RFC2

Capacity KPIs and visualisations

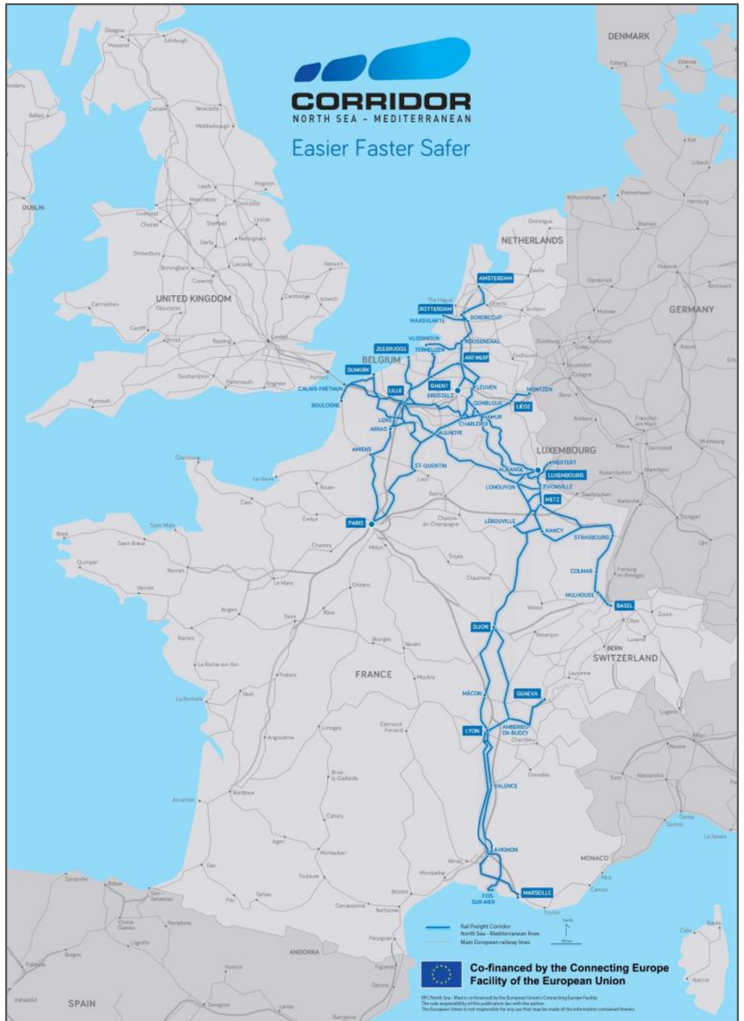
Deliverable	**6 : IT Recommendations**
Date	02.02.2024
Version	1-00

optimising railways

Agenda

1. Context, scope, goals and methodology of the study
2. Data exchange
3. What has been used to produce the KPIs and visualisations
4. Necessary improvements to produce the KPIs and visualisations

Presentation of RFC North Sea-Mediterranean (RFC2)



Source : RFC2 website

Rail Freight Corridors deals with the organization of capacity for freight traffic at an international scale.

Primary functions

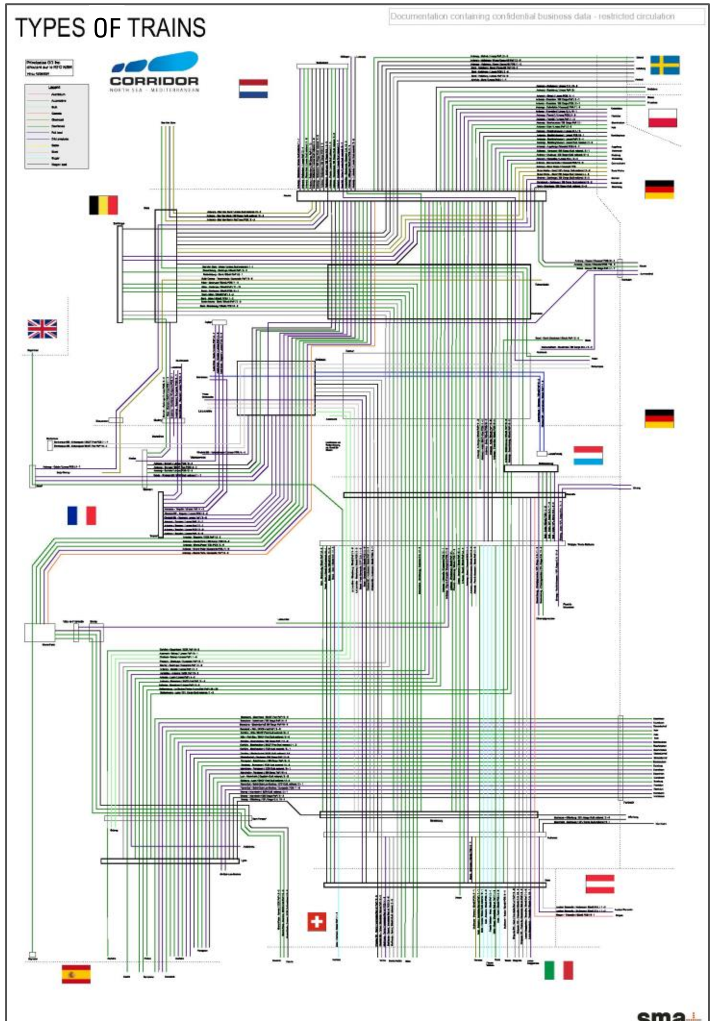
– To coordinate IM's in order to elaborate pre-arranged international path for freight trains and to administrate the RU's requests for those PaPs,

– To facilitate the international coordination process on TCRs.

Additional production functions to monitor train performance and to launch problem-solving processes where the RFC identify low quality in terms of performance.

Additional support functions : to manage legal, financial and communication matters related with the administration of the RFC.

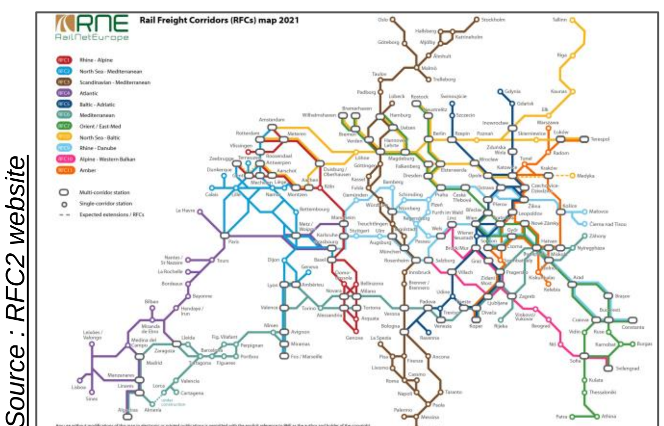
Presentation of RFC2



Source : RFC2 PoC : type of trains, 2021

The RFC2 coordinates capacity issues mainly on :

- The Benelux ←→ Switzerland / Italy routes & South of France routes (more than 90% of the Benelux traffic continues to Italy)
- The Germany ←→ Spain routes,
- The UK ←→ Benelux & South of Europe routes,
- The Belgium ←→ North & Eastern Europe routes.



Source : RFC2 website

Cooperation takes place with other corridors in order to coordinate appropriately the capacity on multi-corridor routes (RFC Atlantic, RFC Mediterranean, RFC Rhine-Alpine, RFC North Sea Baltic).

Context

- In the context of climate change, investments need to be done in favour of rail,
- The degraded state of the networks in many regions lead to a lot of works, which have capacity impacts,
- Since traffic does not usually start and end on a specific network exclusively, coordination methods, visualisations, platforms and tools are needed in a way to harmonize the capacity planning and production processes across the borders,
- The stakeholders involved in capacity planning and allocation processes work with a lot of different tools and don’t have the adequate cross-border decision-making tools. Capacity KPIs are often not defined, and not calculated/computed. In view of this, there is a lack of transnational view in KPIs and processes,
- RailNetEurope is working on TTR project, which should lead to a big change of the planning processes across Europe.

The PoC has shown that the import and treatment of trains and TCRs are possible in a single tool, and that the production of capacity KPIs and visualisations is possible with manual or automatic methods. It has also highlighted some hurdles. It is now time to go a step further:

- Apply these methods on real data and larger scale in order to produce results that can lead to real decisions
- Go over the hurdles, especially the ones linked to the processes in order to produce all the capacity visualisations needed
- Work with the different stakeholders on capacity visualisations and help them to understand the differences between their national processes in order to improve the cross-border planning processes of paths and TCRs.

Presentation of the PoC

Goals & steps

Source : RFC2 PoC

The primary goal was to demonstrate the feasibility of an international freight capacity production process centred around an integrated railway timetabling platform. Highlighting the benefits of such a coordination through original, synthetic and schematic visualisations based on a single database was the main objective.

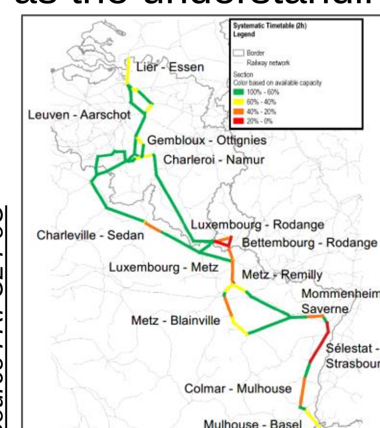
- Creation of a merged international Viriato database
- Import of 2-hour regular timetables
- Capacity analysis of 2-hour regular timetable
- Saturation by path search in 2-hour regular timetable
- Import of yearly timetables and TCR data
- Capacity analysis of 24-hour timetable
- Saturation by path search in 24-hour timetable
- Production of KPIs and dedicated displays

Results achieved

The creation of a transnational merged database (planned infrastructure, trains, TCRs) is possible but some questions related to the IMs data models were raised. Important differences between planning processes which could jeopardise capacity analyses were highlighted.

Using a database with consistent data at the “appropriate level of granularity” allows to produce KPIs, evaluations and visualisations which support the international harmonisation for trains and works, as well as the understanding of capacity stakes.

Source : RFC2 PoC



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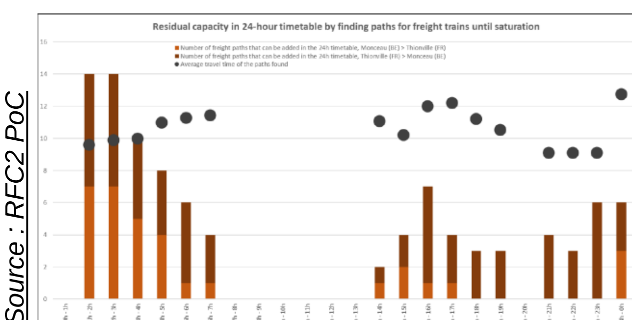
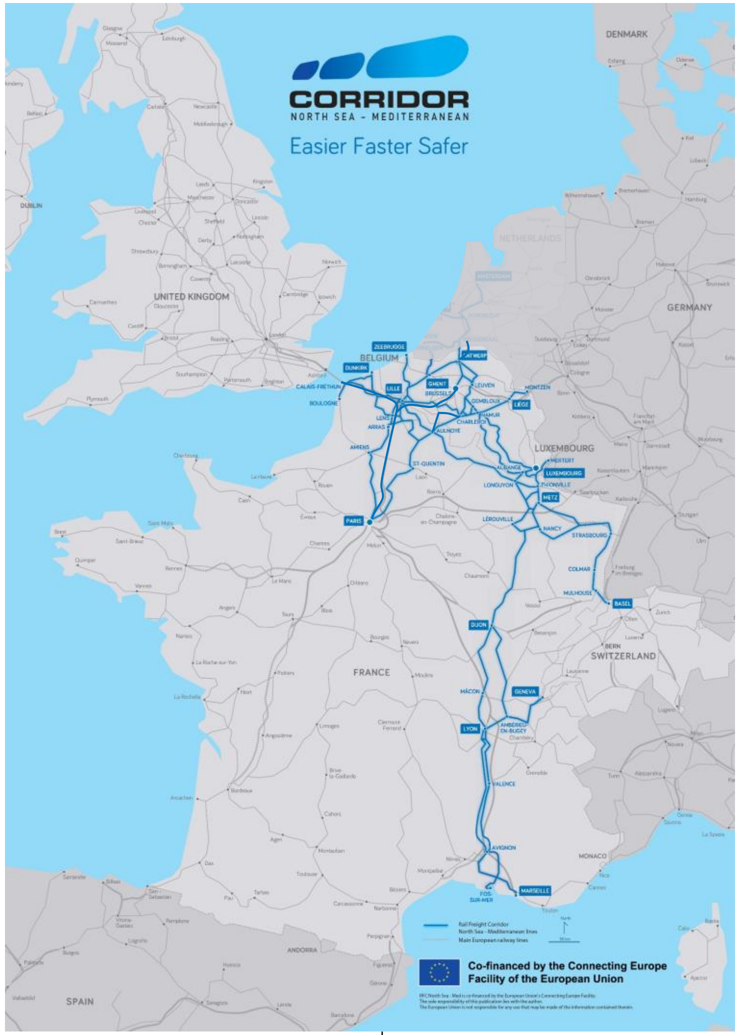


Scope of the study



Geographical scope :

- All the French, Luxembourg and Belgium sections of the RFC NSM.
- Additional sections : Mons –Maubeuge section (via the Quevy Feignie border point),
- The Highspeed lines between the BE/NL Border + Eurotunnel border and Paris
- Alternative itineraries will also be considered if needed/required

Time horizons and data considered :

- Infrastructure : topology and signalling performance
- Timetable : paths with timetables (with added times), track line and station track
- TCRs : closures and time penalties

→ 2021, 2022, 2023, 2024, 2025 : planned (different states) and real

Goals

Produce visualisations to understand capacity issues, and on this basis, suggest process improvements to capacity stakeholders.

- What is the **capacity currently available** ?
- How can the capacity be **increased** in the future ?
- What are the capacity **issues** (where, how much, what kind) ?
- How to **increase** capacity in these points ? How far ?
- How to create a capacity **transnational database** and use it ?
- Are there any **issues** in the capacity **processes** ?
- How can the **decision making process** about capacity be improved ?
- How can stakeholders manage a major **timetable change** ?

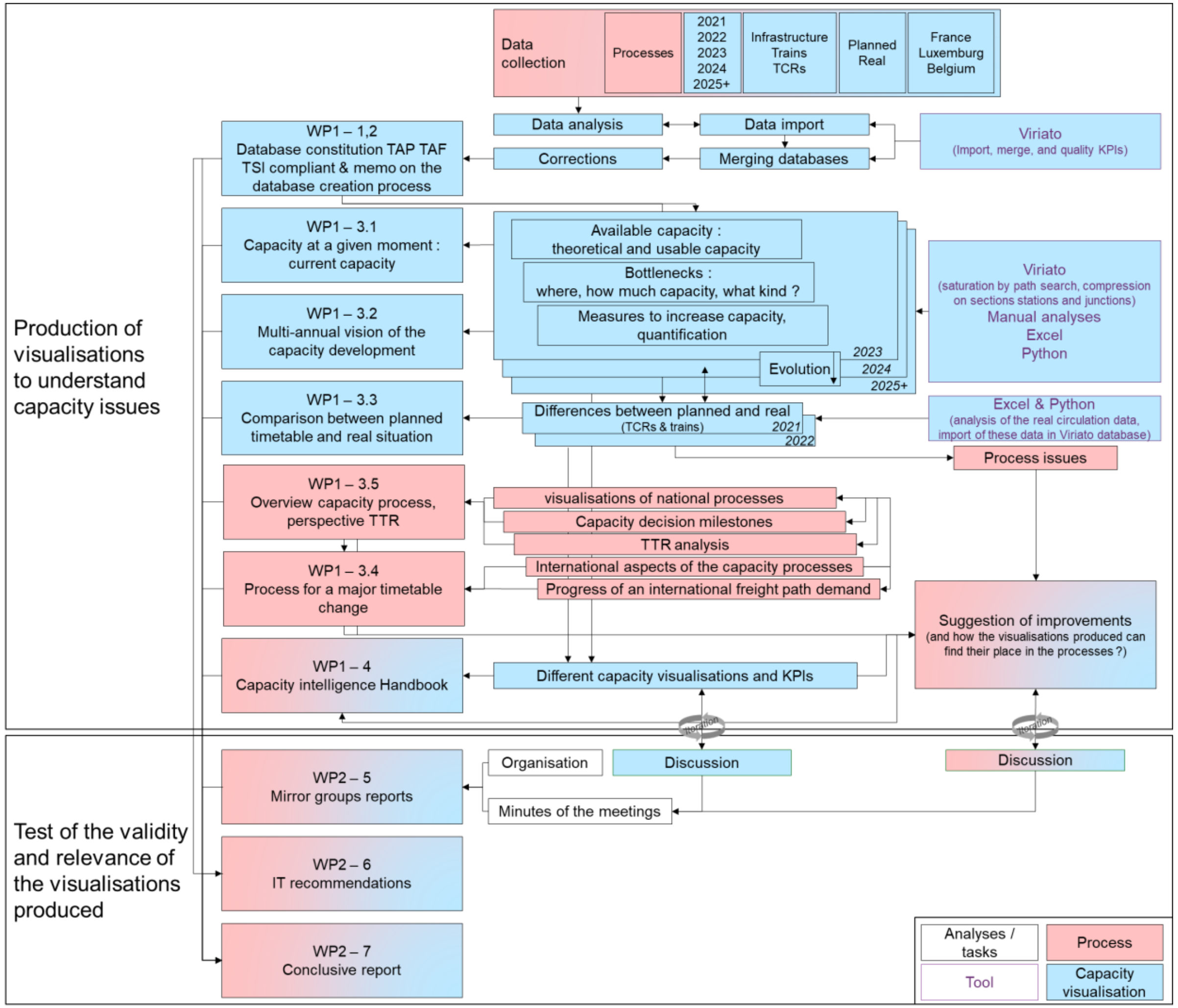
Go further than the PoC

- Work on **official** complete data,
- Add the import and analysis of the **real situation** data,
- Go further on the **365 days** analysis,
- Deepen the analysis on the **stations**,
- Identify some **measures** to have more capacity,
- Quantify the **additional capacity** that could be offered by different **measures**,
- Analyse the processes and the **entire capacity supply** chain, especially the **transnational aspects**,
- **Work with the stakeholders** to improve the visualisations and the capacity processes.

General approach

General methodology phases :

- **Collect, analyse and import** infrastructure, timetables and TCRs data of the 3 countries, of real circulation and TCRs, and planned data for short and middle-term in one single Viriato database,
- **Work on capacity KPIs and create visualisations** in order to characterise current and future available capacity, bottlenecks, and identify measures to increase available capacity,
- **Work on processes**, especially transnational aspects,
- **Discuss with the stakeholders** the capacity visualisations and outline how they can find their place in the different processes and make IT recommendations



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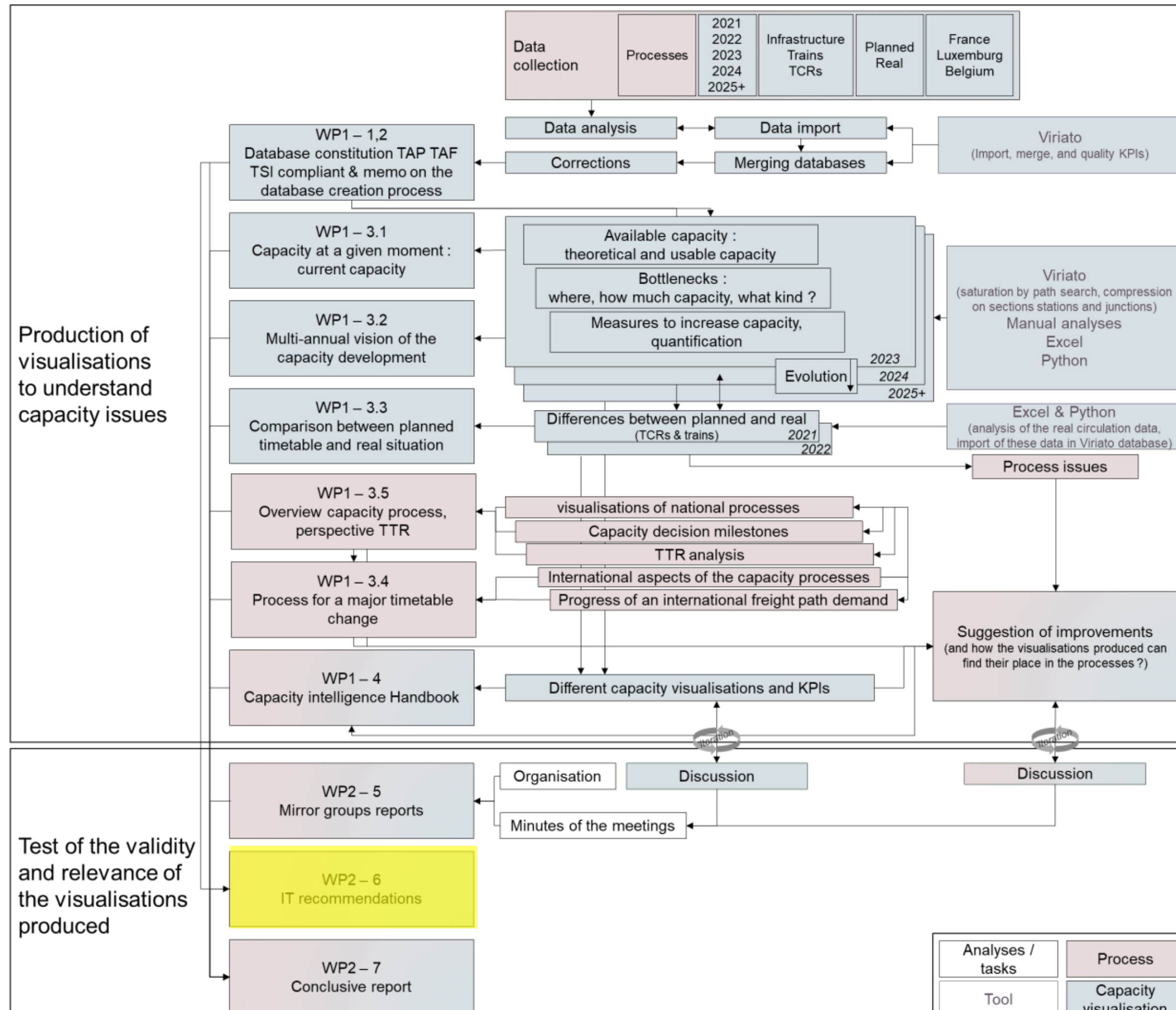

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Agenda

1. Context, scope, goals and methodology of the study
2. Data exchange
3. What has been used to produce the KPIs and visualisations
4. Necessary improvements to produce the KPIs and visualisations

Database format TAF/TAP - TSI

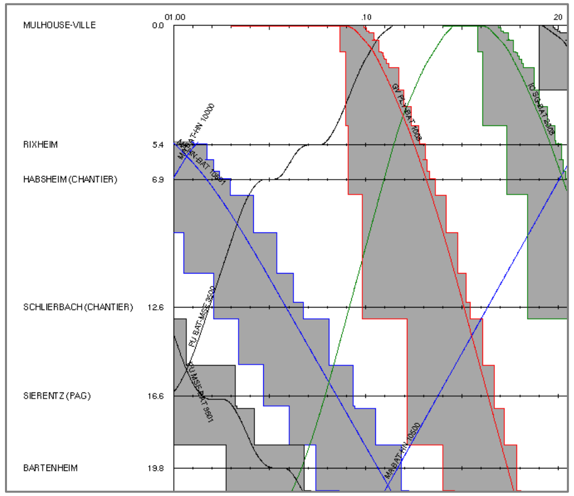
Technical Specification for Interoperability relating to Telematics Applications for Freight/Passenger Services
https://teleref.era.europa.eu/

TAF/TAP – TSI aims to define the data exchange. This table shows the database elements as they was received, which explains why it's not on a TAF/TAP – TSI format.

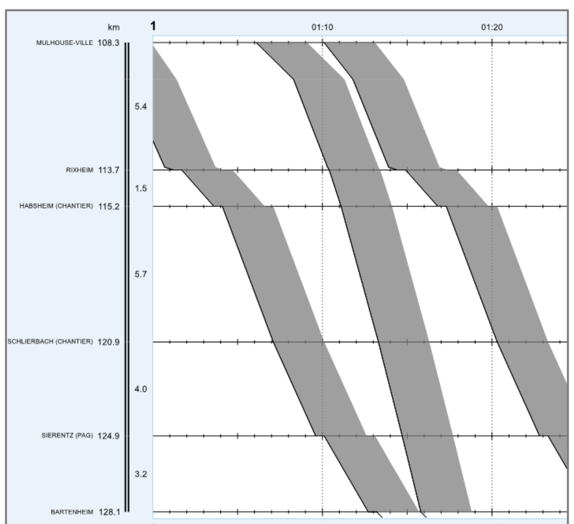
Viriato database	TAF/TAP – TSI	FR	LU	BE
Nodes	Primary Location Codes	CI/CH	Abbreviations	PTCAR
Freight trains shipment	Freight trains shipment	Nothing	Nothing	Nothing
Rolling stock	Traction Details	Internal names	Internal names	Internal names
RUs	Company Codes	Codes which are not listed in RNE CC dictionary	Internal names	Internal names
IMs	Company Codes	Implicit	Implicit	Implicit
Path / Itineraries	Split on border point or handover point	Full path for HS trains only	Full path	Full path
Stops type	Stops reasons	SNCF stop type	Commercial or operational	SNCB stop type
Train numbers	Operational Train Number	Train numbers from IM	Train numbers from IM	Train numbers from IM
Timetable	Dwell times	Dwell times	Stop type reserve	Stop type reserve

→ Make sure that implementation of TAF/TAP – TSI is sufficiently close across the different countries

Headways and separation times



Example of block occupation stairs calculation to determine headways and separation times, with a microscopic tool where all track elements are modelled.



Example of headways and separation times modelled with a fixed value per section, with a macroscopic tool. (same section but not exactly the same trains as above)

In this study we aim to consider the headways and separation times used in the capacity planning phases by the IMs.

In some cases, middle and short-term capacity planning is done by IMs with **microscopic tools** (see chapter 3 of the “Overview processes” deliverable).

At this time, the headways and separation times given by such tools are **too detailed** to be used in our macroscopic tool to calculate KPIs, and they **can’t be imported** in the tool automatically.

For the computation of the considered KPIs, **the accuracy** of the planning rules as described in chapter 2 **is adapted.**

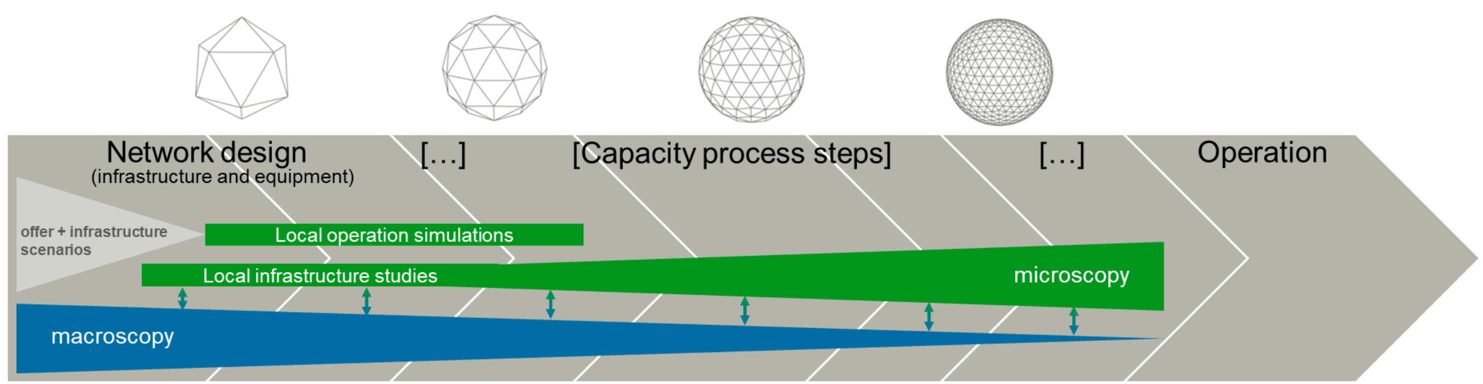
Headways and separation times

Why is the macroscopic level adapted to the constitution of a transnational database and to the capacity KPIs production ?

* The level of precision can always be decreased, but it can’t be increased if data is missing.

** The number of offer + infrastructure scenarios is too high at this step to be planned at a microscopic level. The signalling can’t be modelled as it’s a result of this planning phase.

– Macroscopy is the common denominator of the infrastructure models *,
– For now, algorithms to calculate automatically capacity KPIs only exist in macroscopic tools,
– Some capacity KPIs would require extremely high computing power if they had to be implemented into a microscopic tool,
– Macroscopy is the only way ** to plan jointly and strategically the offer and the infrastructure and equipment (functional requirements), with a continuous refinement approach across the capacity process steps, so it is and will continue to be used in upstream phases :



Headways and separation times

Microscopic tools are widespread and highly heterogeneous across capacity planning processes and stakeholders, which leads to the disappearance of normative rules or documents compiling the headways values per line and station.

The ambition of this project to deploy the calculation of capacity KPIs within the IMs capacity planning processes for the next years will raise the question of the sufficient **legitimacy** and **sustainability of the methodology developed in the current and former study (PoC).**

Legitimacy : see deliverable “Capacity KPIs” : estimation by sampling of the differences in capacity KPIs results between microscopic and macroscopic approaches.

Headways and separation times

Sustainability of the methodology if no more headways and separation times per sections, junctions and stations are published / available

This page is about IT recommendations, the tools mentioned are not developed in the current study.

Planning headways and separation times should be calculated once in advance in an official microscopic tool, imported and persisted in the macroscopic tools, to work on planning and calculate capacity KPIs.

This method requires :

– The standardisation of a format to export headways and separation times from microscopic tools,

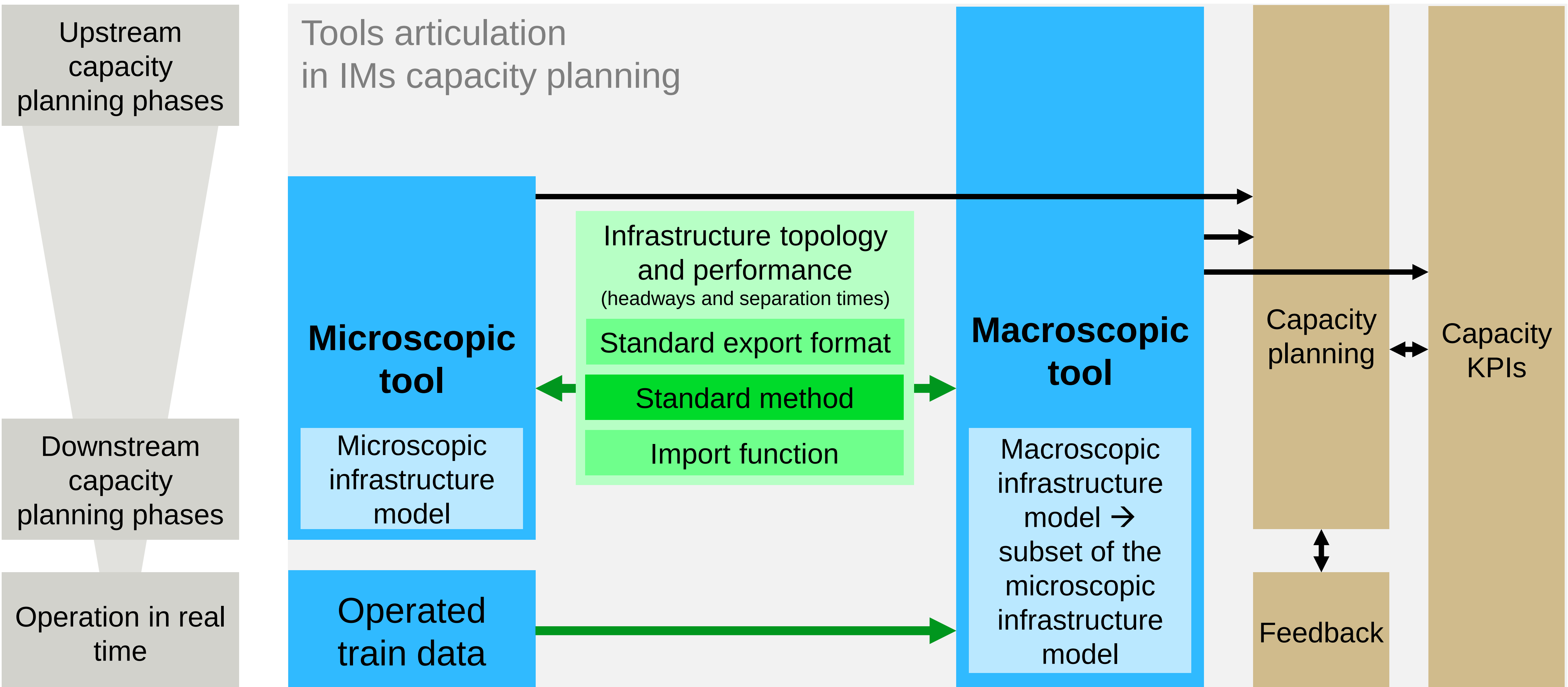
– The standardisation of a method to aggregate the parameters to feed the macroscopic tool : which level of detail should correspond to the one chosen to model the infrastructure, trains, and TCRs ? This step is linked to the infrastructure data exchange subject detailed in the next pages,

– A functionality to import such values in the macroscopic tool.

Headways and separation times

Legend
- Capacity processes phases
- Capacity existing tools
- Capacity tasks
- Steps in progress *
- Steps to implement *
- Existing links
- Links to implement

* Out of the scope of the RFC study



Relevant points

Availability
Export
Collection
Import
Processing

- Relevant point appeared in the study

→ **Proposed solution**

- Real TCRs data (usage of planned TCRs) is an area for improvement

→ **Add this measure in capacity processes, use a common format**

- Exchanging infrastructure data is difficult, particularly signalling performance, linked to modelling choices and lack of standards to make microscopic and macroscopic models work together,

→ **Define standards in infrastructure modelling**

- Implementations of standard trains formats differ across countries and tools,

→ **Continue the work on standard formats (RailML)**

Relevant points

Availability
Export
Collection
Import
Processing

- Relevant point appeared in the study

→ **Proposed solution**

- TCRs data format is very variable (speed restrictions or additional runtimes, and headway differences) data exchange is an area for improvement,

→ **Work on a TCR and speed restriction standard format**

- Complete timetables are transmitted by all IMs, although only part of the network is relevant for international corridor analyses and exchanges

→ **Filtering data transferred would improve import process and control as well as data handling (this could be done through functions existing or to be developed either in the export or import tool)**

Relevant points

Availability
Export
Collection
Import
Processing

– Relevant point appeared in the study
→ **Proposed solution**

– For trains & TCRs, validity (application days) is often a problem when transmitted through attributes open to interpretation (text descriptions, weekly bitmasks with start and end date but times over midnight, etc.),

→ **Yearly validity bitmask with a common semantic regarding times over midnight would help import, especially for TCR**

– Stations and freight yards are modelled in a non-importable format so track occupation plans are hardly importable,

→ **Use default RailML attribute to exchange station tracks and make sure station topologies in IM and common databases are identical**

– Building a common database is quite fast, but correcting it to match the format of transmitted trains & TCR is time consuming,

→ **Build a persistent common database and tools to update it from IM data**

Relevant points

Availability
Export
Collection
Import
Processing

– Relevant point appeared in the study
→ **Proposed solution**

– Databases must be corrected to join each national infrastructure on common border points,

→ **Using standardised European node ID for borders could solve this problem**

– Transnational trains are sometimes transmitted beyond their national perimeter by each IM and must be cut,

→ **Using standardised exchange rules or more flexible import options could solve the need of a post-treatment,**

– Some lines, junctions and stations have been changed because the way they were modelled did not allow to calculate KPIs automatically (3rd track, stations throat as junctions, etc.),

→ **Always do 1st step : what are we putting in the database, and why ?**

Relevant points

Barriers to the construction of databases to process capacity KPIs at an international scale and at different milestones in the capacity processes

- **Characterisation of the data** and **underlying method** should be transmitted with all the exchanged data. Without the assumptions, data can't be processed to produce KPIs,
- Is the data **available** ? Planned or not, this refers to the **capacity processes** of the IMs,
- Is the data **exportable**, in which format ? This refers to the **capacity tools** of the IMs, and to the **standard formats**, currently in progress,
- Is the data **automatically importable** ? **Level of modelling** used to plan trains, TCRs and infrastructure, which can be **micro. or macro.**, is a hurdle to the data exchange : at this time, a macroscopic model is not automatically a subset of a microscopic one.

→ **Detailed and tangible capacity processes have to be harmonised in parallel to the progress in data exchange formats (see D 3.4, 3.5), and transmitted with the data,**

→ **As micro. and macro. levels are complementary in capacity processes, it's necessary to define standards in modelling, and continue the work on data (infrastructure topo. and perf., trains, TCRs) exchange standards to enable automatic communication between them,**

→ **Intelligent API's between macro and micro models could solve this challenge.**

Synthesis

1	Characterise the data and the underlying method when transmitting data
2	Standardise infrastructure modelling and data exchange between macroscopy and microscopy
3	Build a standard format for TCRs and speed restrictions
4	Continue the work on existing standard formats (RailML)
5	Use default RailML attribute to exchange station tracks
6	Add a standard for yearly validities
7	Use standardised data exchange rules for boarders
8	Make sure that implementations of RailML and TAF/TAP-TSI are enough close across countries

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General requirements

The main tool used in the project contains a database with :

- Different infrastructure states (topology and signalling performance)
  - When there are infrastructure evolutions across years
  - When different infrastructure scenarios are explored for the future
- Headways and separation times, per section, station, junction, train type
- TCRs, per direction, per track, including speed restrictions
- Paths, including details such as margins, trains types, etc.

TCRs and paths are organised in scenarios (years, and different capacity planning steps), affected to a given state of the infrastructure, and affected to calendar periods.

Compression tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Compression tools are used with :

- Automatic network decomposition
- TCRs consideration
- Headways and separation times consideration
- Vision of junctions, stations and sections
- Possibility to work on 24h x 365 days with different time windows
- For stations, an additional Excel tool to proceed UIC406 method (with switches areas, station tracks, etc.)
- Possibility to work on sections and junctions on a paths set without timetable (compression of all possible timetables)

Capacity display tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
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Database with

- Possibility to display graphic timetable on long routes
- Possibility to count trains per types and direction, on a given point of the network and during a given time window

Path search tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
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Path search tools are used, considering :

- Headways and separation times
- TCRs and other paths of the given timetable
- One or more model paths
- A saturation strategy
- Stations where trains can stop
- Potential additional times
- A 24h given timetable

Data analysis tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
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Python scripts to :

- Consolidate outputs from capacity analysis on a given timetable and permutations of paths,
- Analyse data either on sections (see network decomposition algorithm), junctions or stations,
- Do an optimisation analysis between given timetable and results from permutations analyses (min & max) : compute an indicator,
- Produce bar charts visualisations.

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Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Python scripts to :

- Consolidate data (observed / planned) at start and end point of each section,
- Generate the indicators at section level : median, average, dispersion, counts, aggregation on common property (type of day, peak hour, train type, travel time, …)

Data analysis tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Python scripts to :

- Consolidate data at start and end point of each path, stopping pattern,
- Generate the indicators at path level : departure time, trip time, distance, speed path, day type, path variation,
- Produce bar charts visualisation to illustrate dispersion across many path characteristics,
- Investigate routes taken by trains having the same origin – destination. It counts yearly occurrence of each path and project them on maps (variability of itinerary for a route).

Data analysis tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Python scripts to :

- Convert TCRs to operable time-space element : convert validities to hourly block and split starting and ending PK into elementary sections - network decomposition given all starting / ending nodes of TCRS and available intermediary nodes from open data of each IM,
- Aggregate on common properties : period of the day, type of day, yearly calendar, type of closure,
- Produce bar & pie charts visualisations to envision each KPIs.

Data analysis tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Python script to :

– Convert TCRs to operable time-space element : convert validities to hourly block and split starting and ending PK into elementary sections - network decomposition given all starting / ending nodes of TCRs and available intermediary nodes from open data of each IM,

– Given a list of possible itineraries, proceed a simultaneity analysis to identify days / nights with TCRs on all the itineraries.

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Data analysis and GIS tools

	Paths & TCRs	Paths	TCRs
Capacity consumption & residual capacity	Capacity consumption rates on sections (map) Capacity consumption rates on junctions (map) Capacity consumption rates on stations (map) Residual capacity (map & graphic timetable) Residual capacity (histogram)	-	-
Capacity consumption analysis	Signalling performance (map) Share TCR & paths / type (maps & histogram)	Paths volumes (maps) Runtimes heterogeneity (map and histograms) Timetable optimisation : sections, junctions (maps) Timetable optimisation : sections, junctions (histograms) Timetable optimisation : wasted capacity (nb)	TCRs volume (map)
General structure	Graphic timetable (graphic timetable) Number of trains / type + TCRs (24h histogram)		Nominal TCR structure (map)
Permeability	-	-	Rate of available capacity for a given path (rate on 1 or more itineraries)
Alternative routes	-	-	Days/nights with TCRs on all itineraries (histogram)
TCRs & Paths statistics	-	Runtimes, speeds, lengths (histograms & maps) Number of paths : year / weekdays (histograms) Number of paths (maps) Share of freight paths (map)	Planned capacity (maps & histograms) Typology of works day/night (pie chart) Typology of closure complete/partial (pie chart) Length, duration capacity planned (histograms)
Calendar stability	Possible unique paths for a 365 days train (nb), or comparison between 1 day / 365 days compressions, level of graphic timetable transparency (%)	Nb of versions / days of circulation (histogram) Changed paths from a year to another (nb) Level of graphic timetable transparency (%) Variability of runtime for a route (histogram) Variability of itinerary for a route (map)	Days with the same planned TCR (nb) Level of graphic timetable transparency (%)
Process stability	-	Stable planned paths across steps (rate)	Stable planned TCRs across steps (rate)
Real-data analysis	-	Delay increase per section (map) Nb of planned paths / real trains (map) Delays across the year / country (histogram) Delays at departure / arrival (map)	Used length / planned length (rate) Used duration / planned duration (rate) Used TCRs / planned TCRs (rate)

Python script and GIS software to :

– Aggregate the different results (for example compression results),

– Project all KPIs and visualisations on maps.

Synthesis

1	Database able to contain : Different state of the infrastructure, including infrastructure topology and signalling performance Different scenarios (paths & TCRs) for a same period, and scenarios for different time periods Paths, TCRs and speed restrictions with some details And able to display capacity (graphic timetable)
2	Automatic compression tool with some characteristics : Consider TCRs Be able to work on all the possible timetables Work on sections, junctions, stations
3	Path search tool able to : Search multiple paths (more than 1 path, more than 1 time) Consider paths and TCRs Allow the work on some parameters (for ex. runtime)
5	Python (or other language) scripts to analyse the data and calculate the different KPIs
6	GIS tool to display KPIs and visualisations on maps

Agenda

1. Context, scope, goals and methodology of the study
2. Data exchange
3. What has been used to produce the KPIs and visualisations
4. Necessary improvements to produce the KPIs and visualisations

Complete database

In order to have KPIs and visualisations for the capacity follow-up over the years and capacity processes steps, these very different data have to be imported in a complete database, so all data (trains, including real data and TCRs, including real data) should have a minimum of provided information.

The infrastructure historical consistency over the year is also required, so that the complete database can have different infrastructure scenarios with validities (dates).

The infrastructure future consistency is also required, even if some alternative scenarios are still coexisting for the infrastructure evolution.

Capacity needs

Capacity has here been considered from different points of view :

– Planned capacity (long middle and short term)
– Real data : delays (past)

But capacity could also be considered before the planning steps : with a look at the **capacity needs**.

That's why a link between the capacity request tools, for TCR and paths, from upstream from the TTR scope to the circulation day, and the capacity analysis tools have to be imagined.

To analyse these needs without any timetable, it's necessary to have a tool that can calculate KPIs without a timetable.

Capacity compression rates

To process sections, junctions and station compressions, it would be interesting to have access to these data :

- Raw headways and separation times
- Headways and separation times margins
- Raw runtimes
- Runtimes margins
- Runtimes added times

Calendar and process stability

Process stability

Proposition to be able to calculate process stability KPIs :

Include in the planning tools an information about the link between the current capacity process step and the previous one, for paths and TCRs.

For example : from 2h systematic timetable to 24h x 1 representative day timetable : for each 24h path, from which 2h systematic path is it activated ?

Calendar stability

Proposition to be able to calculate calendar stability KPIs :

Include in the planning tools an information about the paths : when a same path has different n°, systematically group them in a path n° + variant/version n°. For example : a train has 2 different n° : one for the week and one for the week-end, even if it's the same path with only a rolling stock variation : group them or add an information allowing the tools to identify that it's the same path.

Same for TCRs : systematically group them. For example : a TCR is 6h long from 23h to 5h during 10 weeks, and them 6h long during 1 week : group them of add an information allowing the tools to identify that it's the same TCR.

Synthesis

1	Provide more data about paths, TCRs and real data across years and capacity process steps
2	Provide infrastructure models for past and future
3	Provide data about TCRs & paths needs (even if it's without timetable)
4	Provide more details : paths, headways and separation times : raw times, margins, added times
5	Add markers to link paths and TCRs across capacity process steps
6	Add markers to link paths and TCRs across the year and measure calendar stability
7	Implement a tool to measure real TCRs use

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