RFC2

CORRIDOR
NORTH SEA – MEDITERRANEAN

Co-funded by
the European Union

Capacity KPIs and visualisations

Deliverable	**3.1, 3.2, 3.3 : capacity KPIs and visualisations**
Date	08.03.2024
Version	4-01

optimising railways

sma

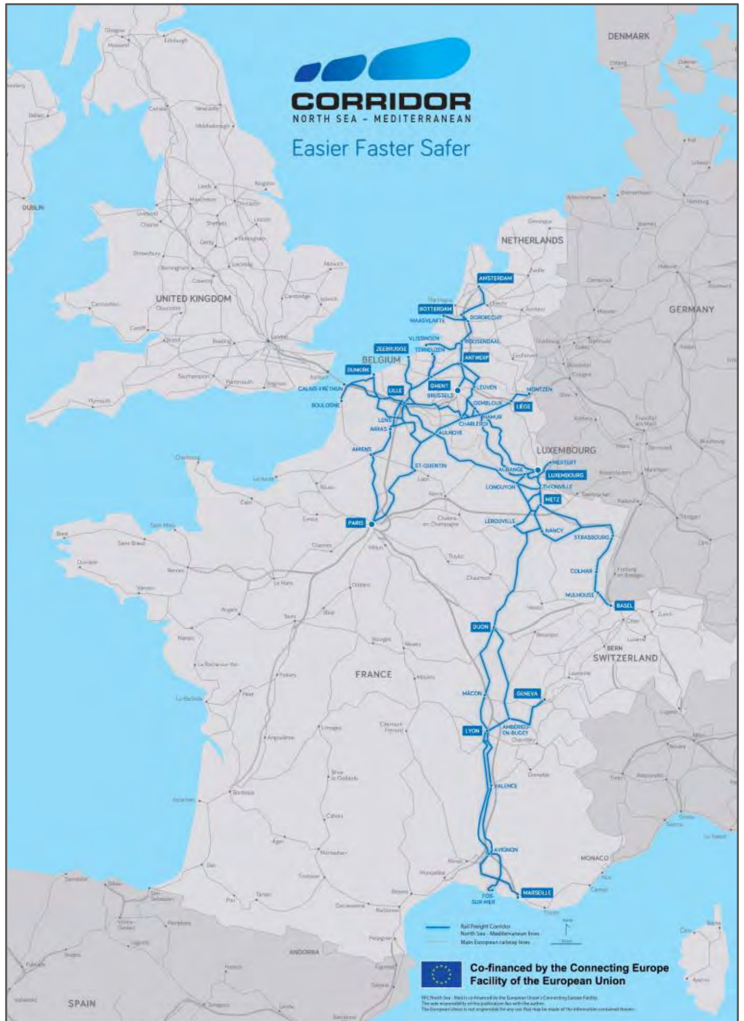
Project governance

Name	Entity	Role
Le Floch Yann	RFC2	Project leader
Chassagne Rébécca	SMA	Project manager
Pelte Kathleen	ACF	Steering committee
Vanbeveren Thomas	Infrabel	Steering committee
Urbain Pierre	SNCF Réseau	Steering committee
Forster Pol	CFL	Steering committee
Stauffer Floraine	TVS	Steering committee

Agenda

1. Context, scope, goals and methodology of the study
2. Assumptions
3. Available capacity at a given moment (2022)
4. Multi annual vision of the capacity development
5. Comparison between planned and real
6. Synthesis

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.

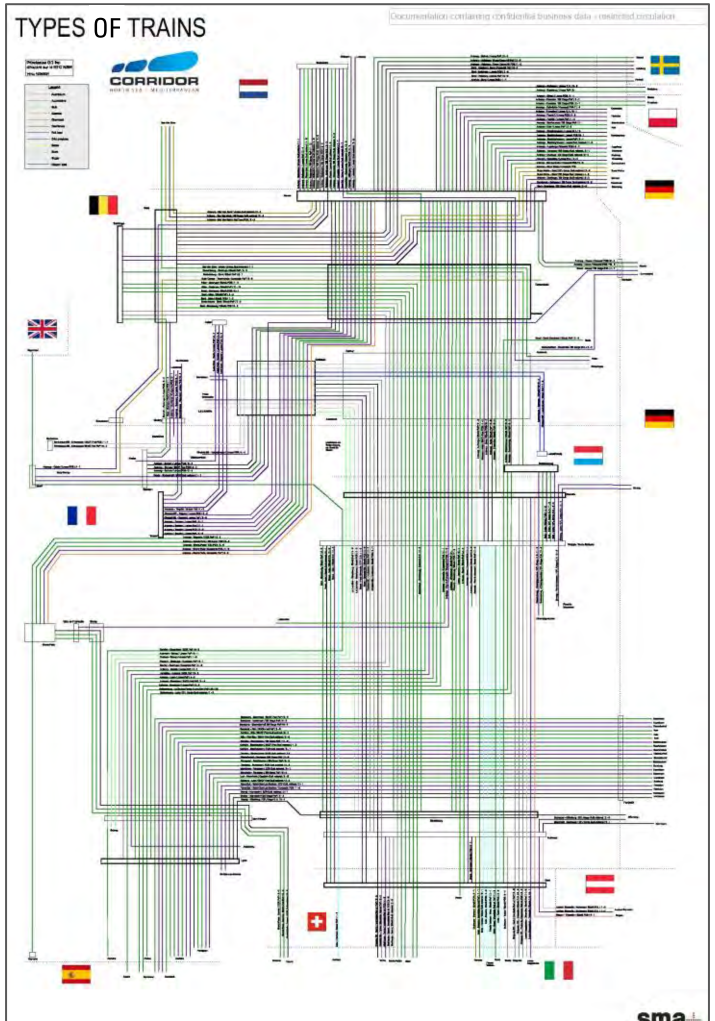
Primary functions

- 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.

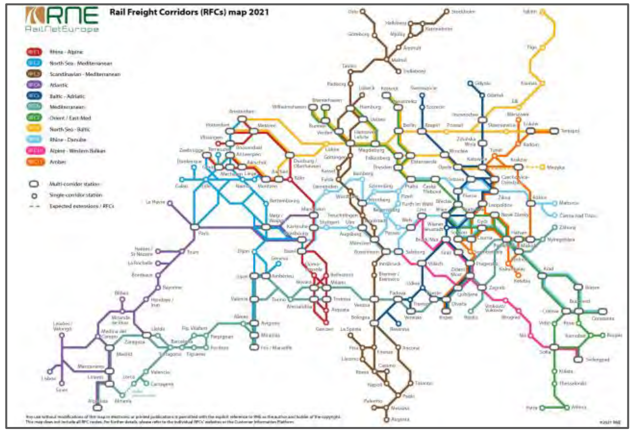
Presentation of RFC2



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, our initiative takes place in this TTR new capacity framework.

The Proof of Concept (see next page) 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

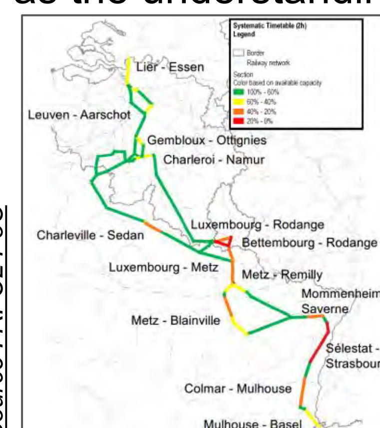
The primary goal was to demonstrate the feasibility of an international freight capacity production process centred around an integrated railway timetabling platform. Highlighting the benefits of such a coordination through original, synthetic and schematic visualisations based on a single database was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

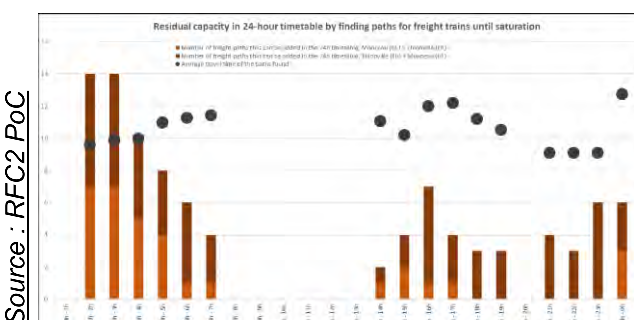
Results achieved

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.

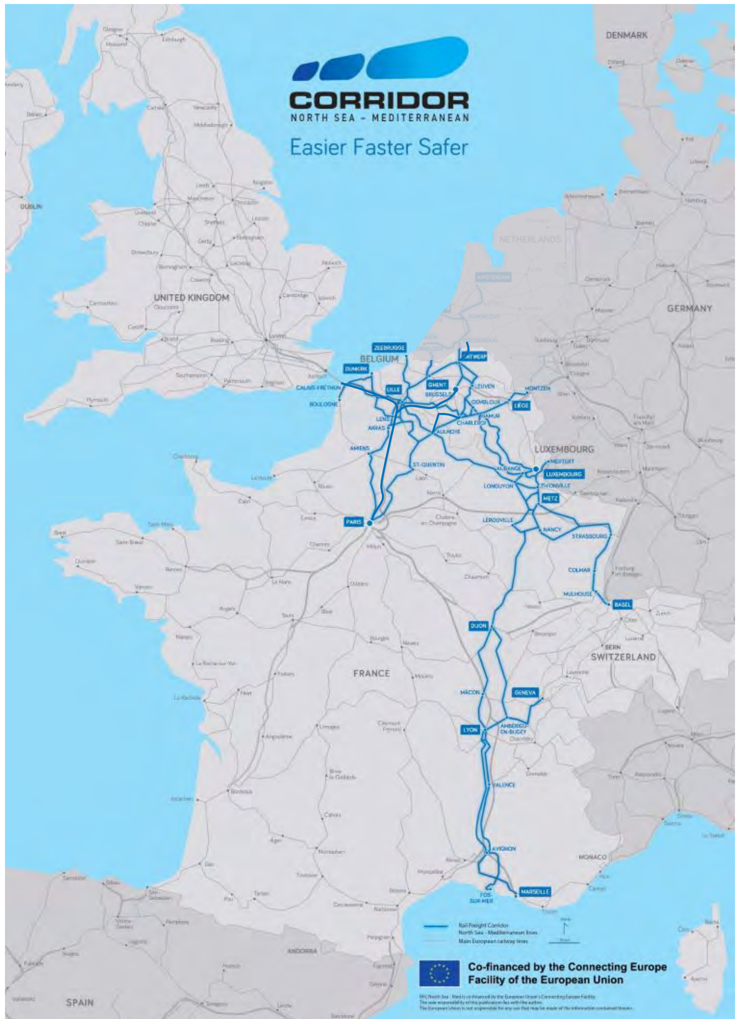


Source : RFC2 PoC



Source : RFC2 PoC

Scope of the study



Geographical scope :

– All the French, Luxembourgian and Belgian 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** ?

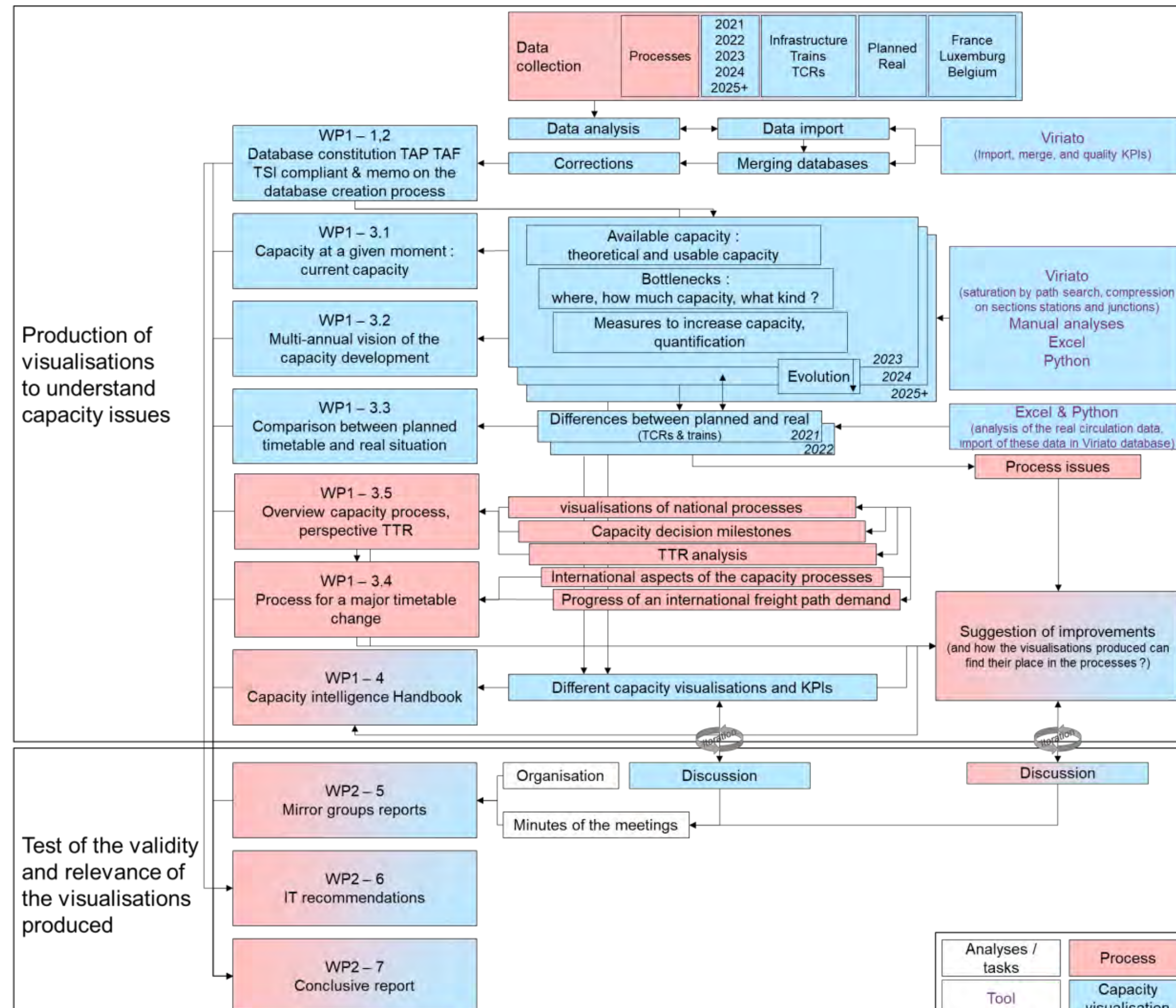
Go further than the PoC

- 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.

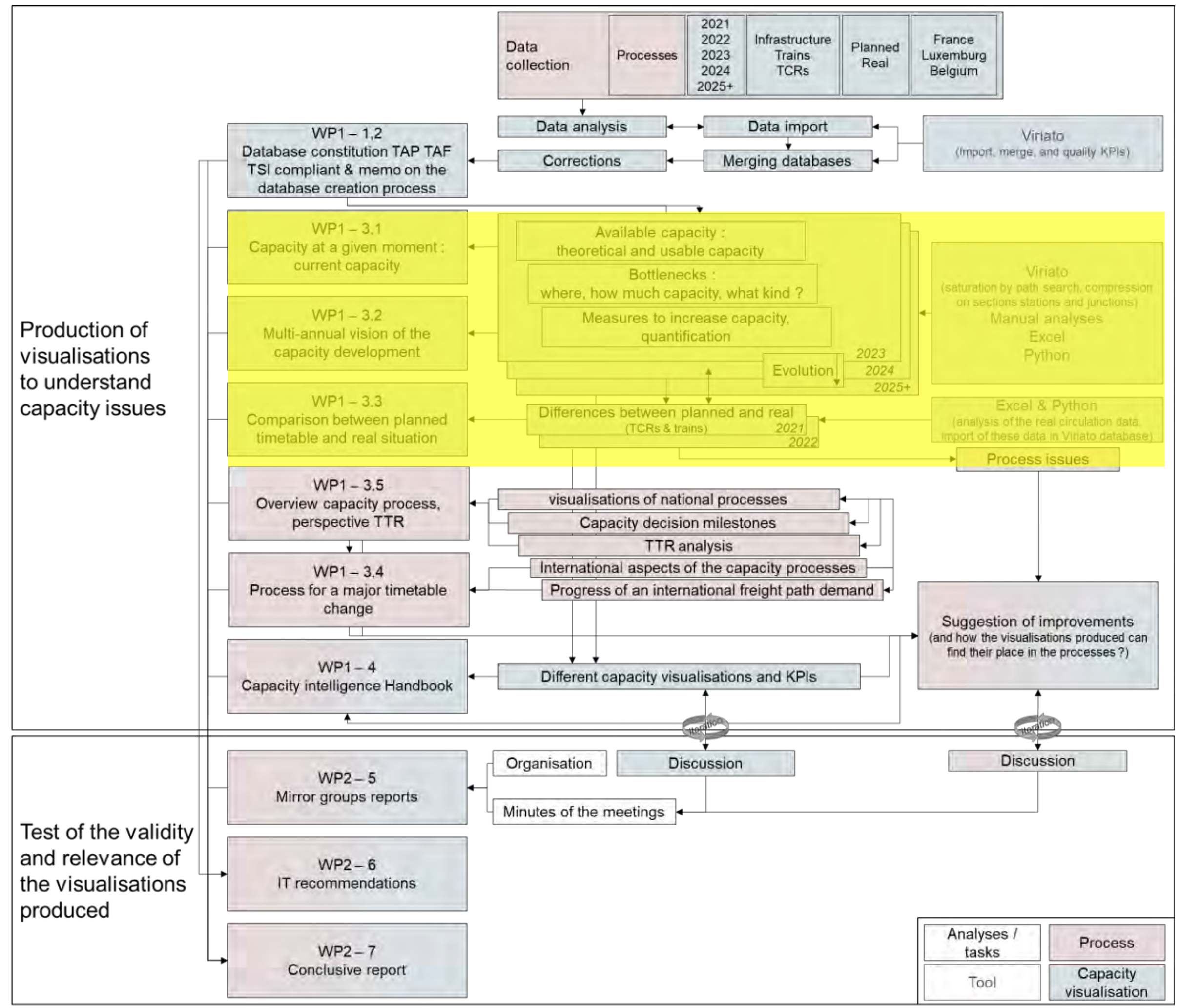
General approach

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



Deliverable 3.1, 3.2, 3.3



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Glossary

The RNE Glossary (2022 edition) is used here, except for the following terms that are different in this study (added or modified).

Runtimes : runtimes considered in planning phases for KPIs on planned timetables, and real runtime for KPIs based on real data. Runtime = raw runtime + reserve + planning additional times.

Headways : minimum planned time between 2 trains running in the same direction, depend on the IM but generally also contain reserve. Composed of a raw headway and reserve.

Separation times : minimum planned time between 2 trains not running in the same direction, depend on the IM but generally also contain reserve. Composed of a raw separation time and reserve.

Saturation : saturating the graphic timetable on a section, junction or station of the infrastructure means adding trains (with fixed runtimes and a max % of additional runtime) to use all the available capacity : 100% of the useable capacity, considering headways and separation times.

Glossary

Capacity consumption rate = see after

Theoretical residual capacity = 100% capacity – capacity consumption rate

TCR : temporary capacity restriction, includes all capacity not usable for trains (line and station), all tracks or 1 track /2, also includes speed restrictions.

Stability :

- Stability of a operations : linked to robustness, punctuality, not used here,
- Across the capacity allocation process : how paths & TCRs planned 10 years before circulation persist in the process (volumes, timetable, etc.)
- The year : how timetables can be different from a day to another within the year and also within the different years.

Glossary

Runtime reserve : time added to the raw runtime, depending on the IMs choice, can be based on the line, the network state, the travel time, the distance, etc. Used to overcome classical disruptions and small impact speed restrictions. See chapter 4 and annexes of the network reference documents of the IMs. Reserve can also be added to stop time.

Additional runtime : time added to the raw runtime and reserves to build the timetable. Additional time can also be added to stop time.

Headway and separation time reserve (buffer time) : part of the headway time and separation time. Time added to the raw headway and separation time, to increase timetable stability.

Capacity consumption rate

To allow yearly representation of capacity consumption rates, a unique network decomposition is needed, based on all 2022 planned trains. This “over-decomposition” can lead to an optimistic view of the capacity (see annexes for a sensitivity test of this assumption).

Capacity consumption rate here does not strictly corresponds to the UIC 406 definition (see after for details), but is based on UIC 406 method.

Capacity consumption rate (= compression rate) is calculated here by a compression of the considered timetable on the elementary sections of the considered network, per direction, with a given time window.

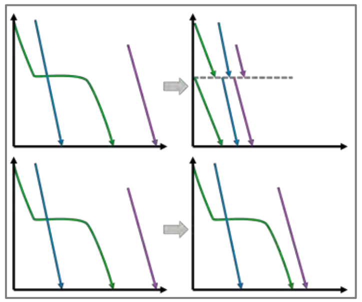
Elementary sections are cut :

- When the set of trains changes : trains origins, destinations, trains going to or coming from another section,
- Or when the infrastructure changes : number of tracks, and on the single tracks lines : crossing stations,

The planned trains paths and the TCRs timetables and runtimes are not changed when doing the compression. Different times are considered as planned : minimum travel time, theoretical margins in travel time or in stop time, timetable construction additional time in travel time or in stop time, stop time for commercial or service stop.

Capacity consumption rate

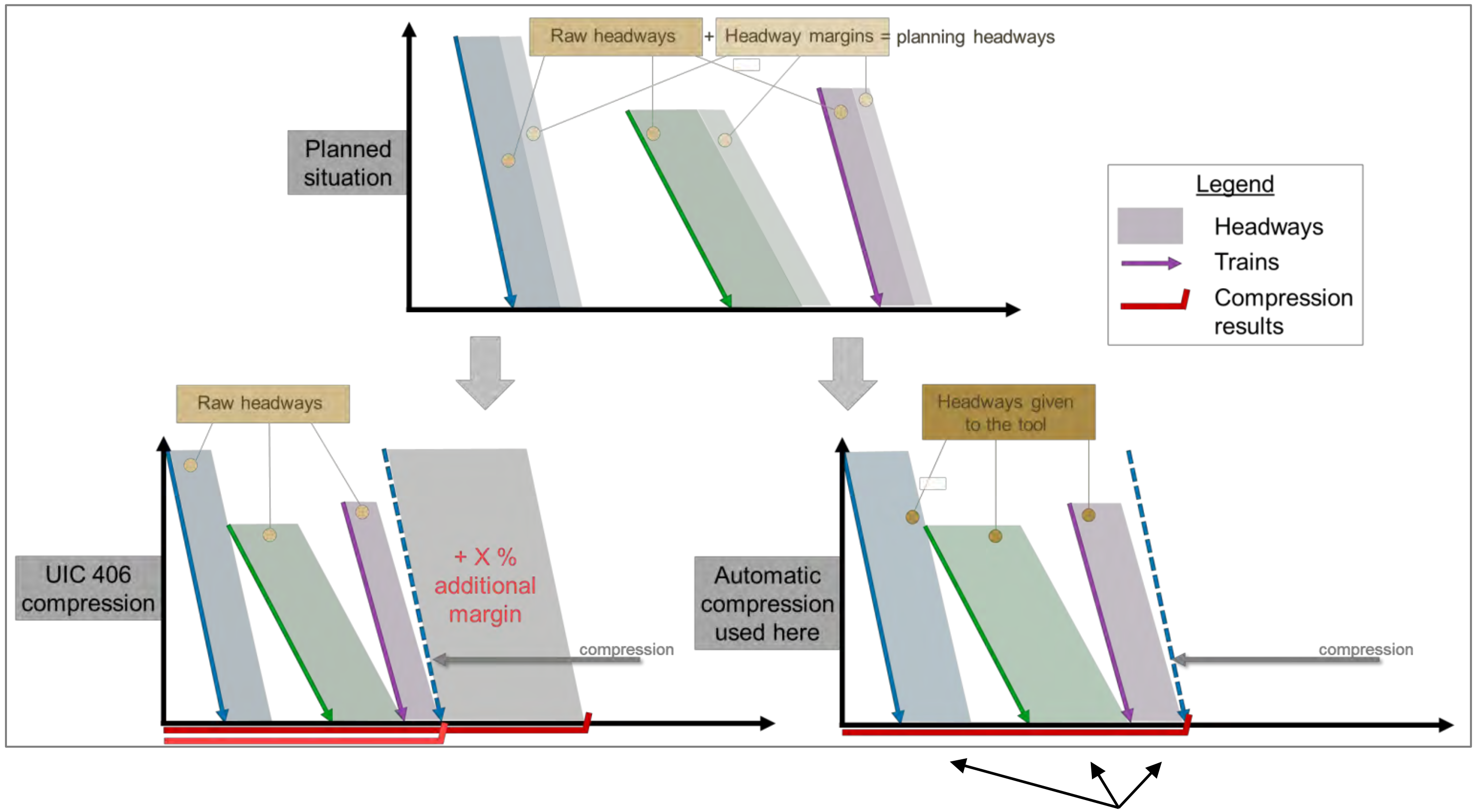
Differences with UIC 406



- Definition of sections : UIC 406 cuts into 2 sections when train sequence (added or removed train, trains order) changes, here it doesn't create new sections for overtakings, consequences : our method is pessimistic,
- In station switch areas, UIC 406 does a specific compression, which is not done here except on chosen nodes (manual), consequences our station automatic KPI is totally different from UIC 406 (see annex 4),
- Technical paths in and around stations are supposed to be considered in UIC 406, but not here as the data is not always available, so UIC 406 thresholds are not used here,
- For TCRs, the sequence of trains and TCRs is not changed in UIC 406, here it can be changed, so it can be a little bit more pessimistic,

Capacity consumption rate

Differences with UIC 406



In the data, headways and separation times are given without the detail of raw headways / margins

- Minimum theoretical distance between the paths is used in UIC 406, here it's the minimum planning distance between paths used by the IM, which sometimes includes margins,
- Additional time rates are added in UIC 406. Here they are not added, because some additional times are contained in considered headways and separation times

Choice of macroscopic approach

Over the used examples, comprising different signalling technologies, **results for micro and macro compression are comparable.**

Macro compression tend to slightly over-evaluate occupation when used separation times / headway do not reflect the real possibilities of the infrastructure.

Section	Type	Micro compression (SIPH)	Macro compression (Viriato)
Dunkerque – Gravelines	Single track	**40%**	**43%**
Don-Sainghin – Lens	Low density automatic block (BAPR)	**21% - 21%**	**21% - 21%**
Neufchâteau – Merrey	High density automatic block (BAL)	**10% - 14%**	**11% - 14%**

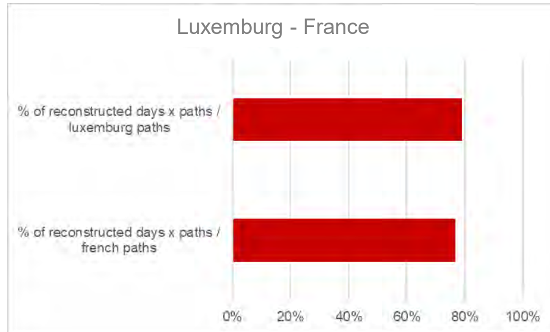
International trains

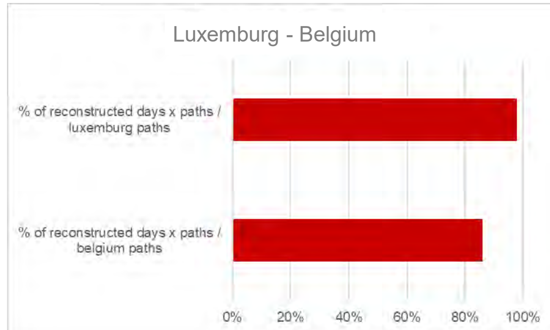
An analysis was conducted on international trains, as a 1st cleaning of the database, to connect trains at border points. Here are the results of the analysis, which shows that some paths couldn’t find there continuation across the border in the provided data.

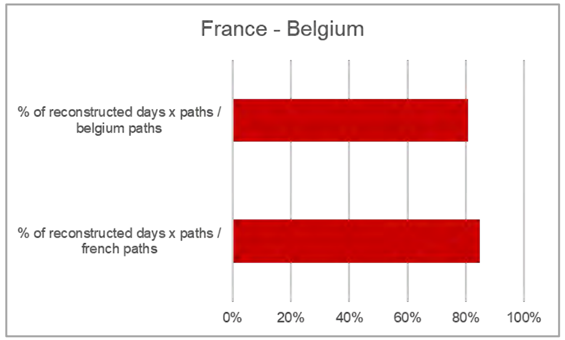
Cross analysis on all year 2022 of international trains to connect them at border point.

Errors may occur as we identify some differences with regards to validity, timetable or type.

Able to identify more than 350 international trains per day (in average).







Main assumptions overview

Capacity KPIs calculation is based on strong assumptions, which have to be chosen in view of the available data.

Other assumptions are detailed in the annexes, as well as sensibility tests.

- Macro / micro approach : the approach should be homogeneous, the associated tool has to support capacity KPIs calculations,
- Compression methods for stations, junctions, sections, differences between the chosen method and UIC 406,
- Level of knowledge and acceptation of the analysed timetables (conflicts, duplicates, stations tracks planning, empty runs, TCRs planning method, etc.),
- Network decomposition in sections,
- Chosen studied routes and associated itineraries,
- Definitions of peak / off-peak / night hours, “normal working days”, if timetable has a low calendar stability, choice of representative days,
- Specific cases treatment (ex : > 4 tracks, T1 or T2 planned TCRs, etc.),
- Markers choice : trains n°, origins, destinations, and level of confidence in those markers

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   3B Bottlenecks
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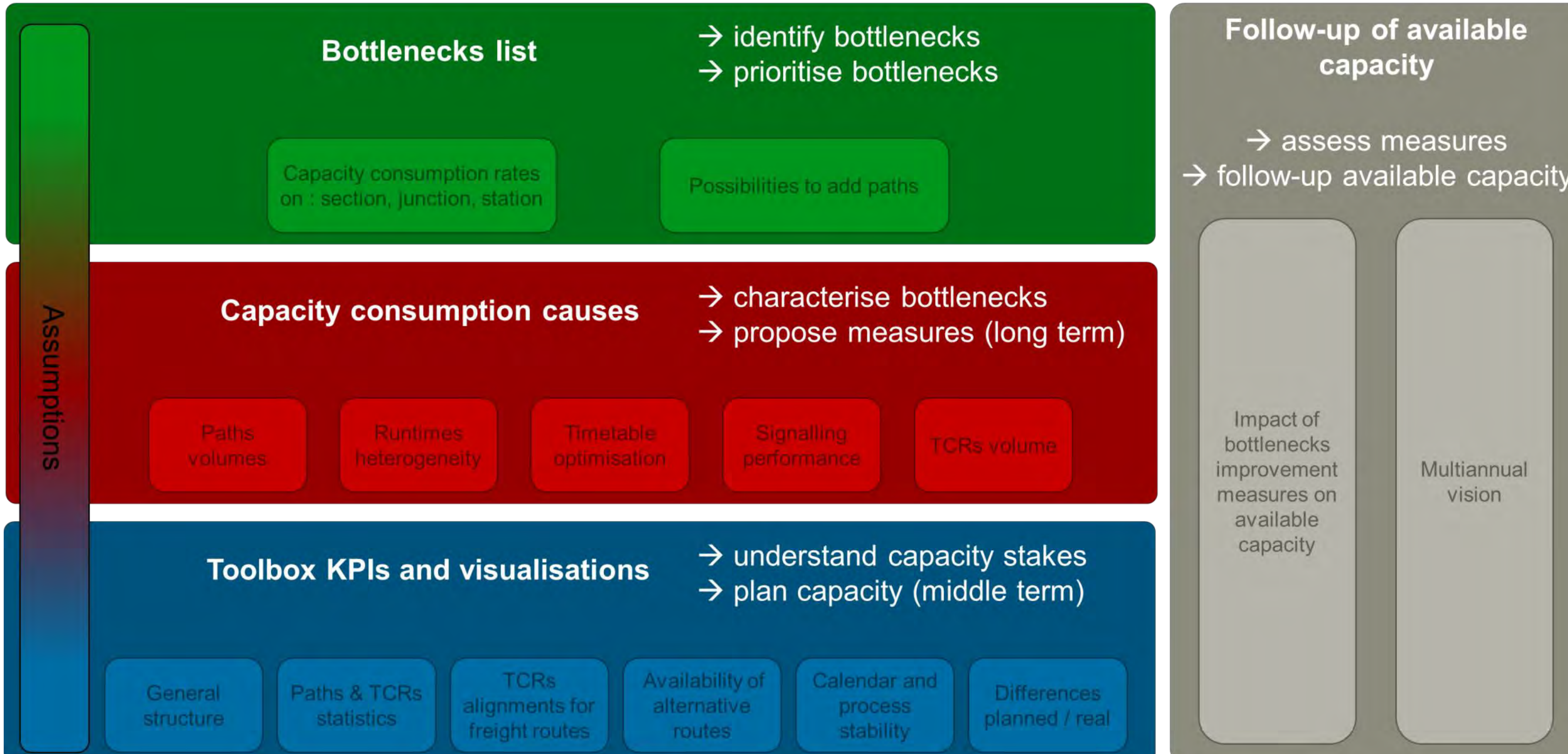
Usages of the capacity KPIs and visualisations

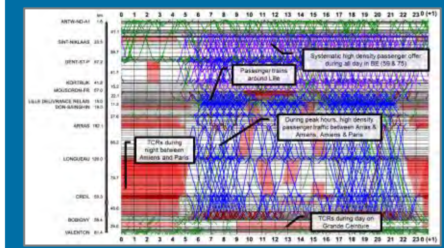
Past, planned, and projected capacity for paths & TCRs



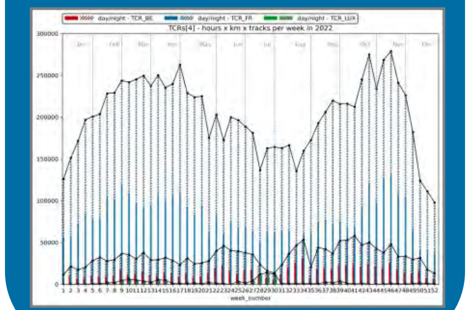
Overview of the proposed capacity KPIs

Available capacity at a given moment & diverse paths and TCRs statistics

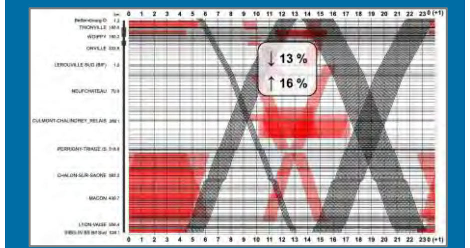
[1] General structure



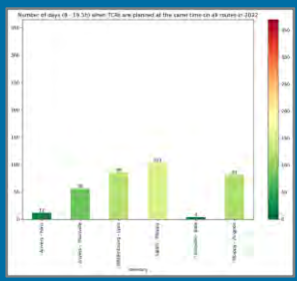
[2] TCR Statistics



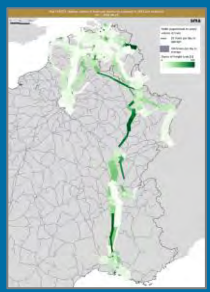
[3] Permeability of the TCRs structure



[4] TCR planning on alternative routes



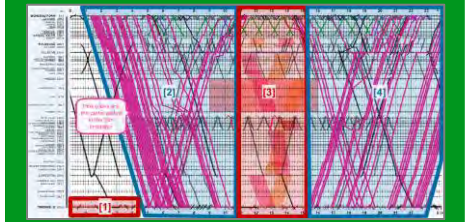
[5] Paths statistics



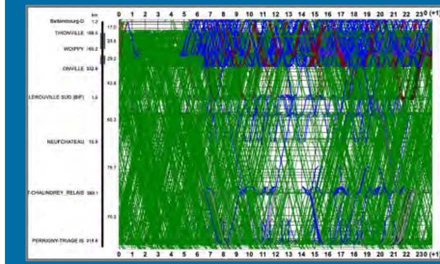
[6] Capacity consumption rate

[7] Analyses of capacity consumption

[8] Residual capacity



[9] Calendar and process stability



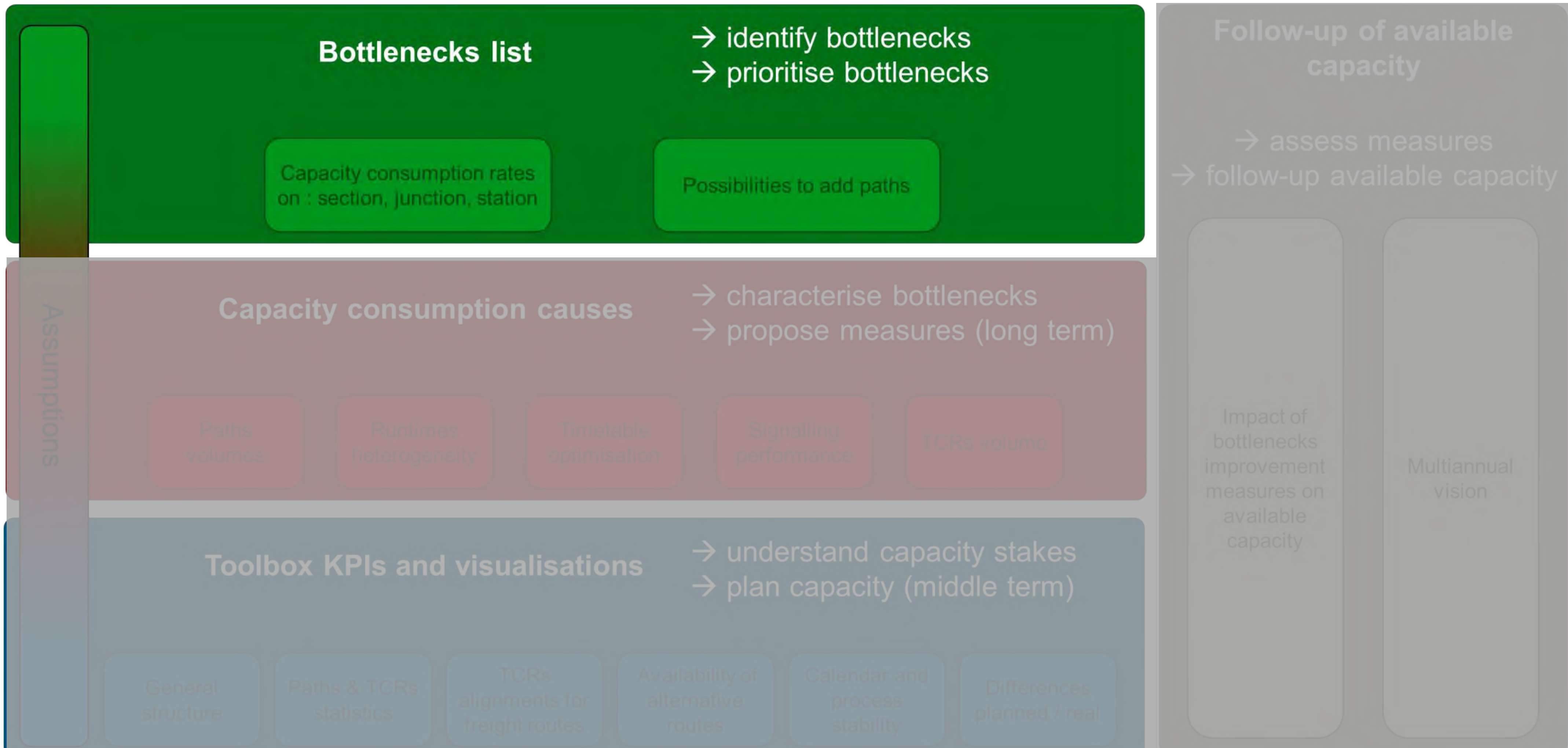
On the following pages, considered :

– Days are written in blue (ex : all year 2022 = all the 365 days of 2022 are analysed),

– Trains are all trains which run at least on 1 section of the perimeter, except if no empty runs, it's then specified

Usages of the capacity KPIs and visualisations

Past, planned, and projected capacity for paths & TCRs



Bottlenecks identification

What is a bottleneck ?

The study is about **capacity bottlenecks.**

Bottlenecks are defined in the study as :

- **Saturated elements of infrastructure** where a high part of the available capacity is used by paths and TCRs (A),
- **Congested routes** (origin, destination, runtime) where paths can't be added in the timetable, by any itinerary (B) ; on a **real or planned given timetable**, on defined infrastructure.

Notion of **delay** can be added if data is available (C).

For the needed or forecasted paths offers with **no timetable** (before timetable building and renunciations), level of potential difficulties can be calculated, on 2h, using all the possible paths orders (D).

A

Elements of infrastructure with compression rates over thresholds

B

Routes where adding paths is not possible, by any itinerary

C

Elements of infrastructure where delays linked to capacity happen

D

Level of potential difficulties **for elements of infrastructure** with compression rates ranges over thresholds

Bottlenecks identification

What is a bottleneck ?

Different **thresholds** can be used, depending on the number of analysed days :

- For compression rates : European regulation document thresholds, or here 24h, average peak-hour, maximum of 1h slices, etc.
- For routes : path search on 1 day, all days, 24h, etc.

		Planned			
Temporal scope	Past	Capacity Planning & Supply	Capacity Model	Capacity Strategy and/or upstream	Needed / forecasted
State of capacity planning & allocation	24h 365 days	24h 365 days	24h 1 day	2h	No timetable
Data	Trains TCRs Delays	Trains TCRs	Train TCRs	Trains	Needed - forecasted trains on 2h or 24h
Bottlenecks proposed definition	A B C	A B	A B		
Bottlenecks approaching notions				A B	D
What is calculated here	A B	A B			
What is not calculated here	C considered Lack of data	-	Not considered	Not considered Lack of data	Not considered Out of scope

Capacity planned on at least 24h x 1 day
→ **Relevance of bottleneck concept**

2h timetable capacity consumption rates can be calculated (≠ bottlenecks)

No timetable ranges of compression rates for all possible paths orders

[6] Capacity consumption rates

Some maps and analyses of the capacity consumption rates are in this chapter and others are available in the annexes and in the portfolio.

To calculate capacity consumption rates, the network is sliced into elementary sections. Rates are also calculated on junctions and stations. The slicing is critically important (see Assumptions chapter and annexes).

The capacity consumption rate calculated indicates the theoretical available capacity (= 1 – capacity consumed by the timetable).

This theoretical available capacity can be wasted by an under optimisation of the timetable (see next chapter [7] “level of optimisation”).

This theoretical available capacity per sections, junctions, and stations is very different from the usable capacity to add paths or TCRs. To be usable to add a path, the theoretical available capacity per sections, junctions and stations have to match together.

The capacity consumption rates calculated here are interesting KPIs, as they enlighten real bottlenecks, but they must be considered with caution, as they don't reflect the usable capacity.

AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[6] Capacity consumption rates

Sections – average compression rates

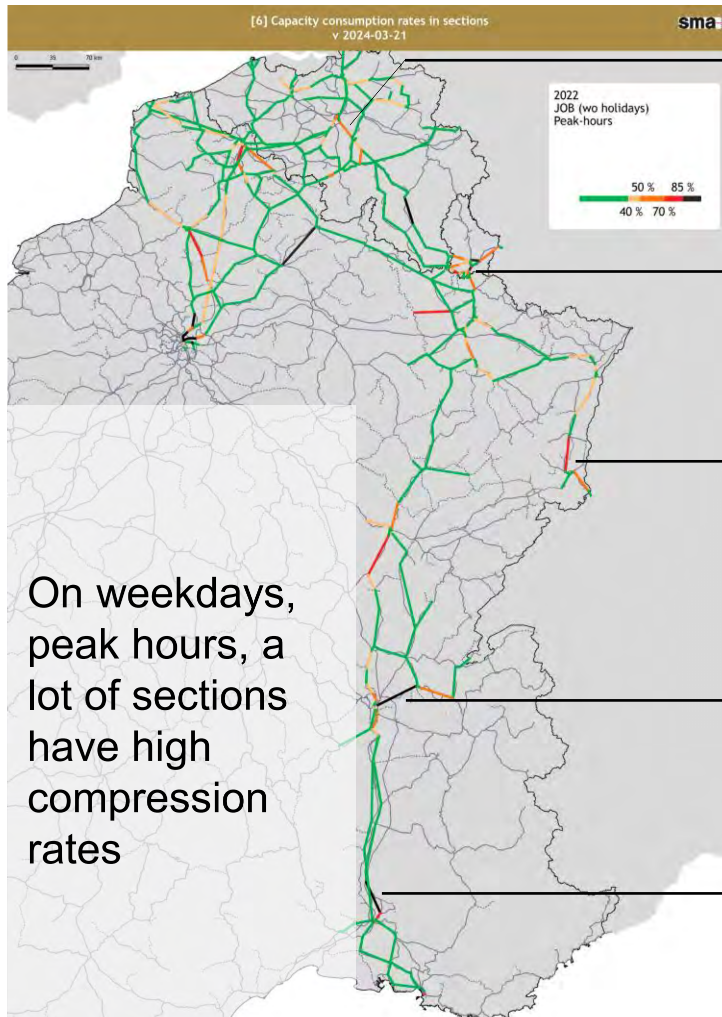
Compression for weekdays, peak-hours

No empty runs

With TCRs

All year 2022

Other maps are available in annexes and portfolio : zooms, off-peak analyses, week-ends, night, etc.



Bruxelles – Ottignies

BE/FR – Luxembourg / Bettembourg

Colmar Mulhouse

Lyon – Ambérieu

This black section seems to be related to a train import problem

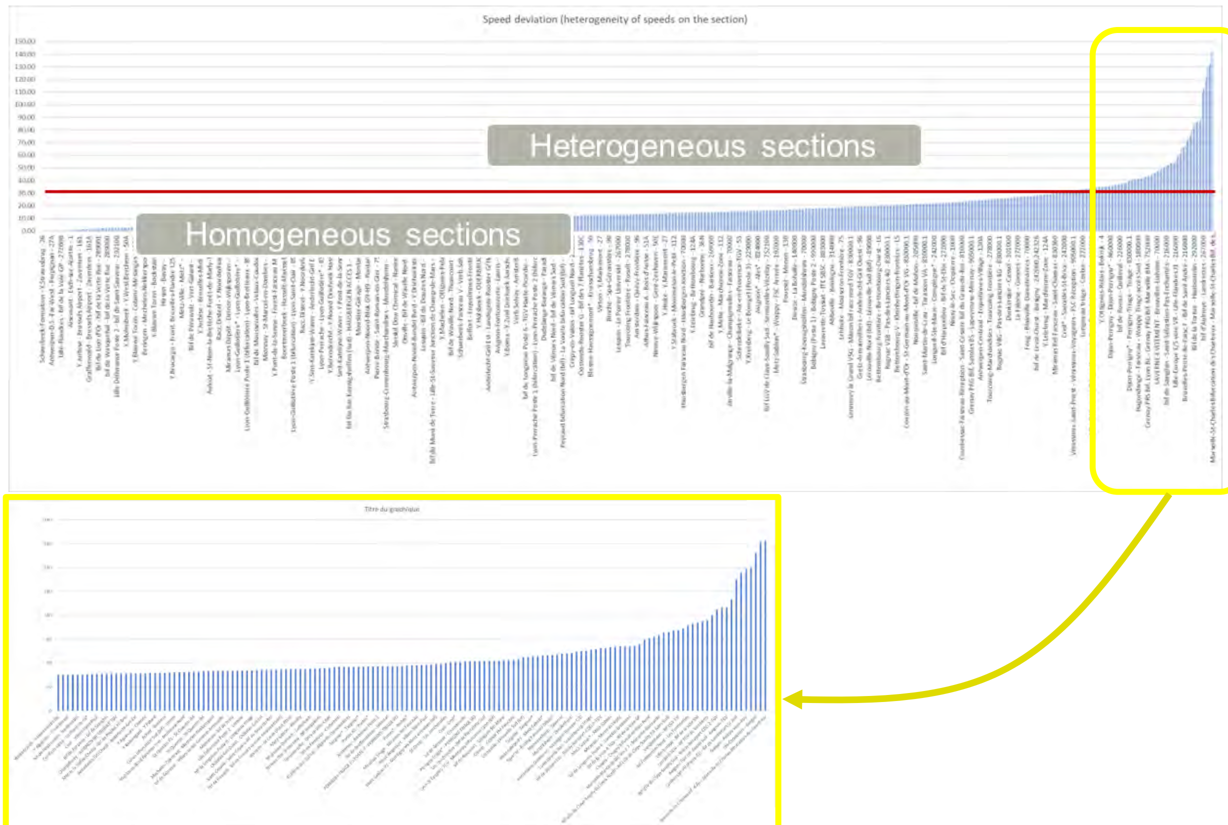
[6] Capacity consumption rates

Sections – example of calculations for European criteria

Thresholds of the European new regulation document

All year 2022

We propose to consider a "heterogeneity KPI" (included in [7])



[6] Capacity consumption rates

Sections – example of calculations for European criteria

Thresholds of the European new regulation document

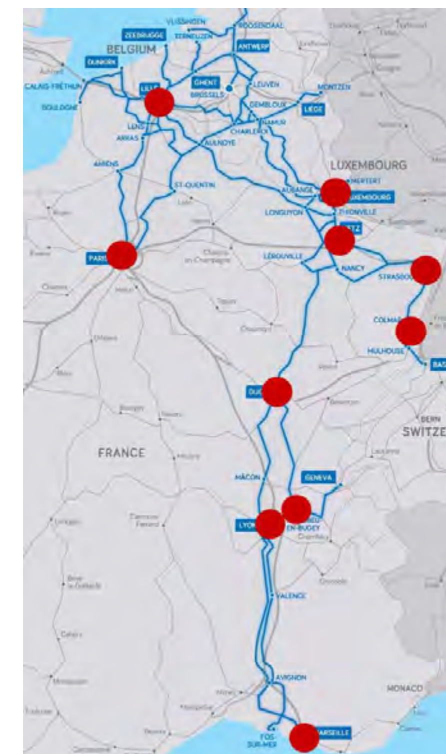
All year 2022

⚠ the compression method used here (see assumption chapter) may match with the European method

⚠ the timetables used are pre-operational, some requests may already have been refused during the previous capacity planning/allocation phases

Section type	Classification	Capacity utilisation	Criteria	Number of sections
Heterogeneous traffic	Highly utilised	> 65% of theoretical capacity	> 4h / day, > 7 days / 10*	25
Heterogeneous traffic	Congested	> 95% of theoretical capacity	> 4h / day, > 9 days / 10*	9
Homogeneous traffic	Highly utilised	> 80% of theoretical capacity	> 4h / day, > 7 days / 10*	25
Homogeneous traffic	Congested	> 95% of theoretical capacity	> 4h / day, > 9 days / 10*	15

* As we do not run this analysis on 365 days, but on a sample of 14 week days, the criteria > 200 or 250 days / year becomes 7 or 9 days /14 analysed days.



[6] Capacity consumption rates

Junctions – average compression rates

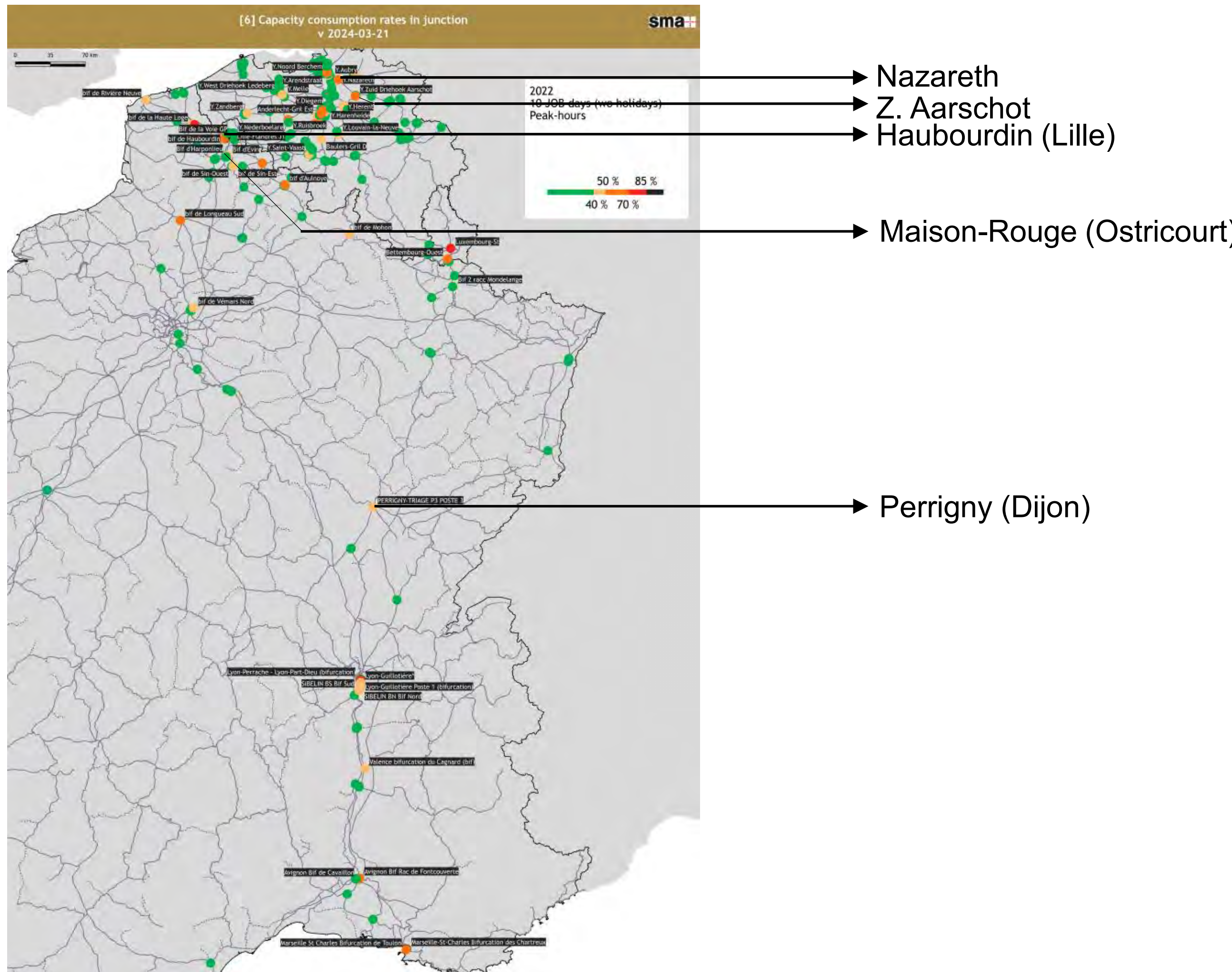
No empty runs

No TCRs

10 days in 2022

In FR we can see here that a lot of junctions are not represented : they were not modelled in the infrastructure database provided by the IM.

Other maps are available in annexes and portfolio : zooms, off-peak analyses, week-ends, night, etc.



[6] Capacity consumption rates

Stations

Some days in 2022 for LUX & BE (depending on which track occupation plans were sent), and all days 2025 for FR (available in data).

Compression is possible in stations, using different methods, for example UIC 406. Viriato can provide a station compression rate, global and per track, but can't provide any switches zone analysis.

To realise a compression which might be a correct measure of the available capacity in stations, some data is necessary :

At least (if only station tracks are analysed) :

- Track assignment,
- Relations between arrivals and departures (rolling stock planning).

To go further (switches areas, complete vision of the available capacity) :

- Itineraries (switches) between line track and station track,
- Technical paths (from and to refuelling zones, maintenance zones, etc.).

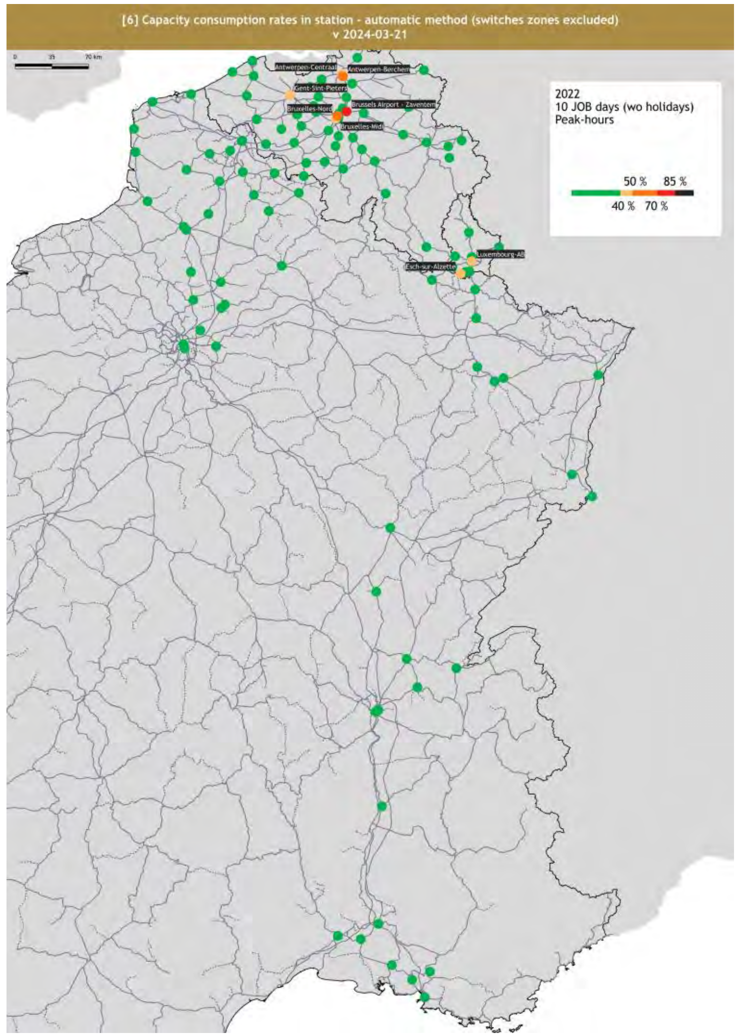
As these data was not available in our database (see Database constitution deliverable), we proposed to choose some stations, and work manually with UIC 406 method, based on the real track assignment plans.

[6] Capacity consumption rates

Stations

All year 2022

Viriato can provide a station compression rate (see opposite), global and per track, but can’t provide any switches zone analysis.



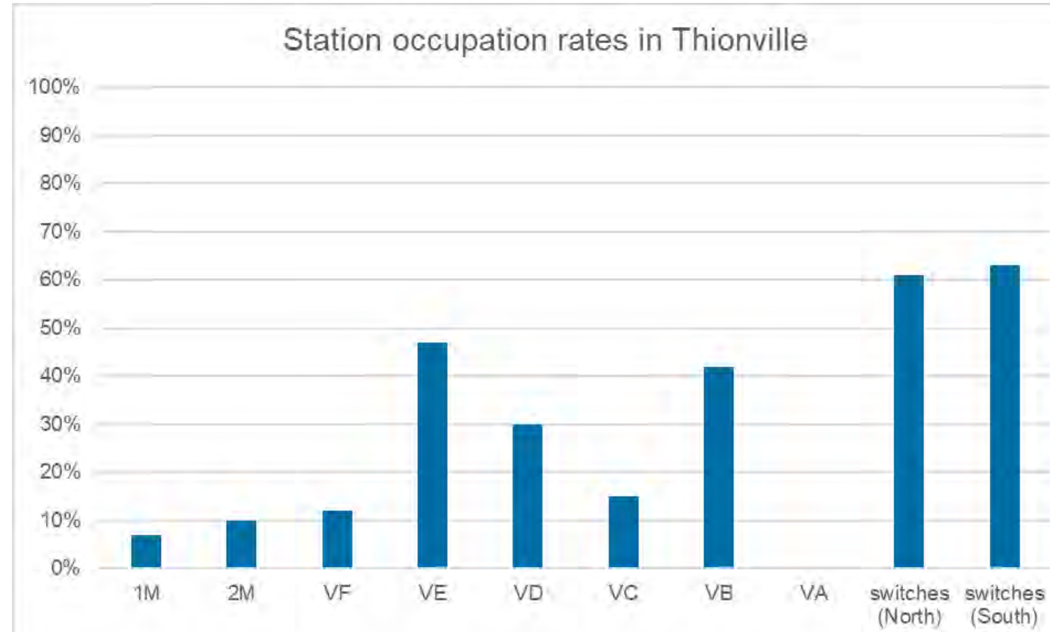
Data provided by IMs and imported in the database no sufficient for this kind of automatic analyses.

[6] Capacity consumption rates

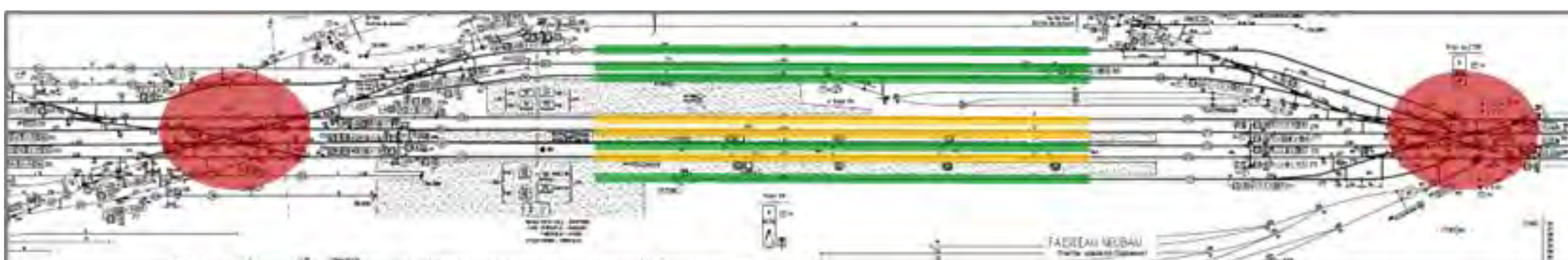
Stations - Example of Thionville

Station track section and switches areas

(systematic timetable PER)



Detailed methodology and analyses of other stations are available in annexes : Hazebrouck, Luxemburg, Gent, Namur, Leuven



[8] Residual capacity

Added paths are *not linked to any path requests*, they are used to evaluate the level of saturation of a route.

The residual capacity KPI is necessary together with the compression rates. It adds a vision of the usable residual capacity. Taken separately, a succession of sections, junctions, stations can be not saturated, but taken end-to-end, it can be difficult to built a performant path.

Here the method is to work on a 24h timetable (if taken from a 24h x 365 days planned timetable, a day has to be chosen).

It's possible to consider the current planned freight paths or not, depending on the aim (evaluate diversions possibilities → with current freight paths ; evaluate the level of saturation of a route → without current freight paths).

The main assumptions are the chosen paths and the additional runtime.

According to the input, whereas track occupation plans are correct or not, the capacity in station will be considered or not.

This KPI can be calculated on 1 itinerary of a route, or all the alternative itineraries of a route.

AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

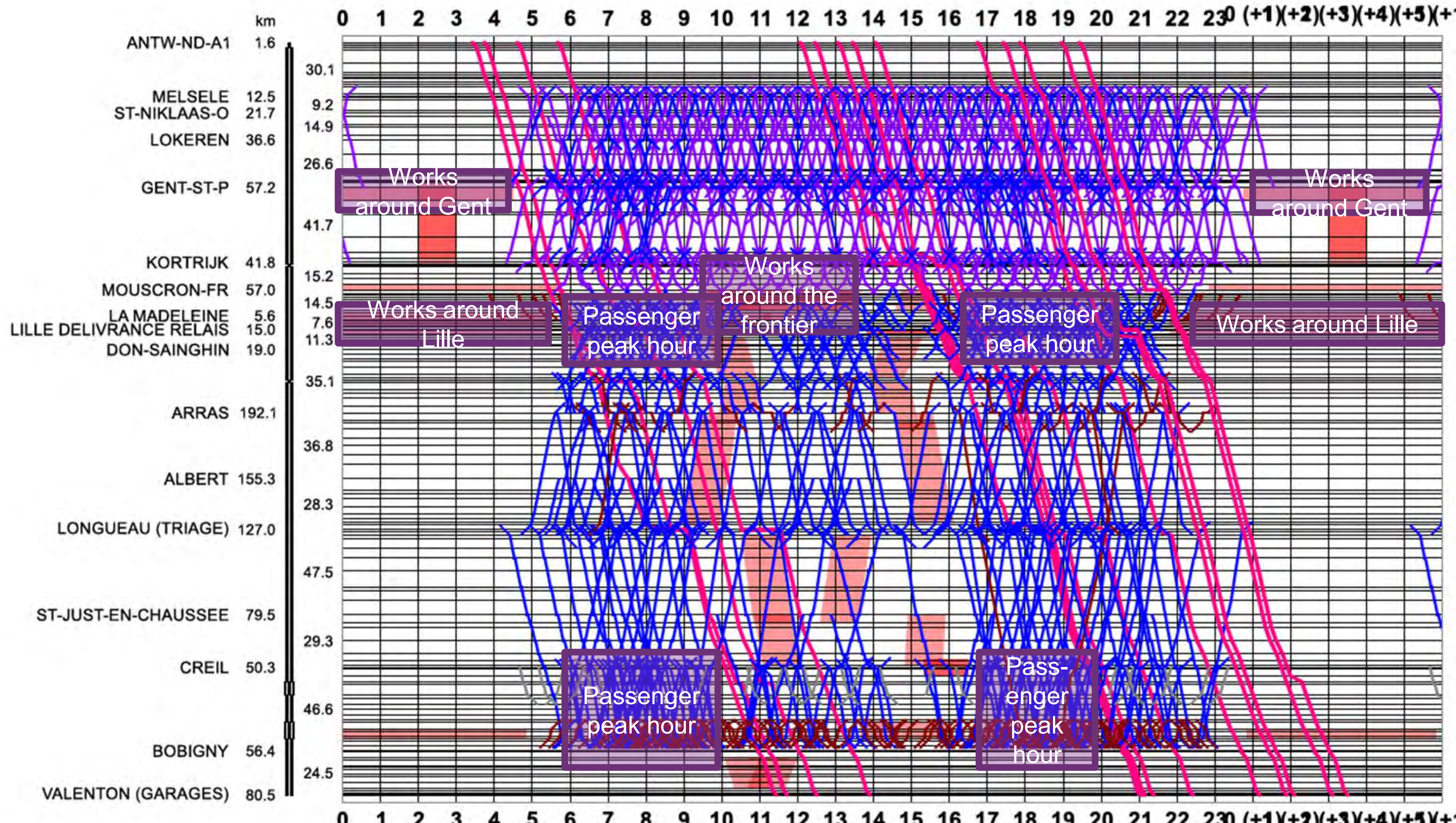
[8] Residual capacity

1 day in 2022

Here is an example of Anvers – Valenton, where usable residual capacity is 14 paths.

Main assumptions : potential increase of runtime = 50% (/ model path which is a real path).

No freight trains.



CORRIDOR NORTH SEA – MEDITERRANEAN

AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

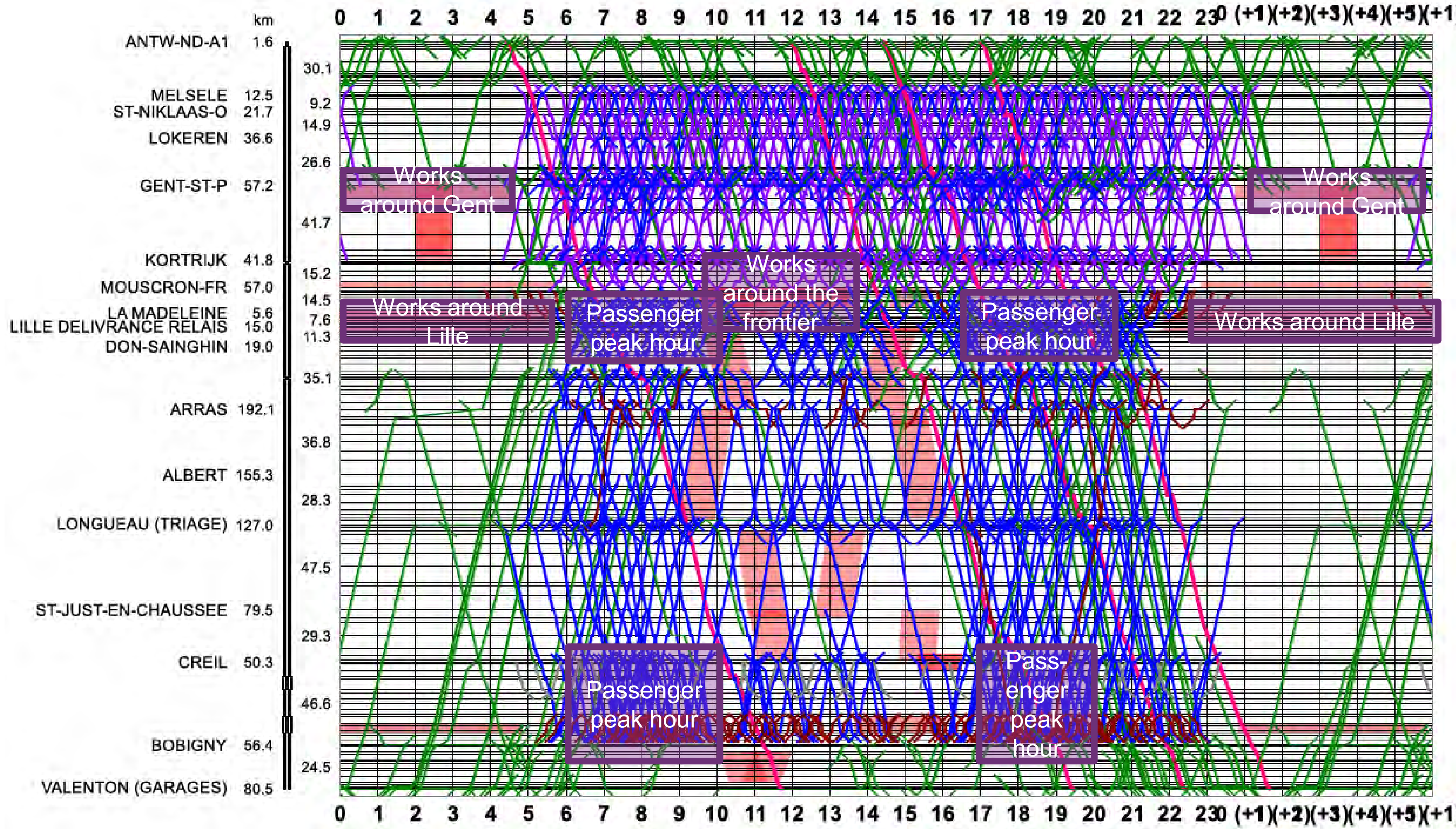
[8] Residual capacity

1 day in 2022

Here is an example of Anvers – Valenton, where usable residual capacity is 4 paths.

Main assumptions : potential increase of runtime = 50% (/ model path which is a real path).

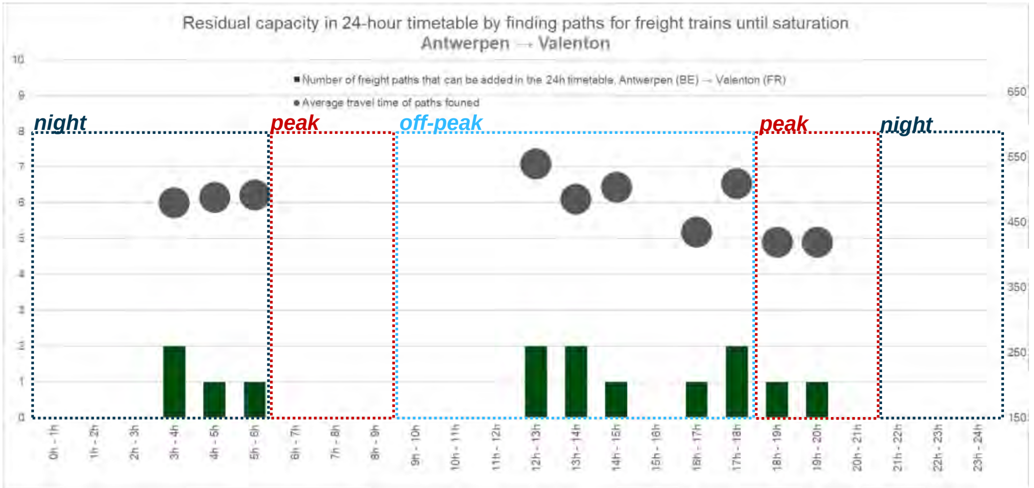
With freight trains.

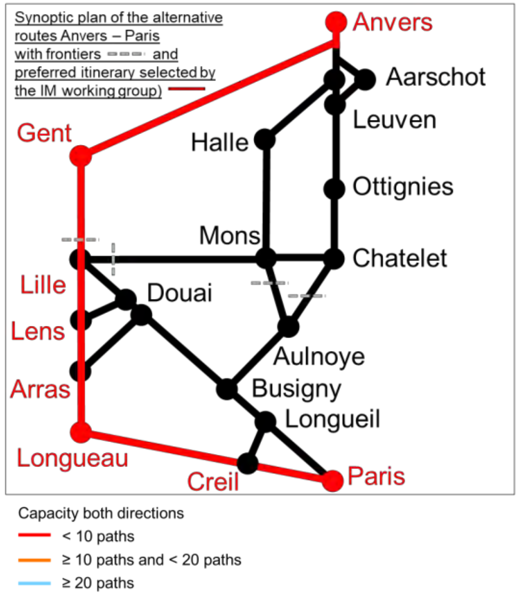


AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[8] Residual capacity

1 day : 17.03.2022





AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

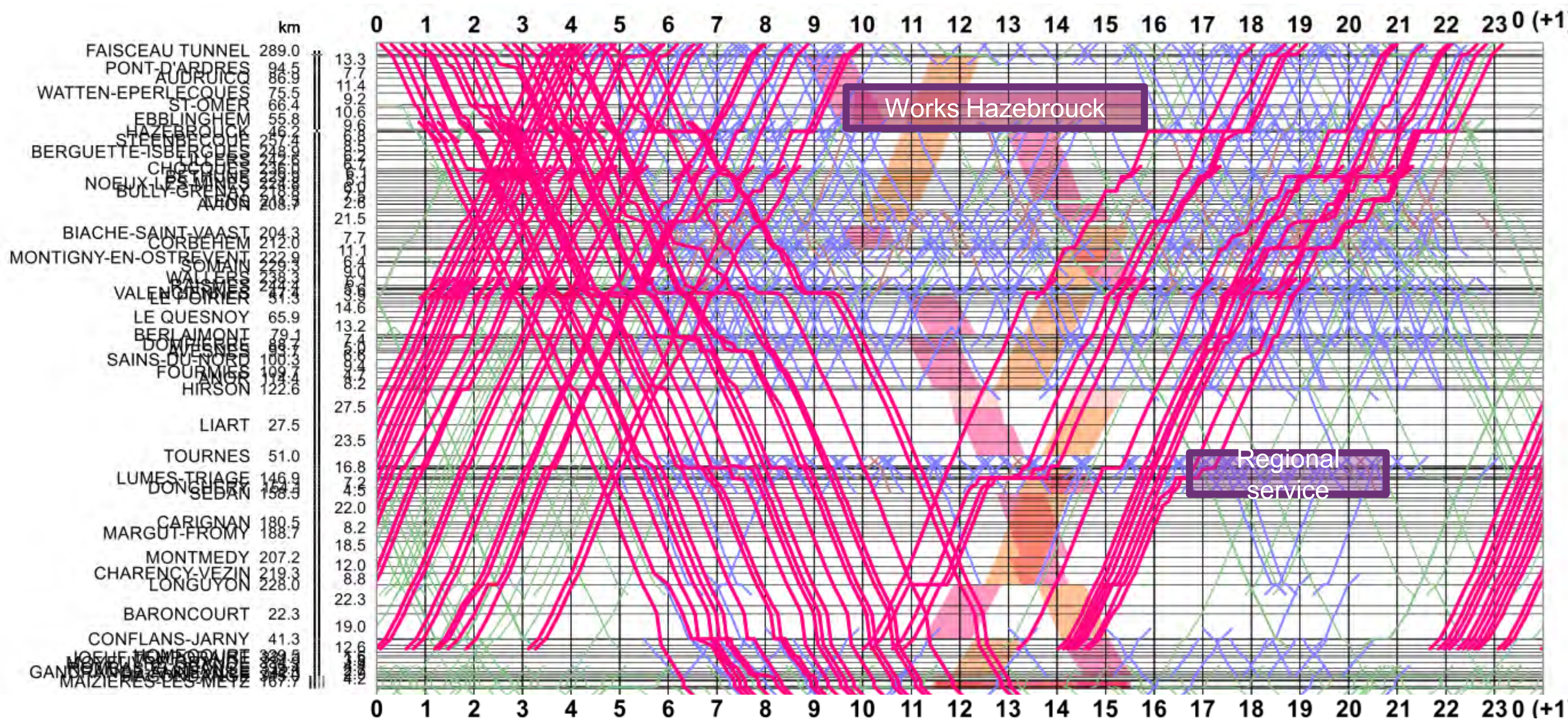
[8] Residual capacity

1 day in 2022

Woippy – Calais through Arras, where usable residual capacity is 31 paths towards Calais and 21 towards Woippy.

Main assumptions : potential increase of runtime = 50% (/ model path which is a real path).

With freight trains.



AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

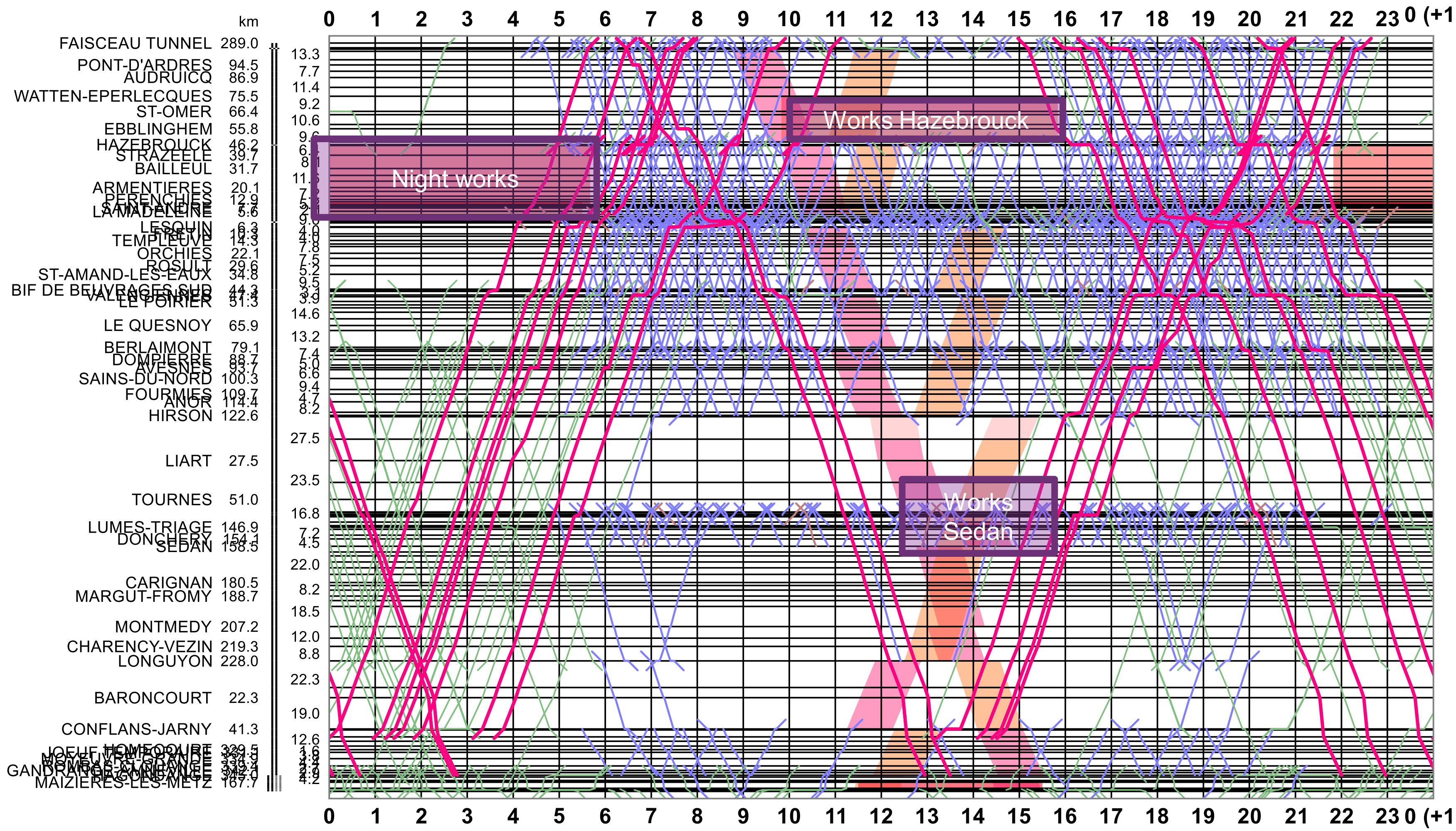
[8] Residual capacity

1 day in 2022

Woippy – Calais through Lille, where usable residual capacity is 9 paths towards Calais and 8 towards Woippy.

Main assumptions : potential increase of runtime = 50% (/ model path which is a real path).

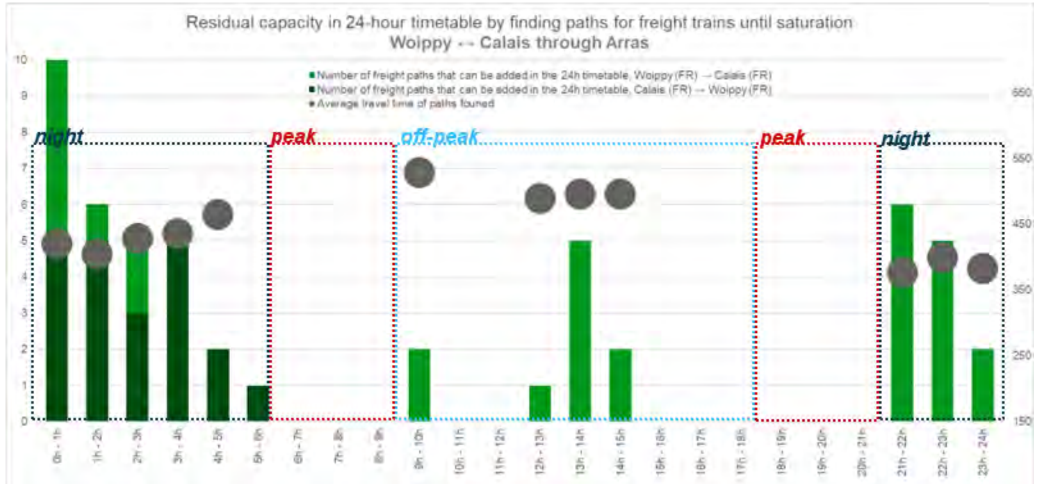
With freight trains.

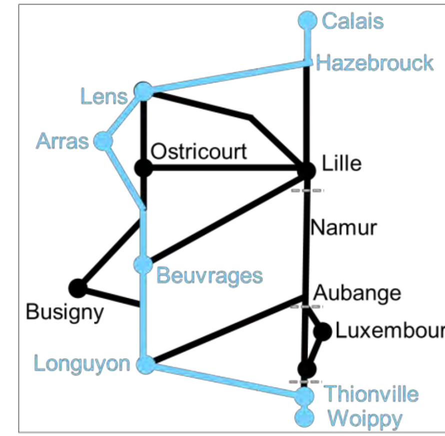


AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

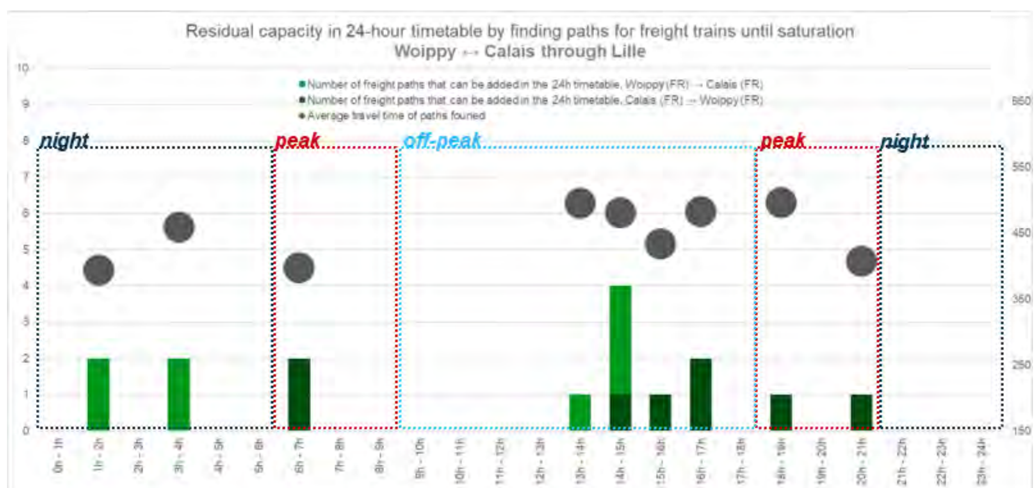
[8] Residual capacity

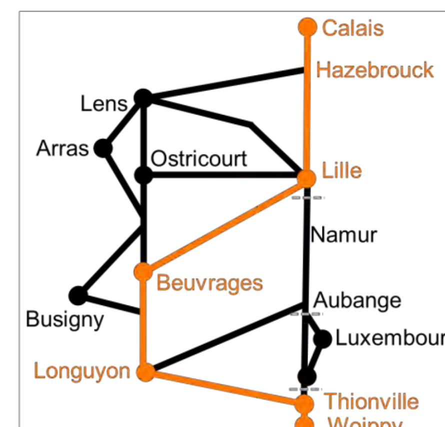
1 day : 17.03.2022





Capacity both directions
- < 10 paths
- ≥ 10 paths and < 20 paths
- ≥ 20 paths





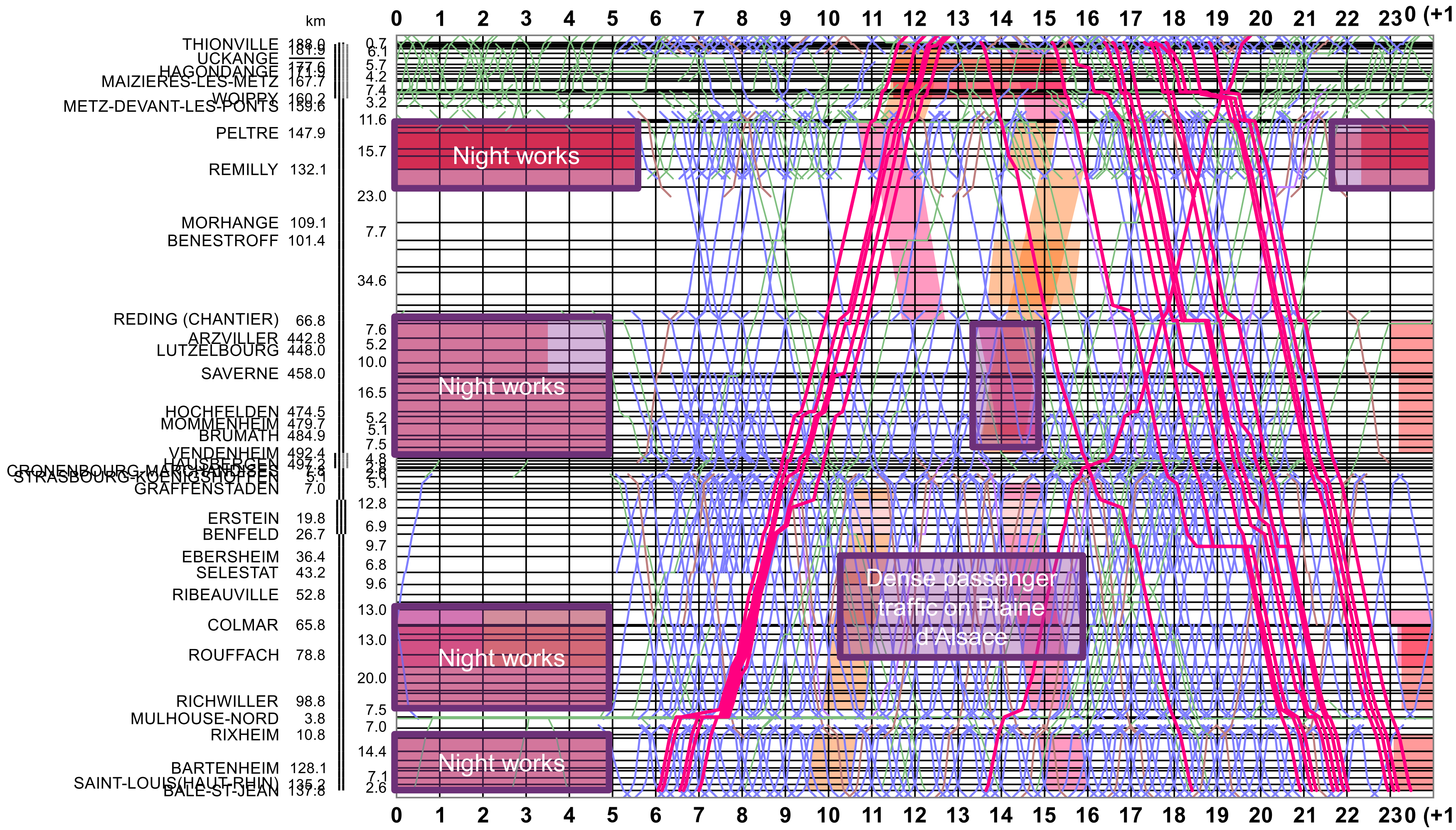
[8] Residual capacity

1 day in 2022

Thionville – Basel, North itinerary (Remilly), where usable residual capacity is 12 paths towards Basel and 6 towards Thionville.

Main assumptions : potential increase of runtime = 50% (/ model path which is a real path).

With freight trains.



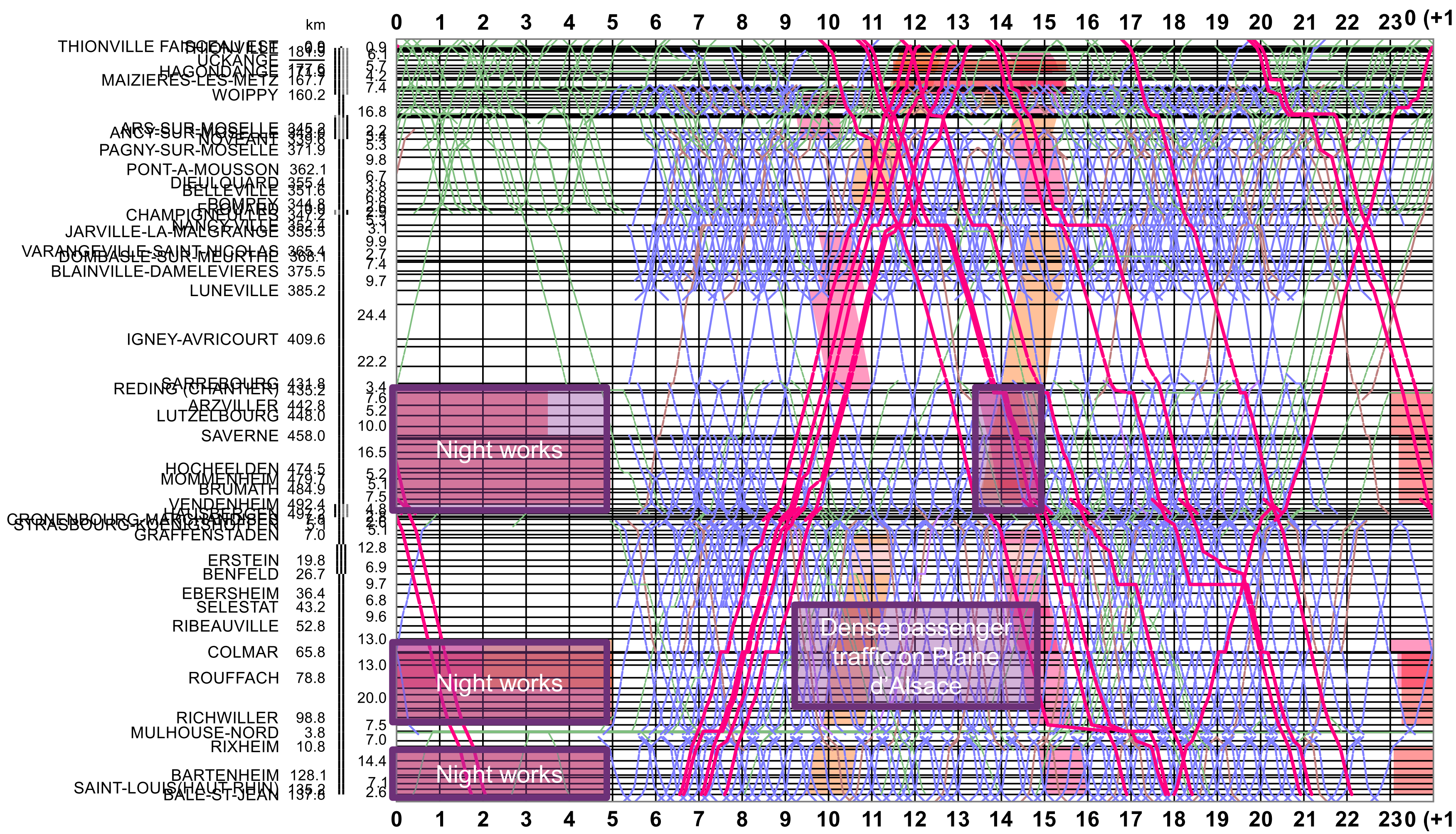
[8] Residual capacity

1 day in 2022

Thionville – Basel, South itinerary (Nancy), where usable residual capacity is 4 paths towards Basel and 6 towards Thionville.

Main assumptions : potential increase of runtime = 50% (/ model path which is a real path).

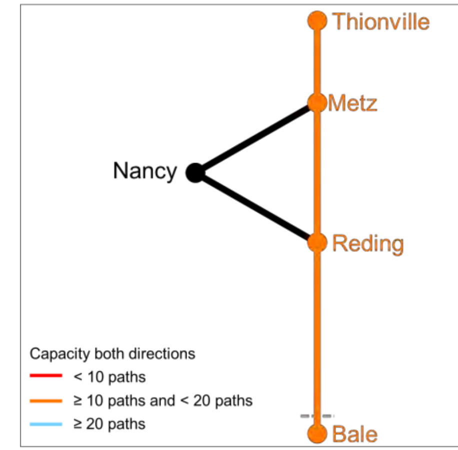
With freight trains.

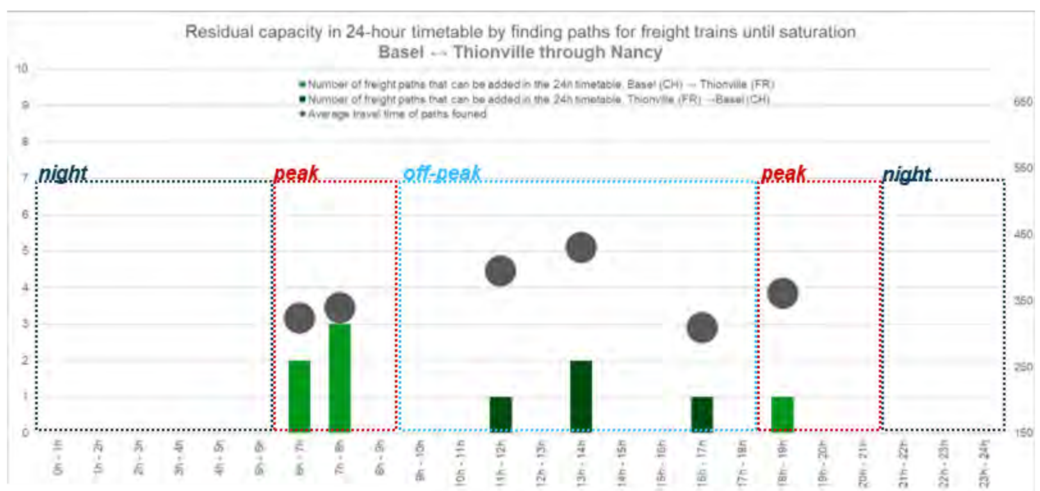


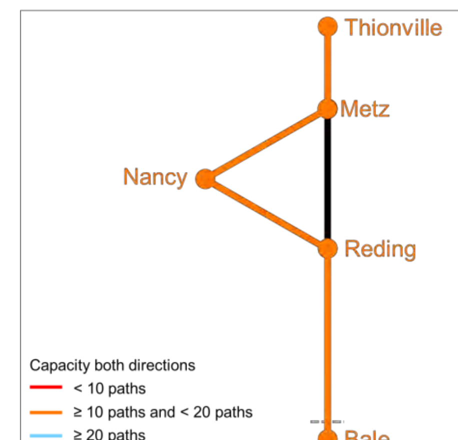
AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[8] Residual capacity

1 day : 17.03.2022







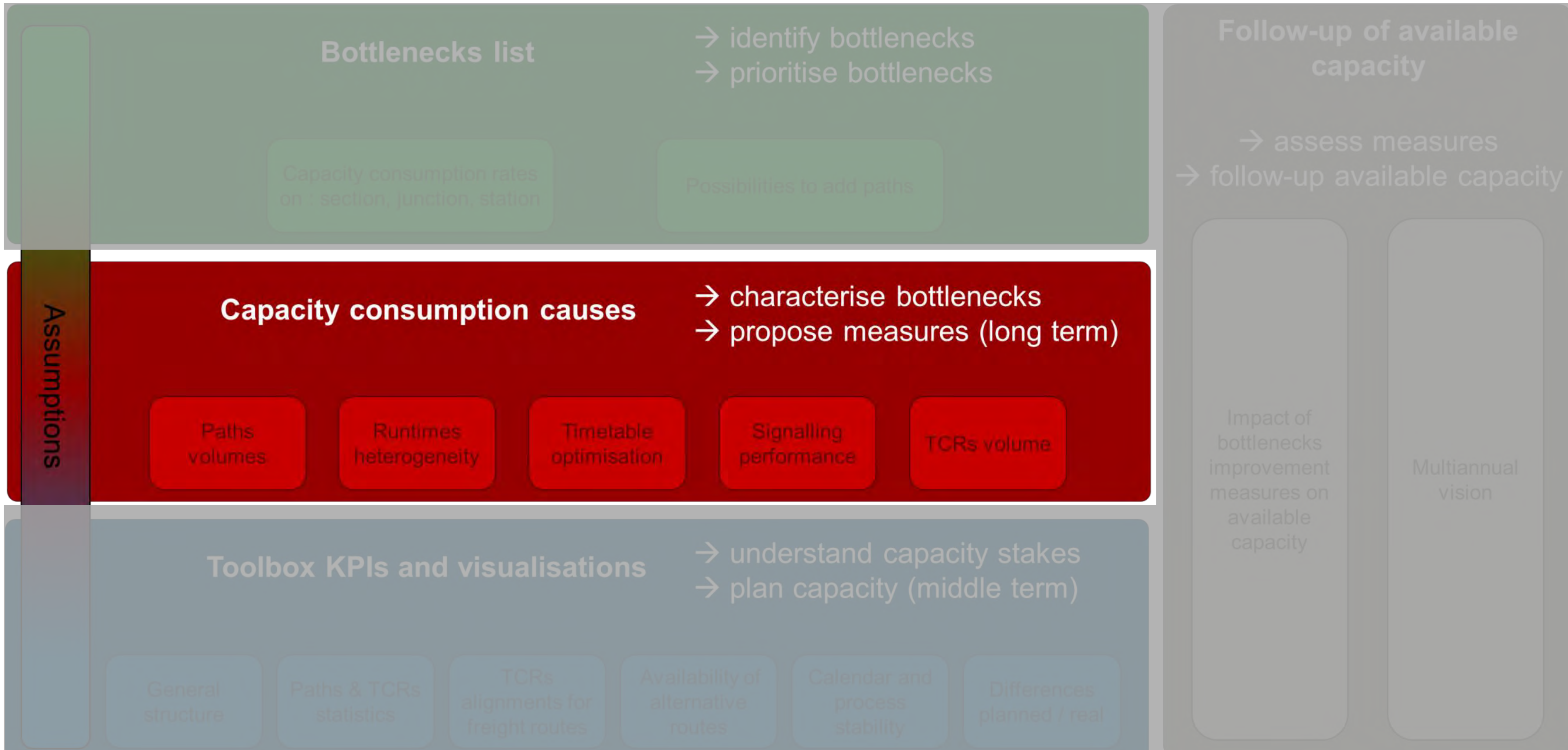
[8] Residual capacity

The usable residual capacity KPI can be used :

- To assess the residual capacity of a 2h systematic timetable :
  - For example, the timetable is structured based on RUs requests/forecasts, but IM wants to keep capacity for other paths which could be asked latest (freight market can be unstable)
  - For example, the timetable is planned on a 2h systematic way, but IM wants to keep capacity to add peak hour trains downstream in the process, in a 24h timetable
- To assess the level of optimisation of a timetable
- To assess the need of re-structure the timetable to answer a request (before the annual path requests X-8.5) in a non-discriminatory way
- To answer a last minute request (after the annual path requests X-8.5)
- To assess the possibility of traffic deviations

Usages of the capacity KPIs and visualisations

Past, planned, and projected capacity for paths & TCRs



[7] Analysis of capacity consumption

Traffic volumes

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

Volume of traffic

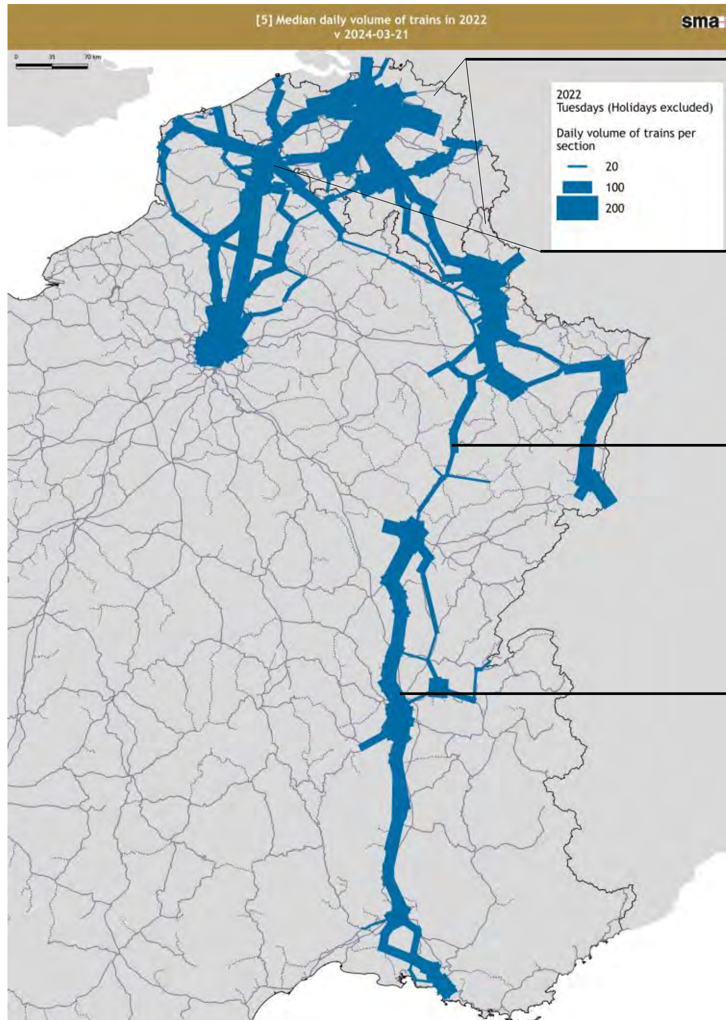
Signalling performance

Runtimes heterogeneity

Level of timetable optimisation

TCRs

All year 2022



Global higher traffic volumes in Belgium and Luxembourg than in France, partly related to the study perimeter, which includes some low population density French areas

High traffic volume around Lille

Low traffic volume on Toul – Dijon

High traffic volume around Lyon

[7] Analysis of capacity consumption

Signalling performance

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

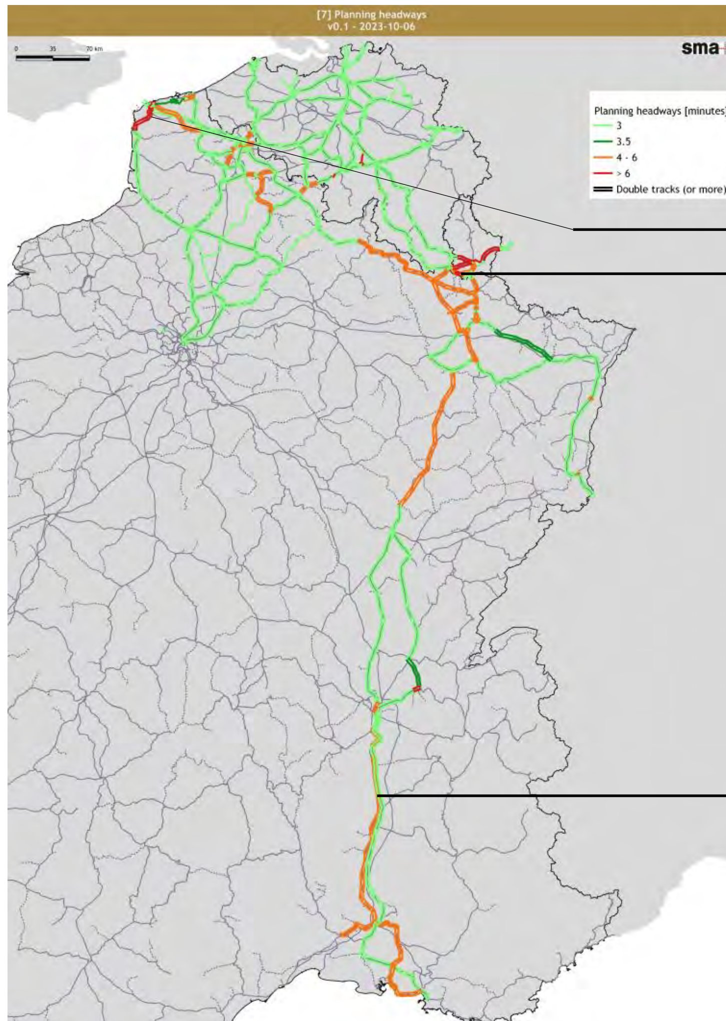
Volume of traffic

Signalling performance

Runtimes heterogeneity

Level of timetable optimisation

TCRs



BAPR Calais – Boulogne

L6f with low signalling performance

Headways 3’ on Rive gauche and 4’ on Rive droite du Rhône

[7] Analysis of capacity consumption

Runtime dispersion between trains

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

Volume of traffic

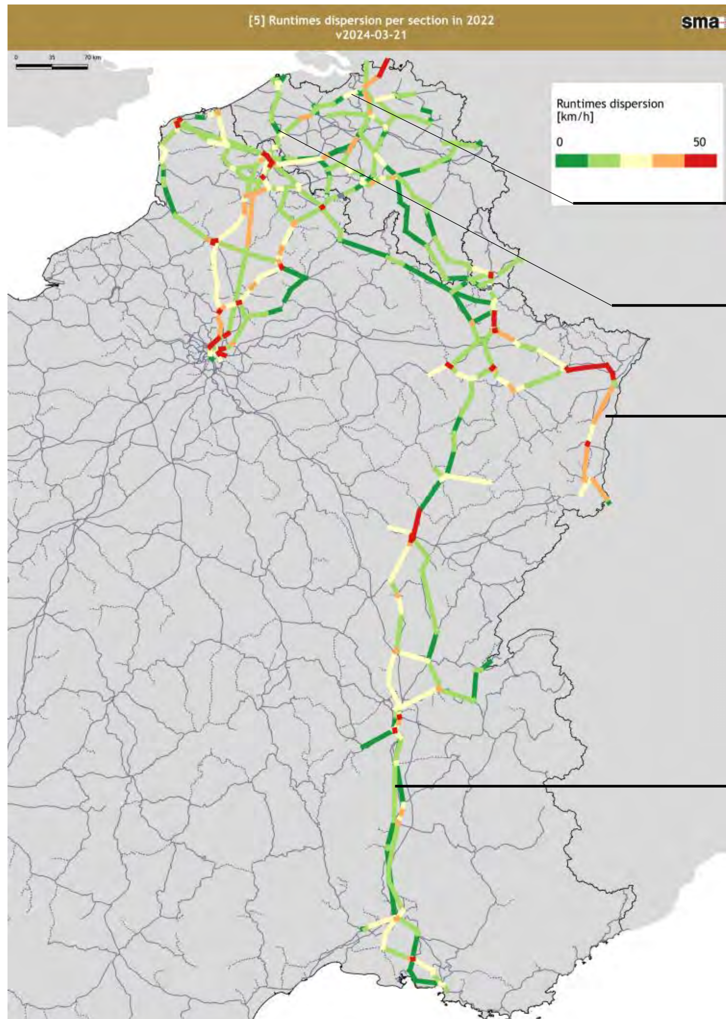
Signalling performance

Runtime heterogeneity

Level of timetable optimisation

TCRs

All year 2022



Heterogeneity on the line 59 on St-Niklaas – Antwerpen, with freight trains, S and IC trains

Homogeneity on Lichtervelde – Kortrijk on the line 66, with few freight trains, and mostly IC trains

Highly heterogeneous “Plaine d’Alsace”

Homogeneous “rive droite du Rhône” (almost only freight trains)

[7] Analysis of capacity consumption

Level of optimisation : paths order

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

Volume of traffic

Signalling performance

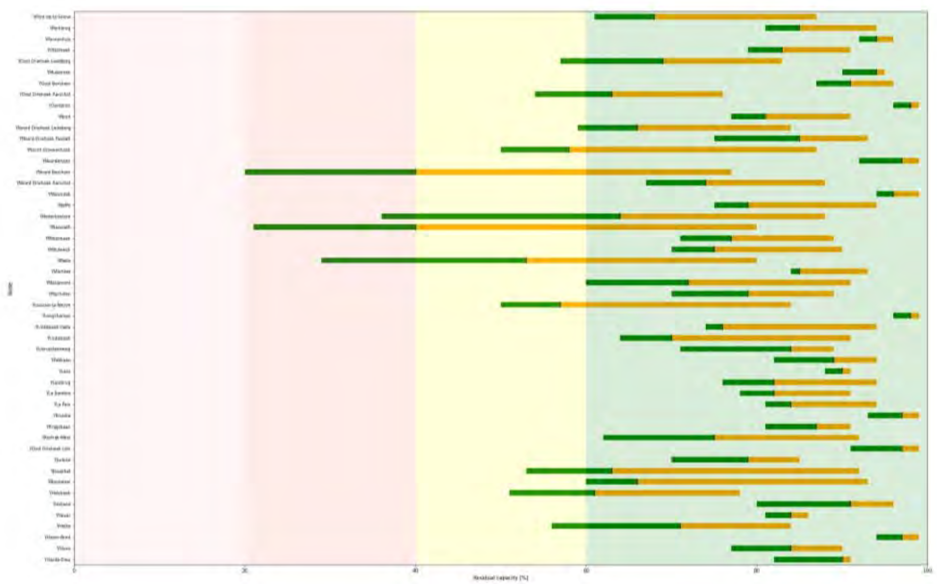
Runtimes heterogeneity

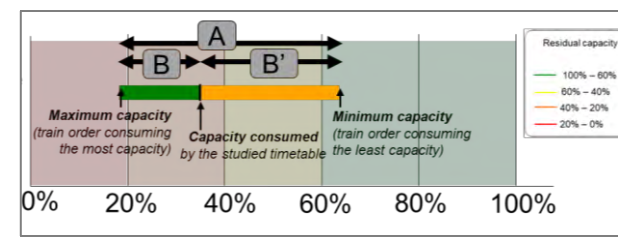
Level of timetable optimisation

TCRs

10 days in 2022

- This representation is based on the automatic timetable compression, considering all the orders of trains possible (permutation analysis), and is available for sections and junctions,
- Position of A represents the **range of residual capacity**, considering the number and paths of trains and the infrastructure's characteristics,
- Length of A represents the width of this range caused by the **heterogeneity of paths** (runtimes, intermediary stops) on sections, and by potential of **different sequences** on junctions,
- Relative lengths of B and B' represents the current state of capacity consumption on this section or junction, as well as the theoretical **optimisation potential** by reordering the timetable.





Extract of the analysis for some junctions of the perimeter, on 10 days, all day (24h)
Detail of the sections and junctions are available in the portfolio

[7] Analysis of capacity consumption

Level of optimisation : paths order

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

Volume of traffic

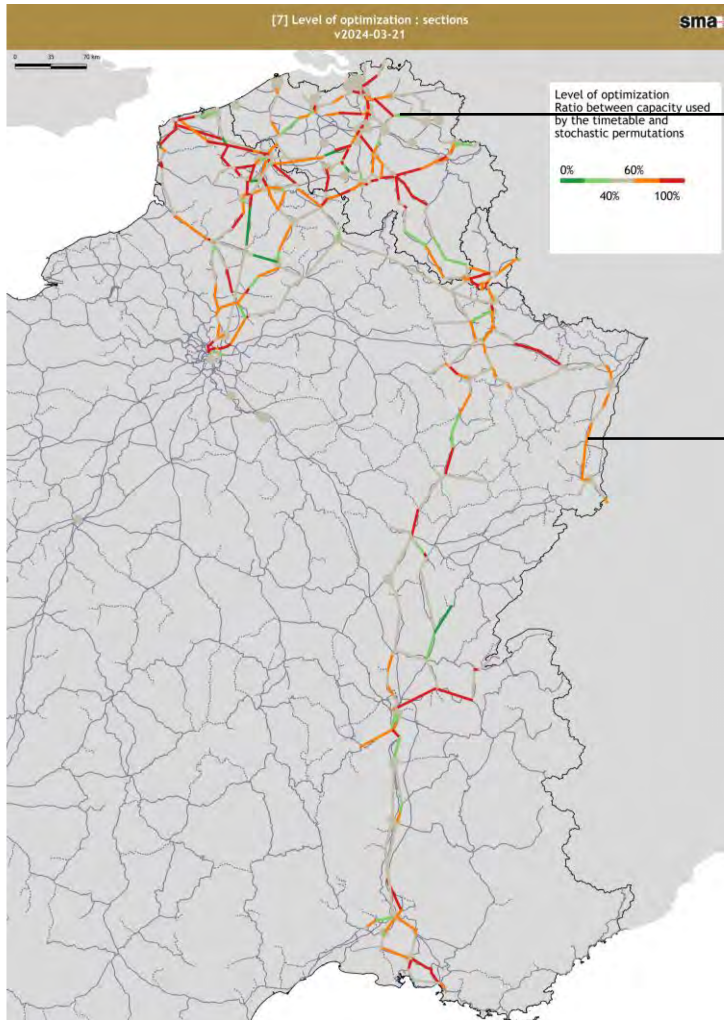
Signalling performance

Runtimes heterogeneity

Level of timetable optimisation

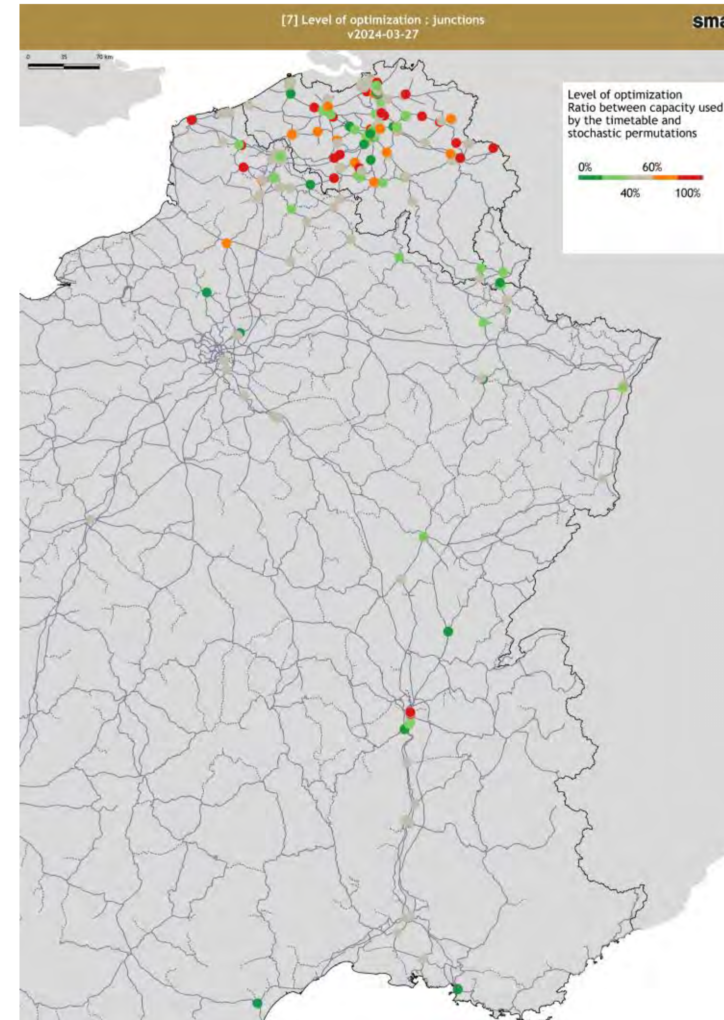
TCRs

10 days in 2022



Aarschot – Hasselt : good optimisation level

Plaine d'Alsace low level of optimisation (commercial constraints)



[7] Analysis of capacity consumption

Level of optimisation : timetable

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

Volume of traffic

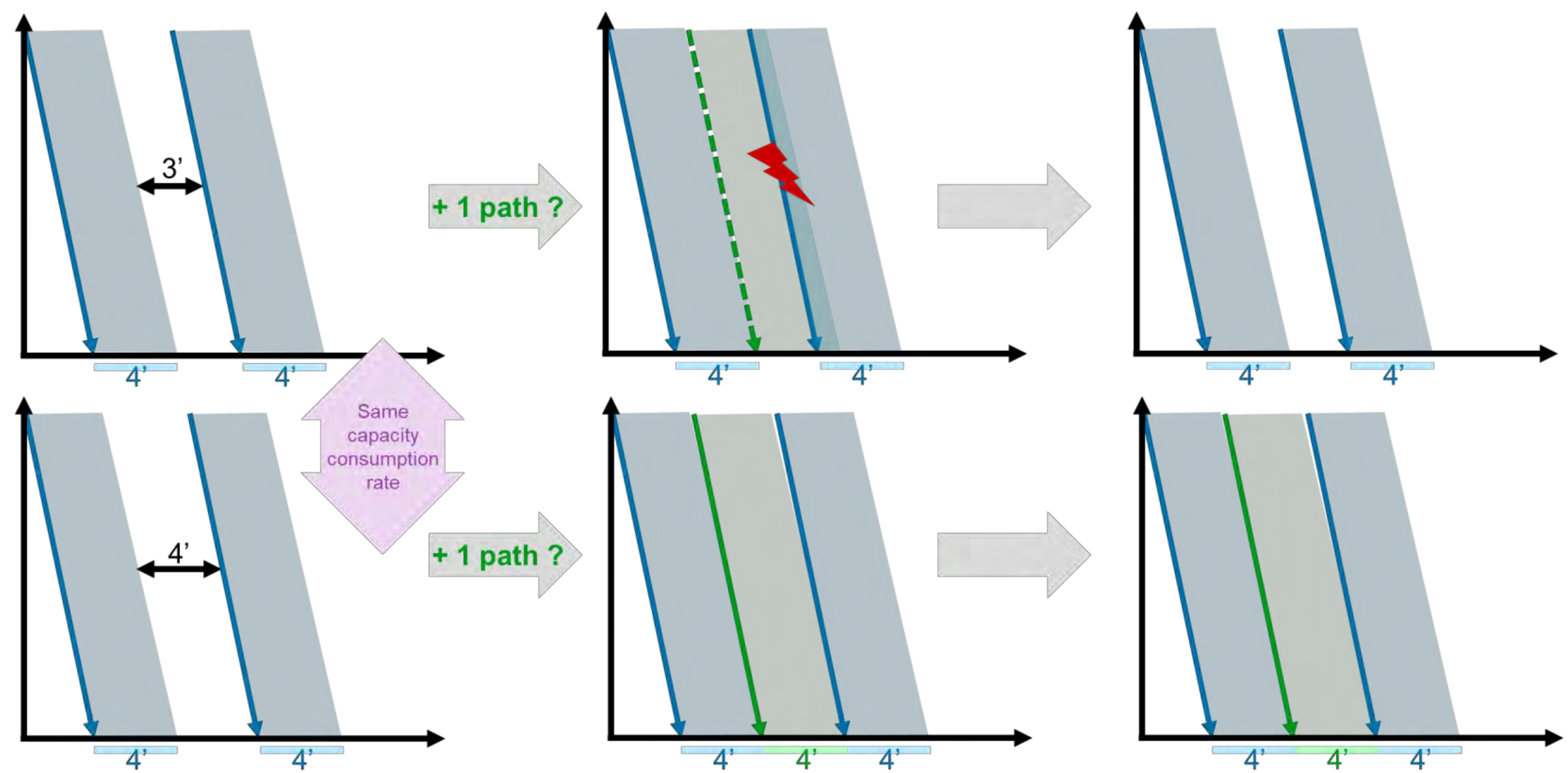
Signalling performance

Runtimes heterogeneity

Level of timetable optimisation

TCRs

10 days in 2022



→ Difference between timetable compression which can show a artificially free capacity, and path search, where real paths have to be found, and where the “wasted” capacity can’t be used.

[7] Analysis of capacity consumption

Level of optimisation : timetable

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

Volume of traffic

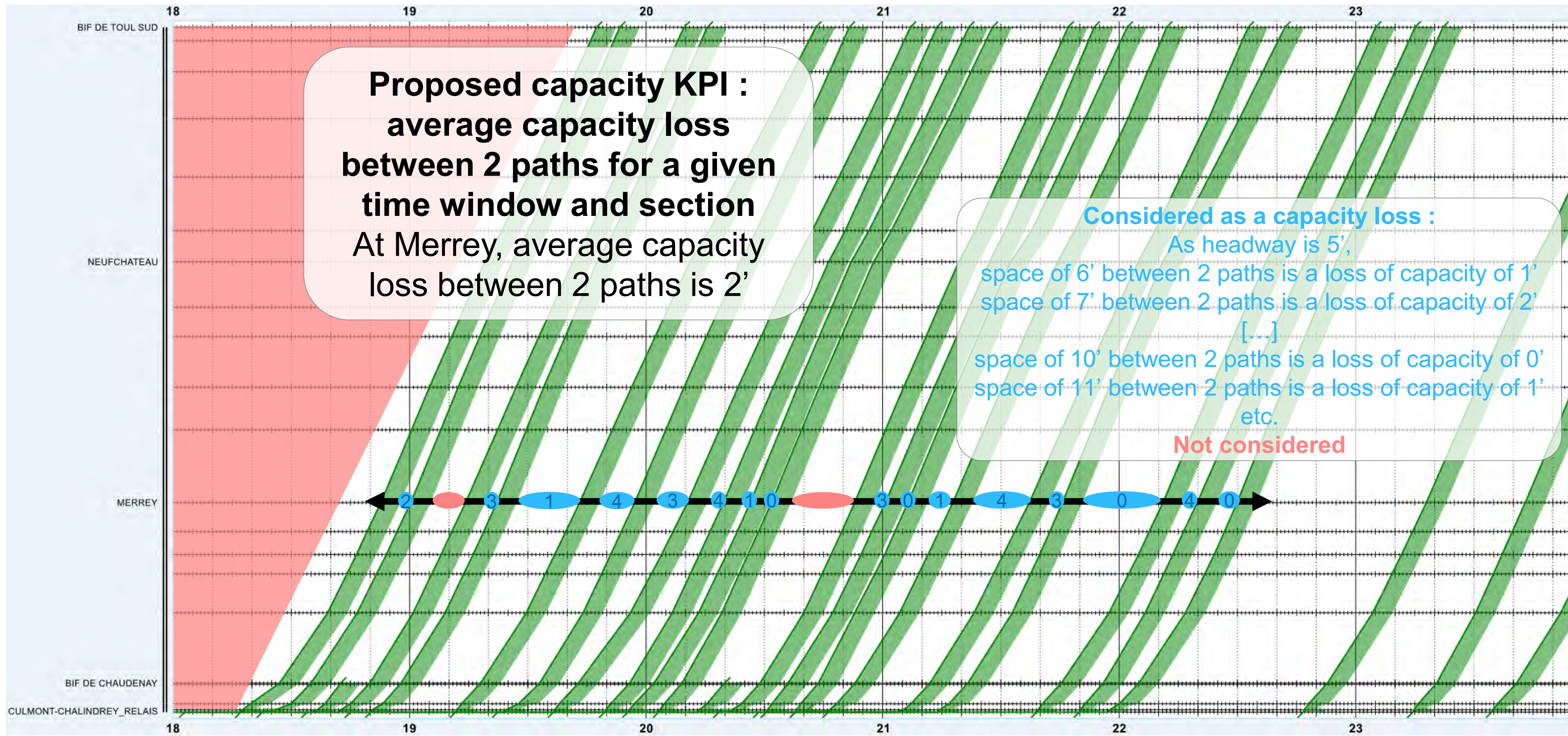
Signalling performance

Runtimes heterogeneity

Level of timetable optimisation

TCRs

10 days in 2022



→ This KPI can be useful for capacity restricted lines, with homogeneous runtimes paths an limited constraints out of the studied perimeter

→ If the capacity considered here as a loss is consciously added between paths as a “robustness” factor, maybe the planning headways have to be increased, or empty paths have to be included in the timetable (if those measures can have an impact of robustness, which is not studied here)

[7] Analysis of capacity consumption

TCRs

Capacity consumption can be linked to a lot of causes.

Among them 5 main causes :

Volume of traffic

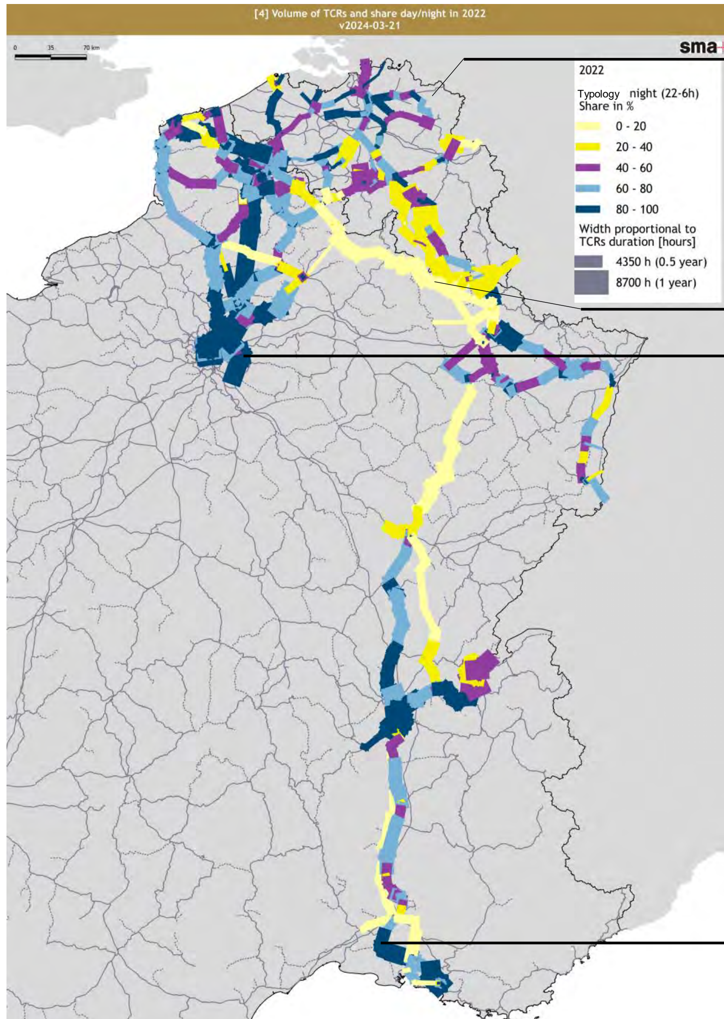
Signalling performance

Runtimes heterogeneity

Level of timetable optimisation

TCRs

All year 2022



Global lower TCRs volume in Belgium, partly related to the TCRs planning philosophy with “génériques” system (TCRs capacity reserved by default in France)

High TCRs volume in Artère Nord-Est

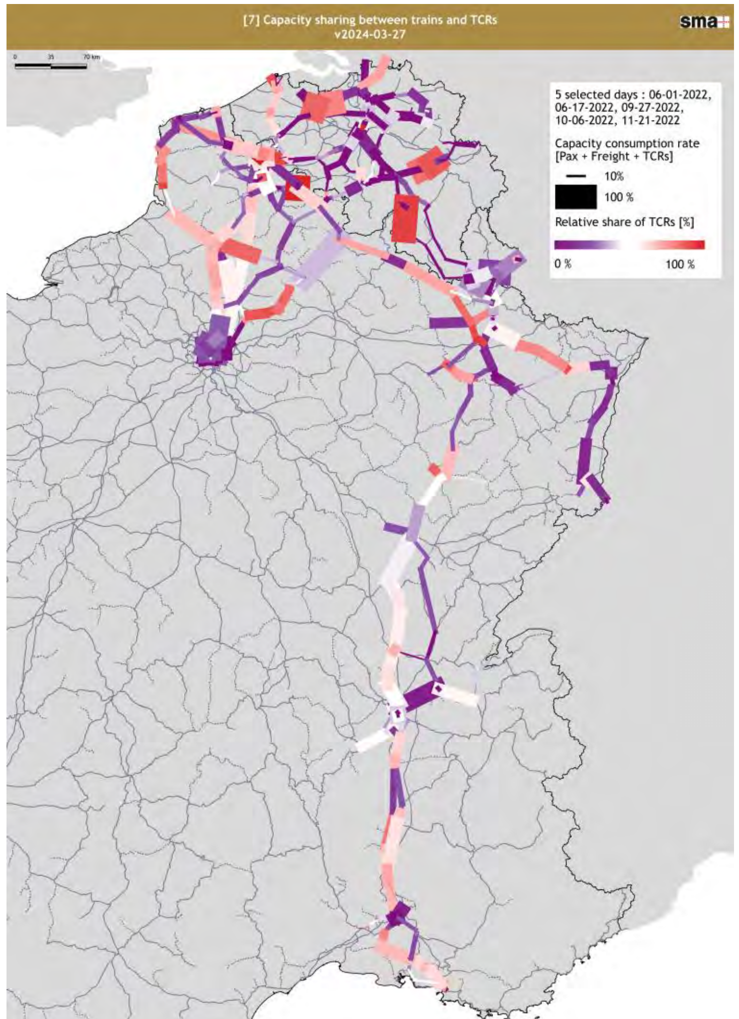
High TCRs volume in Ile-de-France

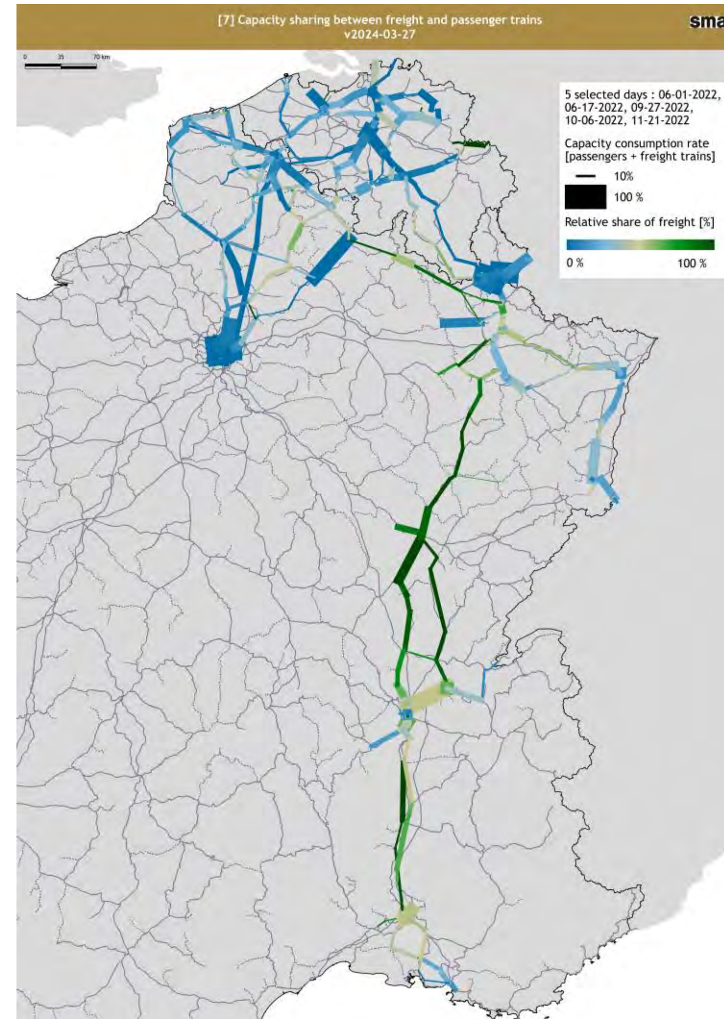
High TCRs volume on Avignon – Marseille via Arles

[7] Analysis of capacity consumption

Capacity sharing

1 day in 2022





AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[7] Analysis of capacity consumption

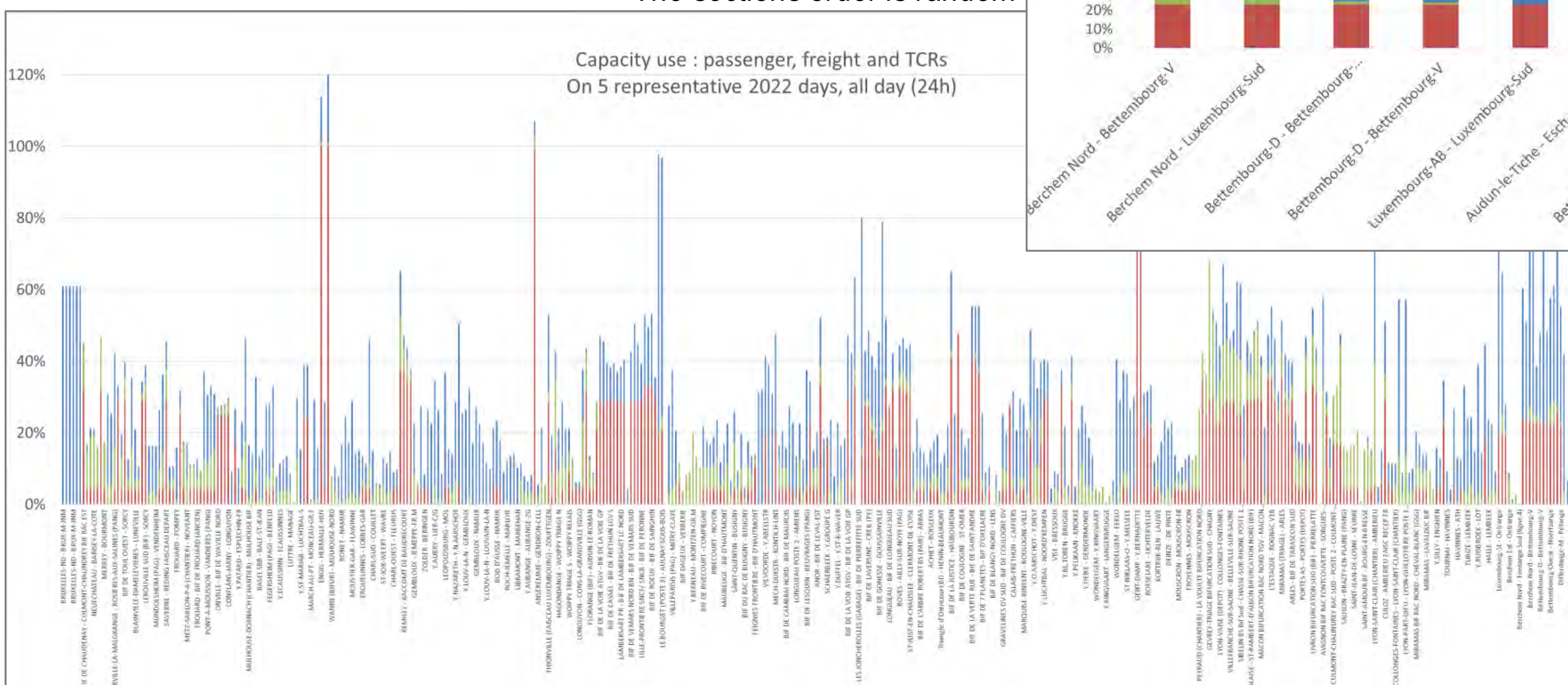
Capacity sharing

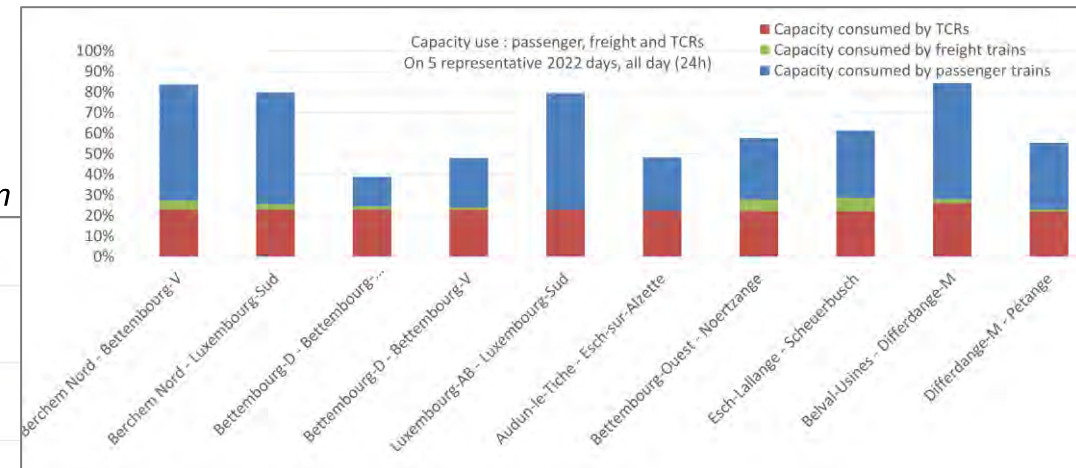
5 days in 2022

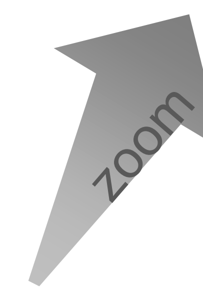
Here on 24h, also available on peak / off-peak hours, night, etc.

Capacity consumption : share freight / passenger / TCRs per section

The sections order is random

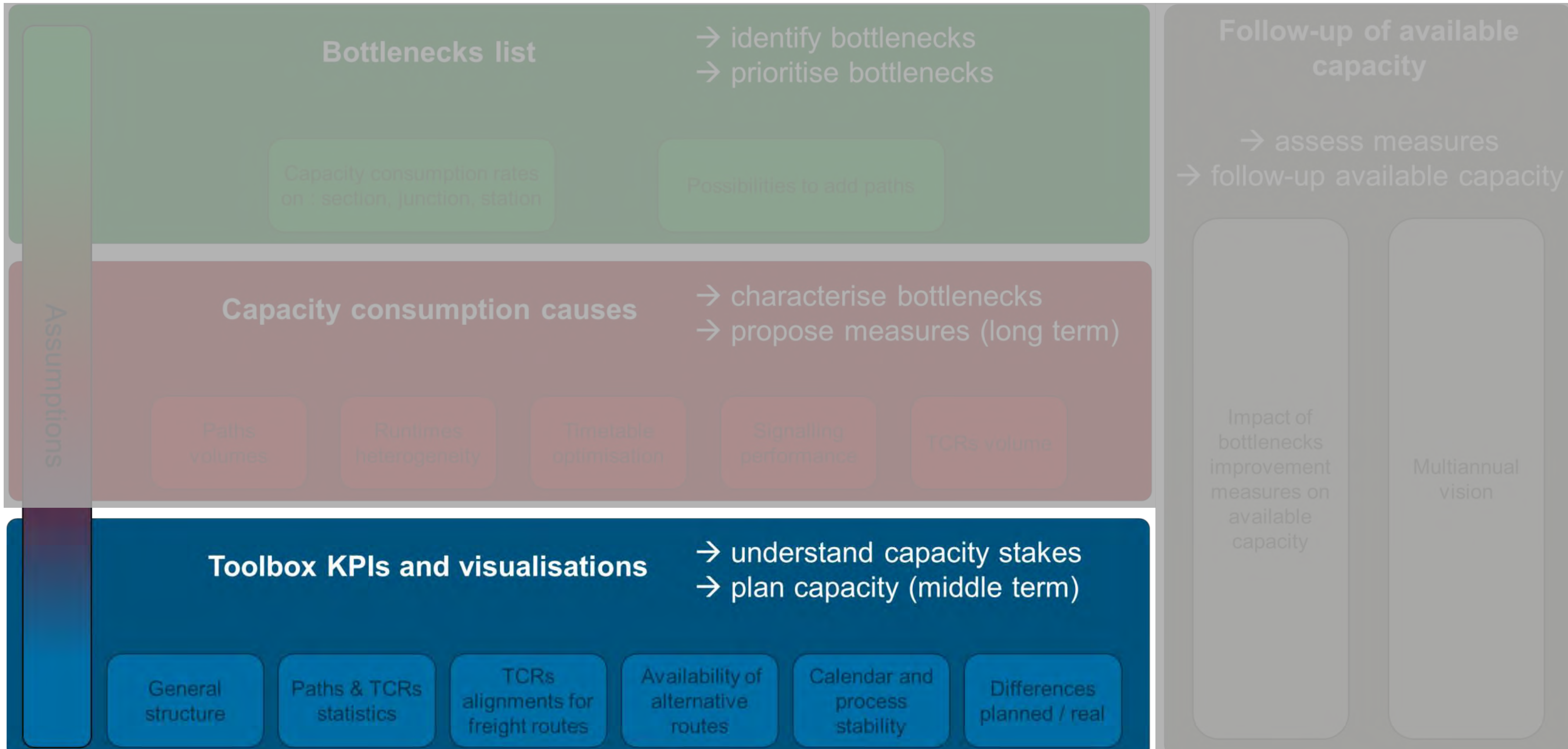






Usages of the capacity KPIs and visualisations

Past, planned, and projected capacity for paths & TCRs



15.09.2022

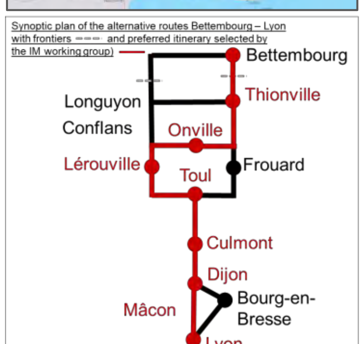
[1] General structure

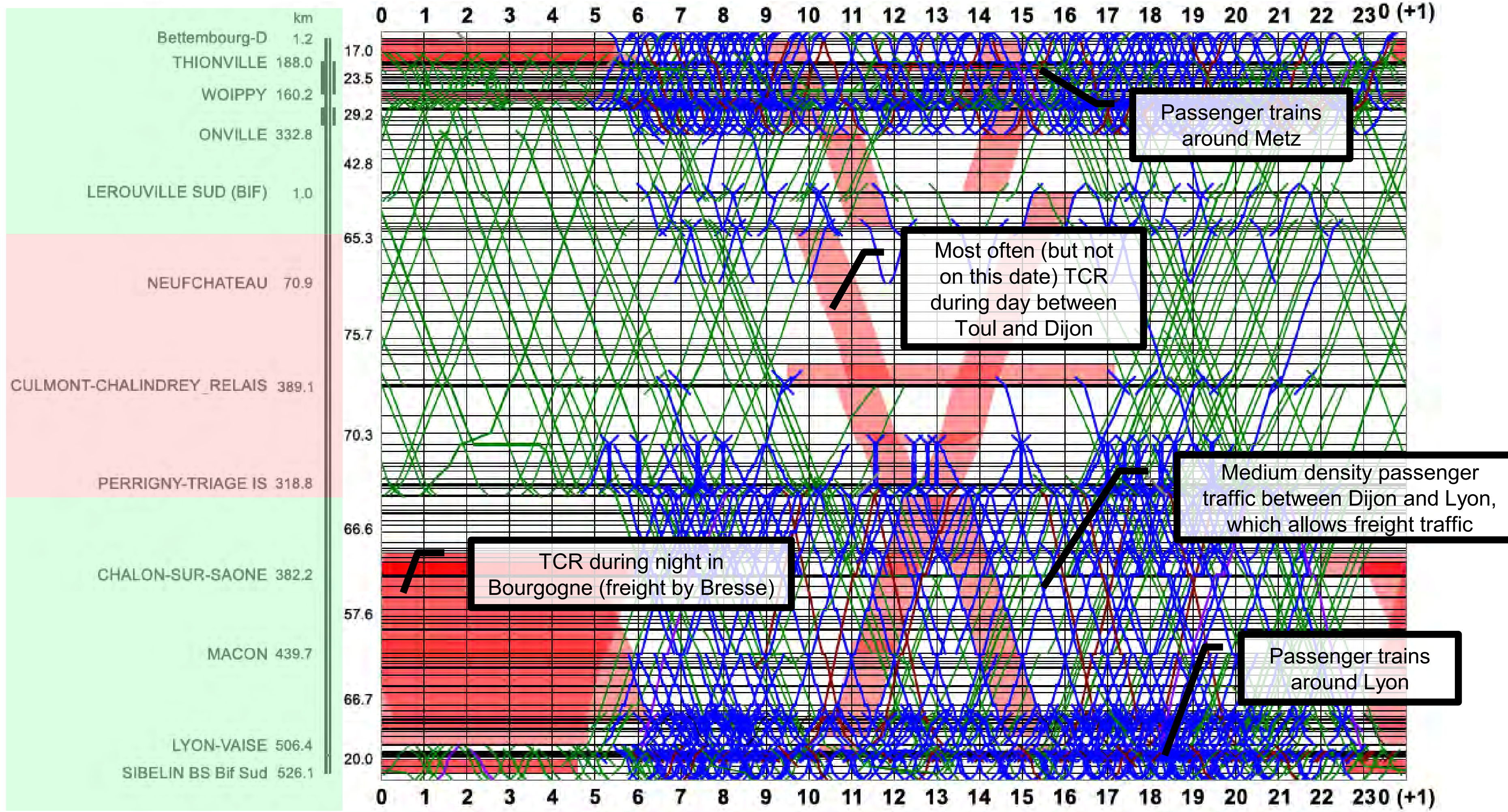
Bettembourg – Lyon (by the chosen itinerary, not the most frequent)

Other routes available in annexes and portfolio

Significant findings about freight trains

Only section without alternative route : Toul – Dijon
On this section TCRs during day are significant
High density of freight traffic on this route North < > South





AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[1] General structure

TCRs

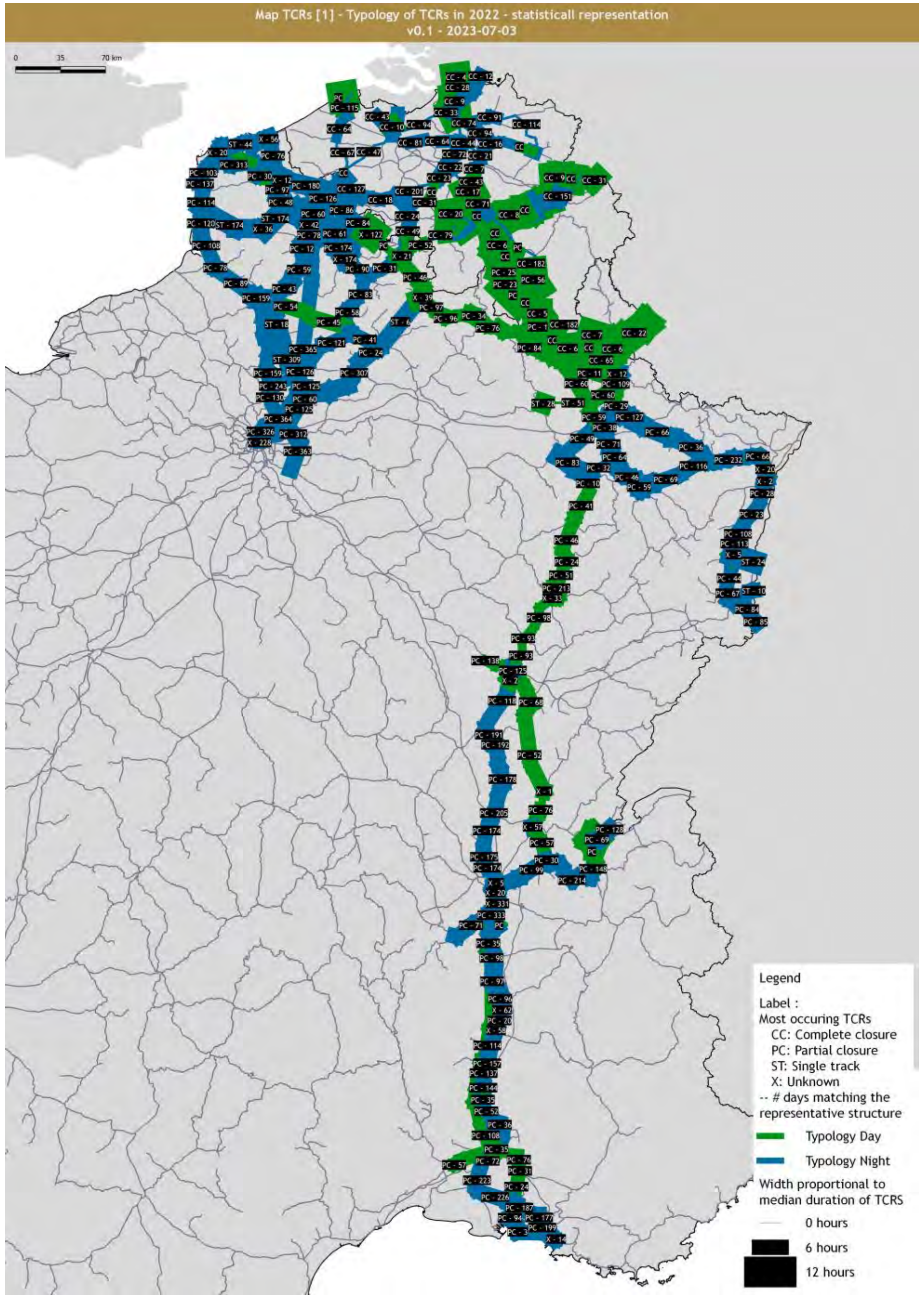
General structure of the planned TCR is based on a statistical analysis (all year).

What is represented here is the most common TCR per section, the one which is planned most often (number of days).

To see the sum of the capacity planned for works, see other KPIs.

Here, French “fenêtres de surveillance” are not considered (they are the most planned TCR on most sections).

→ **This representation shows the TCRs typology (day or night), and the “usual” volume of TCRs (in hours).**



AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[1] General structure

Paths and TCRs

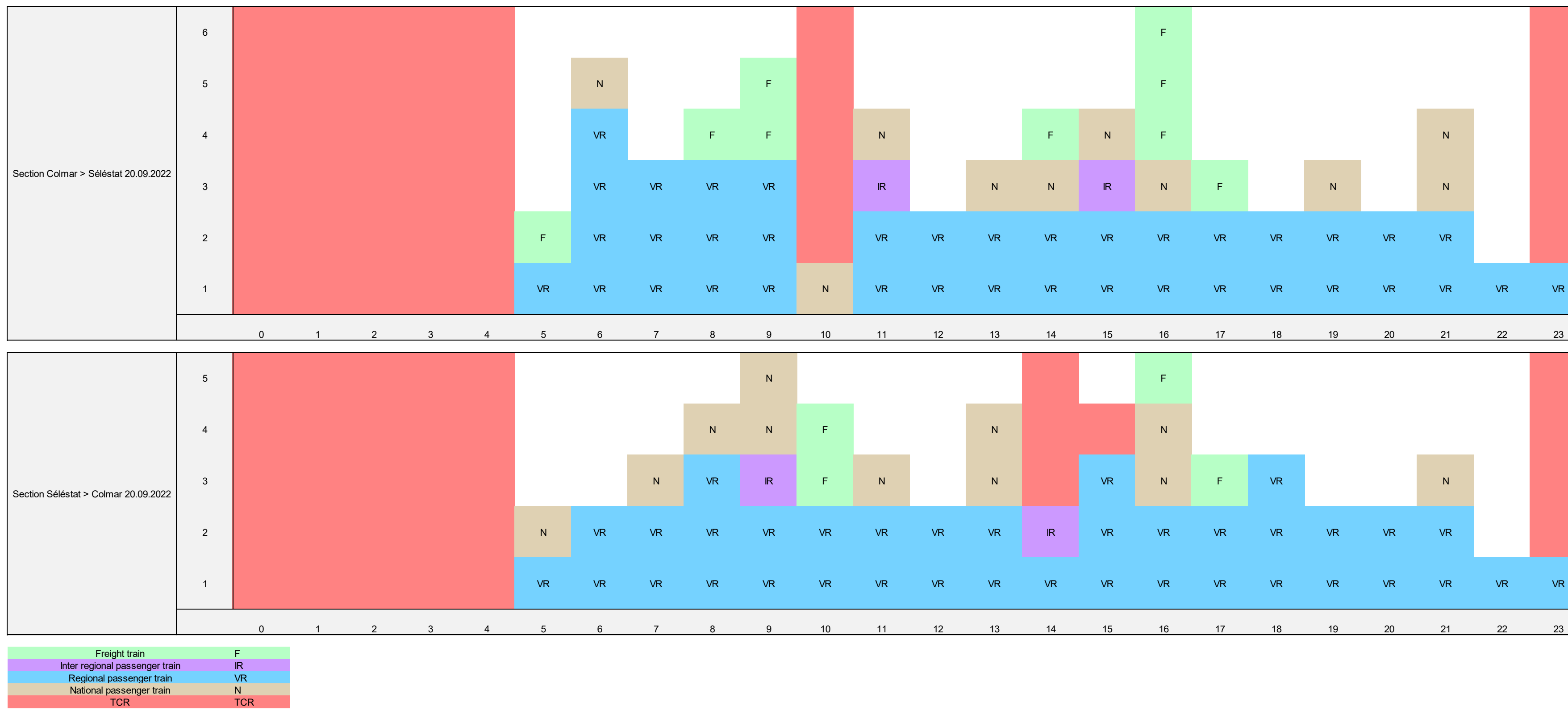
Other sections available in annexes and portfolio

Colmar – Sélestat (FR)

20.09.2022

This image is from the Proof of Concept, for the specific assumption, see PoC deliverable.

⚠ capacity consumption attributed to the different trains is another capacity representation, and can be calculated with different methods.



AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[2] TCRs statistics

Sum of the capacity (hours per section) planned for works in all year 2022, with detail of night / day.

→ **Where do the TCRs have a high impact on available capacity ?**

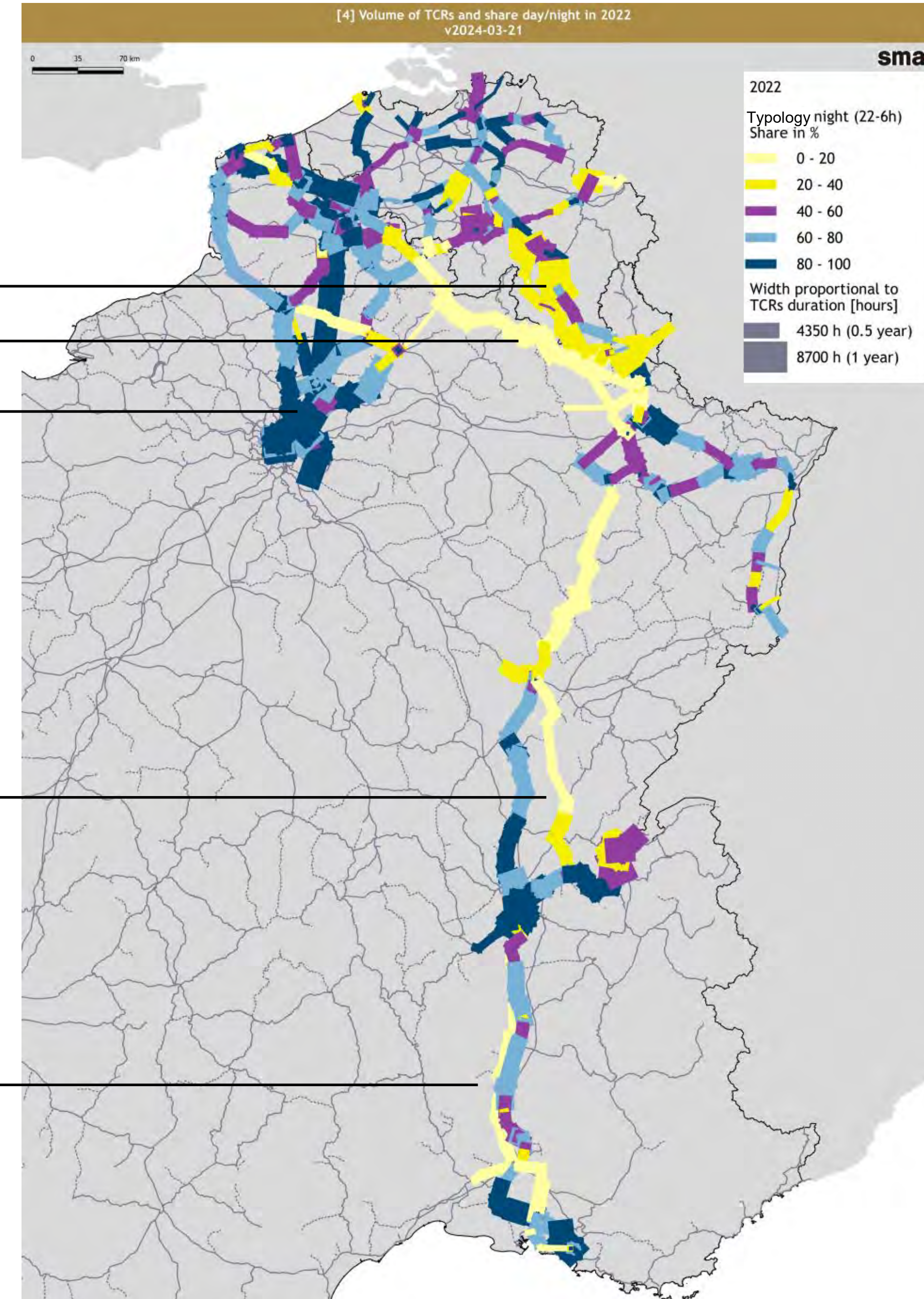
High volume of works on Athus Meuse

High volume of works on Artère Nord Est

High volume of works in Ile-de-France

Alternative routes Bourgogne / Bresse

Alternative routes on Rhône sides

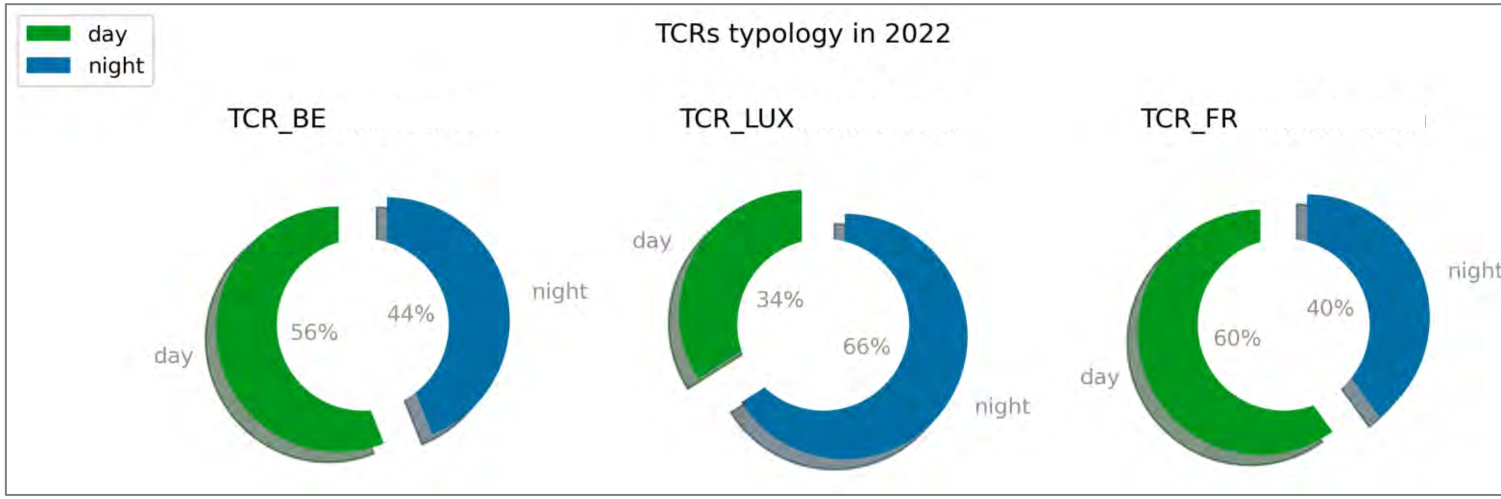


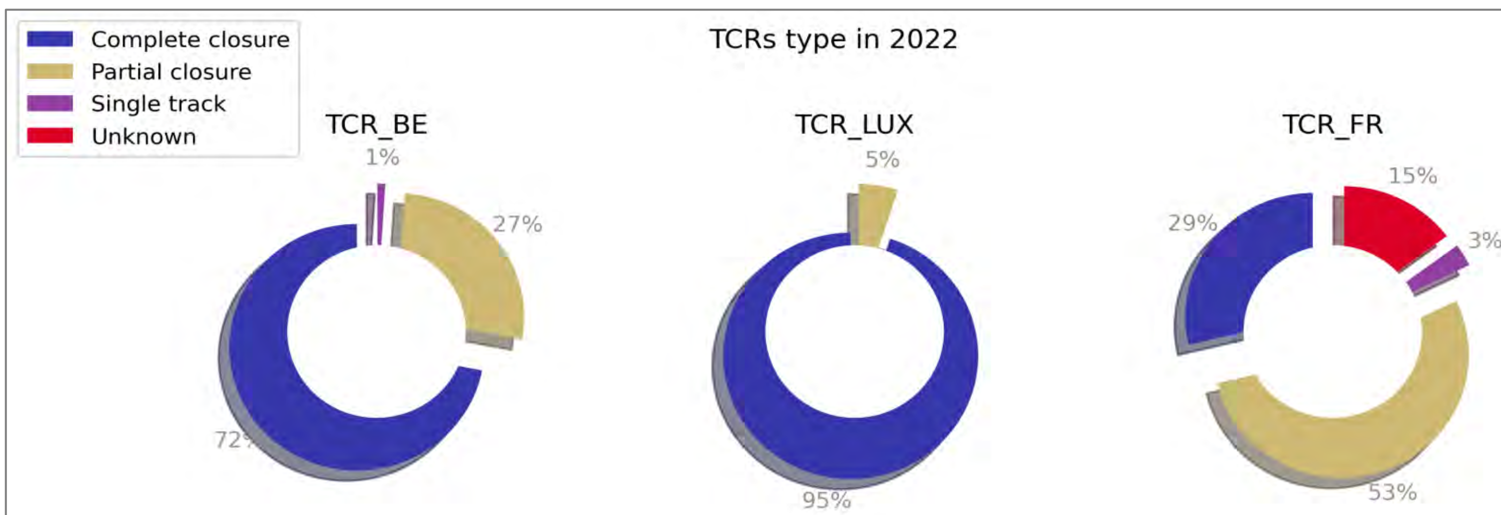
[2] TCRs statistics

All year 2022

% are relative to duration and km

→ **What are the global volumes of TCRs and what is the TCRs planning philosophy in the different countries ?**

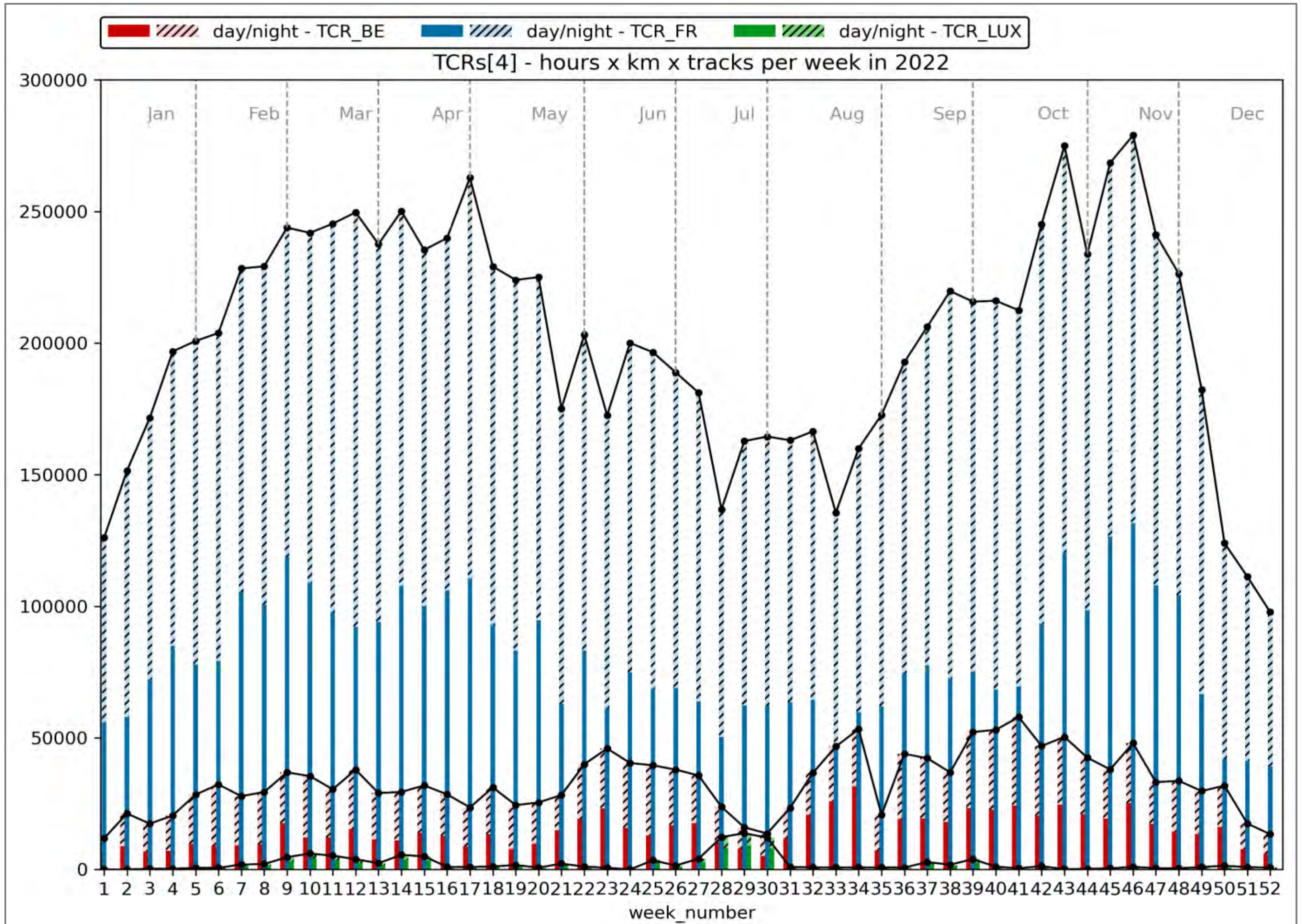




[2] TCRs statistics

All year 2022

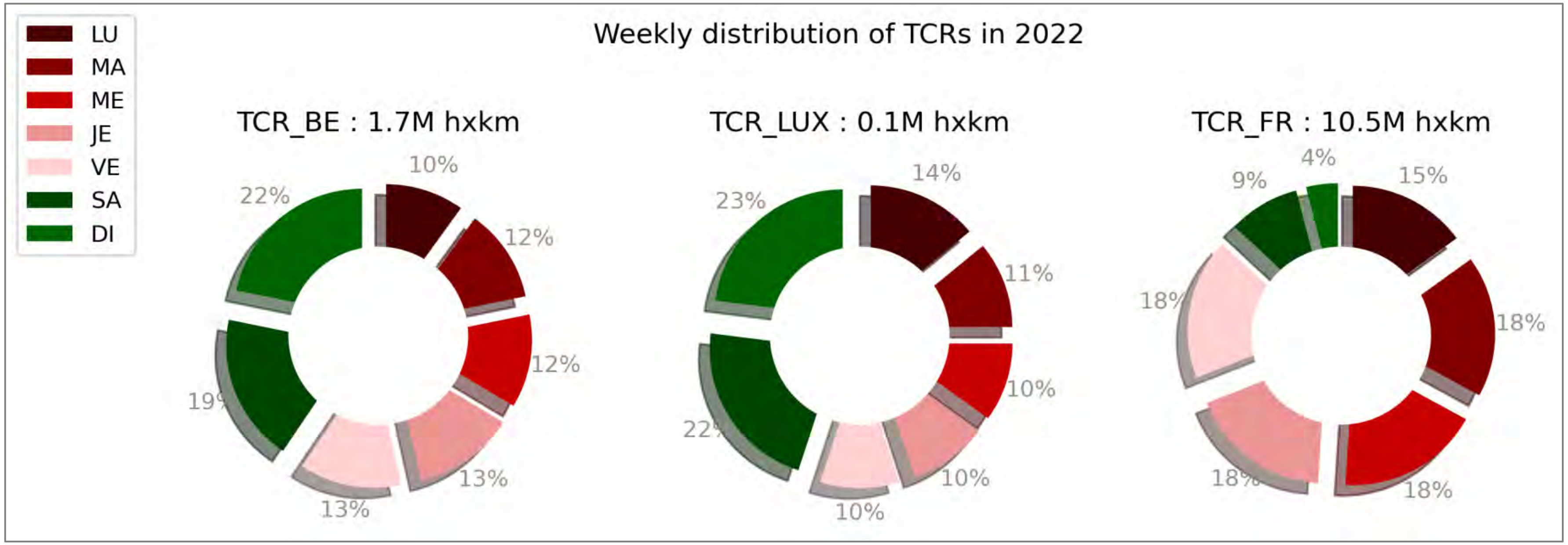
→ **When do the TCRs have the most important impact on available capacity ? What is the TCRs planning philosophy in the different countries ?**



[2] TCRs statistics

All year 2022

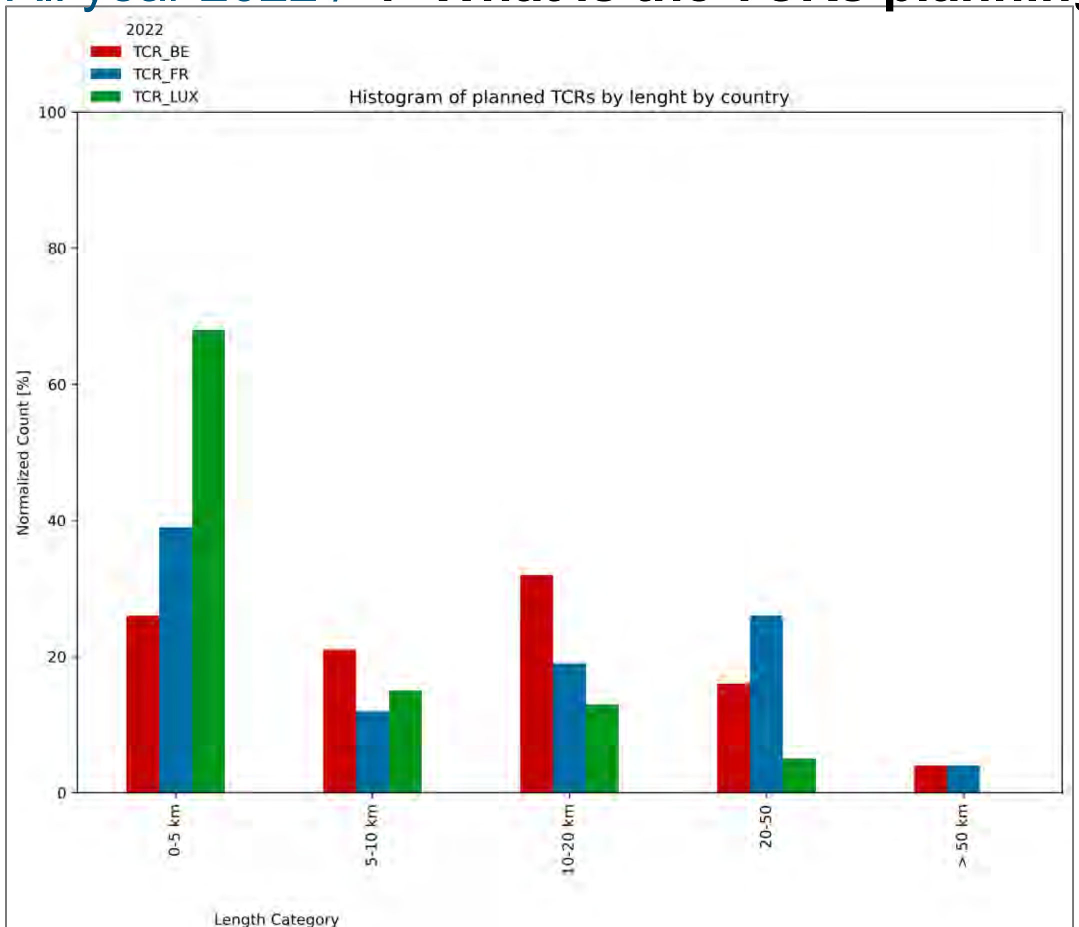
→ **What is the TCRs planning philosophy in the different countries ?**

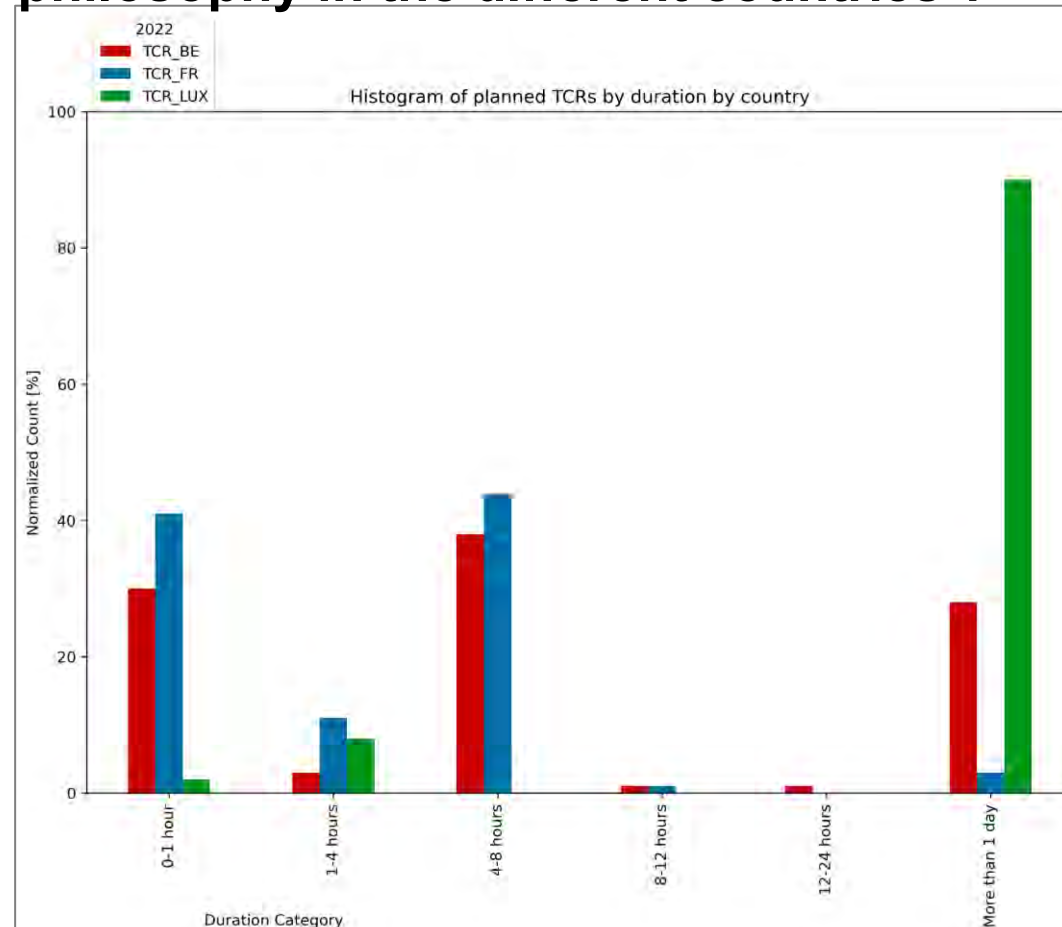


AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[2] TCRs statistics

All year 2022 / → **What is the TCRs planning philosophy in the different countries ?**





[3] Permeability of the TCRs structure

→ are the planned TCRs aligned for freight routes ?

Other routes available in annexes and portfolio

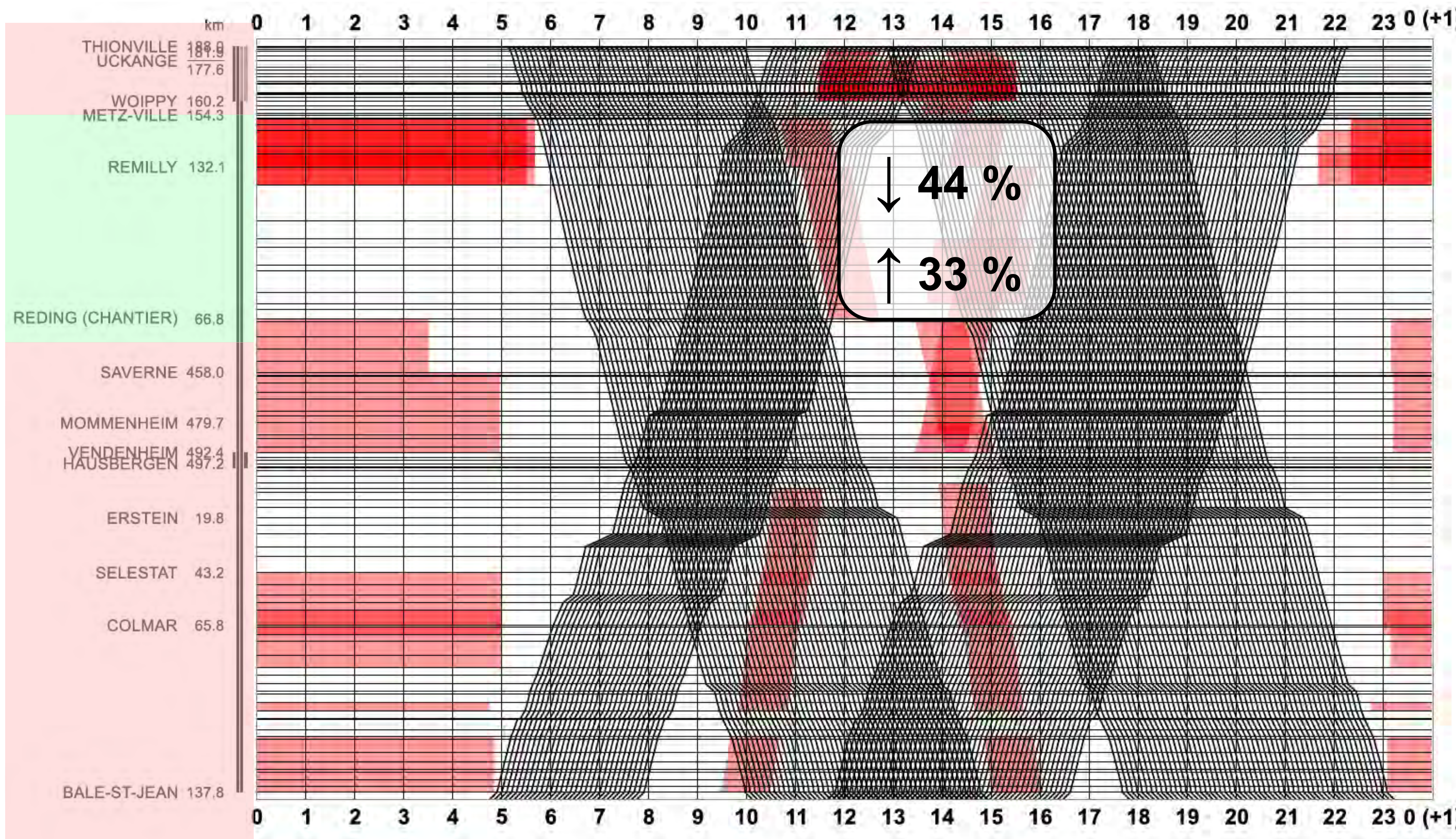
On the chosen itinerary for each chosen route.

On a date which is near to the median hours x km of the year.

Thionville – Basel for the 15.03.22.

⚠ non alignments can be linked to other traffics or other constraints.

⚠ Operational choices of the RU can have an impact on the "raw" runtime used here.



Capacity KPIs : TCRS [3]

Calculated % : usable capacity / total capacity, for 1 path, no path deformation possible (no added runtime), in a graphical timetable with only TCRs, for this example, TCRs "1track/2 are considered as closed (pejorative assumption)

[3] Permeability of the TCRs structure

→ are the planned TCRs aligned for freight routes ?

On all possible alternative itineraries for this route and day.

On a date which is near to the median hours x km of the year.

Anvers – Thionville for the 08.06.22.

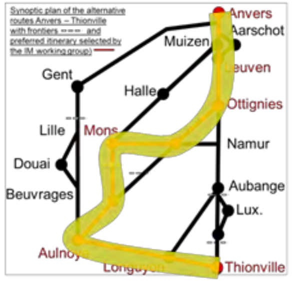
⚠ non alignments can be linked to other traffics or other constraints.

⚠ Operational choices of the RU can have an impact on the “raw” runtime used here.

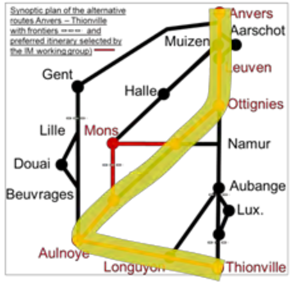
From	To	Via
	North > South	
13.58	20.20	1
20.20	22.30	2
22.30	00.00	3
00.00	01.00	No possible itinerary
01.00	04.30	3
04.30	13.58	No possible itinerary
	South > North	
01:00	05:30	1
05:30	16:00	No possible itinerary
16:00	17:40	1
17:40	20:00	3
20:00	21:00	No possible itinerary
21:00	01:00	3

↓ **56 %**

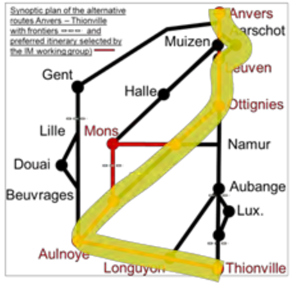
↑ **52 %**



1



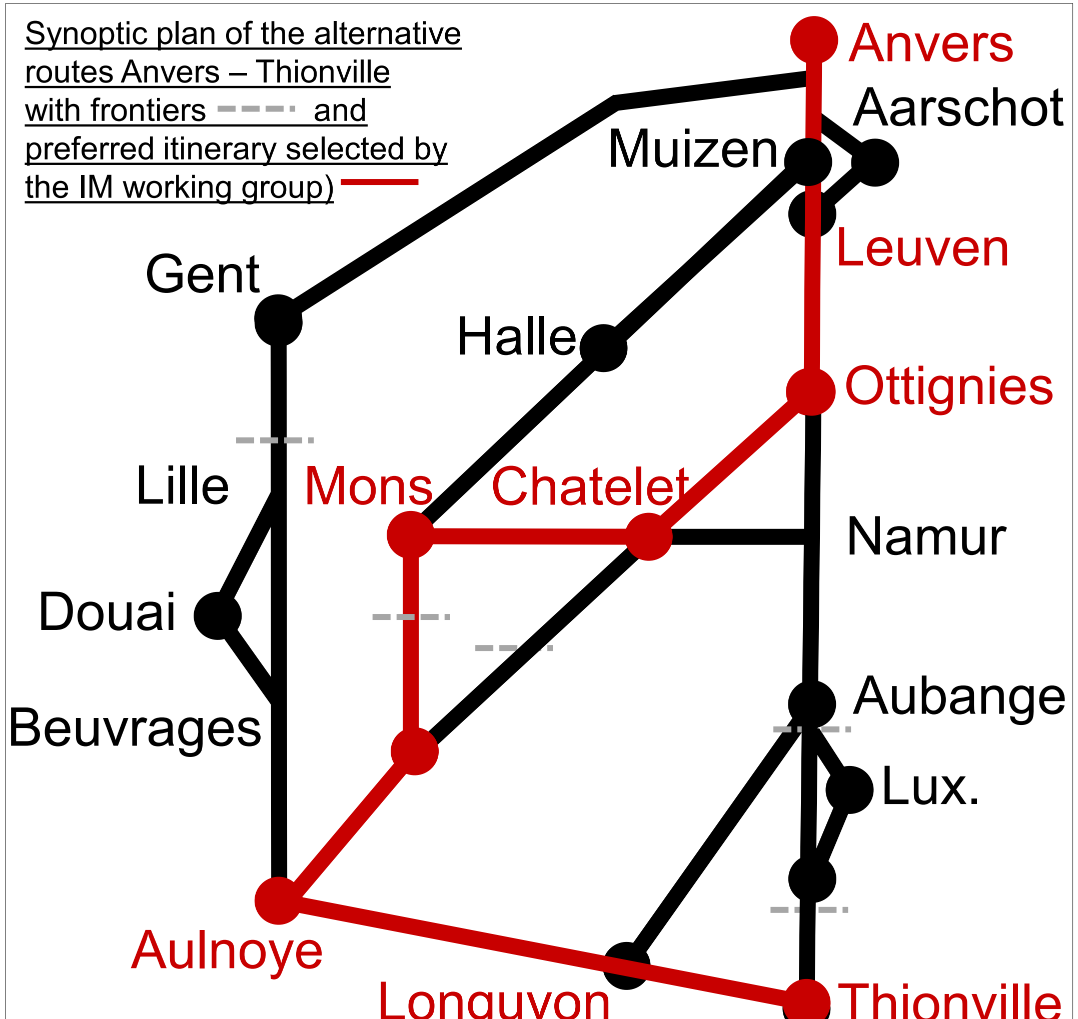
2

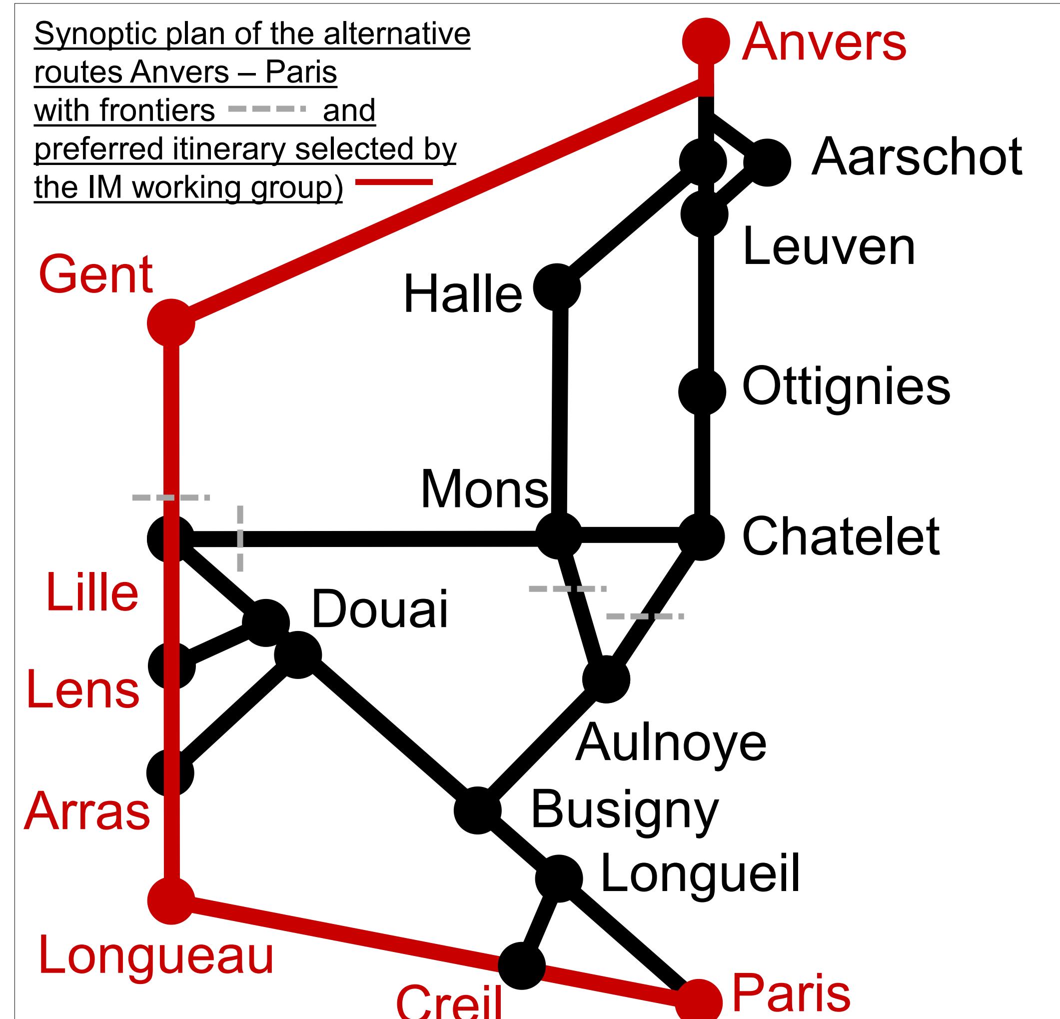


3

[4] TCRs planning on alternative routes

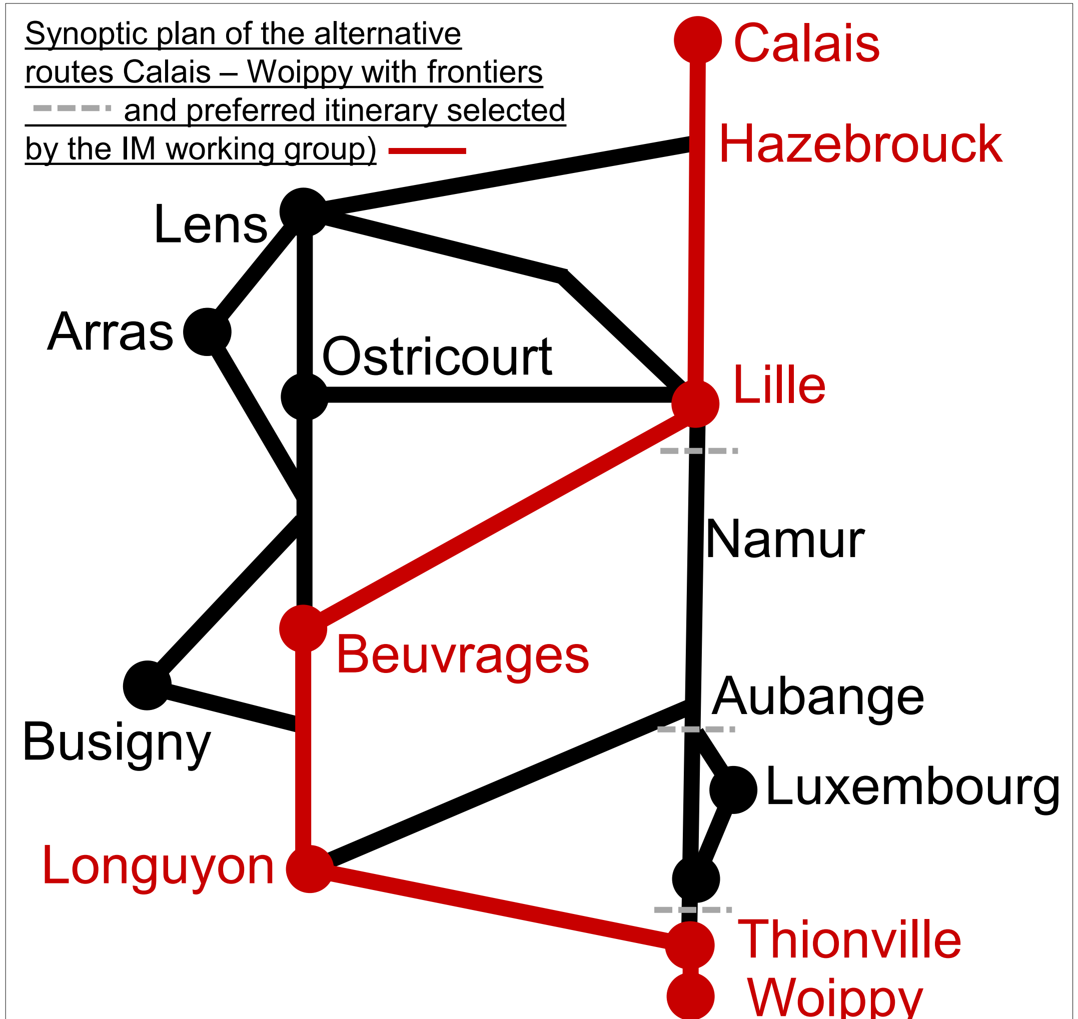
Chosen routes and studied itineraries

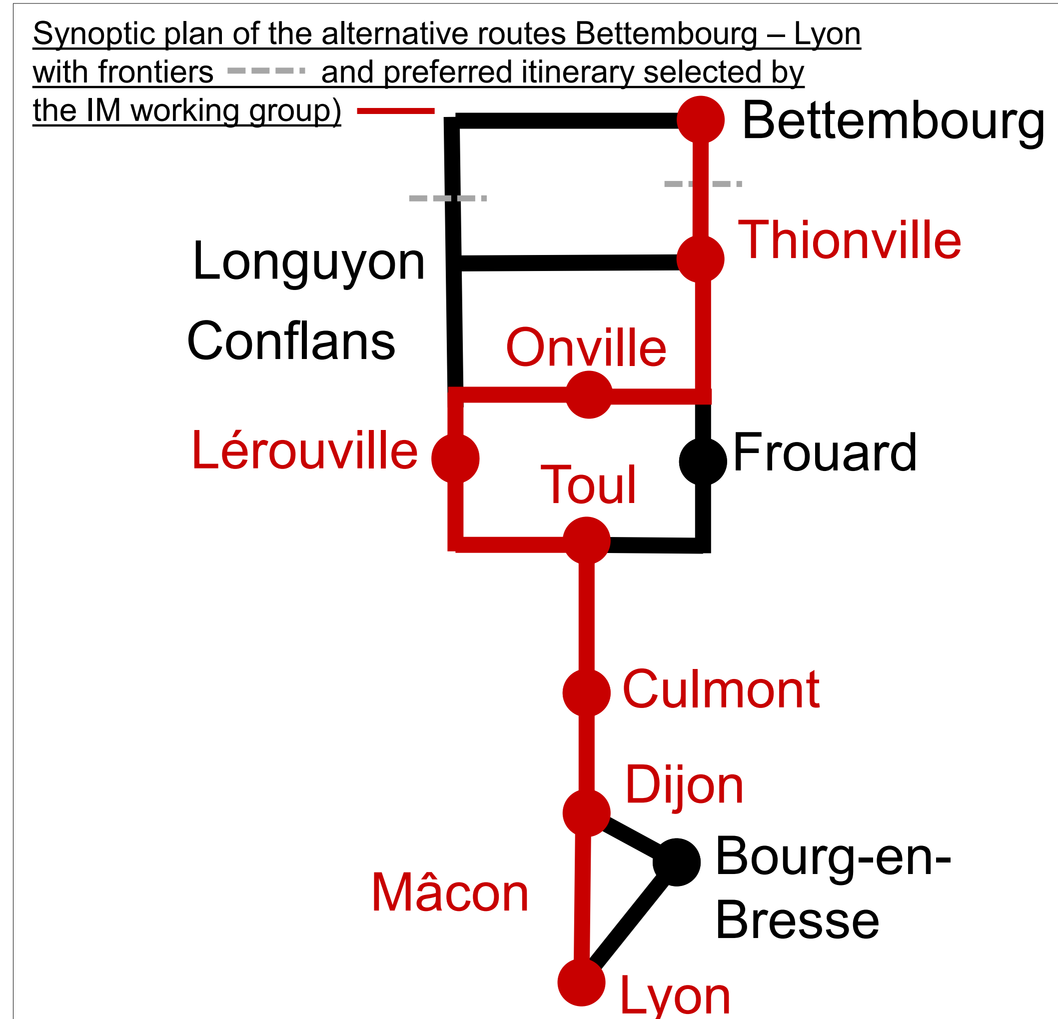




[4] TCRs planning on alternative routes

Chosen routes and studied itineraries

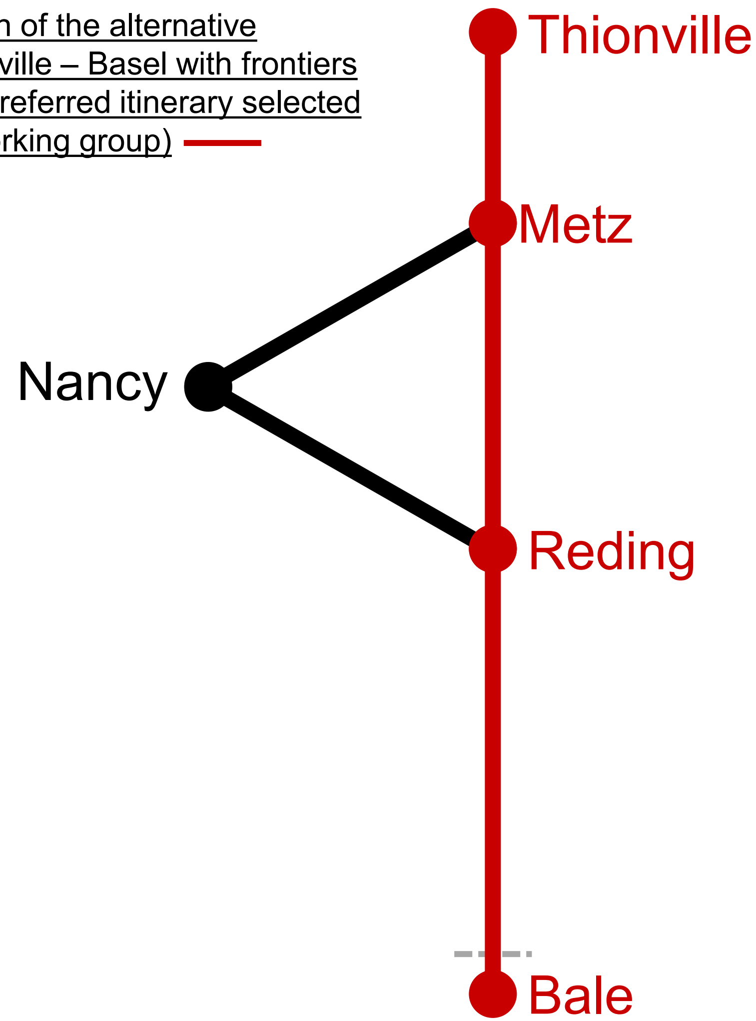




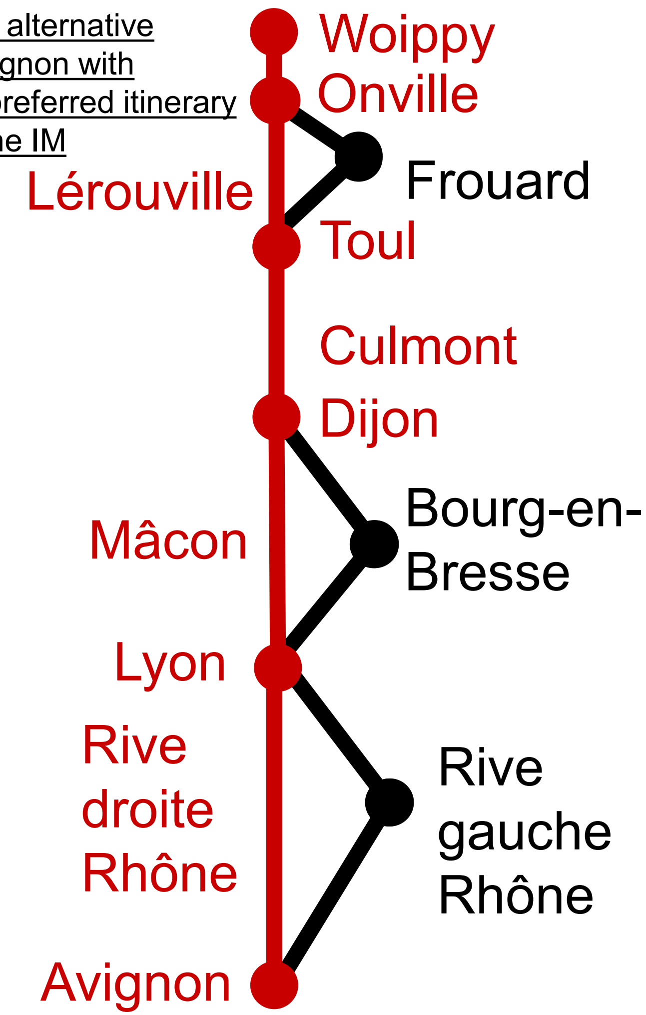
[4] TCRs planning on alternative routes

Chosen routes and studied itineraries

Synoptic plan of the alternative routes Thionville – Basel with frontiers and preferred itinerary selected by the IM working group)



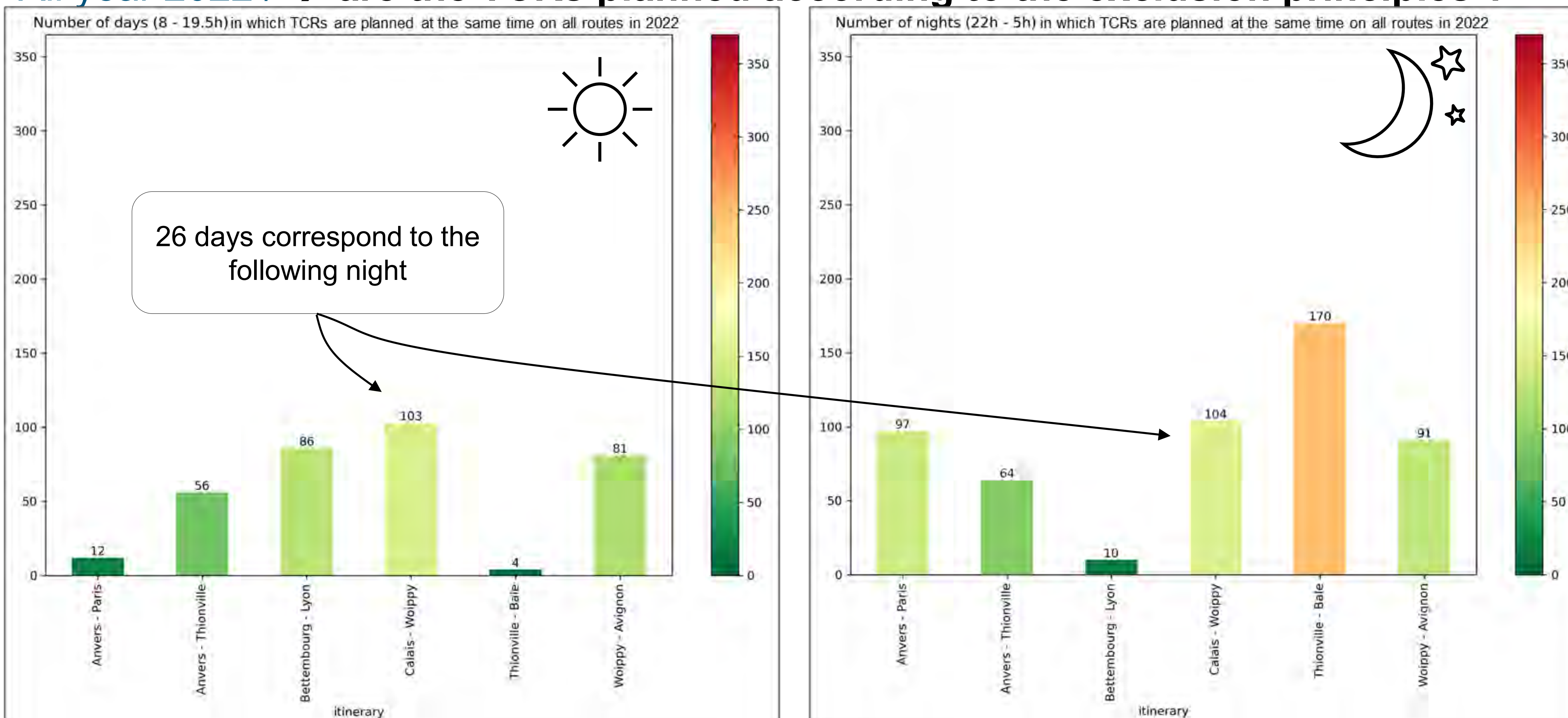
Synoptic plan of the alternative routes Woippy – Avignon with frontiers and preferred itinerary selected by the IM working group)



[4] TCRs planning on alternative routes

Results

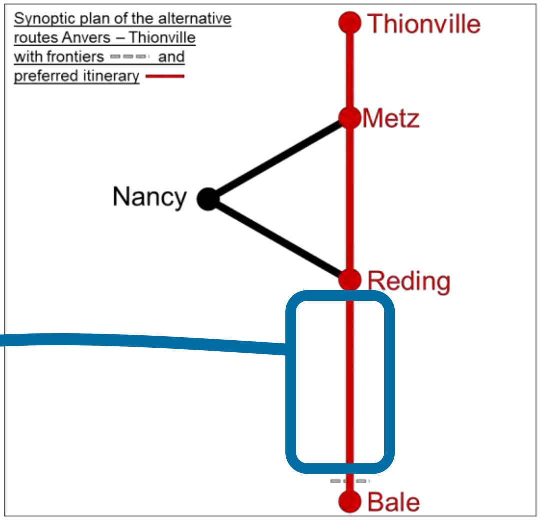
All year 2022 / → are the TCRs planned according to the exclusion principles ?

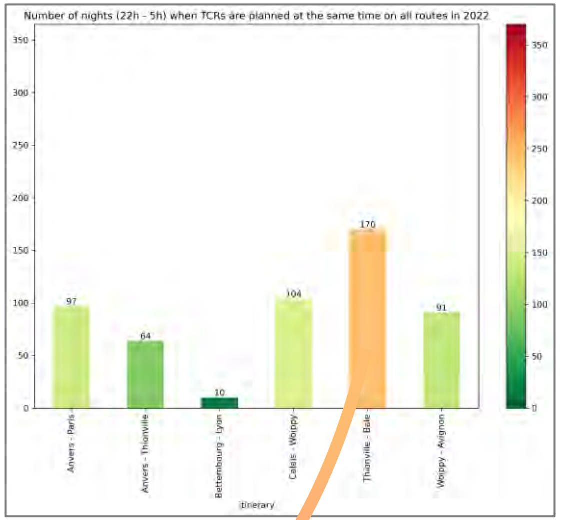


AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

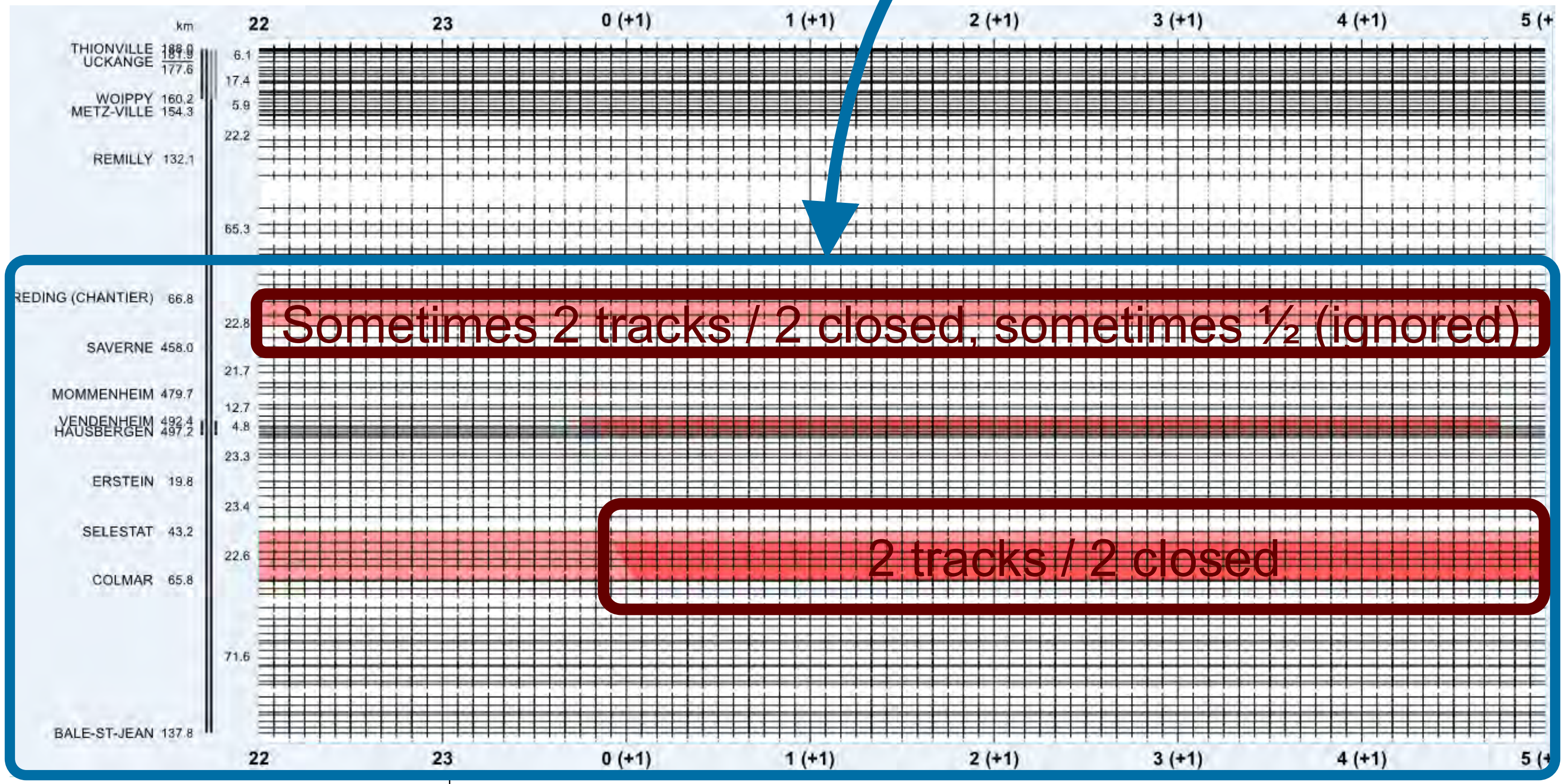
[4] TCRs planning on alternative routes

Example





Example : Thionville – Basel



Zoom on one of the identified « closed » night

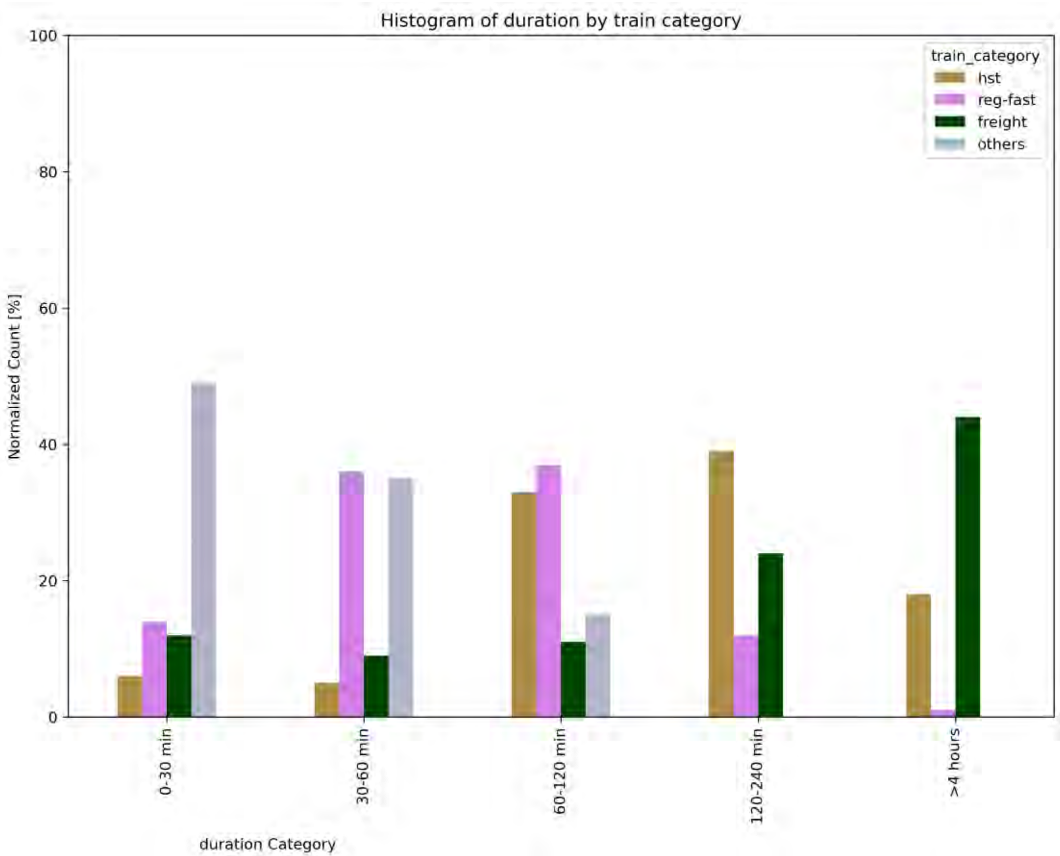
No alternative route between Reding and Basel.

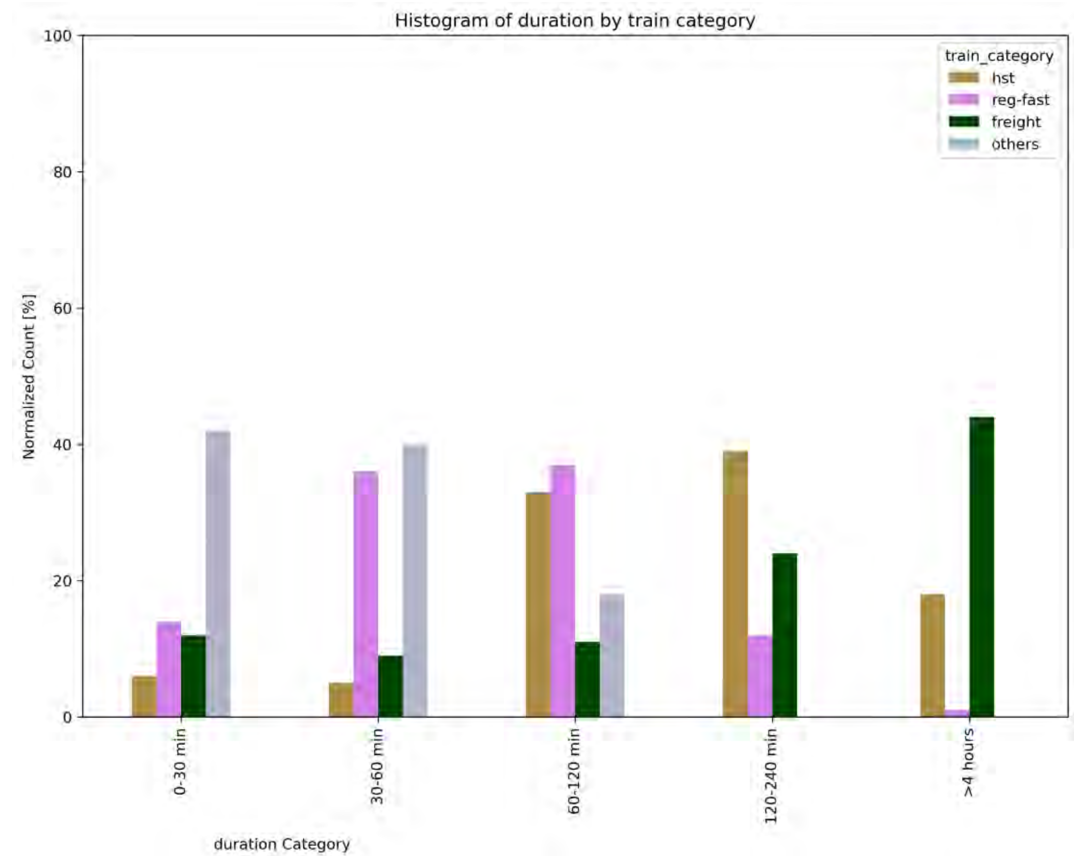
A part of this night, 2 tracks / 2 are closed for works between Reding and Saverne and Sélestat and Colmar, where there is no alternative route.

[5] Paths statistics

Durations

Without empty runs





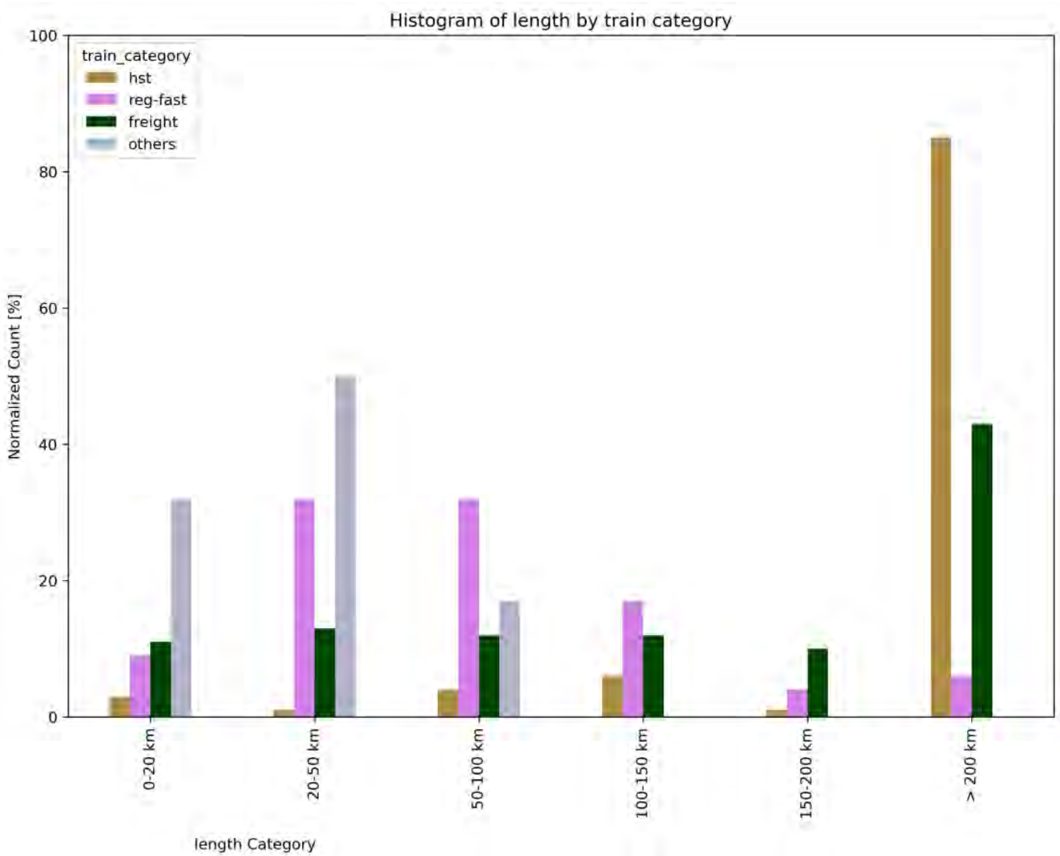
All year 2022

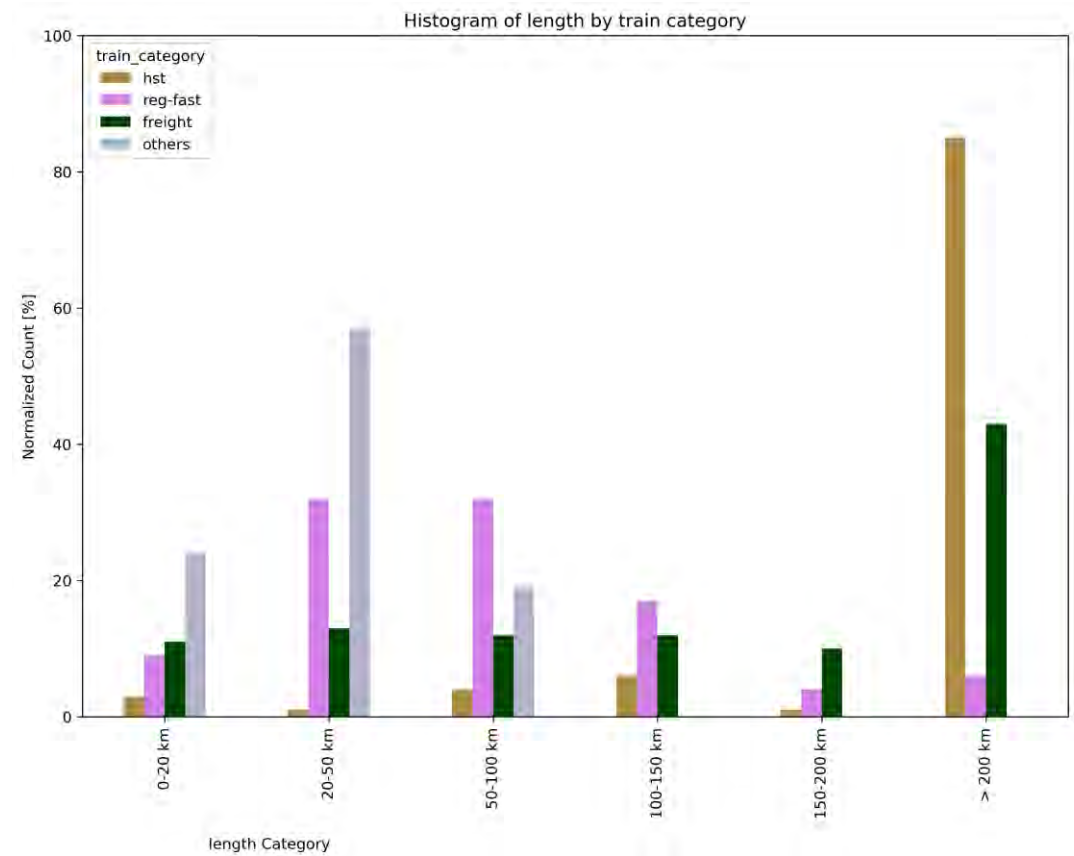
AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

[5] Paths statistics

KM

Without empty runs



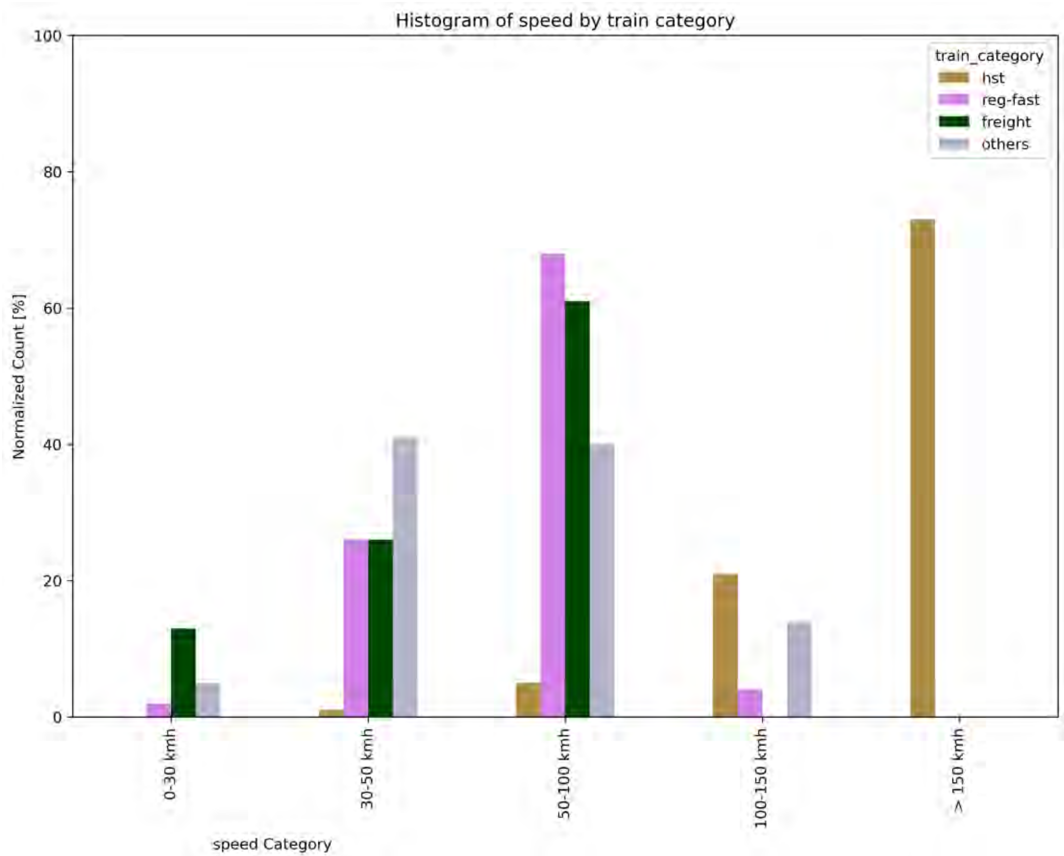


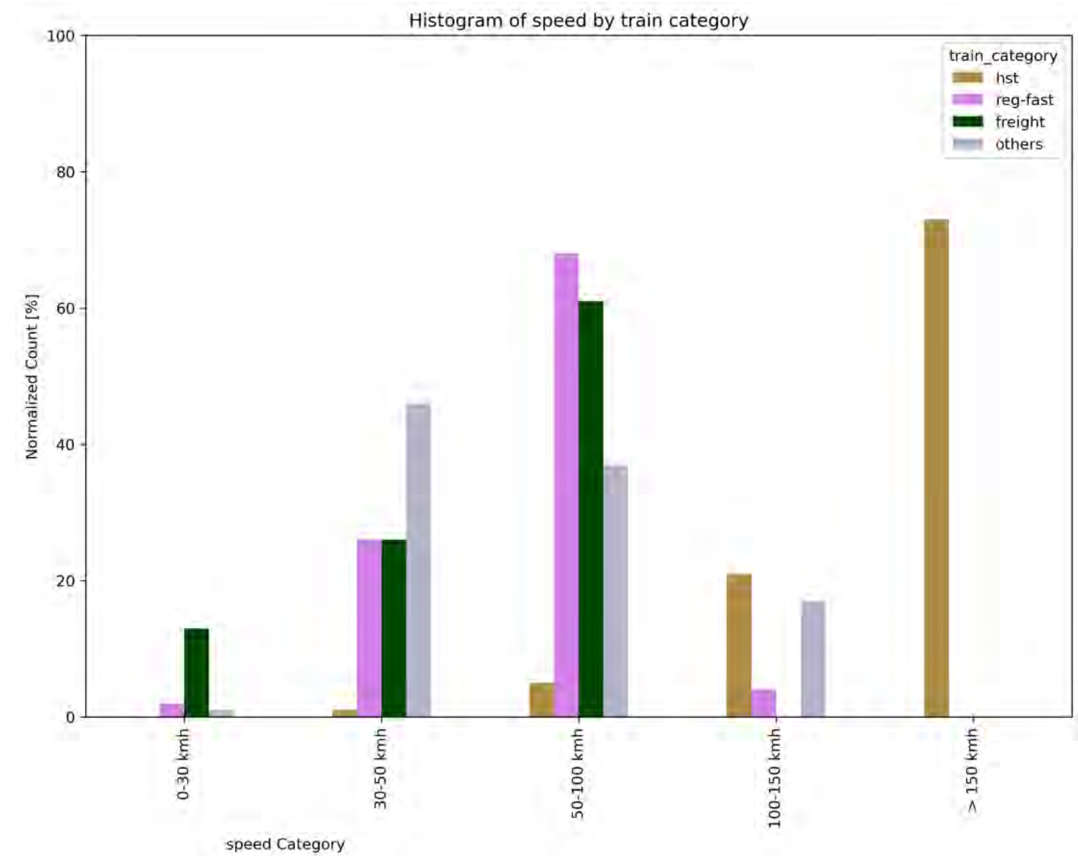
All year 2022

[5] Paths statistics

Speeds

Without empty runs



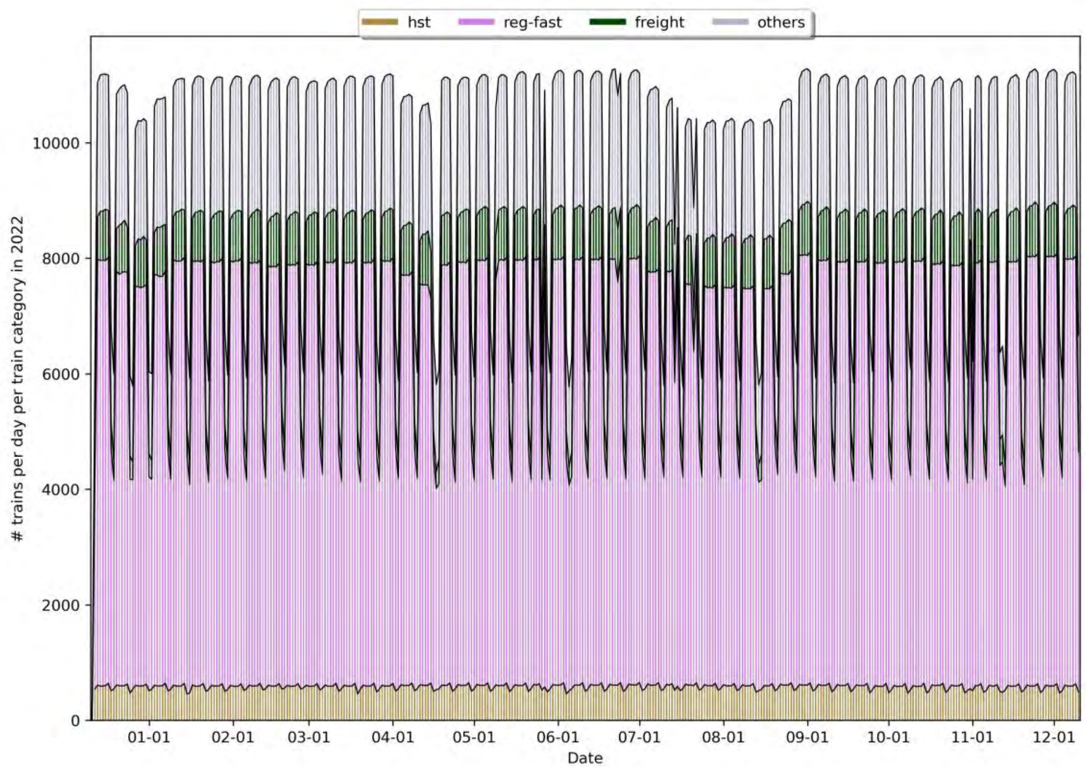


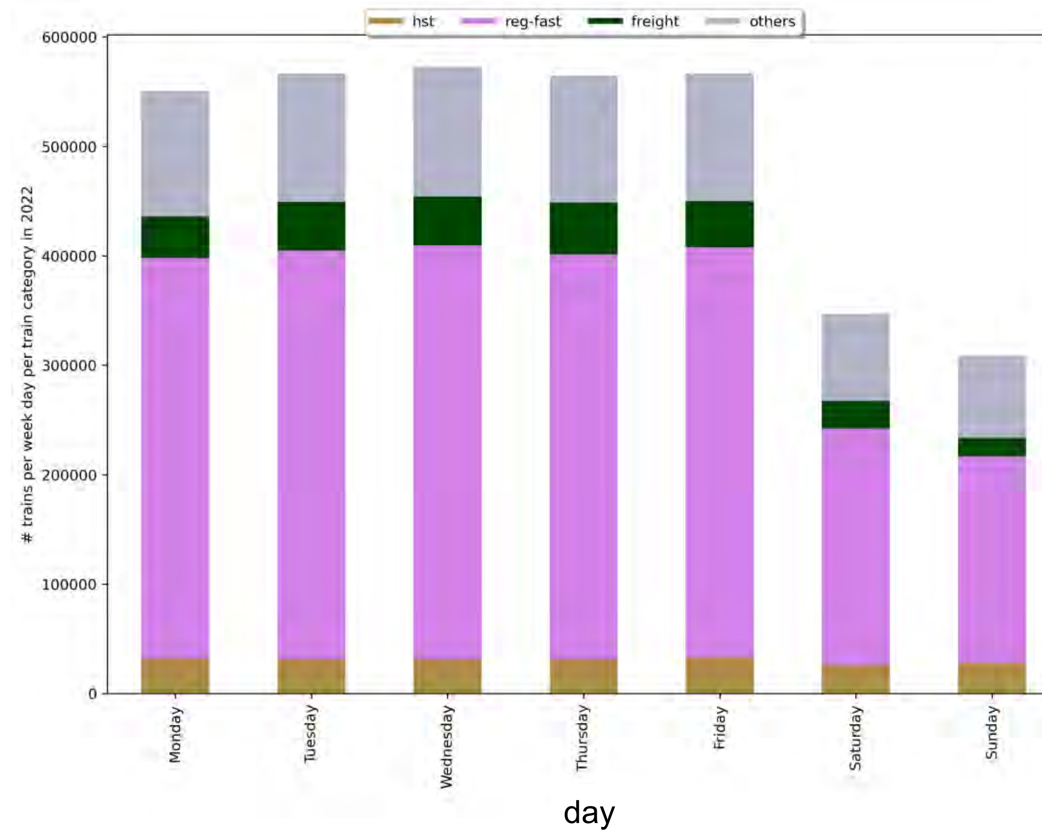
All year 2022

[5] Paths statistics

Number of paths

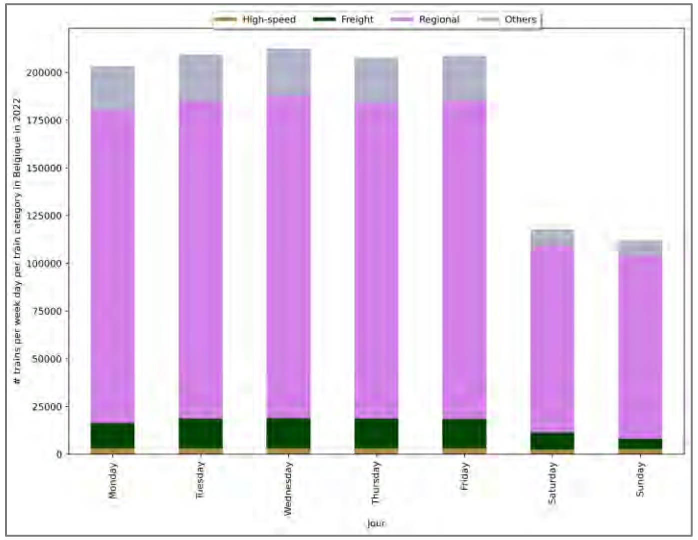
All year 2022 / → **what are the types of planned paths, in which proportion, when ?**

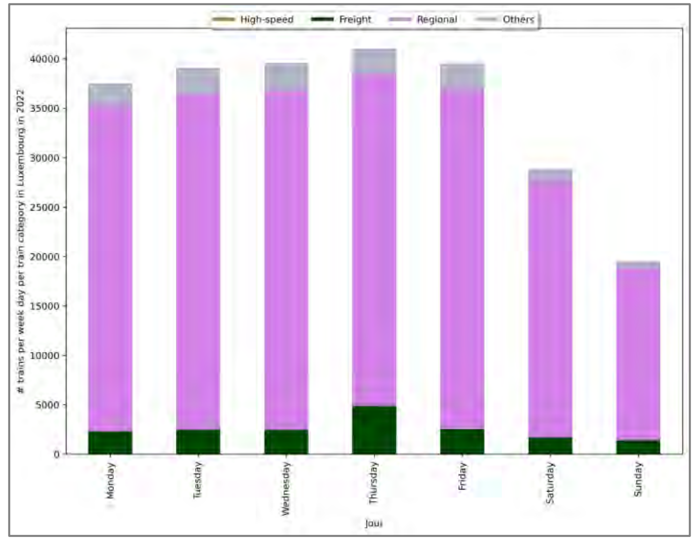


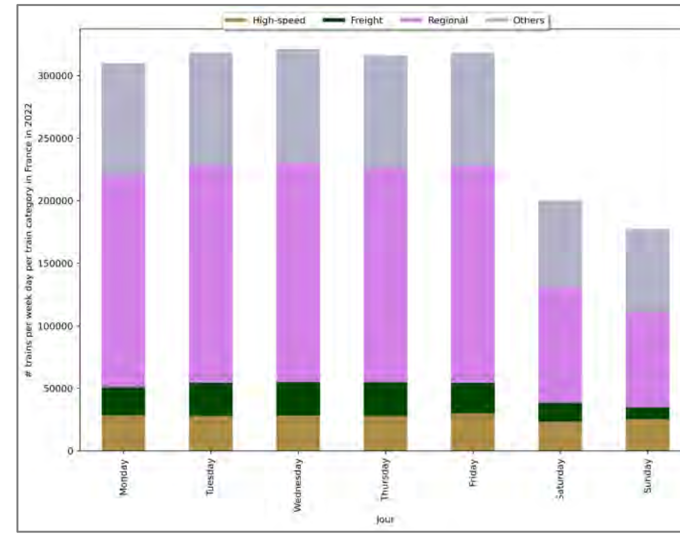


[5] Paths statistics

Number of paths







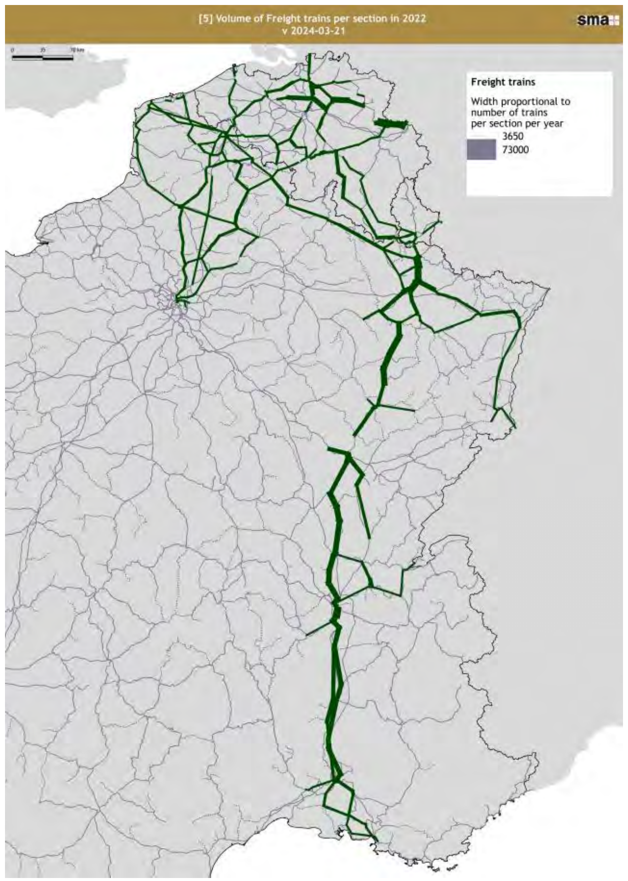
AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

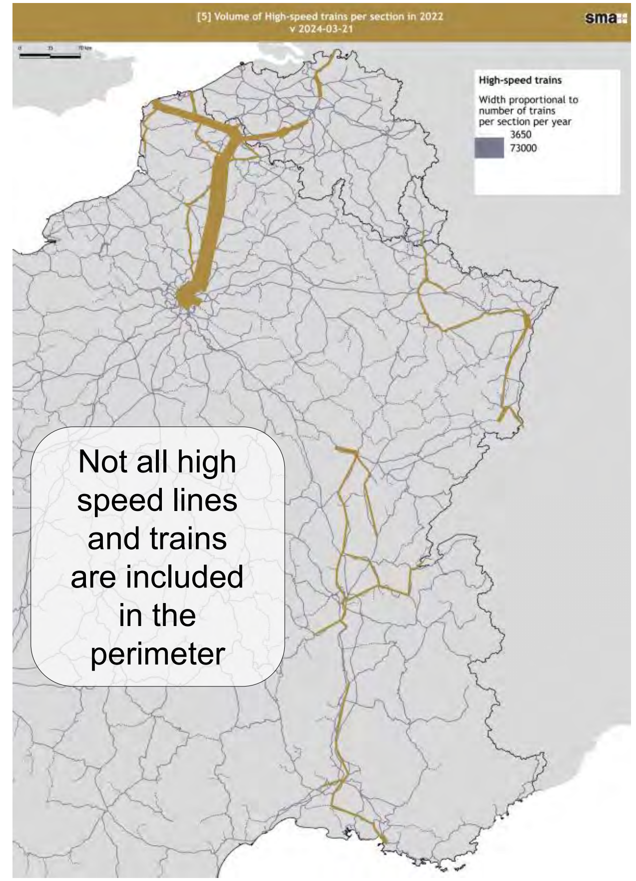
[5] Paths statistics

Yearly number of trains per sections

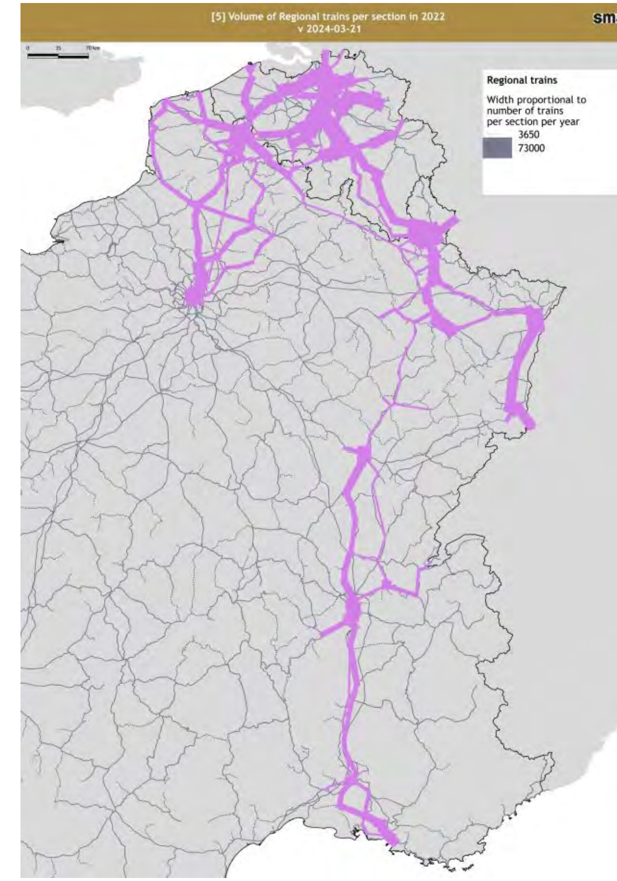
All year 2022

→ **where do the different types of planned paths run ?**





Not all high speed lines and trains are included in the perimeter

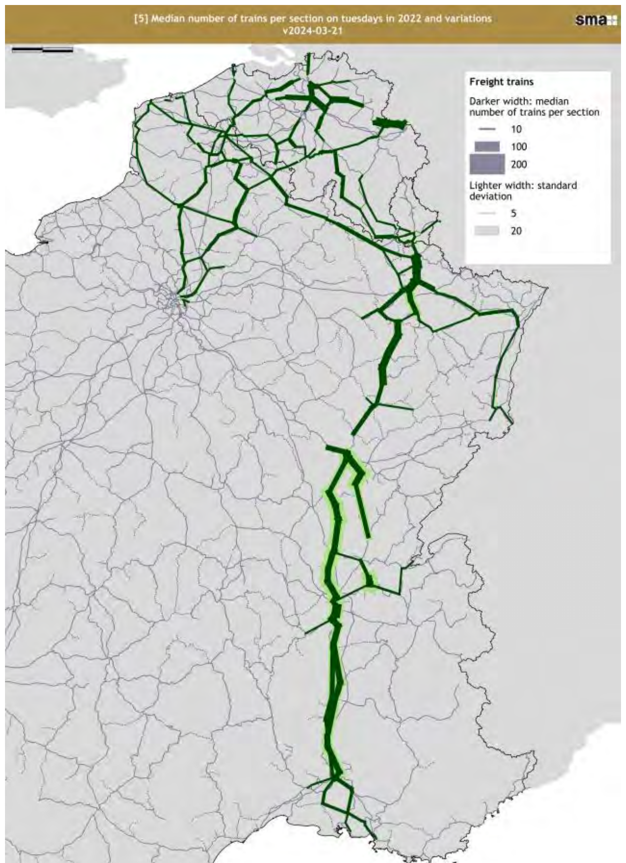


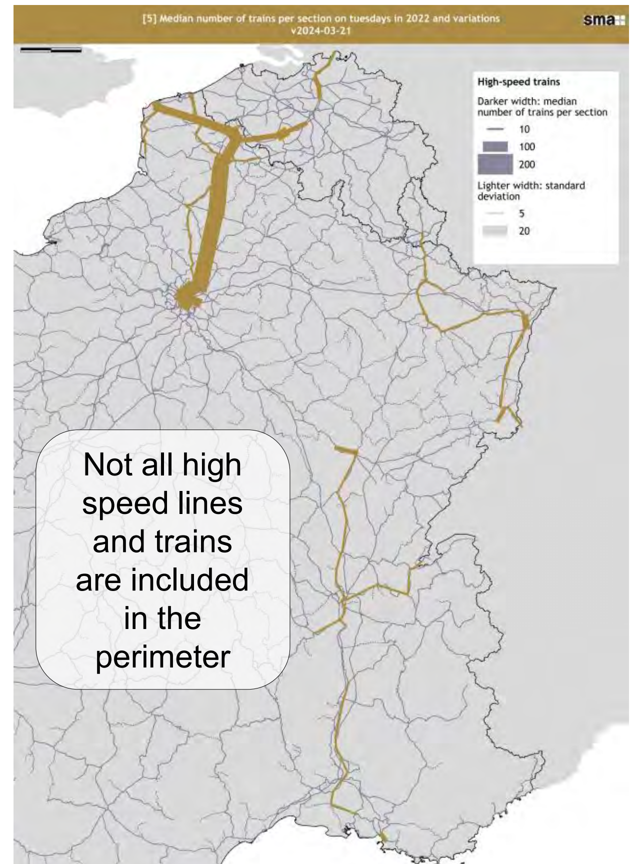
AVAILABLE CAPACITY AT A GIVEN MOMENT (2022)

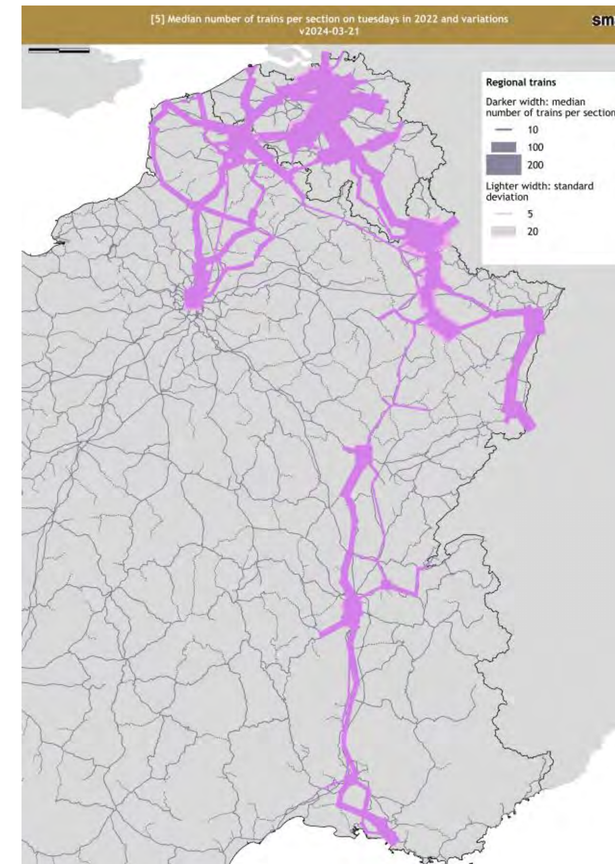
[5] Paths statistics

Daily volume per type of trains & variations (Tuesday)

All year 2022







→ Here we can see how capacity is used by different types of planned paths, and the variations that can be observed

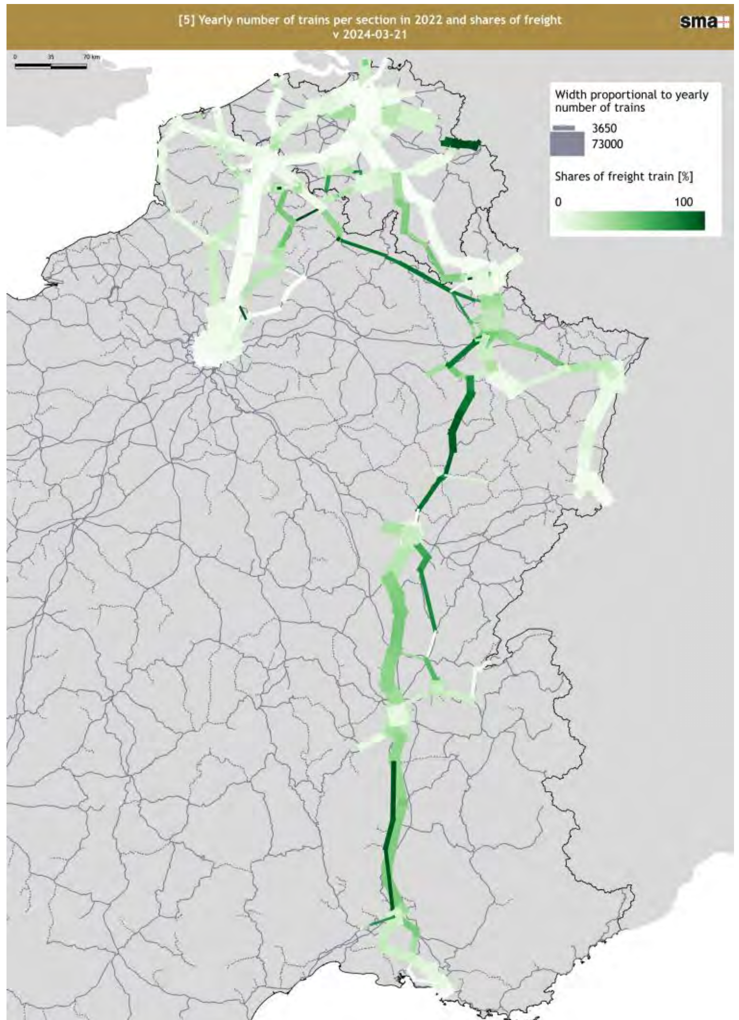
Variations can be seen on the Anvers – Bruxelles axis for regional fast trains, RER Lille – Paris North, Luxembourg, Lyon for regional slow rains, from Dijon to Marseille for freight trains.

[5] Paths statistics

Yearly number of trains and shares of freight

All year 2022

→ **This representation shows where capacity is highly used by trains, and where the freight paths use the available capacity.**



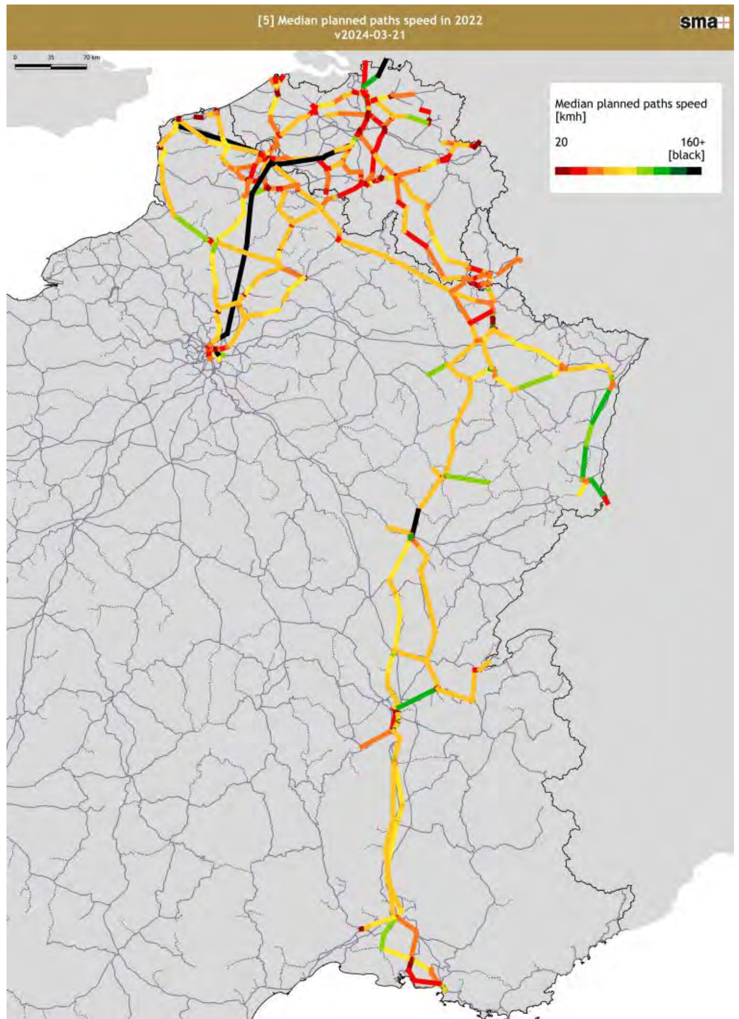
[5] Paths statistics

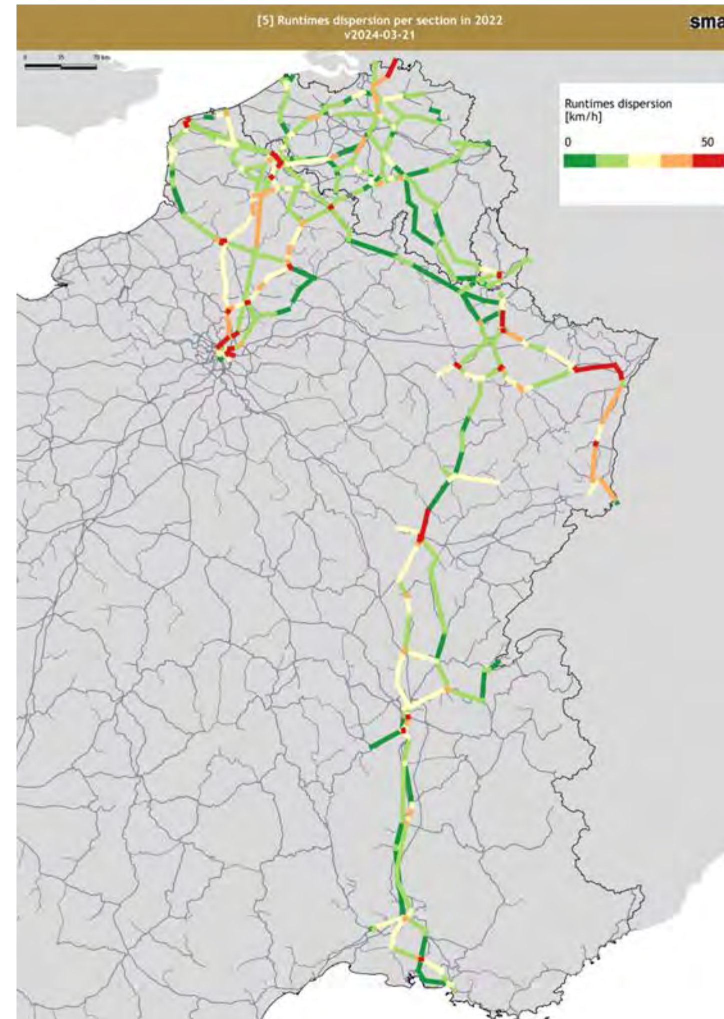
Speeds and runtimes heterogeneity

All year 2022

→ **On the left, we can see the median speed of the planned paths per section,**

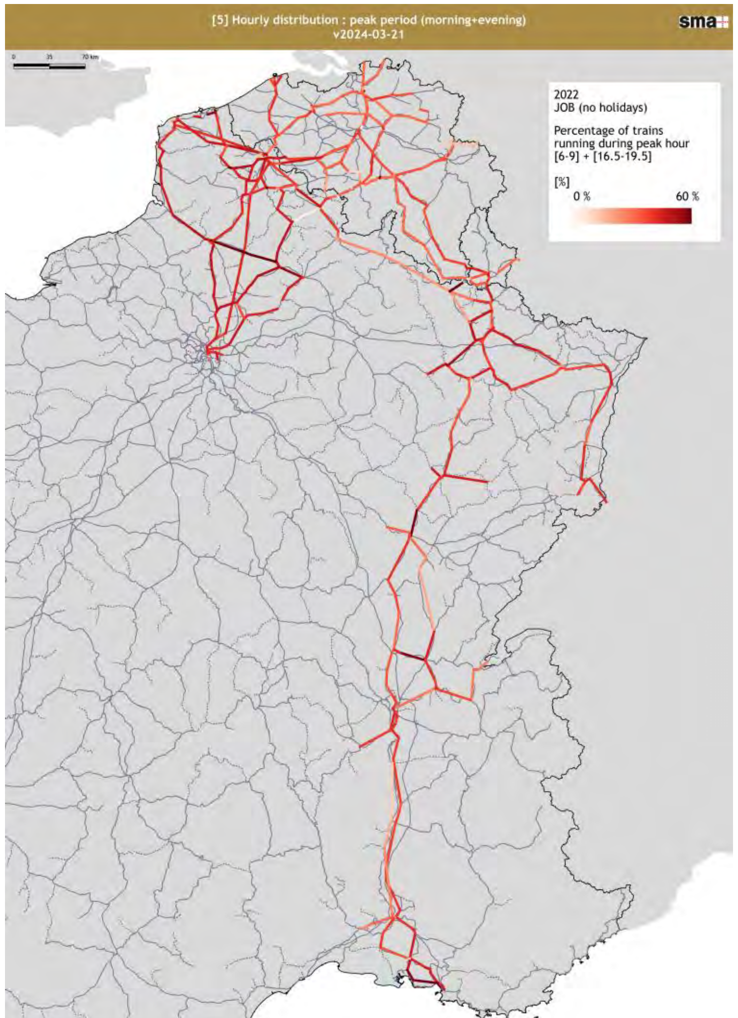
→ **On the right, we can see how runtimes are different between trains on the same section, which is a major factor of the capacity consumption**

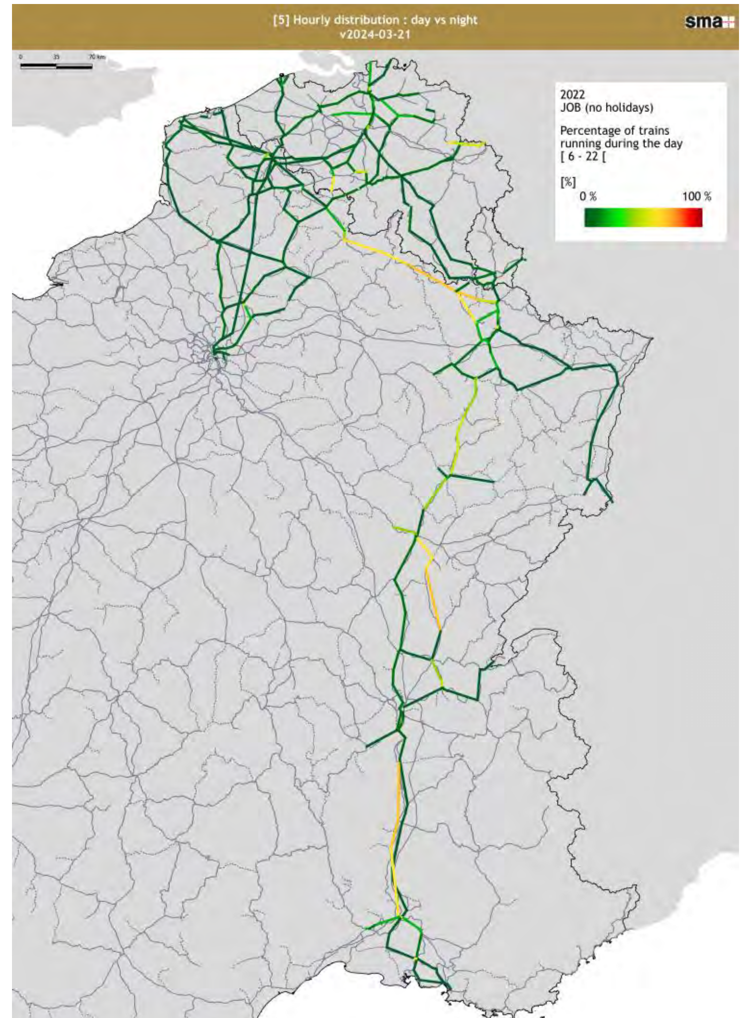




[5] Paths statistics

Daily repartition of traffic (peak vs. off-peak hours, day vs. night)





In France, the traffic is more focused during the peak-hour than in Belgium, where is seems to be more spread during the day.

% of traffic during the day vs. during the night highlights lines where freight traffic is more important.

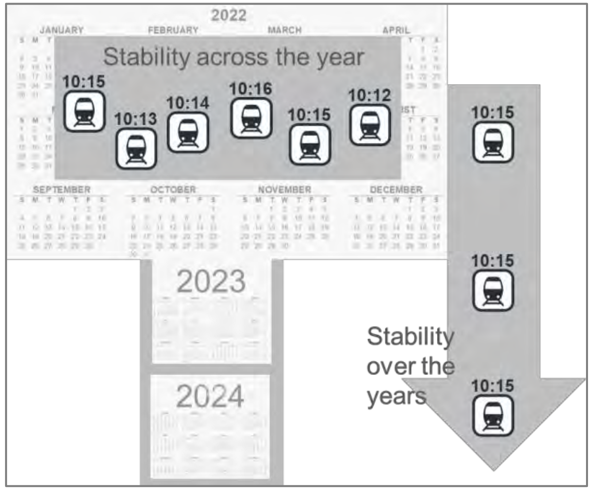
Calendar and process stability

Introduction

This chapter is not about robustness and punctuality.

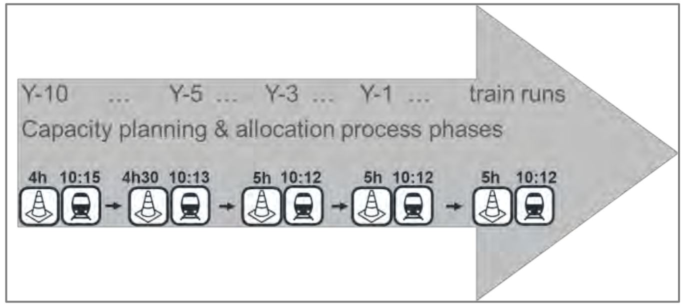
Calendar stability

Stability of the planned paths & TCRs across the year : how timetables can be different from a day to another within the year and also within the different years.



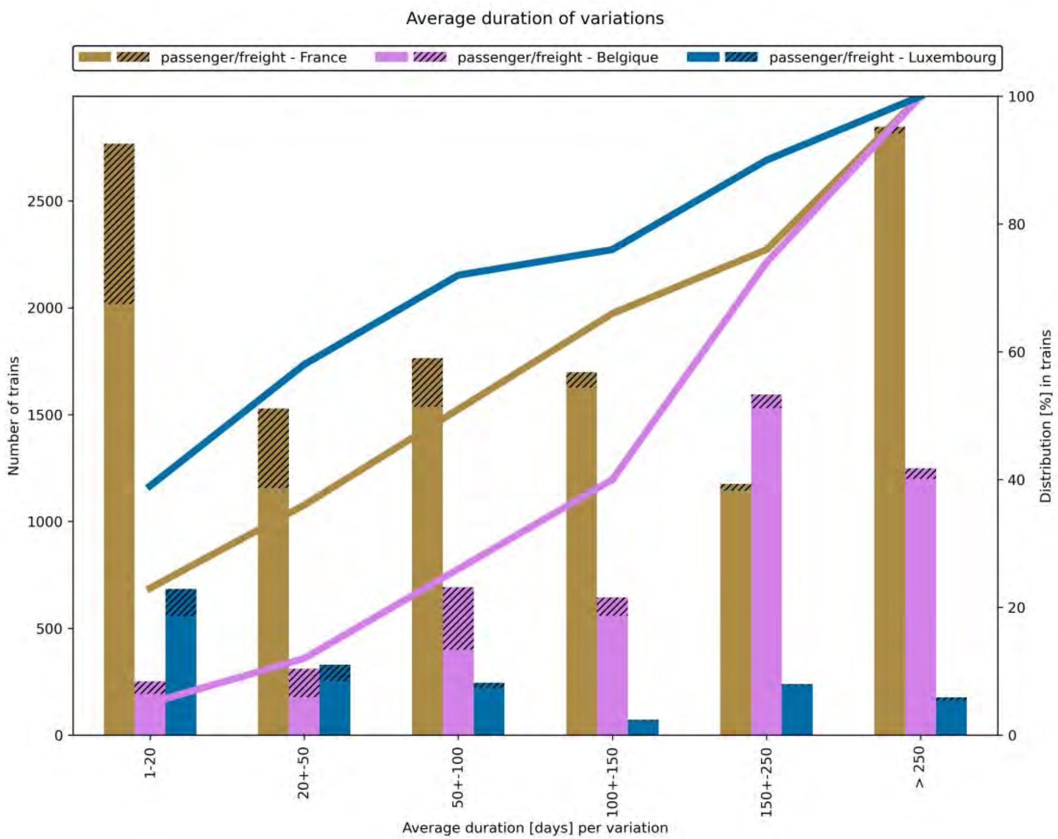
Process stability

Stability of the planned paths & TCRs across the capacity planning and allocation process : how paths & TCRs planned during the upstream phases persist along the downstream phases of the process (volumes, timetable, etc.).



[9] Calendar stability

Stability (calendar stability during the year)



In Luxembourg, in average, one path version covers less days than in Belgium.

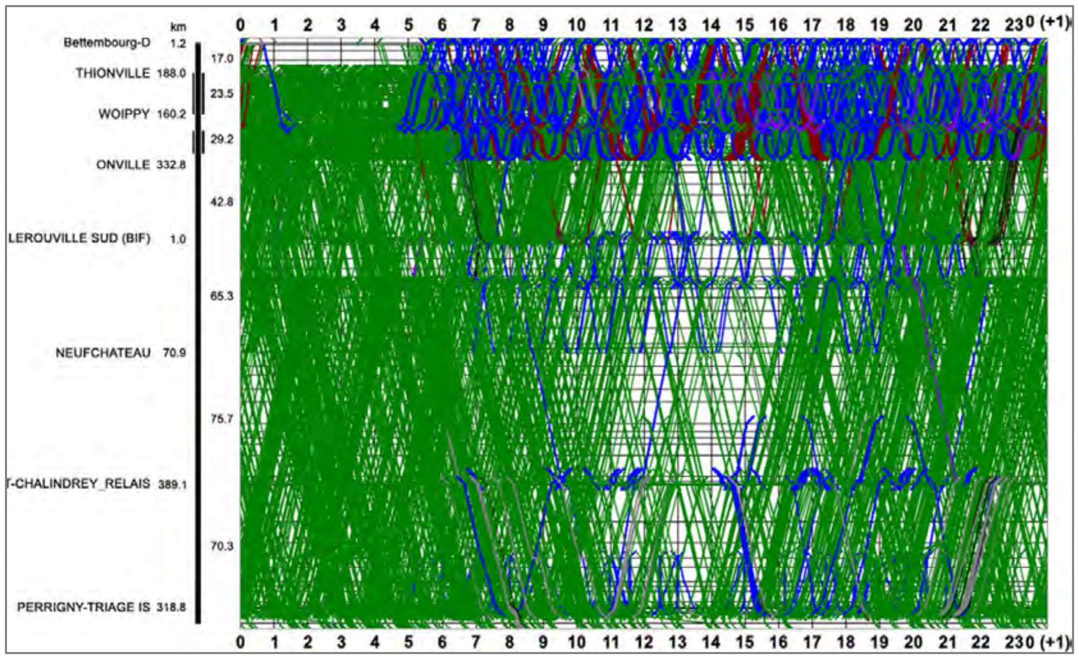
→ Calendar instability seems to be better in Belgium than France and Luxembourg

All year 2022

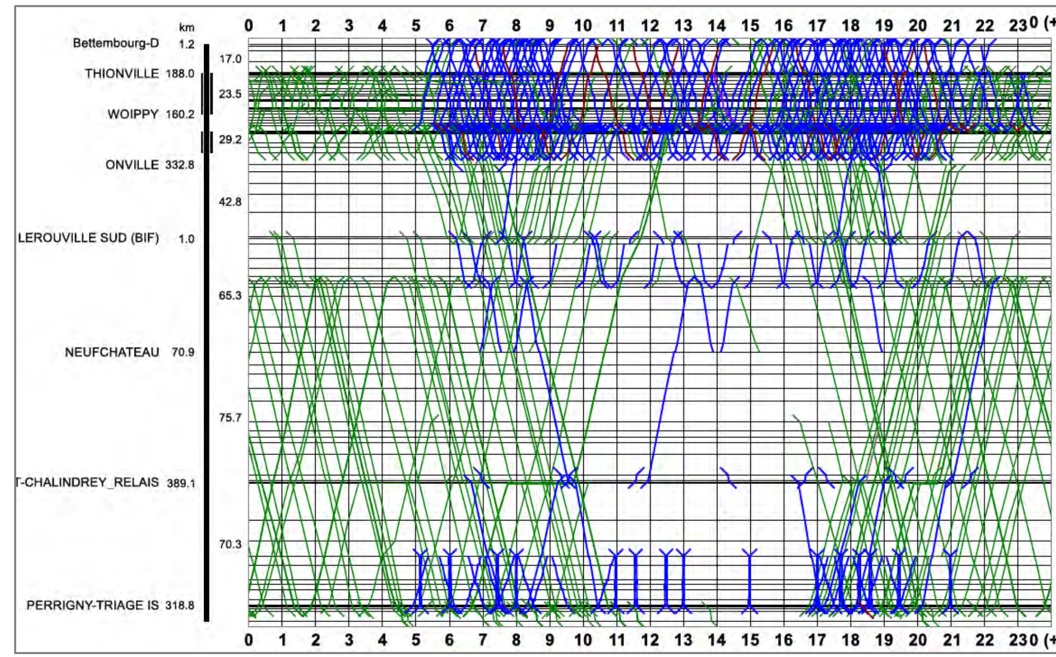
[9] Calendar stability

Stability (calendar stability during the year)

365 days planned for 2023 (FR = adaptation, LUX = adapted)



1 day planned for 2023 (FR = adaptation, LUX = adapted)



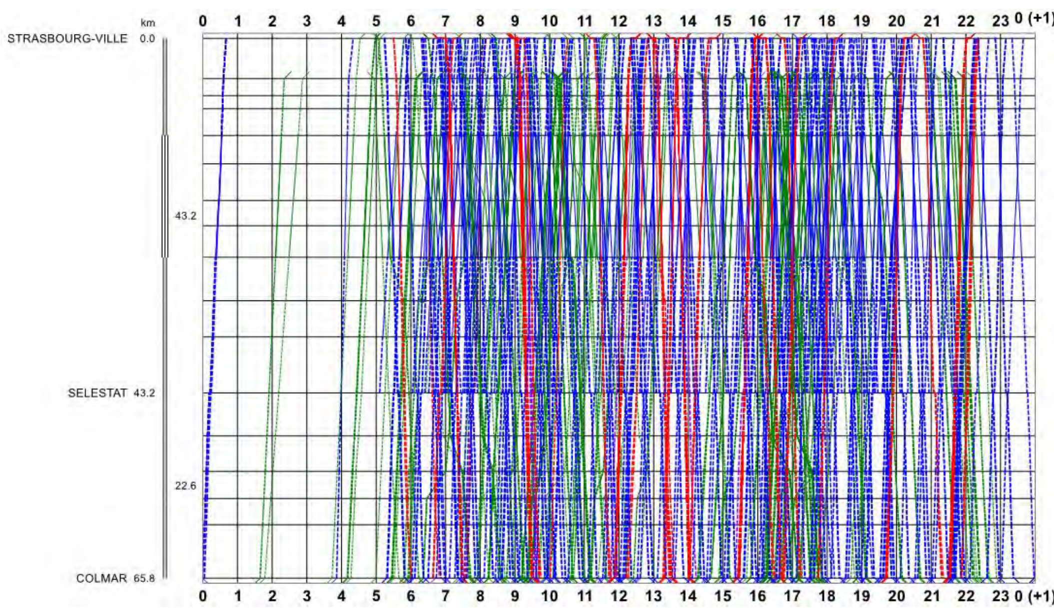
Here we can see the non-repetition of the paths from day to day. For a same path, a lot of versions exist and it limits the available capacity for a potential new daily path.

Possible KPIs to measure calendar stability : available capacity for a 365 days paths (with only one version), path compression on 1 day / paths compression on 365 days, volume of “blank” in the graphic timetable, etc.

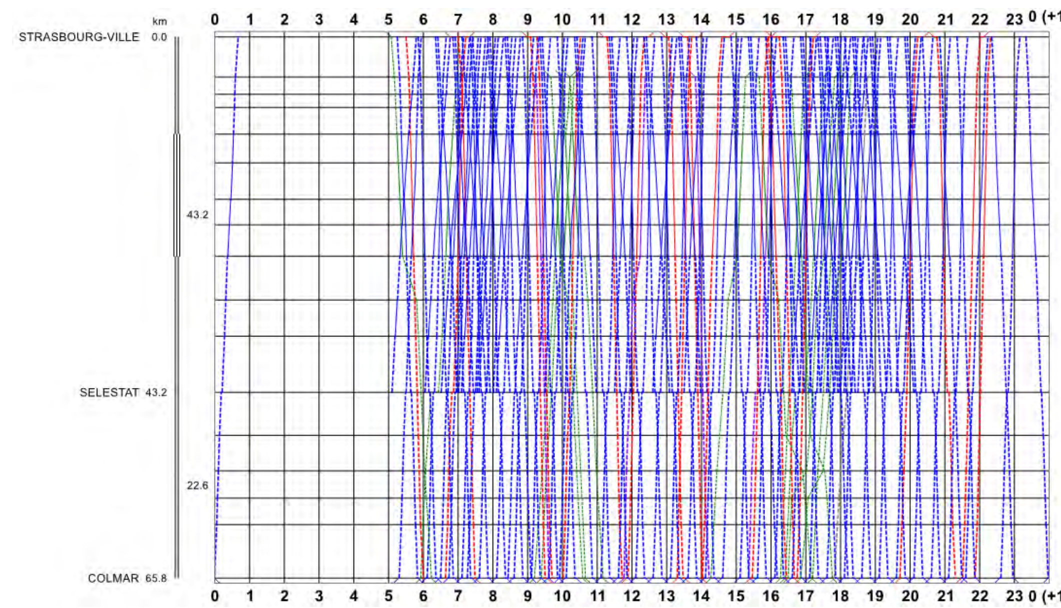
[9] Calendar stability

Stability (calendar stability during the year)

365 days planned for 2022



1 day planned for 2022

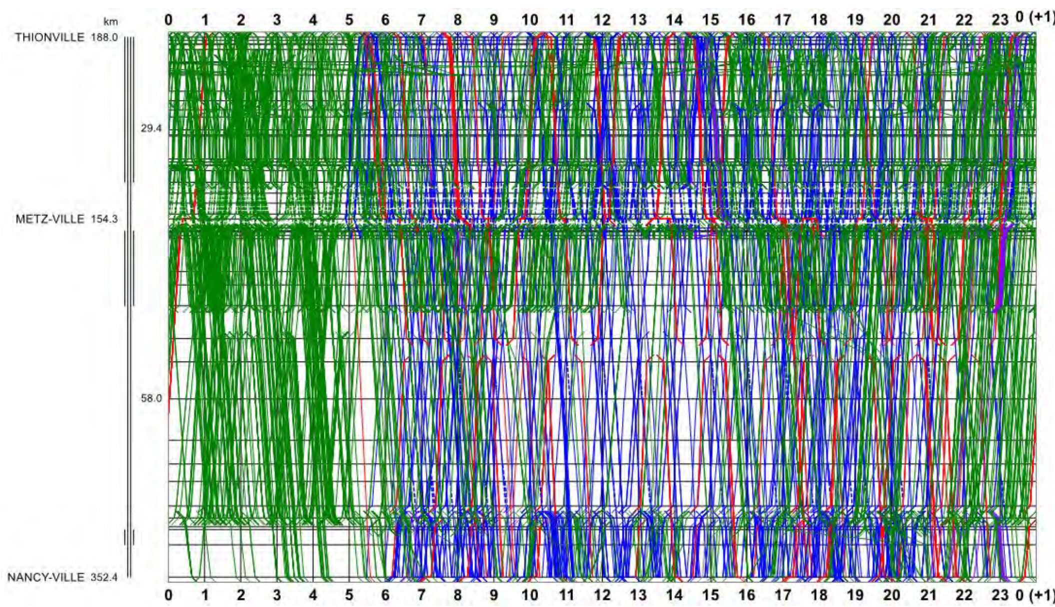


115000 rail line between Strasbourg and Colmar has a good calendar stability : very few variation of regional offer and some discrepancies on freight and high speed trains depending on the day.

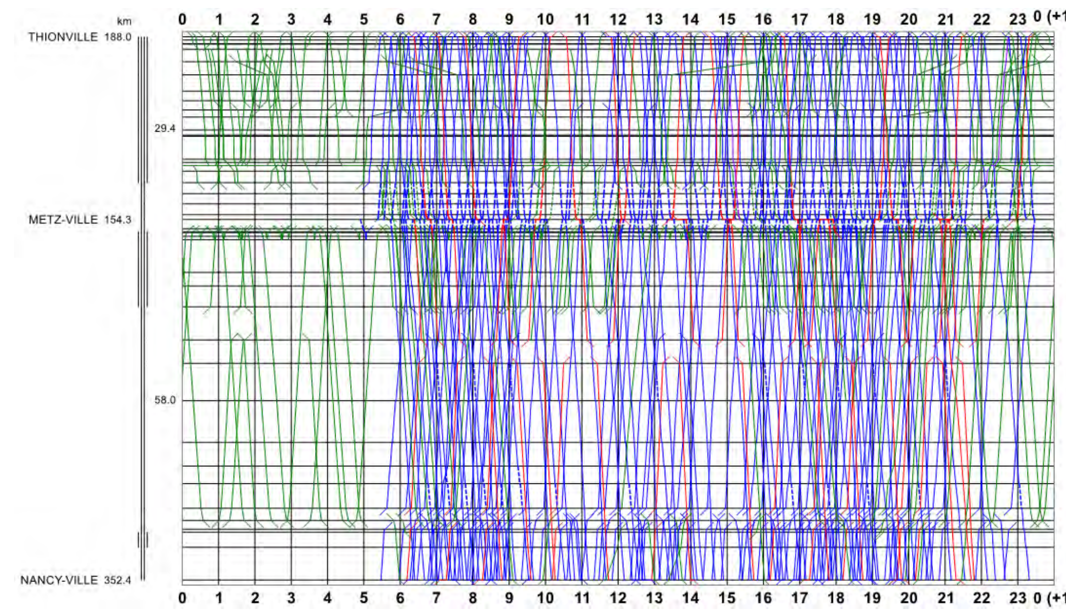
[9] Calendar stability

Stability (calendar stability during the year)

365 days planned for 2022



1 day planned for 2022

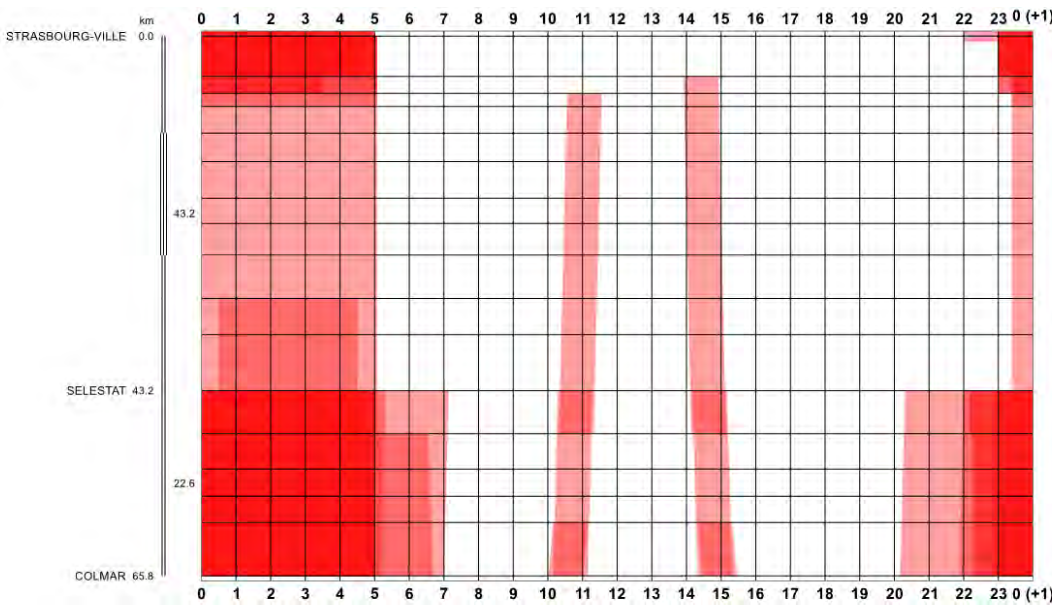


The rail line between Thionville and Metz does not have a good calendar stability. The calendar of high speed train is stable, but there are a lot of discrepancies in regional and freight offer.

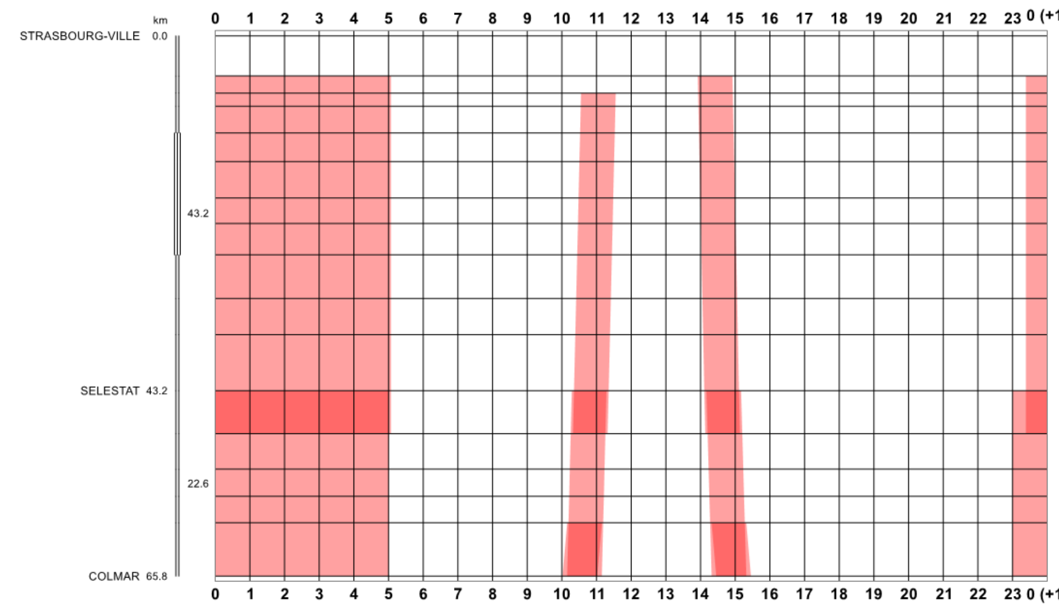
[9] Calendar stability

Stability (calendar stability during the year)

365 days planned for 2022



1 day planned for 2022

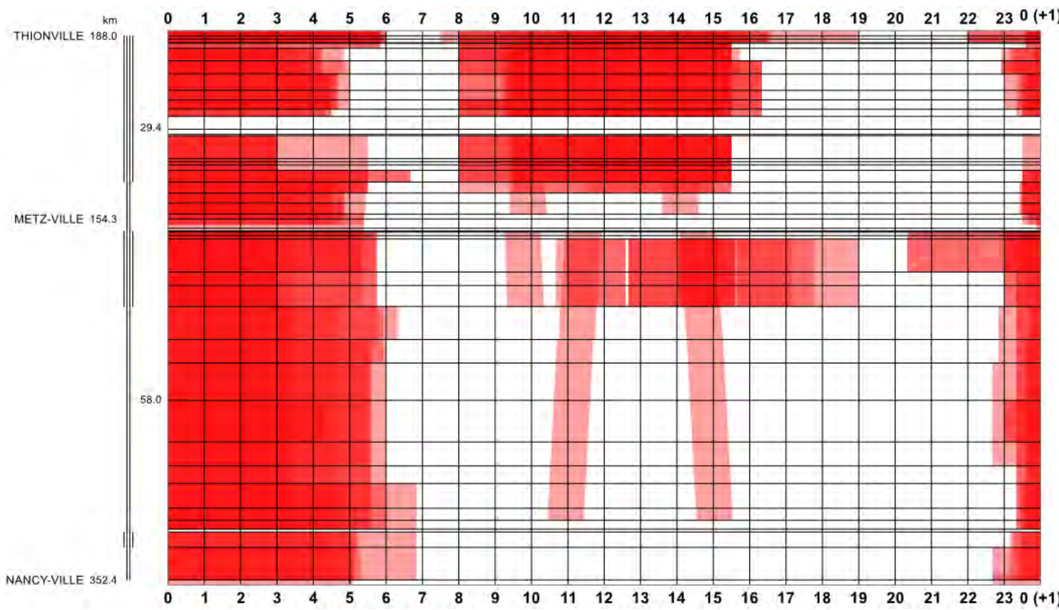


115000 rail line between Strasbourg and Colmar has a good calendar stability on works planning : wide range guaranteed without works during the day.

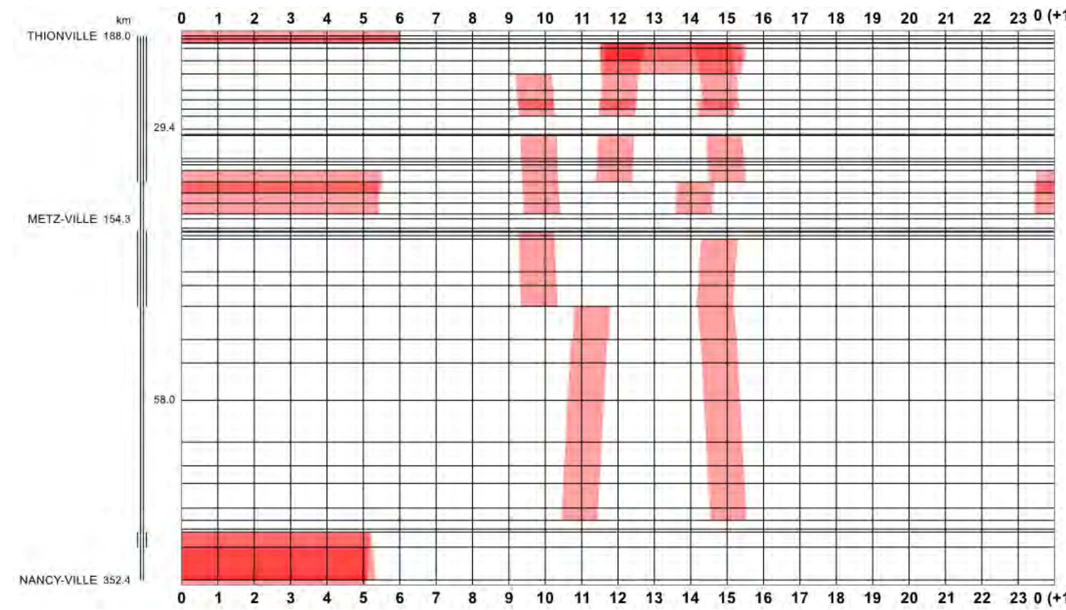
[9] Calendar stability

Stability (calendar stability during the year)

365 days planned for 2022



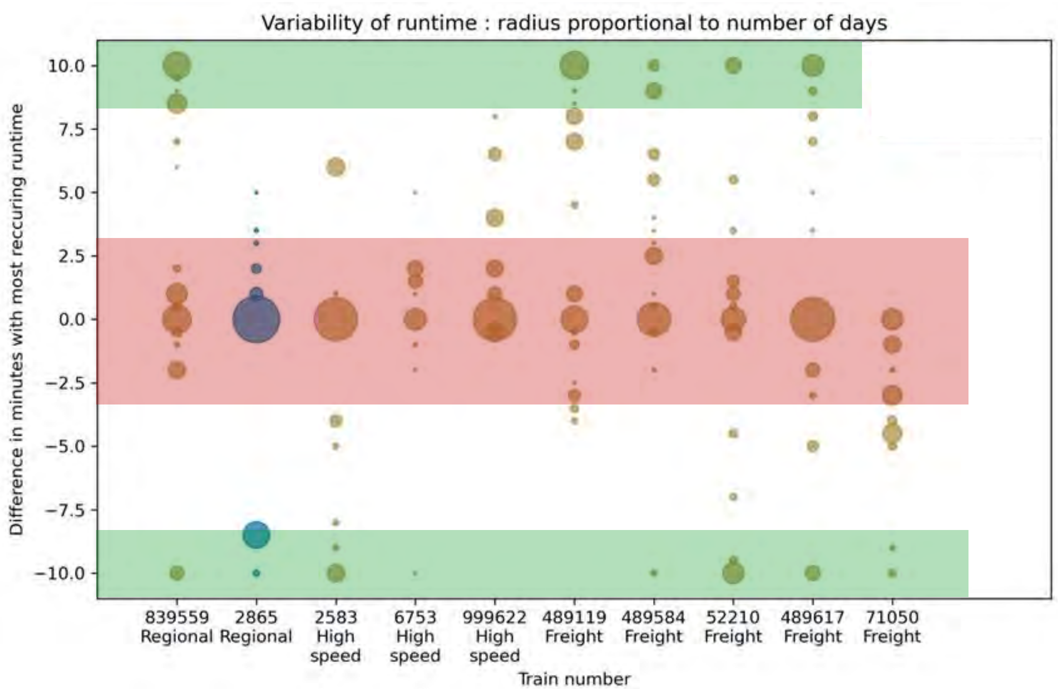
1 day planned for 2022



The rail line between Thionville and Metz does not have a good calendar stability. According to the day, the localisation and temporality of TCRs are variable .

[9] Calendar stability

Stability (calendar stability during the year)



When looking at the different path versions for some trains, it appears that a lot of versions, not always representing a lot of circulation days, are very close to the main path in runtime. Paths versions which are +/- 10' different in runtime could be other itineraries during works.

→ This representation can help the understanding of the versioning causes

→ Some paths have same OD, train n°, and runtime, but still different versions

All year 2022

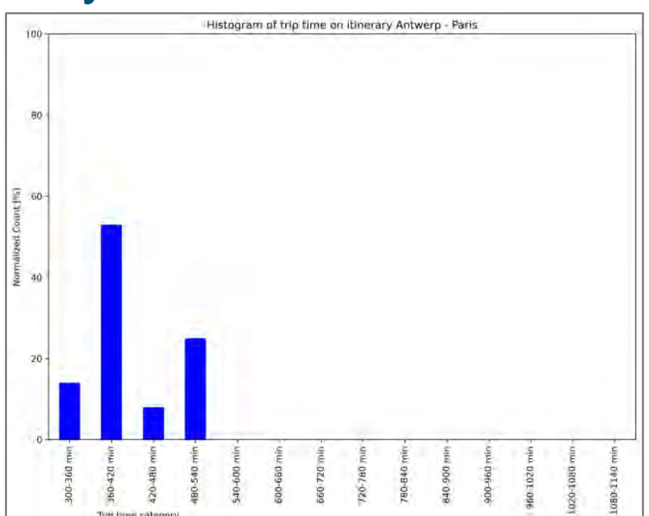
[9] Calendar stability

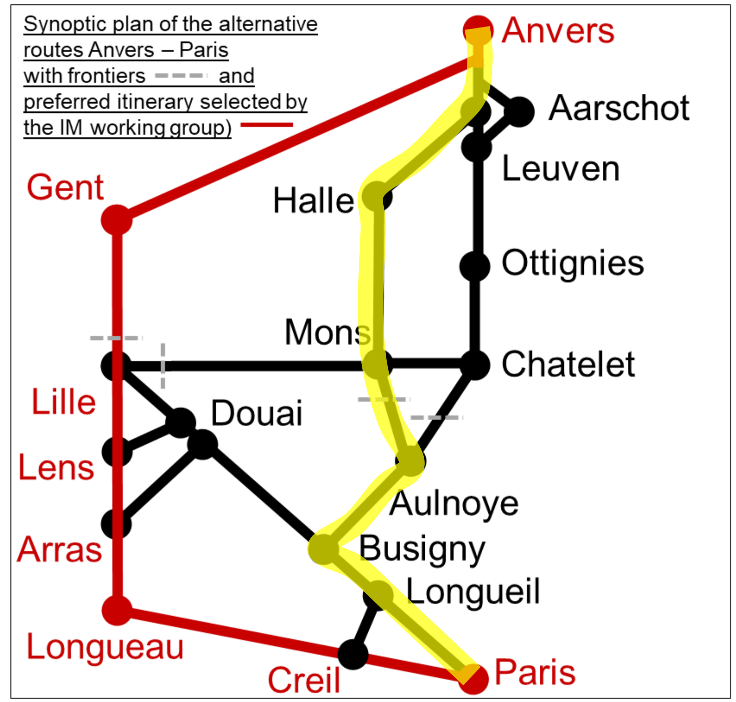
Stability (calendar stability during the year) : itineraries

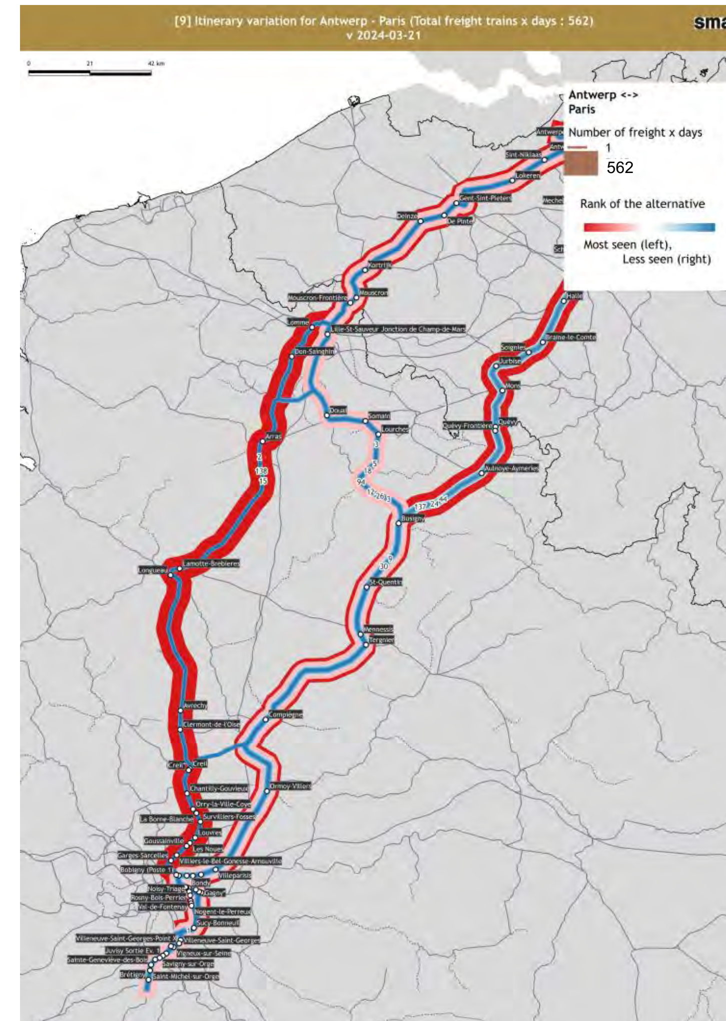
Other routes available in annexes and portfolio

Trains running on Anvers – Paris are planned via the preferred itinerary but also go via Bruxelles and Busigny.

All year 2022







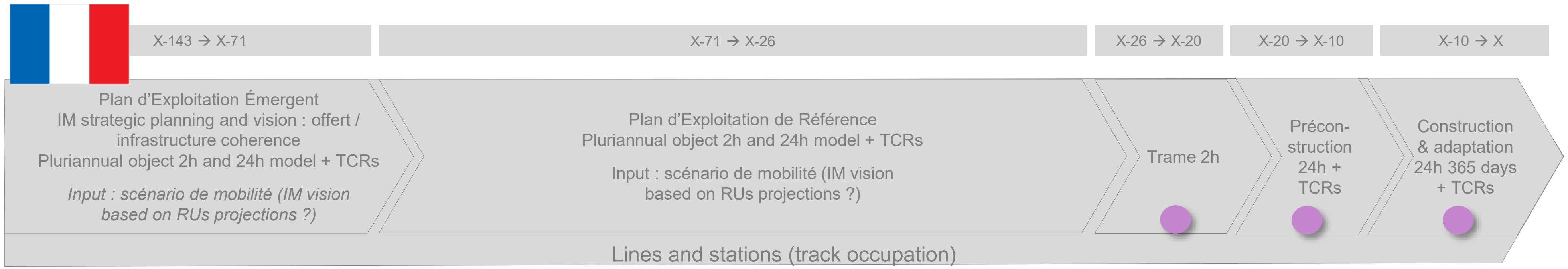
[9] Calendar stability

Stability (calendar stability during the year)

- Calendar stability is an important capacity KPI : it's more difficult to allocate a daily path in an environment with high calendar instability,
- Excessive versioning can be linked to TCRs, RUs requests, capacity allocation process, IMs tools, etc., and increase exponentially, here are examples of what has been implemented to reduce the versioning :
  - LUX proposes to group rolling stock in its tool (avoid a version for a path with 2 similar rolling stock),
  - LUX advises RUs against the paths versions requests for TCRs,
  - French IM forbids versions at less than 3' difference of travel time,
- To calculate the calendar stability with a "train numbers based" method, it's necessary to have a train number stability,
- To calculate this KPI it's necessary to consider all the versions (so potentially it's calculated after the end of the planned year)

[9] Process stability

Paths and TCRs stability across the capacity allocation process



Annual service 2022 is provided by SNCF Réseau at the end of 3 different steps of the capacity process.

We compare the different versions of some paths across these steps.

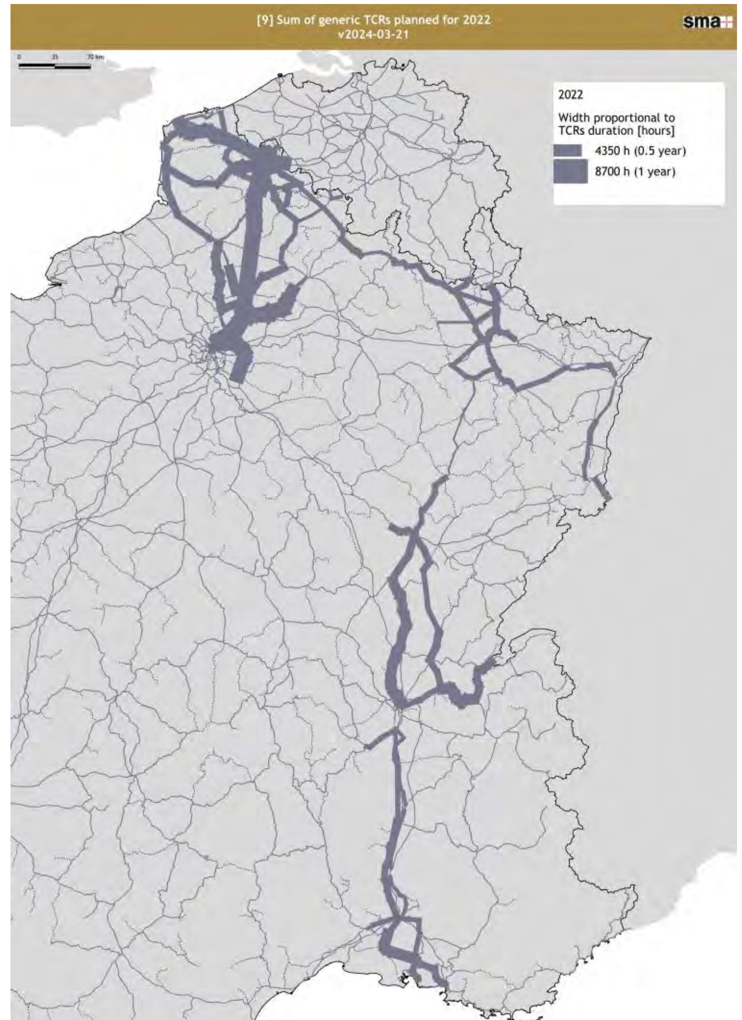
The stability KPIs proposed here can't be automated for now, because of the data quality, so :

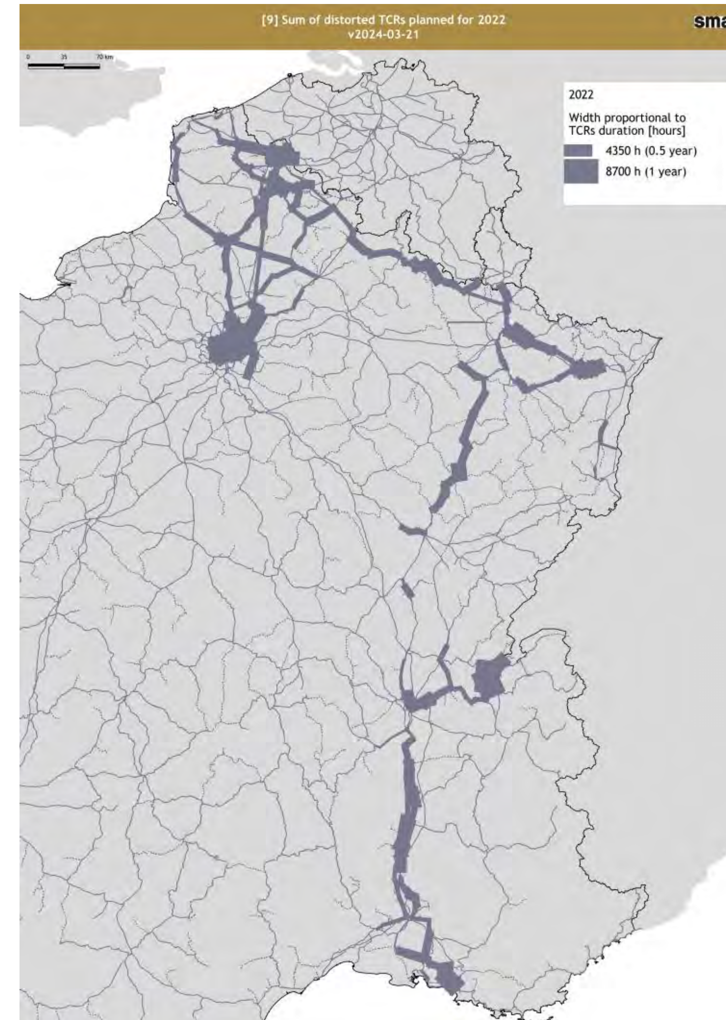
- 3 path- families are chosen here as examples for paths
- Only France is analysed for TCRs

[9] Process stability

TCRs stability across the capacity allocation process

- BE : no data
- LUX : changes between the beginning of the TCR planning > 3 month before the service change are in the data, could be manually importable (not done here), in 2022 for 223 TCR objects, 189 change requests,
- FR : differences between the “structure générique” and “déformées”.



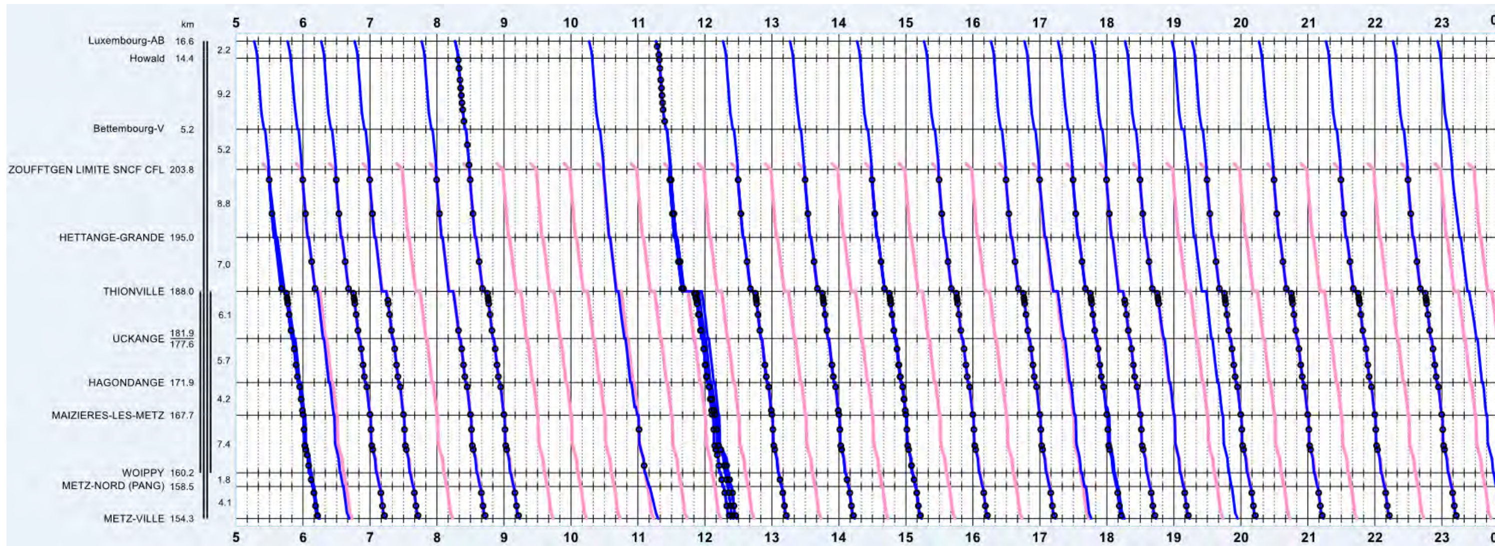


[9] Process stability

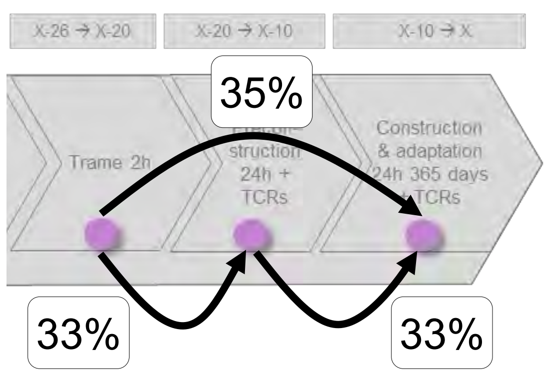
Paths stability across the capacity allocation process : ex. LUX > Metz

Comparison between steps « Trame 2h » in pink and « Construction 24h x 365 days » in blue.

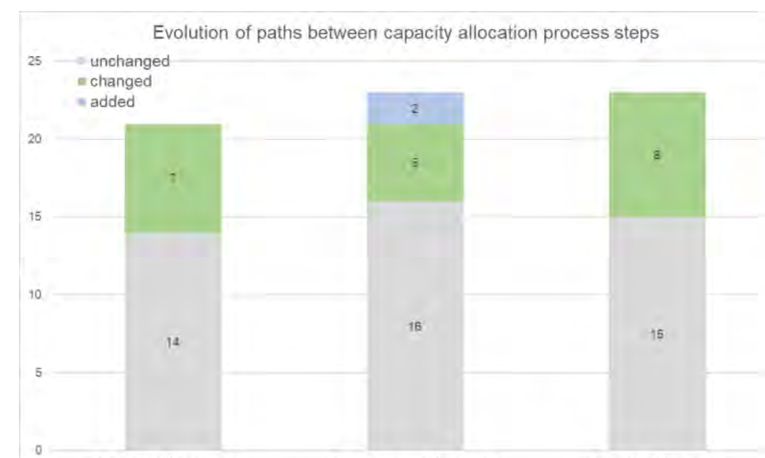
8 trains over 23 (35%) are different.



Detailed methodology, and examples of a freight train and a Strasbourg – Basel TER200 train are available in annexes



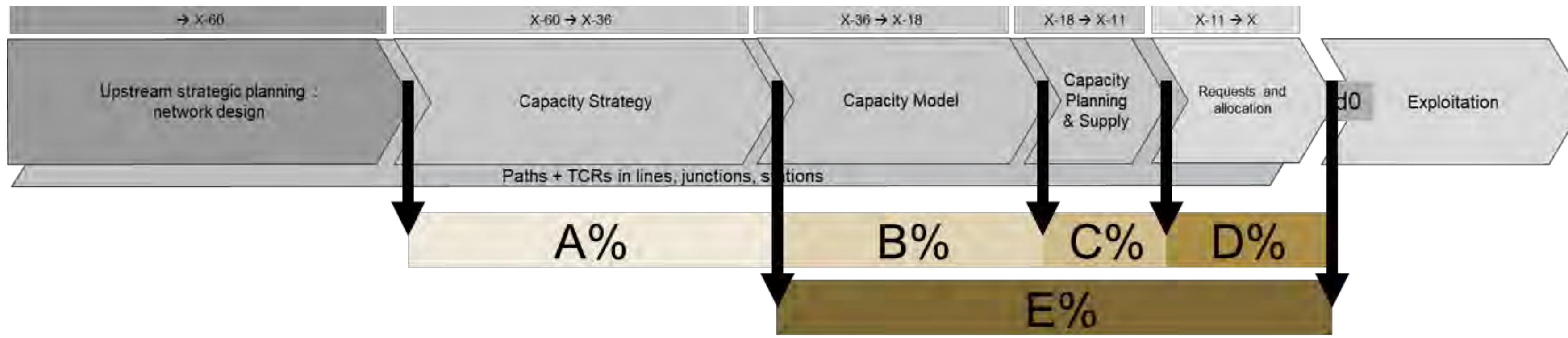
Paths that have been changed from a step to the next one, and between the first and the last step of the analysis.



[9] Process stability

Paths stability across the capacity allocation process

Proposed KPI to measure the stability across the capacity allocation process.



The 4 paths evolution KPIs are calculated between the end of the main capacity planning and allocation steps, beginning after the end of the upstream strategic planning phase, until the last planned state of the paths. A 5th KPI can be added, between the end of the capacity strategy and the last planned state. Added and changed paths can be separated.

Assumptions : % are counted in “paths.day”, changes are considered if a path is added or deleted, if the departure or arrival time is changed, and, for passengers only, if a stop is added or cancelled. These assumption depends on the aims of the different paths across the steps (are they planned to be exactly copied or not, for example some freight paths).

Hurdles : **historical states of the paths have to be available in the tools**.

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Agenda

1. Context, scope, goals and methodology of the study
2. Assumptions
3. Available capacity at a given moment (2022)

   3A Proposed KPIs

   3B Bottlenecks
4. Multi annual vision of the capacity development
5. Comparison between planned and real
6. Synthesis

Bottlenecks prioritisation

Here some bottlenecks have been identified, based on analysis A. Analyses B and C couldn't be managed entirely and analysis D was out of scope.

That is why the identified bottlenecks are not prioritised here.

Once the bottlenecks are identified and prioritized, it's necessary to :

- Separate those linked to specific works or other punctual capacity objects
- Group them to find the areas to study
- Use the capacity analysis KPIs and the toolbox to understand the stakes. 5 bottlenecks have been studied in this way here, 1st one is following and the others are available in the annexes.

A

Elements of infrastructure with compression rates over thresholds

B

Routes where adding paths is not possible, by any itinerary

C

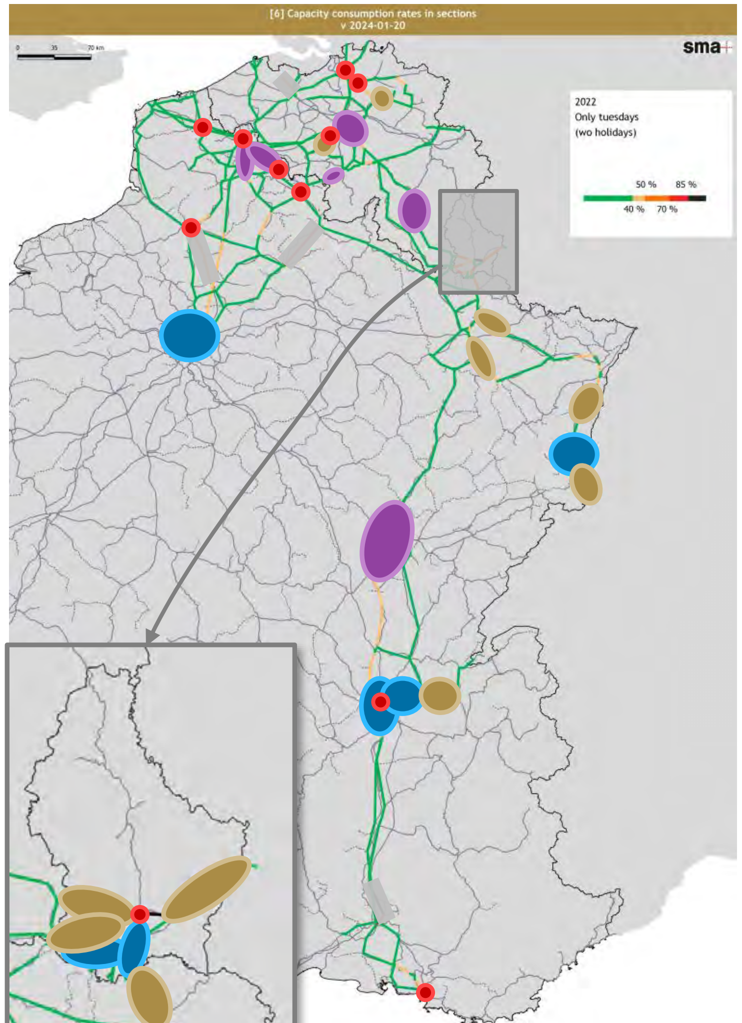
Elements of infrastructure where delays linked to capacity happen

D

Level of potential difficulties **for elements of infrastructure** with compression rates ranges over thresholds

Bottlenecks identification

Here based on Tuesdays (no holidays) 2022 with trains and TCRs



Lines with a majority of sections > 50%, and some sections > 70%, or single sections > 70%

Ile-de-France
Lyon – Ambérieu
L6 Luxemburg
L6f Luxemburg
NFL (noeud ferroviaire lyonnais)
Colmar – Mulhouse

Sections between 60 and 70%

Chagny – Is-sur-Tille
Rochefort – Libramont
Lille – Ostricourt
Watermael – Ottignies
Lille – Valenciennes
Hourpes – Lobbes

Sections between 50 and 60%

Thionville – Zoufftgen
Aarschot – Diest
Ambérieu – Culoz
Rixheim – St-Louis
Metz – Rémilly
Blainville – Nancy – Pont-à-Mousson
Tubize – Braine-le-Comte, Ruisbroek – Lot
L5 Luxemburg
L7 Luxemburg
L3 Luxemburg
Sélestat – Strasbourg

Junctions (some are grouped) *

Hazebrouck
Anvers
Longueau
Lille
NFL
Beuvrage

Nazareth
Marseille
Luxembourg
Aulnoye
Ruisbroek

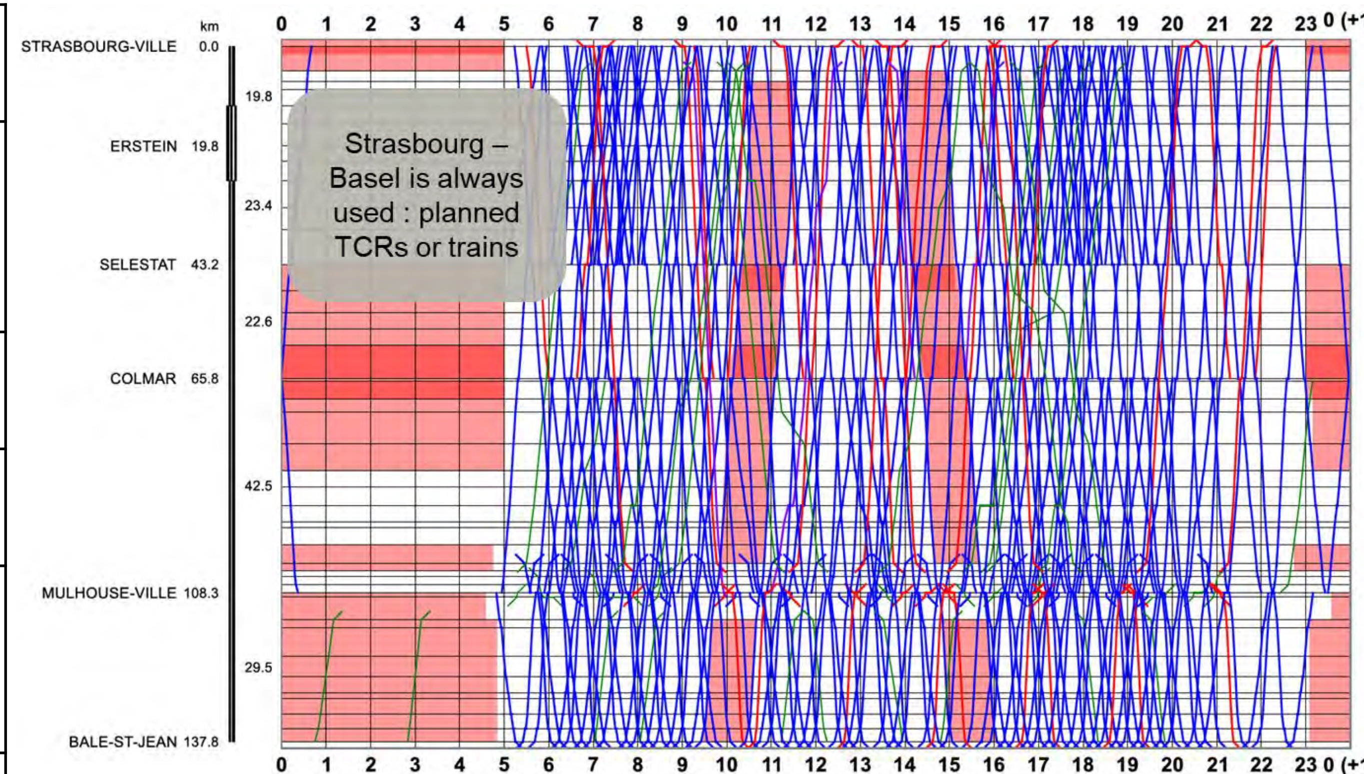
** Few junctions appear in France because a lot of them weren't modelled in the provided database*

Bottlenecks characterisation

Name	Kind	Values	Traffic volume	Signalling performance	Runtimes heterogeneity	TCRs	Timetable optimisation	Other reasons
Strasbourg – Basel		Ex. CMR-MSE 79%	X		X	X	X	
Luxembourg / Pétange - Bettembourg		Ex. Berchem-BET 89%	X	X		X		
Lyon – Ambérieu		Ex. Lyon-Ambérieu 100%	X		X		X	
Lier – Aarschot – Diest / Leuven	Sections, junctions combination	Ex. Y. Nazareth 66%	X		X			Combination
Lille / Lens – Somain		Ex. Ostricourt – Lille 69%						Combination

Bottlenecks : zoom on Strasbourg – Basel

▼ negative impacts on capacity		High heterogeneity of runtimes on the sections
		High volume of trains during all day : high speed, TER200, freight, regional and local trains
		High volume of TCRs during the night + 1h during the day
		Low timetable optimisation due to commercial constraints
▲ positive impacts on capacity		Good signalling performance
Diverse significant observations		Over-decomposition of the network due to infrastructure topology
		Low calendar instability of paths and TCRs

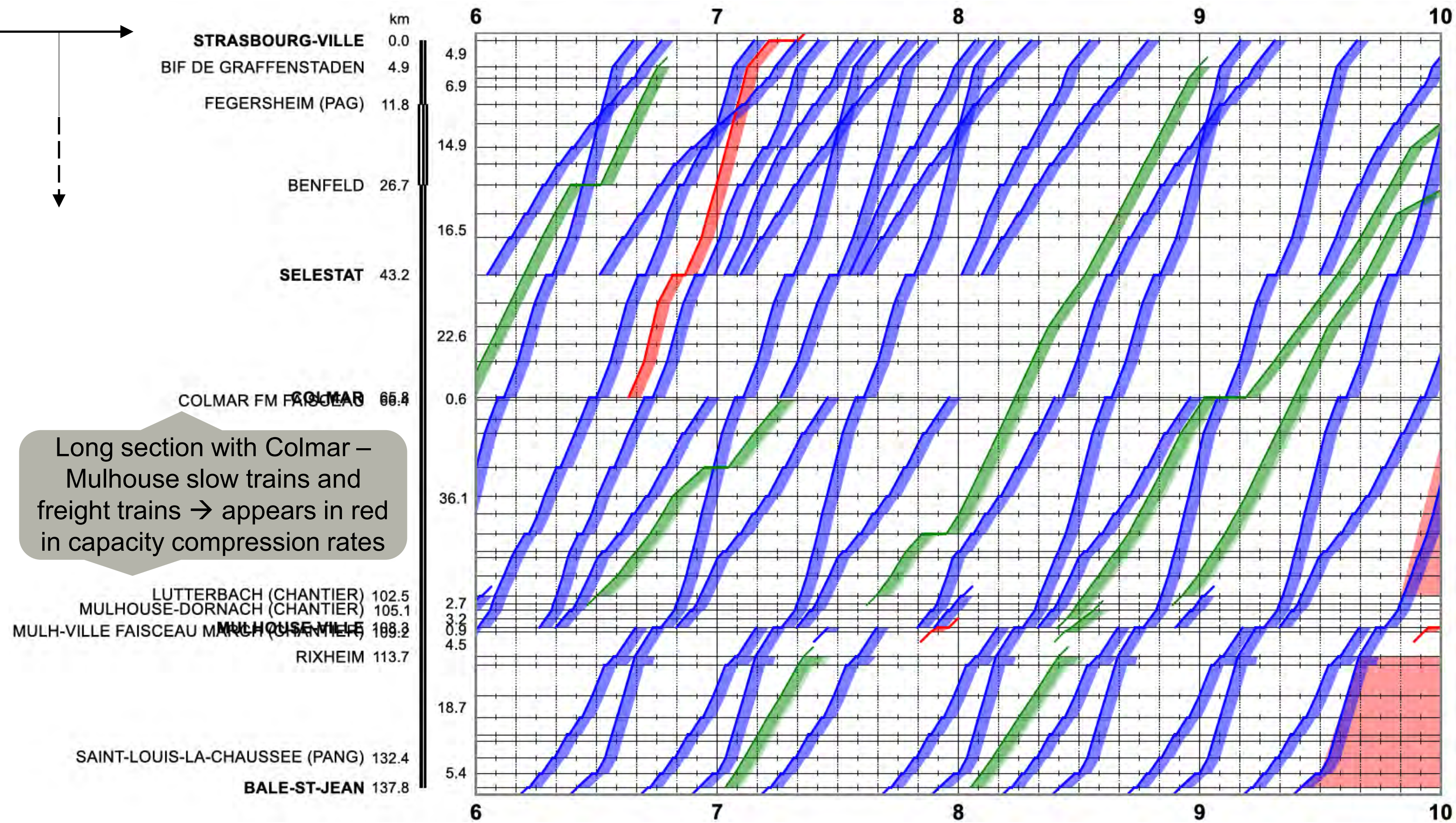


Bottlenecks : zoom on Strasbourg – Basel

Over-decomposition of the network due to infrastructure topology (network is cut where name are displayed here).

UIC 406 rules are used here, but with the 365 days analysis can lead to an over-decomposition (see chapter 2).

Names > where sections are cut



CORRIDOR NORTH SEA – MEDITERRANEAN

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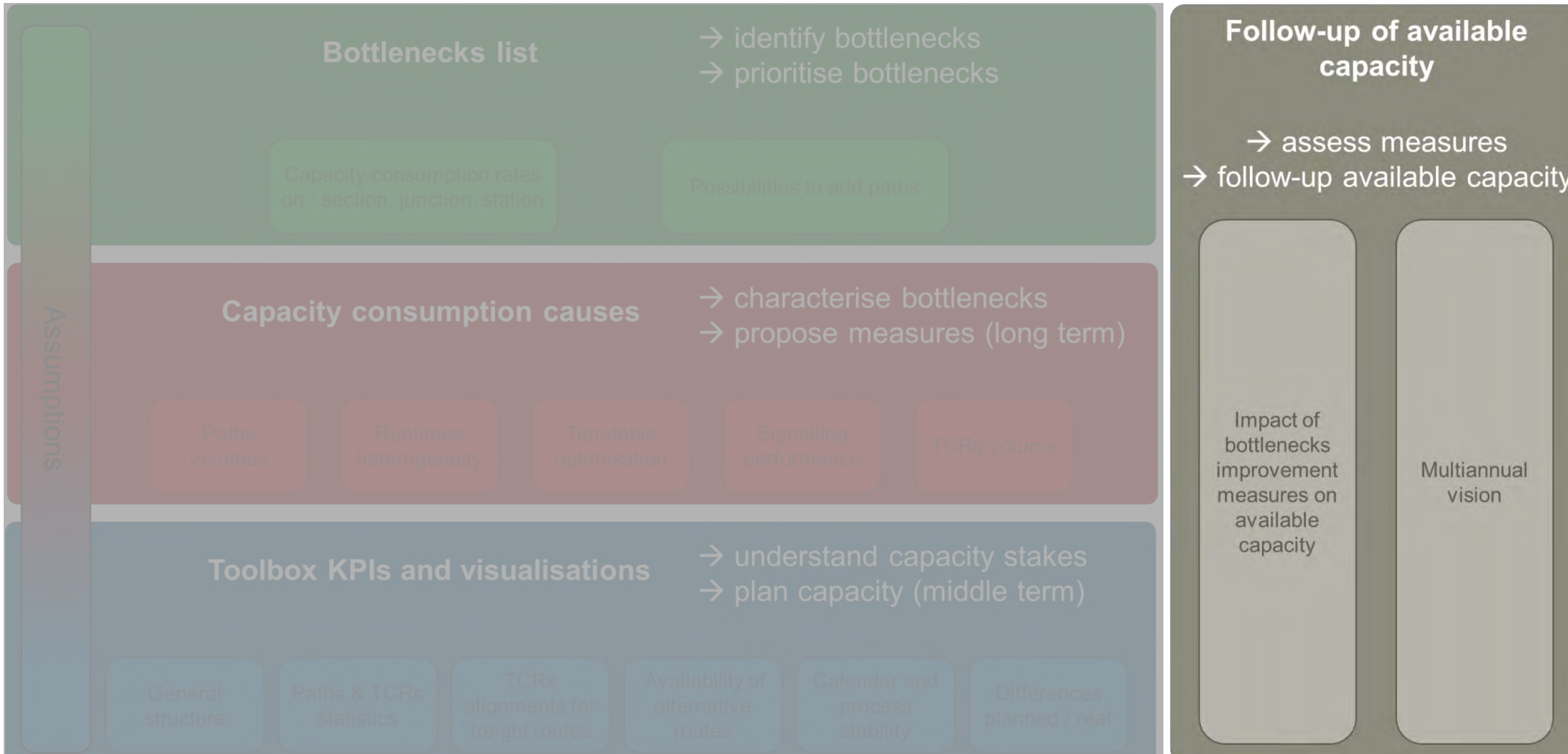
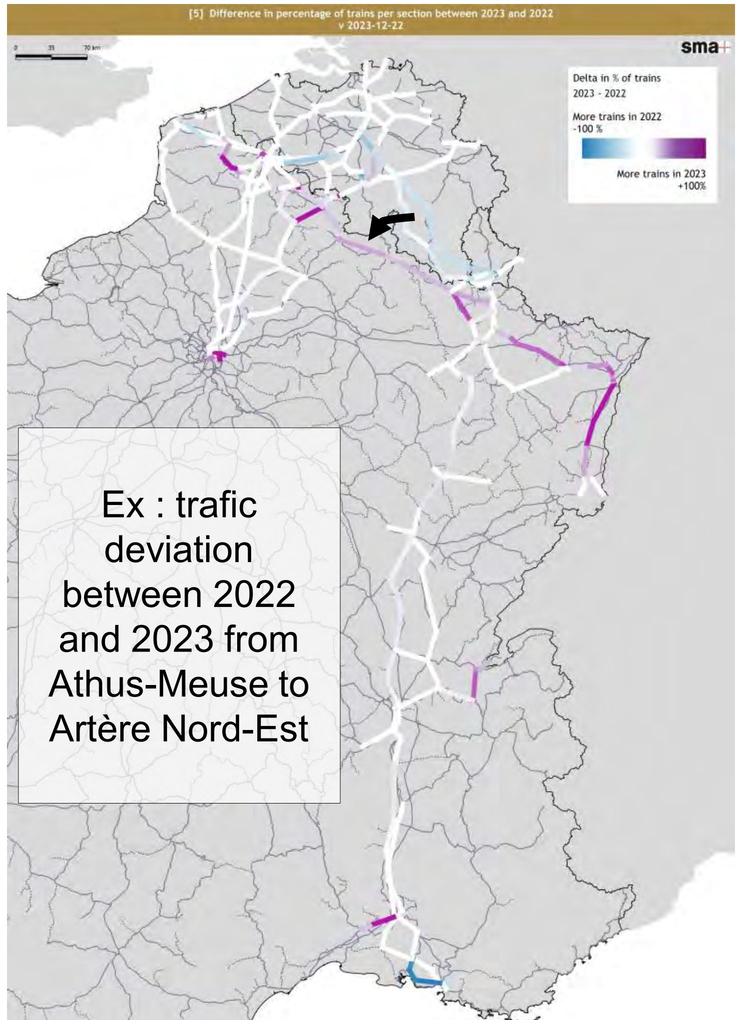
Usages of the capacity KPIs and visualisations

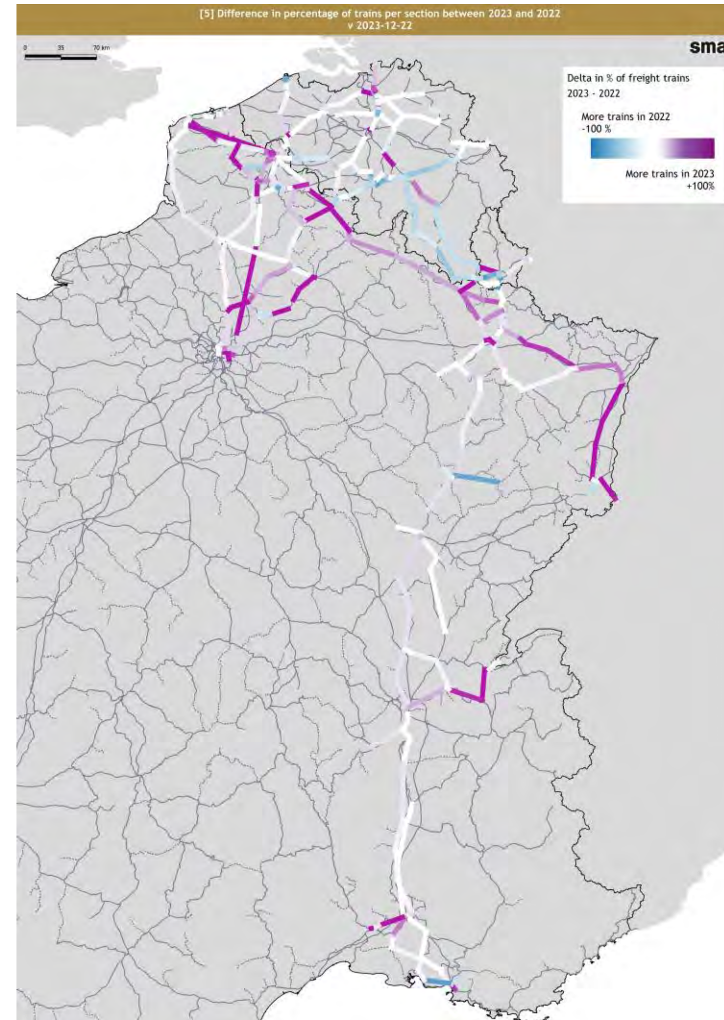
Past, planned, and projected capacity for paths & TCRs



[5] Paths statistics

Yearly volume of trains can be interesting to visualise the main changes in the traffics or itineraries.





[6] Capacity consumption rate

Stations - Example of Thionville

OTR in Thionville station track section

Higher occupancy rates in PEE 2030 are the consequence of increased frequencies compared to PER 2025

Track	OTR (Occupancy Time Rate) PER 2025	OTR (Occupancy Time Rate) PEE 2030
1M	OTR = $\frac{8}{120} * 100 = \mathbf{7}\%$	$\mathbf{10}\%$
2M	OTR = $\frac{12}{120} * 100 = \mathbf{10}\%$	$\mathbf{7}\%$
VF	OTR = $\frac{14}{120} * 100 = \mathbf{12}\%$	$\mathbf{12}\%$
VE	OTR = $\frac{56}{120} * 100 = \mathbf{47}\%$	$\mathbf{10}\%$
VD	OTR = $\frac{36}{120} * 100 = \mathbf{30}\%$	$\mathbf{59}\%$
VC	OTR = $\frac{18}{120} * 100 = \mathbf{15}\%$	$\mathbf{45}\%$
VB	OTR = $\frac{50}{120} * 100 = \mathbf{42}\%$	$\mathbf{64}\%$
VA	OTR = $\frac{0}{120} * 100 = \mathbf{0}\%$	$\mathbf{0}\%$

Result : switches areas

Infrastructure improvements for PEE 2030 explain the lower occupancy rate at this time horizon.

Switch Area	OTR (Occupancy Time Rate) PER 2025	OTR (Occupancy Time Rate) PEE 2030
North	OTR = $\frac{73}{120} * 100 = \mathbf{61}\%$	**52%**
South	OTR = $\frac{75}{120} * 100 = \mathbf{62.5}\%$	**49%**

[6] Capacity consumption rate

Stations - Example of Thionville

OTR in Thionville station track section

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VD	OTR = $\frac{36}{120} * 100 = \mathbf{30}\%$	**59%**
VC	OTR = $\frac{18}{120} * 100 = \mathbf{15}\%$	**45%**
VB	OTR = $\frac{50}{120} * 100 = \mathbf{42}\%$	**64%**
VA	OTR = $\frac{0}{120} * 100 = \mathbf{0}\%$	**0%**

Result : switches areas

Infrastructure improvements for PEE 2030 explain the lower occupancy rate at this time horizon.

Switch Area	OTR (Occupancy Time Rate) PER 2025	OTR (Occupancy Time Rate) PEE 2030
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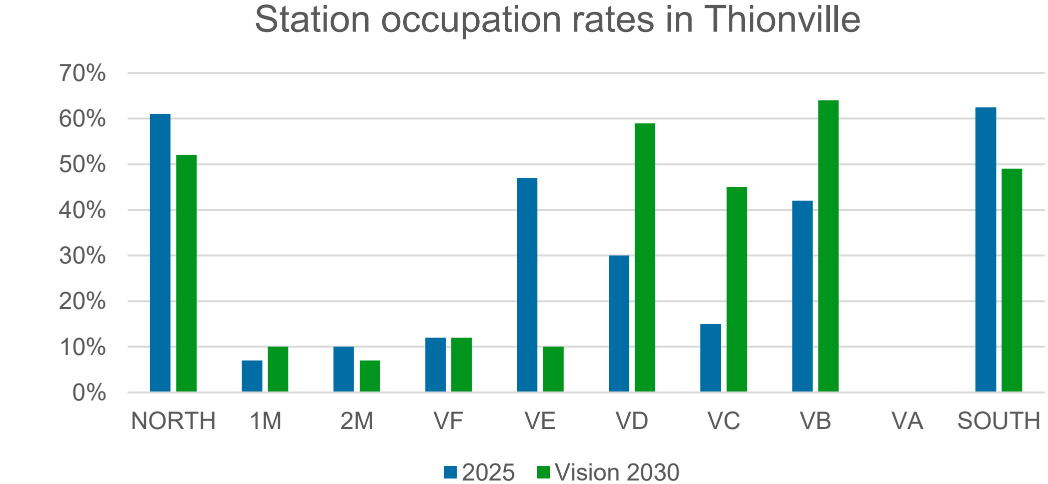
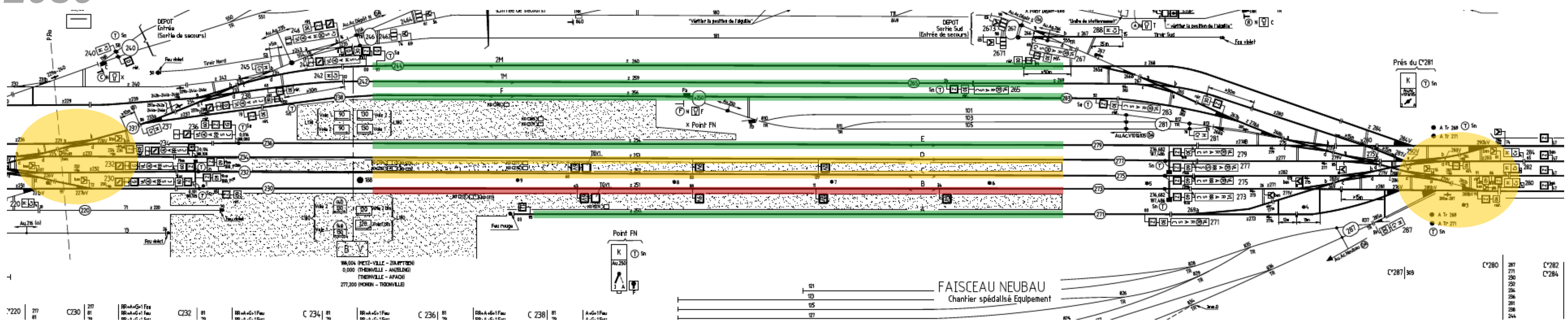
South	OTR = $\frac{75}{120} * 100 = \mathbf{62.5}\%$	**49%**



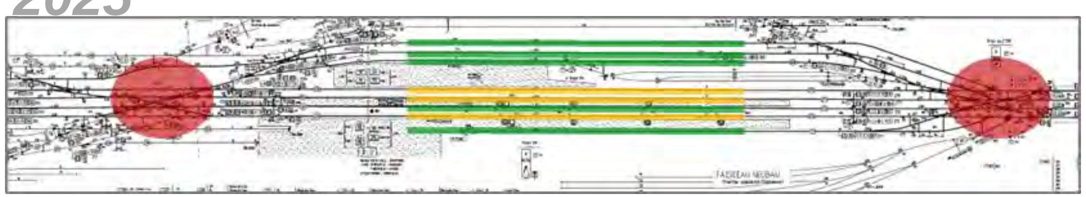
[6] Capacity consumption rate

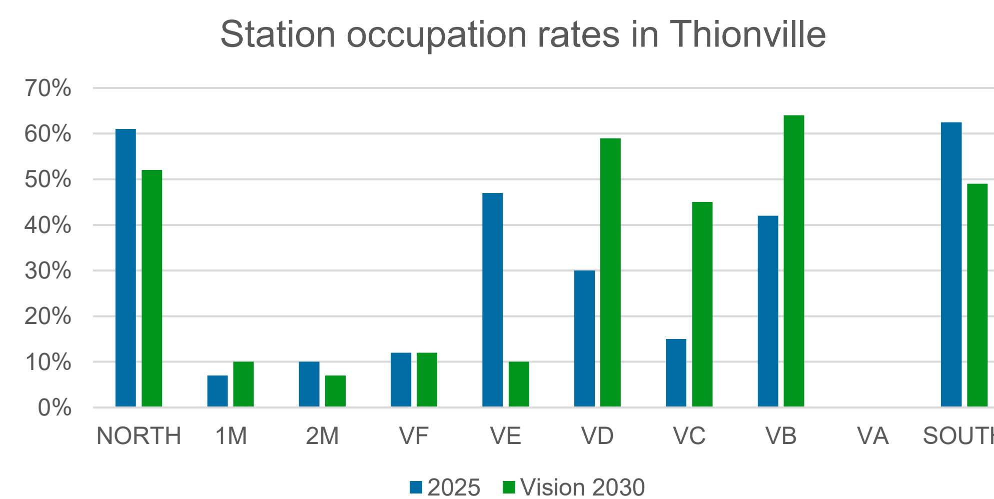
Stations - Example of Thionville

2030



2025





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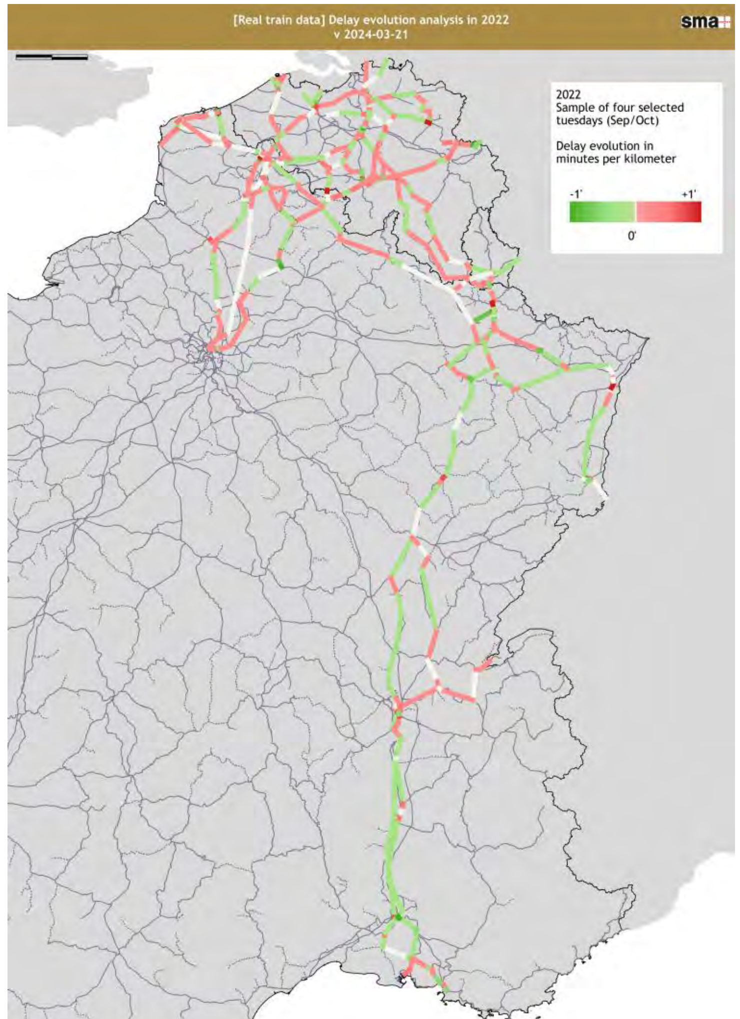
Delays increasing per section

⚠ The real data KPIs have to be considered with caution (see Database constitution deliverable)

Delays are an interesting capacity KPI :

all the other proposed KPIs are only based on the planned paths & TCRs, but the real measured traffic flow can allow to take a step back from the capacity planning and allocation, and sometimes even shows the real bottlenecks.



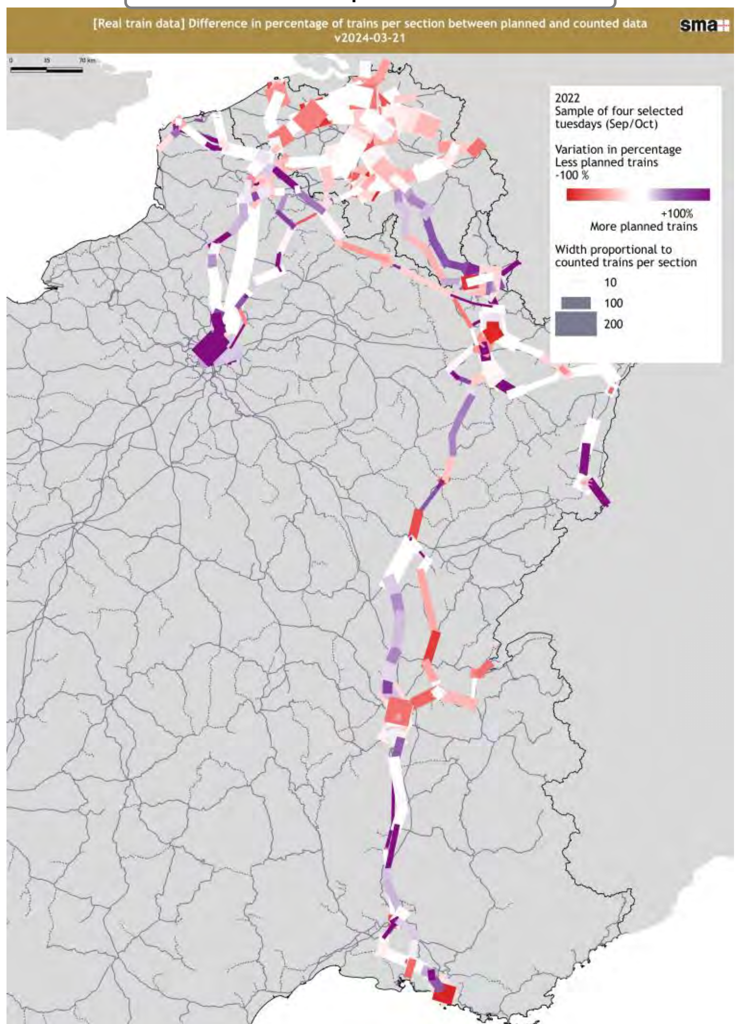
This map of the delays evolution per section shows :

– In Belgium : more trains → more delays,
– In principal nodes (Lyon, Metz, Bettembourg, Lille, Paris, Amiens, Strasbourg, Nancy, Marseille, Bruxelles, etc.) trains run late,
– On sections where there is not a lot of trains : Rive-droite-du-Rhône, Toul – Dijon, delays decrease,
– On Plaine d'Alsace, delays don't increase (systematic timetable ?)

Number of trains

⚠ The real data KPIs have to be considered with caution (see Database constitution deliverable)

Difference planned / real



→ Some differences can be linked to the capacity planning process step when data has been extracted (here, not so close to the circulation day)

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Relevant points

TCRs

Indications of the 3 countries differences in TCRs planning, to help the understanding of the KPIs.

- In LUX, “massification” (= clustering) of the TCRs is preferred,
- In FR also, on “week-end coups de poing” but it’s less clear in the KPIs because there are also a lot of TCRs not following this principle,
- In LUX, for now, the night hours without paths can be used (after a request) to plan works. It’s following logic of opportunity, but it could change in the next years because of the increasing amount of paths at night → capacity for works will decrease,
- “Massification” (= clustering) is preferred by IM’s for costs and safety reasons, but need to be balanced with traffics constraints (freight and passengers).
- In BE, due to safety rules evolutions, works on one track while trains run on the other track are decreasing.

Relevant points

TCRs

- The TCR planning following alternative itineraries principle seems correctly done,
- TCRs planning process is often manual (not digitalised), as well as the coordination between IMs,
- It has appeared very difficult to find good capacity KPIs for TCRs, without having a manual analysis of the situation for each day, which is not possible if 365 days have to be treated, because every work situation has to be considered separately with all its local constraints,
- The TCRs planning is far from an industrial process for IMs, which leads to a “train by train, day by day” planning also for RUs,
- Massification can help this industrialisation,
- The way TCRs planning tools operate can introduce a bias in the KPIs,
- IMs TCR planning philosophy is different : ex. concept of “générique” TCR : capacity for works by default, or planned specifically for works.

Relevant points

Paths

- The different KPIs should have a “all itineraries” approach, to have an overview of the availability and performance,
- The capacity organisation (path order, etc.) is important to complement the “used capacity” vision with a “level of optimisation” vision,
- IMs path planning philosophy is sometimes different,
- Real data (delays) is difficult to process, and we couldn’t link the delays with the other capacity KPIs, although it would have been relevant

Relevant points

Paths & TCRs

- Capacity compression rates for sections, junctions and stations can't be read without the "route" view, with the residual capacity KPIs,
- Capacity share between paths and TCRs is a major KPI to understand capacity stakes on the network,
- Statistics and other representations can help the understanding of a subject, but the capacity stakes are always fully transparent with a graphic timetable,
- The calendar stability subject has appeared. A high instability has an important impact on the different capacity KPIs calculation and production of the visualisations.

Synthesis of the KPIs and visualisations

Type of KPI / visualisation …

Bottlenecks list
KPIs and visualisations
Capacity consumption causes

… calculated on

All 365 days	All 365 days	All 365 days
10 – 20 days	10 – 20 days	10 – 20 days
1 day	1 day	1 day
Couldn't be calculated		

		Paths & TCRs	Paths	TCRs
Bottlenecks list	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 causes	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)
Toolbox	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)

What are the hurdles & how to solve it ?

After the **database constitution** and the **process analysis**, phases where hurdles have been encountered, which are summarised in the 2 **corresponding deliverables**, here are the **main hurdles** we encountered when **calculating the proposed capacity KPIs.**

Insufficient data quality / missing data → see database constitution & processes analysis deliverables

- Capacity consumption rates on stations
- Residual capacity
- Possible unique paths for a 365 days train
- Stable planned paths & TCRs across steps
- Real TCR data analysis

Insufficient tooling → build more performant tools, work manually

- Capacity consumption rates on stations
- Residual capacity
- Share TCR & paths / type
- Timetable optimisation
- Possible unique paths for a 365 days train

What are the hurdles & how to solve it ?

After the **database constitution** and the **process analysis**, phases where hurdles have been encountered, which are summarised in the 2 **corresponding deliverables**, here are the **main hurdles** we encountered when **calculating the proposed capacity KPIs.**

Insufficient calendar stability → reduce calendar instability, or edit as many KPIs and visualisations as needed (365), or choose days

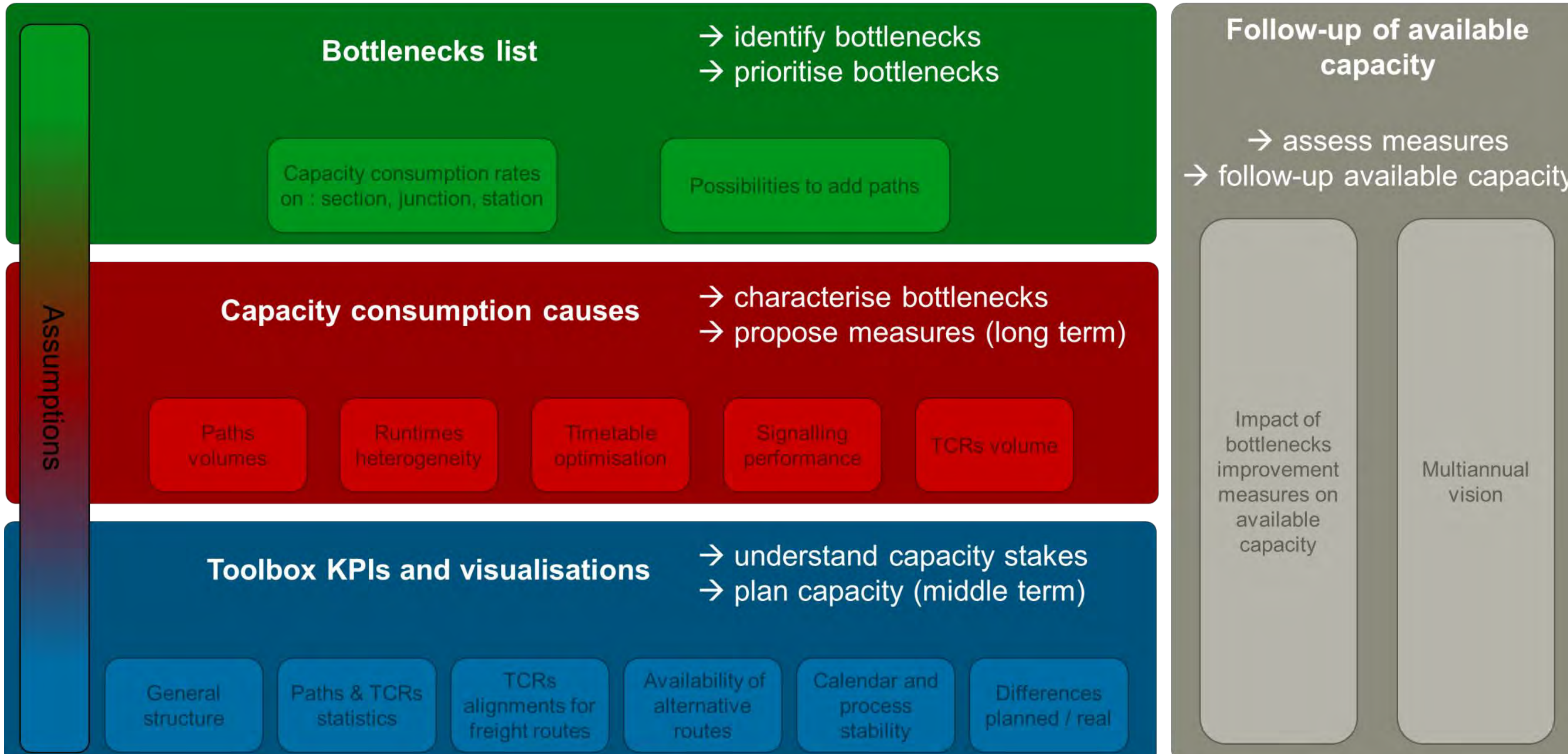
- Graphic timetable
- Number of trains / type

Insufficient time for the study / prioritisation

- Capacity consumption rates on stations (map)
- Residual capacity
- Share TCR & paths / type
- Changed paths from a year to another

Usages of the capacity KPIs and visualisations

Past, planned, and projected capacity for paths & TCRs

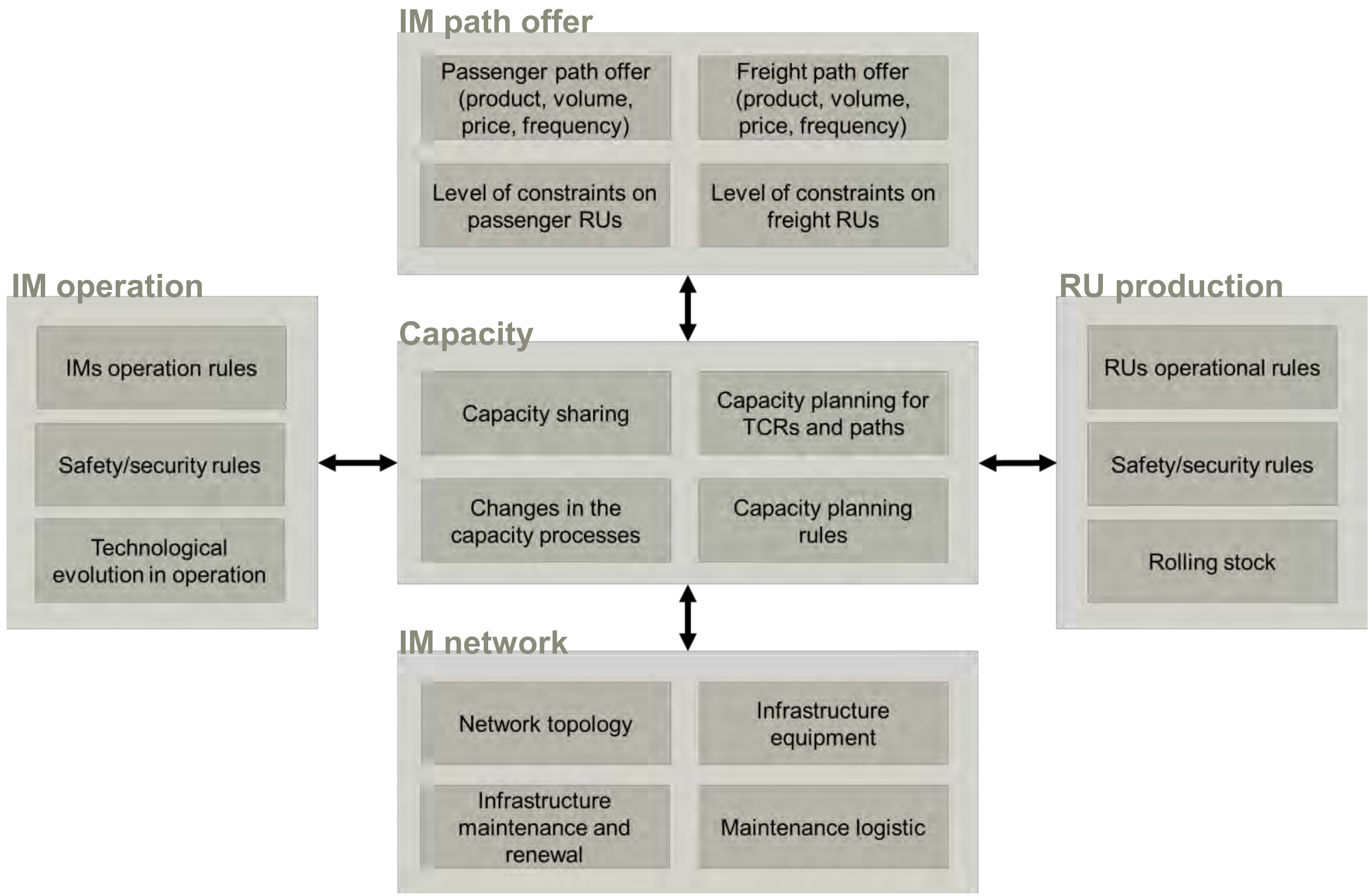


Which decisions do the capacity KPIs enlighten ?

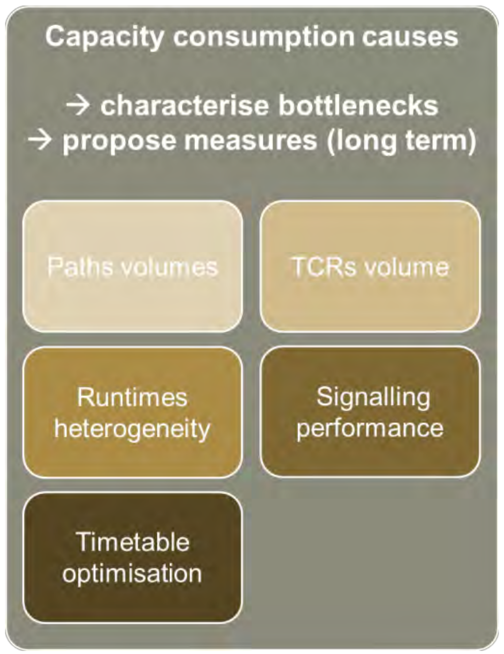
IMs can activate different kinds of levers to **work on capacity**, depending on :

- **What is needed** : increase capacity, increase path performance, work on delays, etc.,
- The **political and economical** choices.

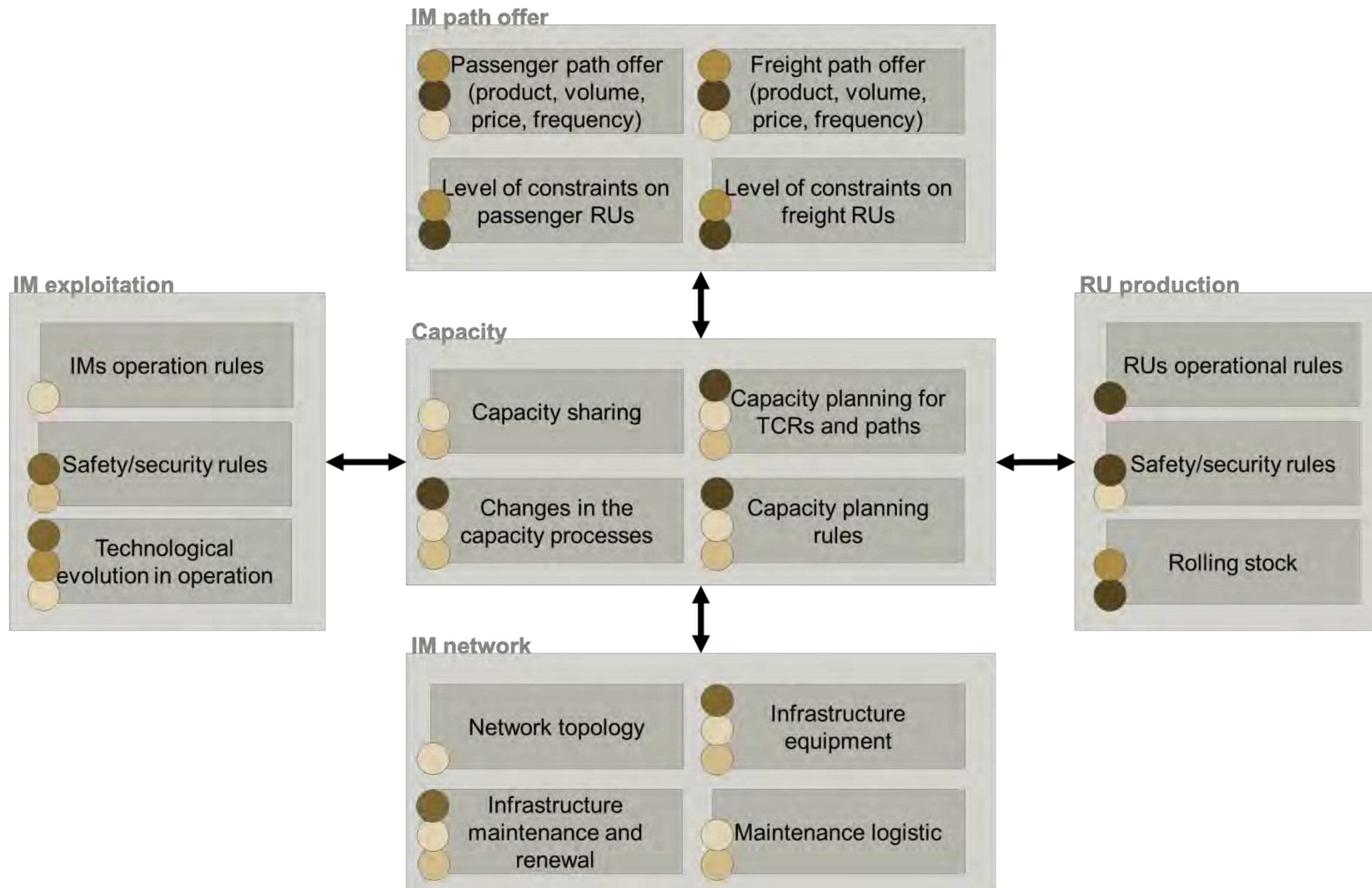
“How do the capacity KPIs help decisions ?” is a question out of the scope of this study, and refers to the capacity planning methods.



How do the KPIs enlighten capacity decisions ?



Bottlenecks characterisation allows to shortlist the measures, which can then be mixed into different capacity evolution scenarios, compared, and implemented by the stakeholders.



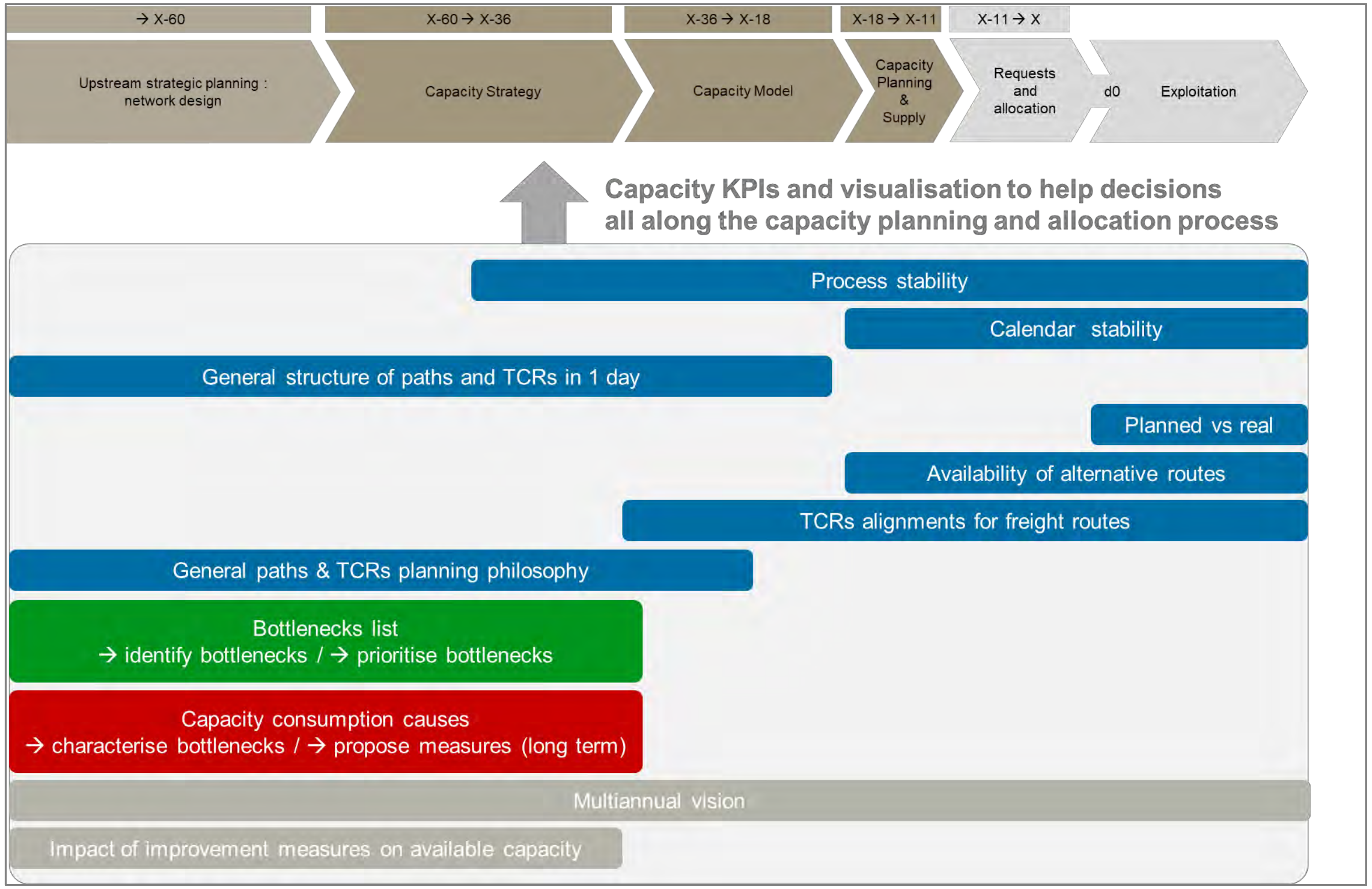
How to insert capacity KPIs in the processes ?

Usages of the proposed capacity KPIs and visualisations within the TTR process structure (tactical) and upstream (strategic).

The capacity KPIs and visualisations proposed in this study can be useful at all steps of the capacity planning and allocation processes.

They are also useful to make the process more fluid.

The same KPIs can also be used to quantify potential capacity increase due to foreseen improvements on timetabling, infrastructure, etc.



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Contact

SMA und Partner AG
Gubelstrasse 28
8050 Zurich
Switzerland

Phone +41 44 317 50 60
info@sma-partner.com
www.sma-partner.com