

1. ULUSLARARASI RAYLI SİSTEMLER MÜHENDİSLİĞİ ÇALIŞTAYI

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“In a nutshell”

Assessing railway infrastructure capacity

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Analysis of traffic and transport processes: General view

Motivation

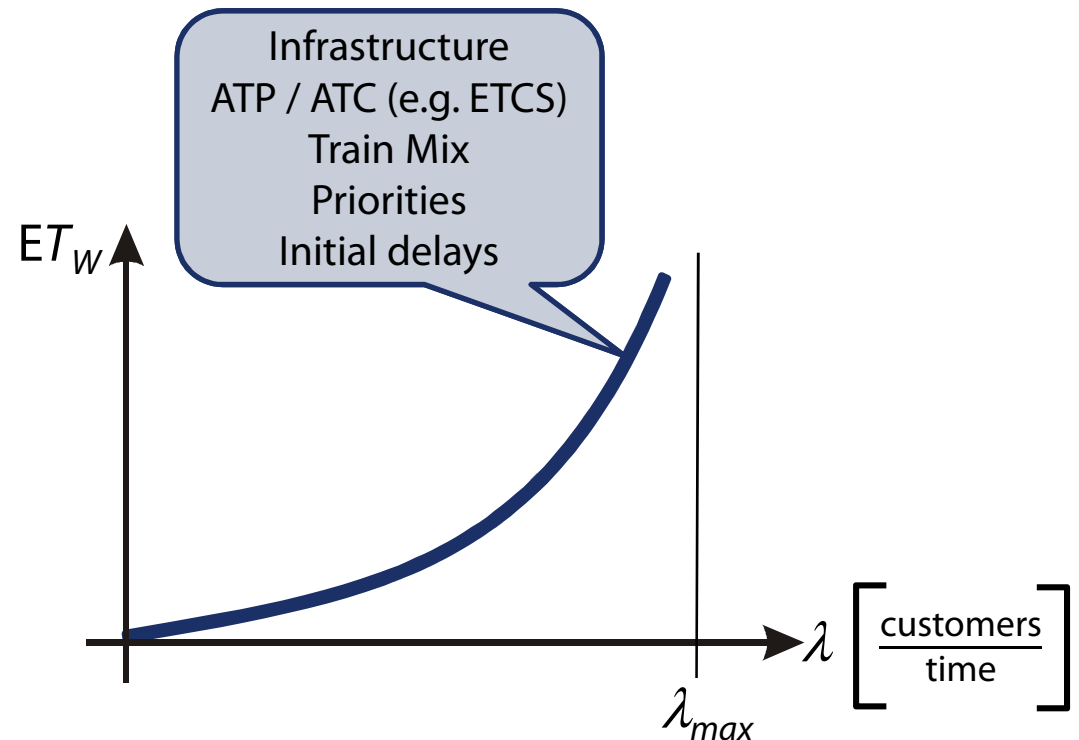
- Optimal layout of (new) infrastructure
- Efficient regulation of facilities

Targets

- High throughput
- Short throughput time
- Moderate costs

Consequences

- Waiting time
- Waiting lines/queues



Analysis of traffic and transport processes: General view

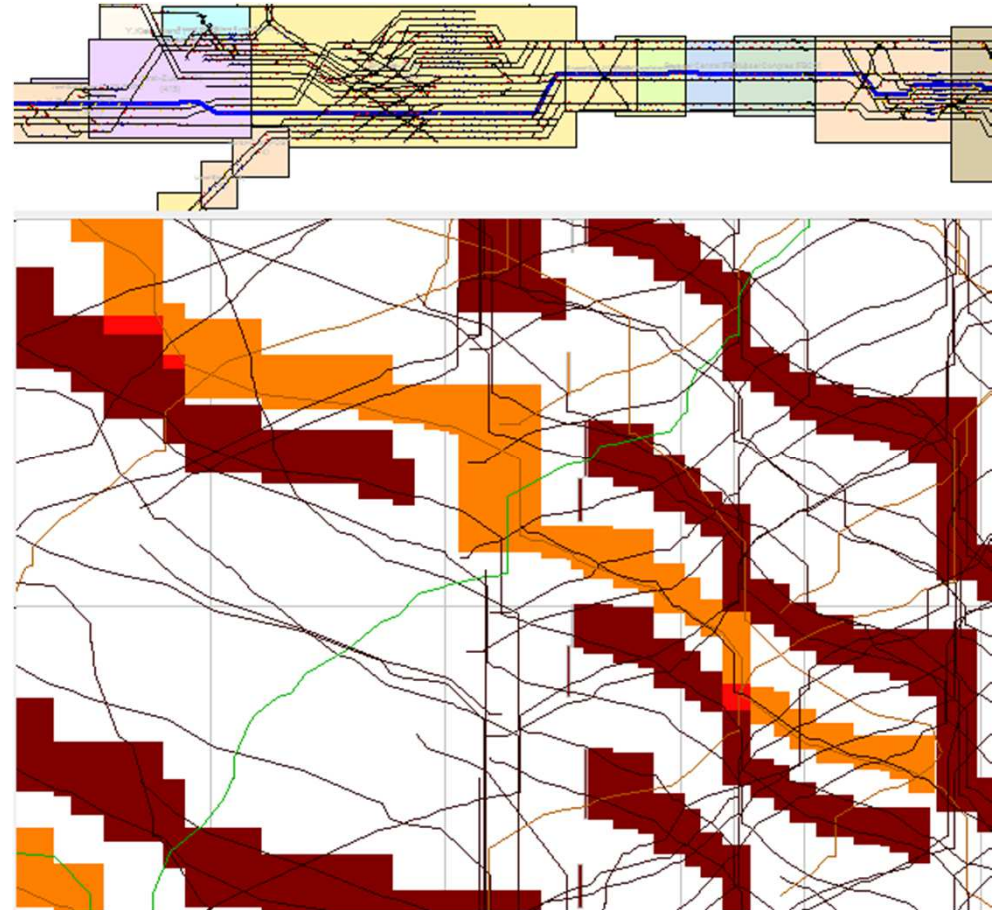


	Current High Speed Lines		Current Conventional Lines
	High Speed Lines –being constructed		Conventional Lines – being constructed
	High Speed Lines – projected		Conventional Lines – projected
	High Speed Lines – the projects are going on		Conventional lines – the projects are going on
	High Speed Lines – non-projected		Conventional lines – non-projected

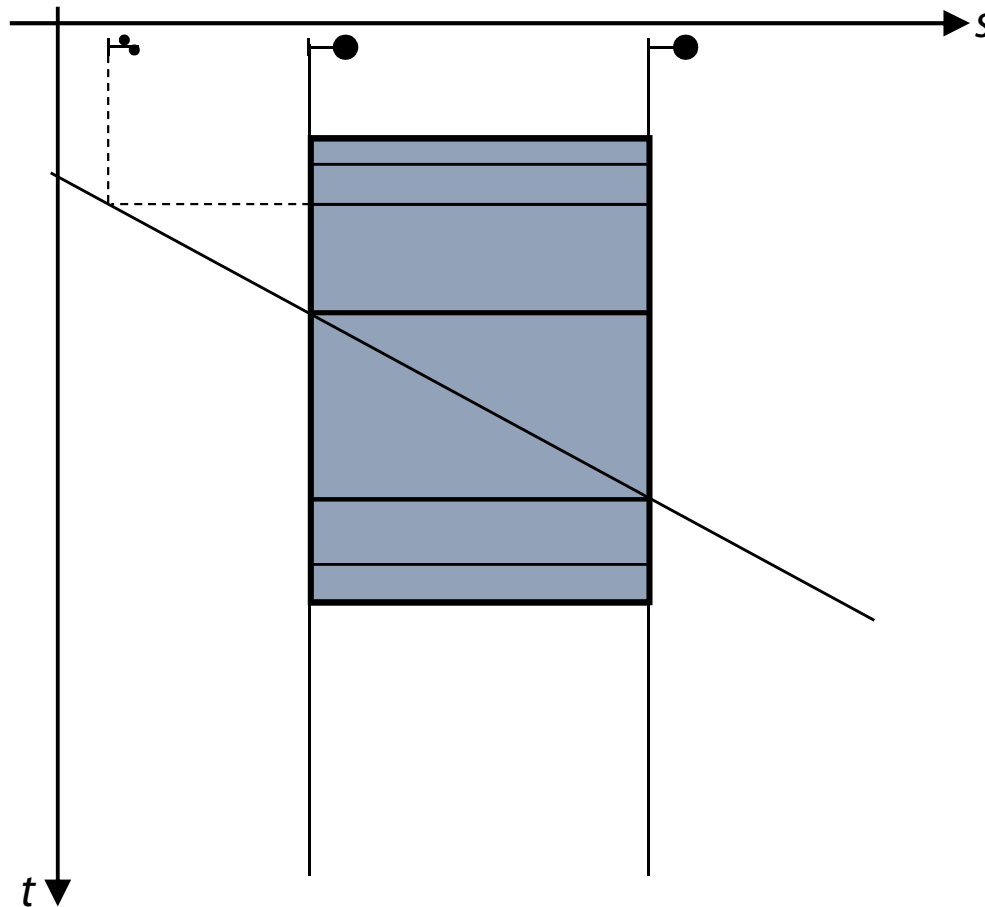
Analysis of traffic and transport processes: Railways

A common understanding of the term “capacity” is mandatory!

- Object of capacity management and capacity allocation: the train path.
- Each train path has a specific capacity consumption.
- Capacity of railway lines and stations depends on the mix of train paths.
- Timetabling in “open access” requires precise capacity management!



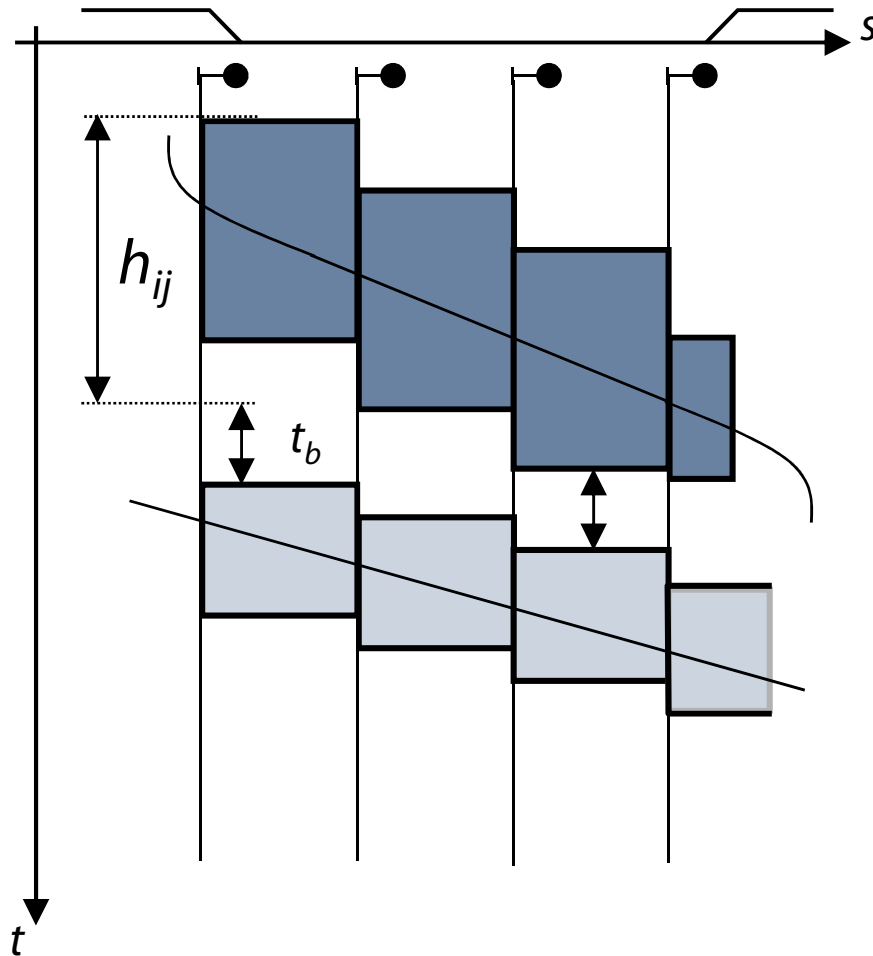
The blocking time model describes the capacity consumption.



Physical occupation
+ clearing time
+ approach time
+ switching times
+ response time

= blocking time

Each train move is represented by its blocking-time series.



Application of blocking time series

- Exact consideration of capacity occupation
- Guarantee of conflict-free timetabling
- Precise evaluation of the impact of infrastructure changes.
- Minimum headway times h_{ij} merge impact parameters to a powerful representation.

Minimum headway times give hints on possible infrastructure optimisations.

- Analysis of the minimum headway times provides information on the operational impact of the infrastructure and signalling.

Speed in points and pre-signalling distance limits capacity.

Short sectioning takes no effect.

Occupation of platform section determines minimum headway time.



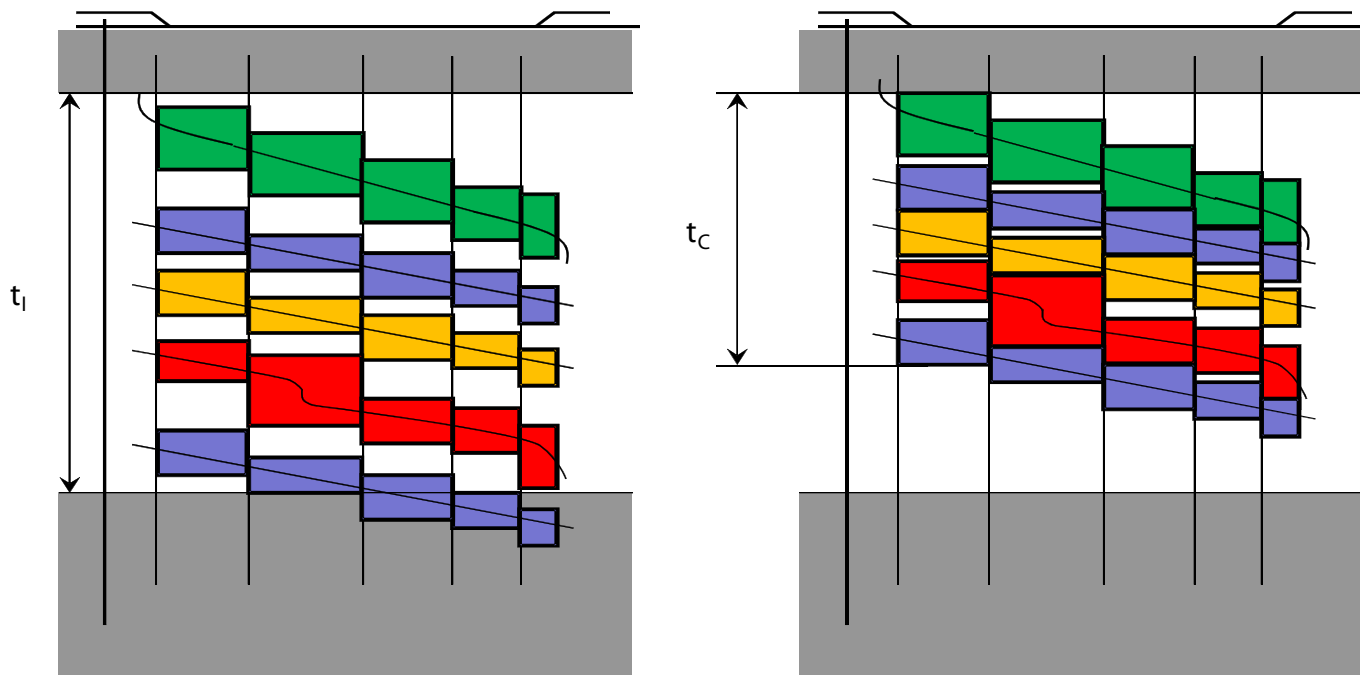
From minimum headway times to capacity...

Timetable-dependent approaches

- Exact timetable is needed
- Concatenation (UIC Code 406)
- Saturation
- Lines
- Suitable for analysis of timetable properties

Timetable concatenation by UIC Code 406

- UIC Code 406 : Capacity consumption based on concatenation of blocking times
- Applied to blocking-time theory
- Move stepped blocking-time series close together
- Determination of the occupation ratio $\rho = t_c / t_l$
- Recommended values: $\rho = 0.6 \dots 0.85$ (depending on line and traffic mix.)



From minimum headway times to capacity...

Timetable-dependent approaches

- Exact timetable is needed
- Concatenation (UIC Code 406)
- Saturation
- Lines only
- Suitable for analysis of timetable properties

Timetable-independent approaches

- Operation programme is sufficient
- Scheduled waiting times
- Unscheduled waiting times
- Lines and stations
- Suitable for mid-term to long-term infrastructure planning

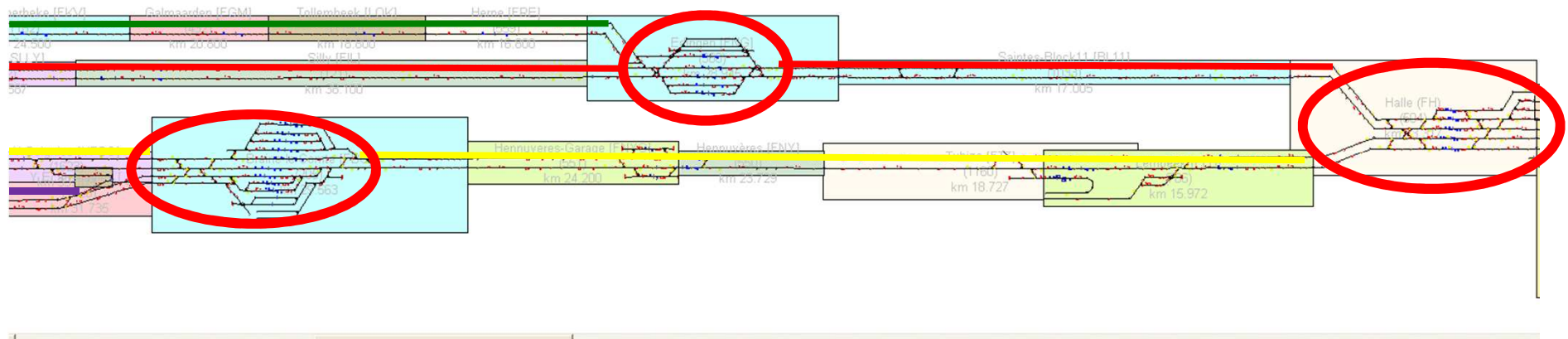
The analytical method adds the advantages of queueing theory to the modelling of railway operations.



Beside pure line capacity also the nodes have to be analysed.

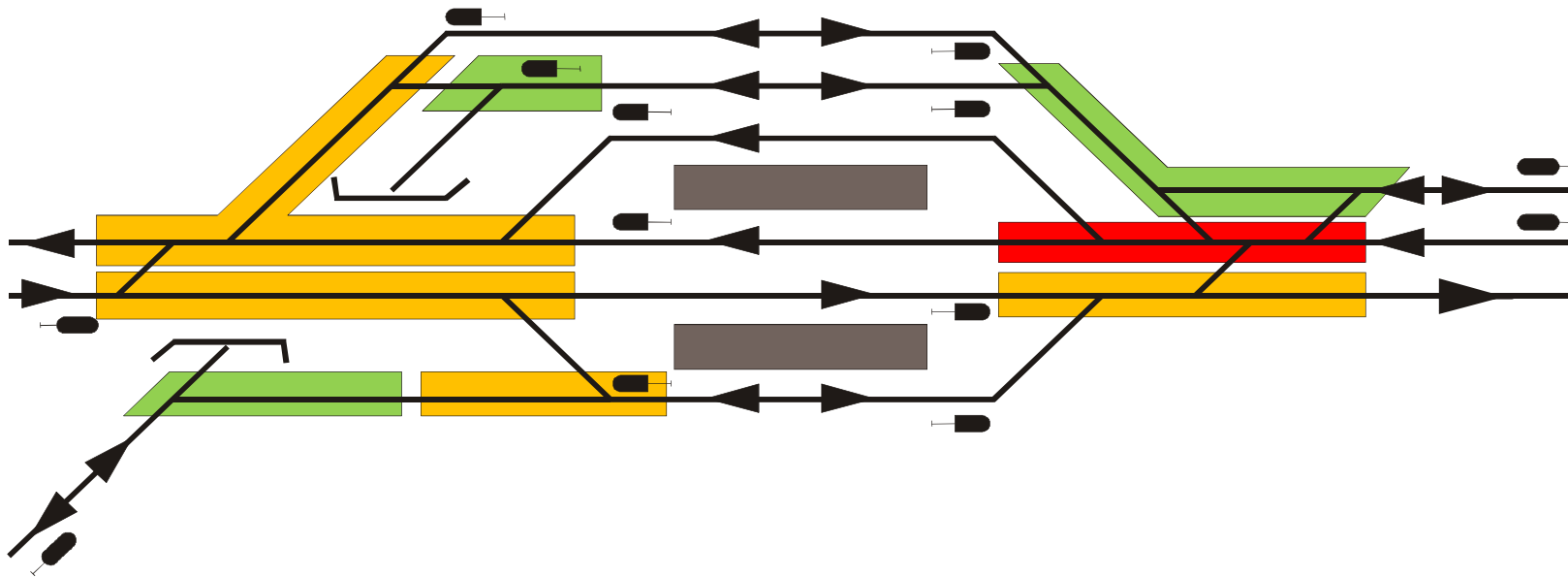
Analytical capacity method calculations are performed for lines and nodes.

- Line sections are separated by major junctions where a reordering of trains is possible.
- Nodes are connecting the lines.

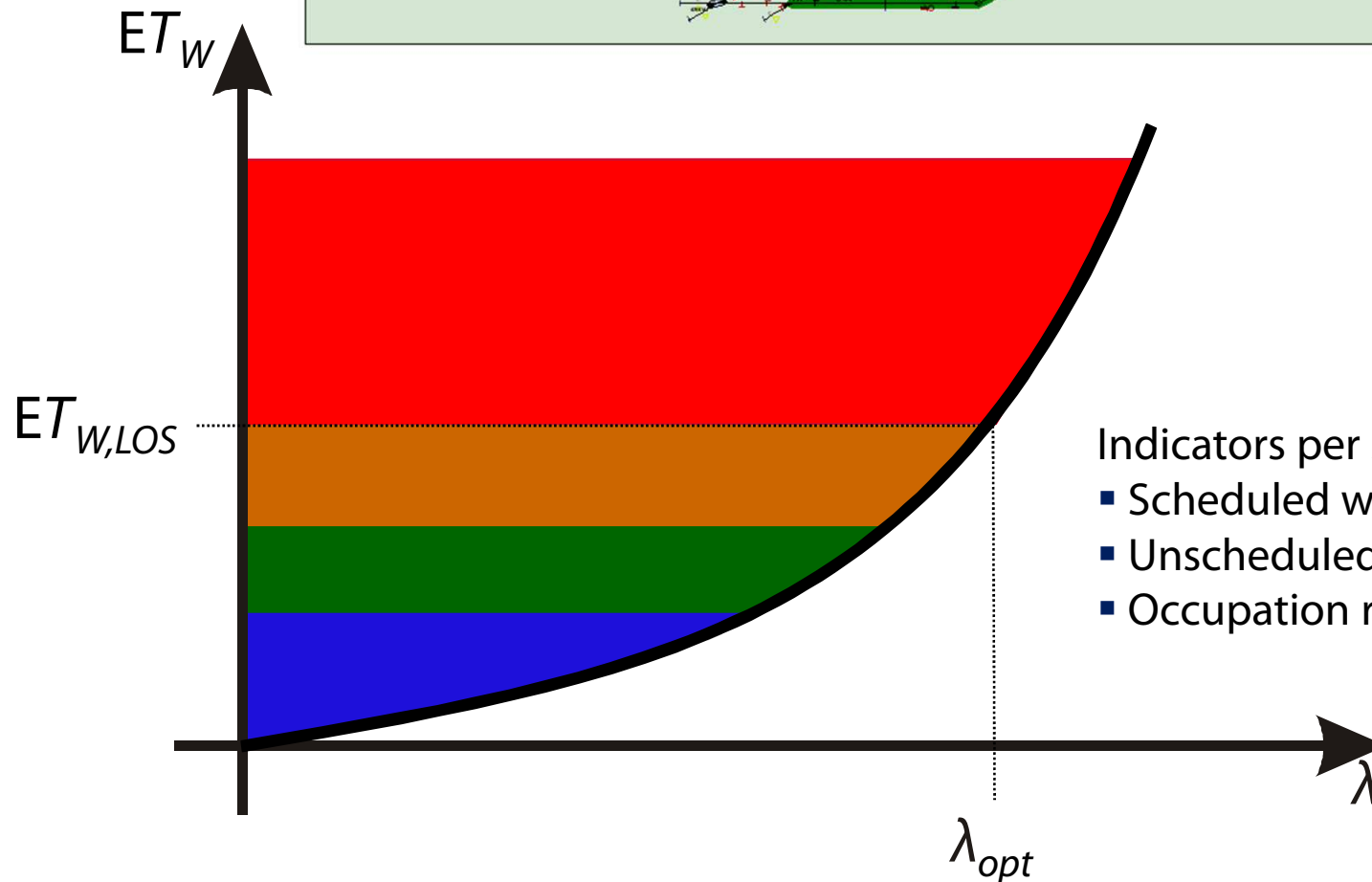
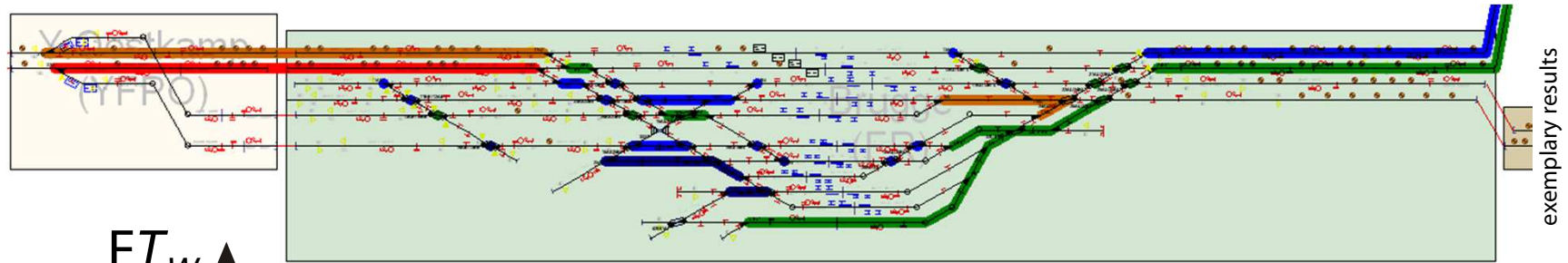


Serial-route nodes represent the smallest unit.

- The infrastructure is (automatically) decomposed to server systems, whose capacitive behaviour is described by an inter-arrival process and a service process.
- Inter-arrival process: The operating program is given by means of pattern trains.
- Service process: The matrix of minimum headway times is calculated for each serial-route.
- Indicators are calculated per serial-route node separately.
- Capacity bottlenecks or surpluses can be identified to adopt infrastructure layout.



Performance indicators are evaluated for each serial-route node.

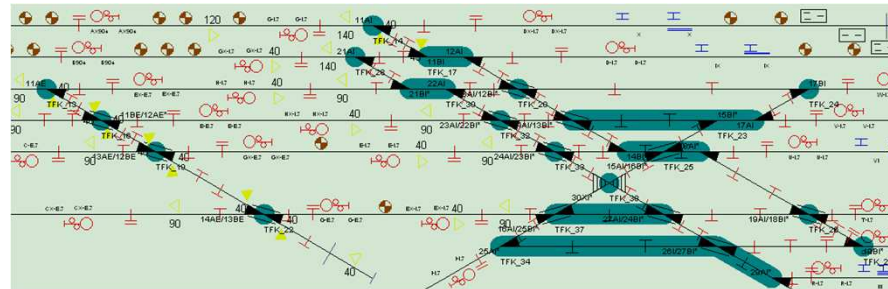


- Indicators per serial-route node:
- Scheduled waiting time
 - Unscheduled waiting time
 - Occupation ratio (UIC Code 406)

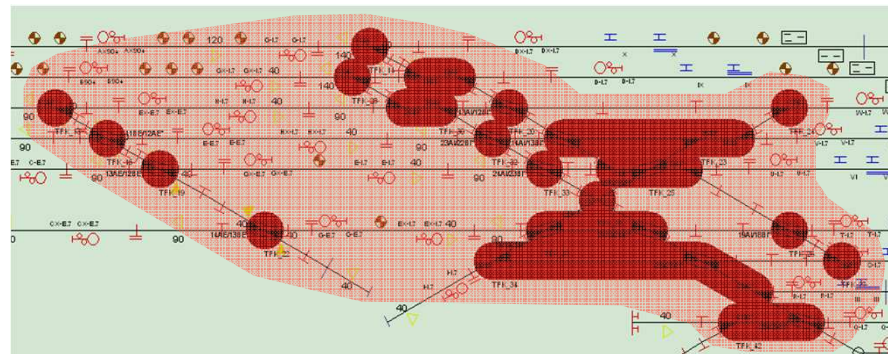
Bottom-up approach allows to cope individual questions.

The analytical method is applied for three different server types

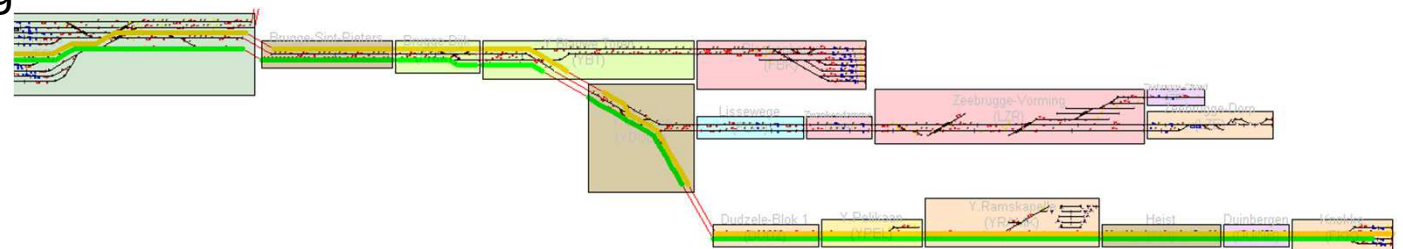
- Serial route nodes (SRN) to assess individual bottlenecks



- Route nodes as a set of SRN, e.g. station's head



- Lines with overtaking possibilities



Infrastructure planning and the future train-path market in Turkey require proper capacity models!

Common understanding of capacity consumption per train path is mandatory.

- Along the whole process of infrastructure planning and timetabling, a compatible understanding of the capacity consumption per train movement is advisable.
- Blocking-time philosophy provides standard for various signalling systems (incl. CBTC).

Various capacity assessment approaches rely on the blocking-time model.

- A timetable-independent approach is preferable for infrastructure design.
- A timetable-dependent approach is favourable for timetable/demand evaluation.
- In the future, the Turkish railway system will require application of both approaches.

Analytics (queueing theory) provide a powerful toolset.

- The analysis of future infrastructure variants is independent of exact timetable knowledge.
- Capacity is directly linked to operation's quality.
- Results are achieved quickly and can be compared efficiently.
- With the upcoming invest in Turkey, clever planning in advance reduces costs at the end!