Use Cases Demonstrators
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 / Expand railway domain coverage
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
Using OntoRail within L4R: Annotate

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
Using OntoRail within L4R: Federate

Federation will involve
- Building consensus on relations between models
- Identifying modelling recommendations to reflect & facilitate federation
- Identification of potential for additional modelling domains
Using OntoRail within L4R: Evolve and Expand

Source Models are subject to evolution / expansion
- Identify new rail domains to cover in model(s)
- Identify potential links with other domains
Verify Import Faithfulness

The graph view is complementary to UML and allows easy navigation in, and between, packages.
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.
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
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, …).
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?

1998

900 MHz spectrum

GSM-R

inter-site distance

2025

900 MHz & 1900 MHz spectrum

Reuse of 900 MHz Infrastructure?
Simulating reuse of 900 MHz infrastructure

Telecom needs projected on topology

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, …)

Tools
- Live Model (IT code)
- Sample networks

Documentation
- Ontorail ontologies

Links
- RINF
- Transmodel?
Towards CCS+ with RSM
OntoRail knowledge engine powering the Dictionary as an input to L4R Conceptual Data Model and System Architecture

Investigating transformation from ontologies to project-specific models
Weaving System Architecture & System Modelling

- **Consolidate**
  - Initial import / Updates
  - "tagging" mirror classes

- **Annotate**

- **Federate**

- **Governance**

- **Expand**
  - new rail domains / Other domains (UML/Ontologies)

- **Evolve**

**Upper Ontologies**
- **Tools (TRL9+)**
  - CDM
  - System Architecture

**Project-specific models**

**Ontologies for CDM**

**MBSE ontologies**

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

- https://rsm.uic.org
- https://gitlab.com/rail.system.model/rtm
- 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