Digital Capacity Management (DCM)

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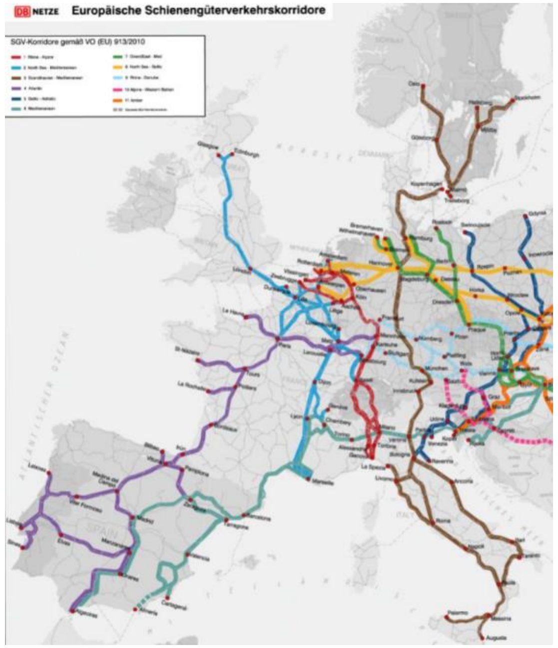
30.10.2020 | Masterplan Belgian Railfreight

Agenda

1. **DCM - Background and Objectives**
2. DCM in Germany
3. DCM for Timetable Redesing (TTR)
4. Discussion and next steps

Expected traffic volume for rail transport requires investments in digital algorithms



- Increased traffic volume expected
- Lack of increased capacity with new lines and stations

Potential Impact of digitalized capacity management

Optimization algorithms for train path planning	**+ 3% capacity gain**
Optimization algorithms for train path assignment for freight trains	**- 5% travel time on average**
Online booking of train paths for short term freight	**Timetable within 3 minutes**

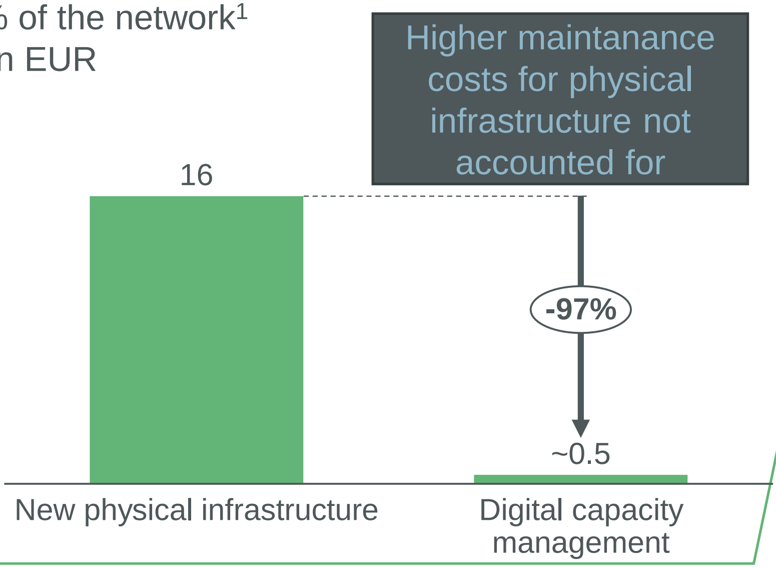
Digital Capacity Management should be treated as investment to be paid by the EC/National Governments

Efficiency of Digital Capacity Management (DCM) – Order of magnitude

ROUGH ESTIMATE

High efficiency of investment in Digital Capacity Management (DCM)

Initial investment for capacity increase of 4% on 50% of the network[1]
in bn EUR



Investment of roughly 500 Mio. EUR[2]

- Cost of connecting all 10 European countries (IMs and Rus) on the main freight corridors to DCM – first validation bottom-up by IMs and RUs
- Funding for upgrading of IT needs to be provisioned for each individual country

Investment with same effect as actual investment in new physical capacity

- Implementation of DCM with significantly lower lead-time than investment in new tracks
- With current financing model, IMs with little incentive to provide pan-European Digital Capacity Management
- Digital Capacity Management in Germany was funded by the government and therefore treated as investment in physical infrastructure

[1] Current European Railway net: 270,000 km, cost for additional capacity: 3 Mio. EUR/km
[2] The study "TTR migration concept and IT landscape" refers to 675 Mio. EUR, including costs for countries, which are not part of the first wave

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Click&Ride – the first innovative product has been introduced to the railway market

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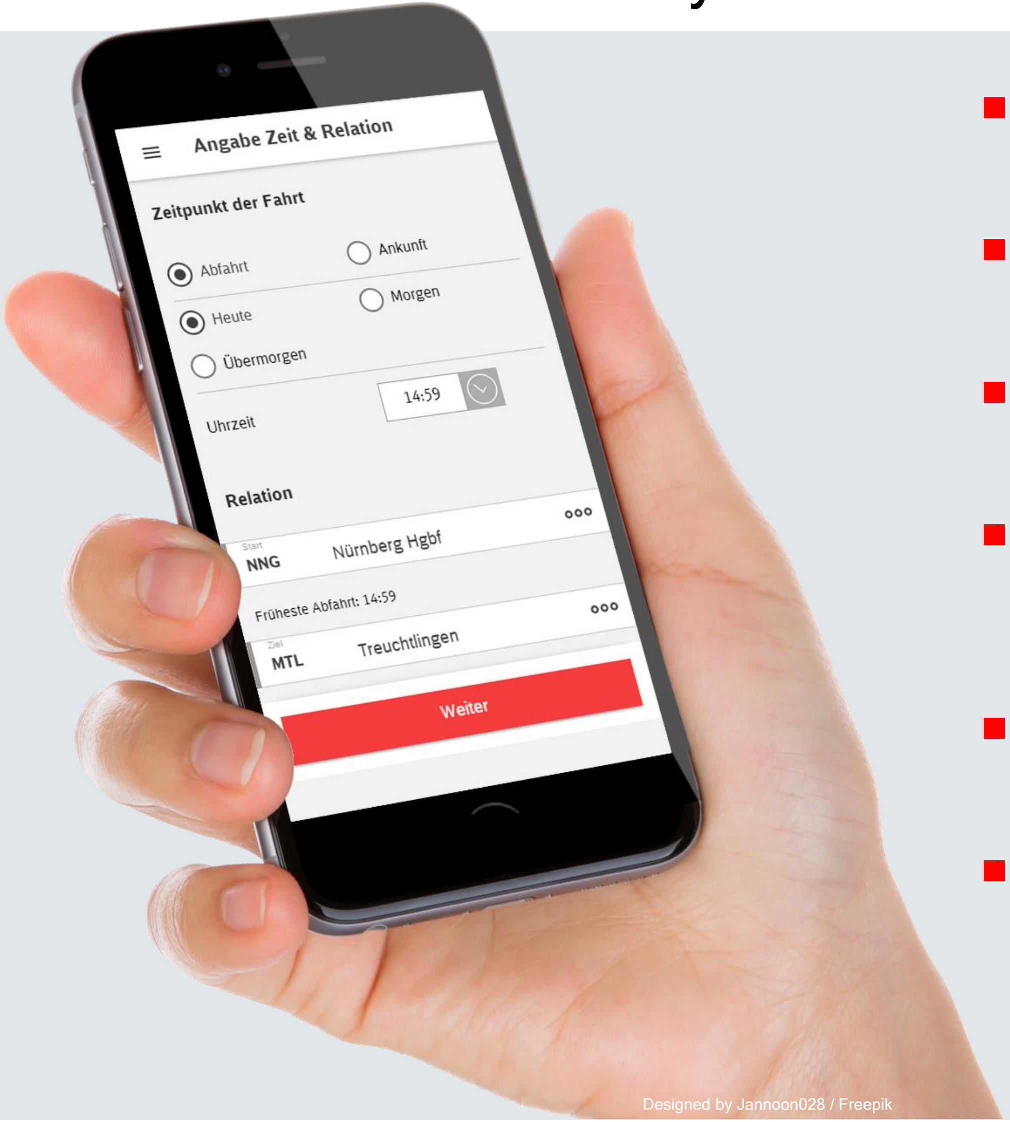


- Planning horizon: min 45 min and max 48 hours before the desired departure of the train
- Train path request with desired departure and / or arrival time is possible
- Train path and timetable within max 3 minutes instead of max. 48 hours
- Click&Ride is in full operation since December 17th 2019, more than 800 bookings via the app in the first two months Jan and Feb 2020
- Plan to automatise more than 200.000 path offers in 2020
- Implementation for yearly timetable in pipeline

Cutting-edge mathematical optimization models are the core for the new digital timetabling process

Change in timetable procedure

Standards

Standardized trains with pre-planned slots

Harmonized Planning

Optimized capacity by harmonization and bundling

Optimized train path assignment

Optimizing a train path based on standardized slots

Optimization models

$$\sum_{i\in\{1,\dots,\tau\}} \sum_{j=(n_1,n_2)\in\mathcal{A}} \Big(t_{i,j}\cdot x_{i,j} + \sum_{k\in O(n_2)} x_{i,j}\cdot x_{i,k}\cdot (T_{i,k} - T_{i,j} - t_{i,j})\Big) \to \min \quad (3)$$

s.t.

$\forall i \in \{1,\dots,\tau\}$:

$$\sum_{j\in Q} x_{i,j} = \sum_{j\in S} x_{i,j} = 1, \quad (4)$$

$\forall i \in \{1,\dots,\tau\}\ \forall n \in \mathcal{N} \setminus (Q \cup S)$:

$$\sum_{j\in I(n)} x_{i,j} - \sum_{j\in O(n)} x_{i,j} = 0, \quad (5)$$

$\forall i \in \{1,\dots,\tau\}\ \forall n \in Q\ \forall j \in O(n)$:

$$T_{i,j;\min} \le T_{i,j} \le T_{i,j;\max}, \quad (6)$$

$\forall i \in \{1,\dots,\tau\}\ \forall n \in Q\ \forall j,k \in O(n)$:

$$T_{i+1,j} - T_{i,k} \ge 0, \quad (7)$$

$\forall i \in \{1,\dots,\tau\}\ \forall j = (n_1,n_2) \in \mathcal{A}\ \forall k \in O(n_2)$:

$$T_{i,k} - T_{i,j} + \mathcal{C}\cdot\overline{x_{i,j}} + \mathcal{C}\cdot\overline{x_{i,k}} \ge t_{i,j} + t_{H,\min}, \quad (8)$$

$$T_{i,k} - T_{i,j} - \mathcal{C}\cdot\overline{x_{i,j}} - \mathcal{C}\cdot\overline{x_{i,k}} \le t_{i,j} + t_{H,\max}, \quad (9)$$

$\forall j,k \in \mathcal{A}\ \forall m \in \{1,\dots,\varphi\}\ \forall i \in \{1,\dots,\tau - m\}; j, k$ *share blocks*:

$$T_{i+m,k} - T_{i,j} + \mathcal{C}\cdot\overline{z_{i,j;i+m,k}} + \mathcal{C}\cdot\overline{x_{i,j}} + \mathcal{C}\cdot\overline{x_{i+m,k}} \ge t_{head;i,i+m;1}, \quad (10)$$

$$T_{i+m,k} - T_{i,j} - \mathcal{C}\cdot z_{i,j;i+m,k} - \mathcal{C}\cdot\overline{x_{i,j}} - \mathcal{C}\cdot\overline{x_{i+m,k}} \le -t_{head;i,i+m;2}, \quad (11)$$

$\forall i \in \{1,\dots,\tau - (\varphi+1)\}\ \forall j,k \in \mathcal{A}; j, k$ *share blocks*:

$$T_{i+\varphi+1,k} - T_{i,j} + \mathcal{C}\cdot\overline{x_{i,j}} + \mathcal{C}\cdot\overline{x_{i+\varphi+1,k}} \ge t_{head;i,i+\varphi+1;\min} \quad (12)$$

$\forall p \in \mathcal{P}\ \forall i \in \{1,\dots,\tau\}\ \forall j \in \mathcal{A}; j, p$ *share blocks*:

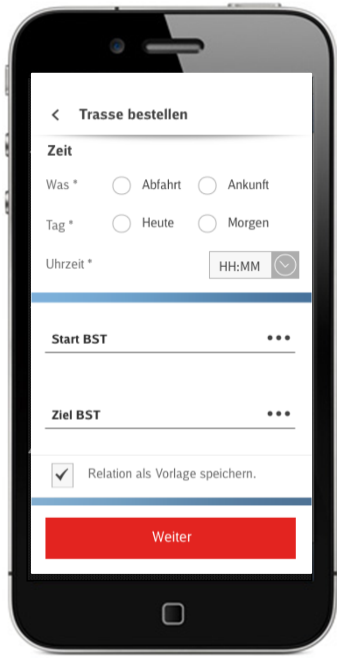
$$T_{i,j} + \mathcal{C}\cdot\overline{z_{i,j;p}} + \mathcal{C}\cdot\overline{x_{i,j}} \ge t_{head;i,p;1} + T_p, \quad (13)$$

$$T_{i,j} - \mathcal{C}\cdot z_{i,j;p} - \mathcal{C}\cdot\overline{x_{i,j}} \le -t_{head;i,p;2} + T_p. \quad (14)$$

$\forall i \in \{1,\dots,\tau\}\ \forall l \in \{i,\dots,i+\varphi\}\ \forall j,k \in \mathcal{A}: T_{i,j} \in \mathbb{Z},\ x_{i,j}, z_{i,j;l,k} \in \{0,1\}$

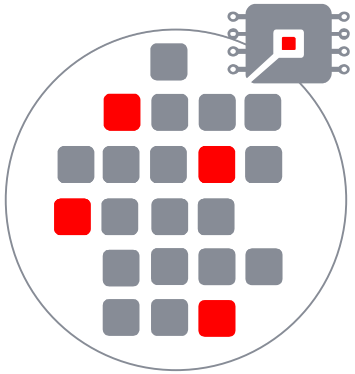
Automatic Timetabling Model

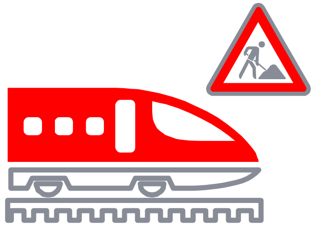
Simple Access



Click&Ride App

Click&Ride is the first step in digital capacity management, ongoing innovations and developments





	IT Implementation	Final Testing	Production
Adhoc Requests Click&Ride *Freight Trains*	✓ 16-19	✓ 2019	✓ 2020
Annual Timetable *Freight Trains*	✓ 16-20	2020+	2021+
Re-Scheduling *Passenger and Freight Trains*	19-21	2021+	2022+

Cornerstones of the projetct neXt in Germany

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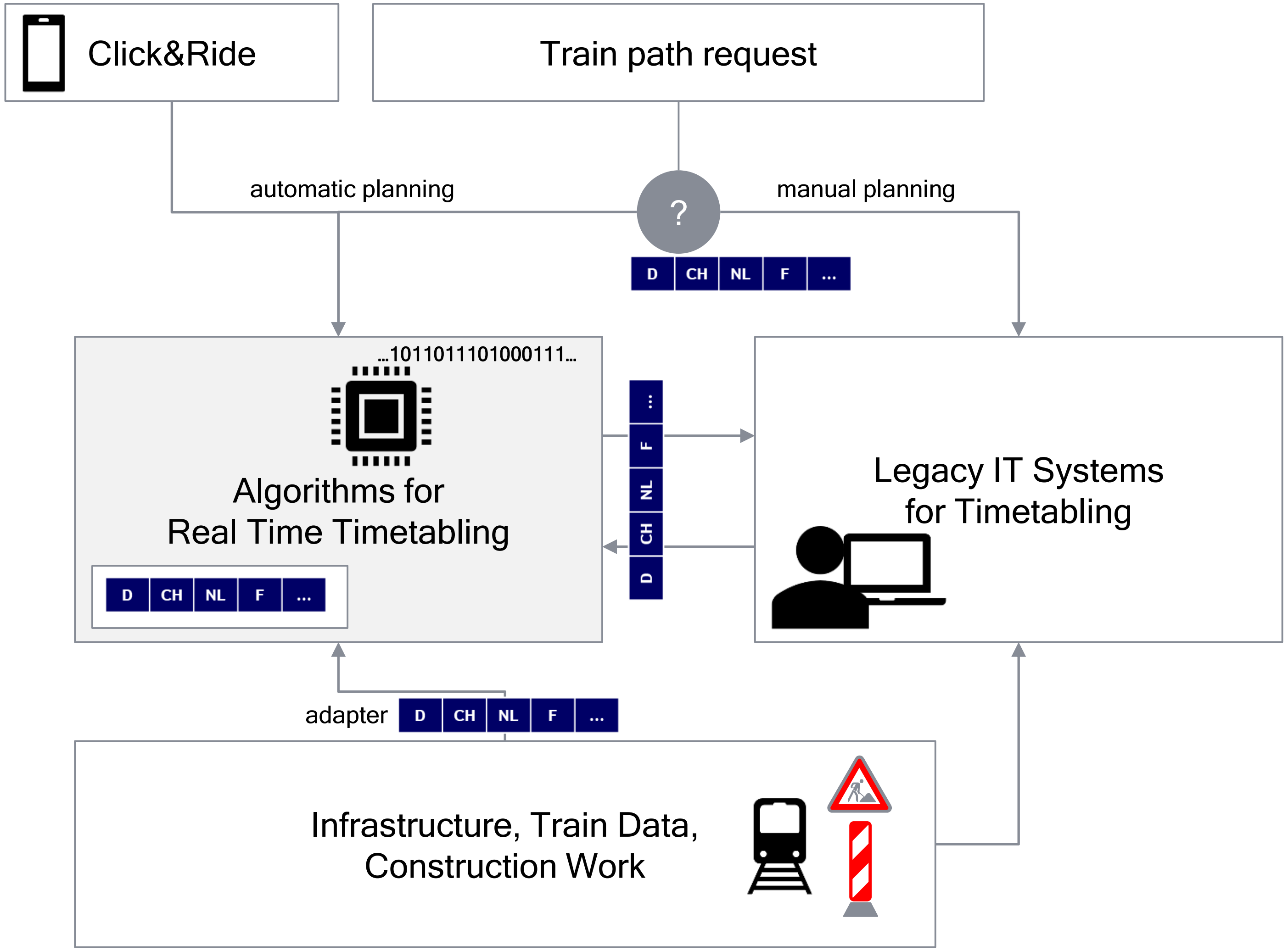
3 Years Project (2016 - 2018)

18 Scrum Teams

~250 People in Project Team

Essential parts of the neXt solution can be adopted for other IMs to reduce complexity and speed up implementation



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Using digital scheduling for TTR

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- Historically, processes and structures in Timetabling and Capacity Management focus on addressing the needs of **Passenger** Traffic in **yearly planning cycles**

- The Redesign of the timetabling (and capacity) process (TTR) will address the needs of both passenger and **freight**. To achieve this, **TTR** will include (among other things) a **multi-annual Capacity Model** and **Rolling Plannning**

- Digital Scheduling will allow **real-time transparency about and access to** capacity. These capabilities are excellent tools for multi-annual Capacity Modelling and Rolling Planning

- DB Netz has developed **algorithms** for real time timetabling which are already applied for ad-hoc traffic (“Click&Ride”). Using these algorithms for **simultaneous planning problems** is in preparation

- We are suggesting to benefit of automatised timetabling **for TTR** and to seek **EU funding for a European-wide roll-out** under coordination of RNE. DB Netz is happy to share digitalization know-how gained in the last couple of years.

From Capacity Model to capacity requests

A) Capacity Model
(X-36 – X-18)

Content:
- Capacity harmonization and partitioning
- Definition of capacity safeguarded for short-term requests
- TCR planning and coordination

B) Capacity Planning
(X-18 – X-11)

Content :
- Fixing major, high and medium impact TCRs
- Final consultation with applicants on capacity partitioning
- Capacity product publication ("Capacity Supply")

C) Annual Requests
(X-11 – X-2)

Content :
- Annual timetable requests submitted on time
- Late path requests
- Path studies
- Refinement of TCRs

D) Short-term Requests
(X-4 – X+12)

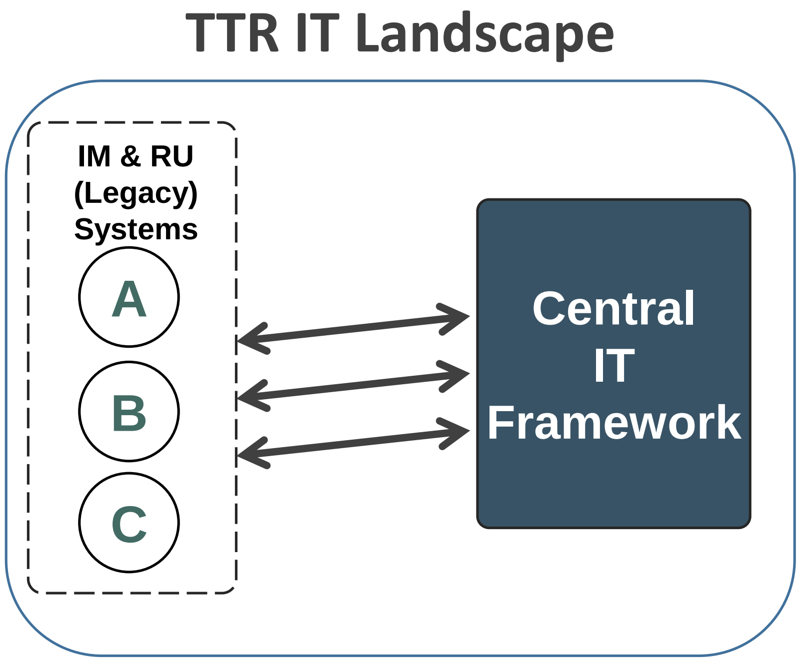
Content :
- Ad hoc path requests
- Rolling Planning requests
- Fixing minor impact and late TCRs, including path alteration
- Path modification and cancellation processes

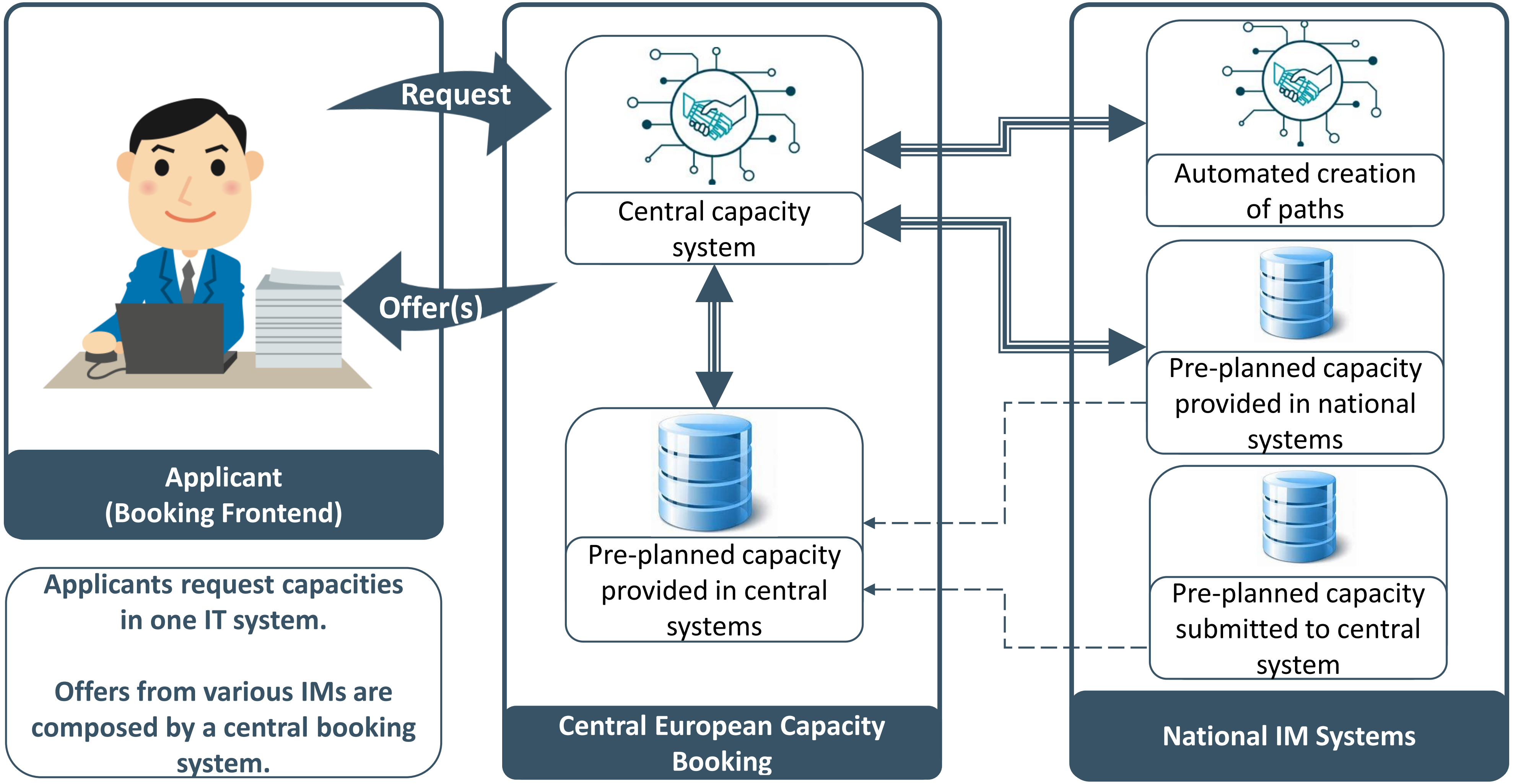
Temporary Capacity Restrictions (TCRs)
(X-24 – X+12)

Basic IT Architecture

The future TTR IT landscape is split into **three main blocks**:

- The **central IT framework**, developed by RNE
- **National systems**, which need to communicate with the central IT framework
- **Communication between central and national systems** based on TAF/TAP TSI standards





Applicants request capacities in one IT system.

Offers from various IMs are composed by a central booking system.

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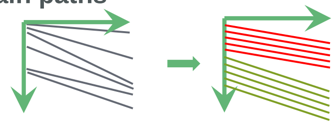
Backup

European Digital Capacity Management has a strong impact on the goals of the Green Deal

Levers and Benefits of Digital Capacity Management

Levers

1 Harmonization and bundling of train paths



- **Higher supply of capacity** on current infrastructure: ~+4%

2 Optimization of train paths based on pre-constructed train path snippets

- **Less travel time:** ~ - 6% due to optimized train path

Benefits

Infrastructure Managers (IM) | **Railway Undertakings (RU)**

More transparency on available capacity

Enables implementation of **long-term timetables**, e.g., “Deutschland-Takt” **and TTR (Time Table Redesign)**

Higher efficiency due to **automatic time tabling** and **train path assignment**

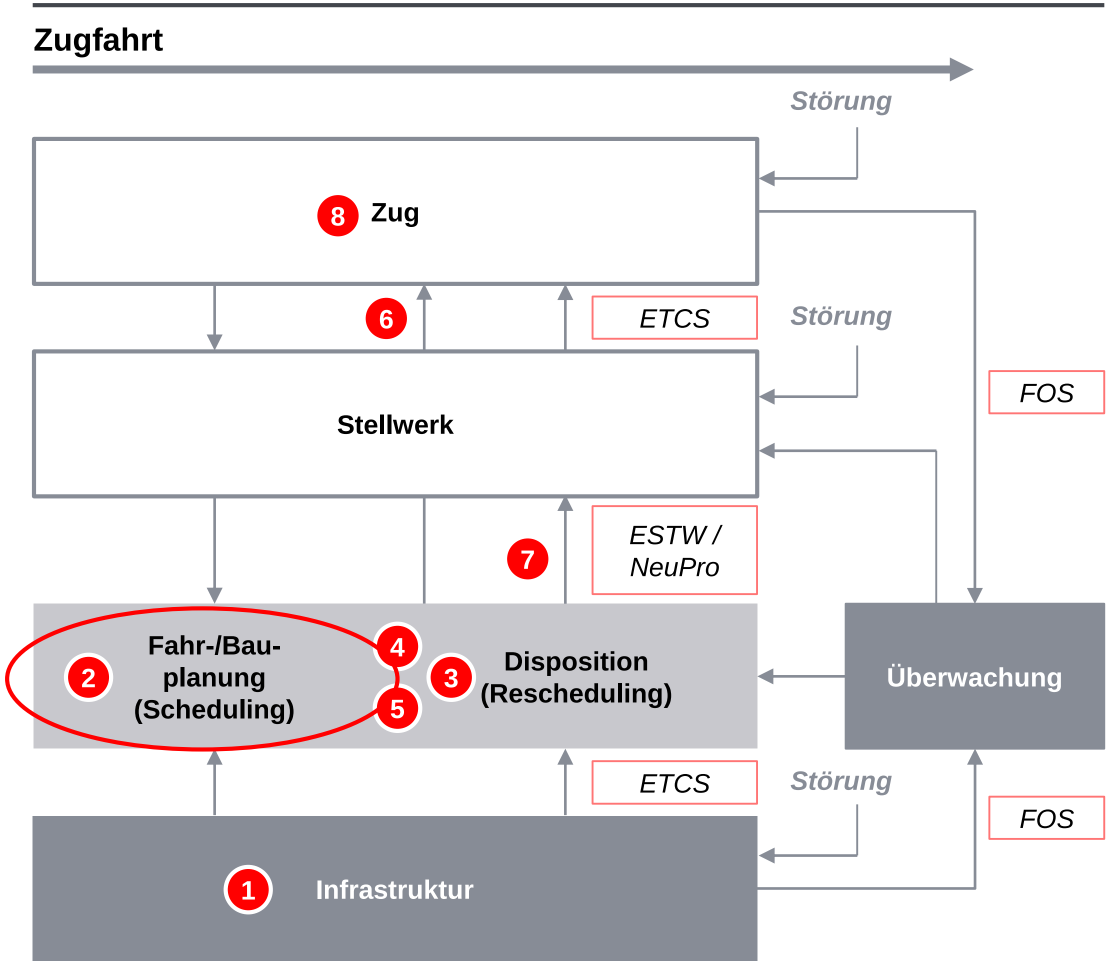
15% better utilization of drivers and locomotives due to optimized round trips and reduced synchronization times at borders

10% energy savings due to less energy – consuming stops for rail freight

Easy and simple access to optimized train paths across Europe

Automated, standardized interfaces

Digital Timetabling is core for the digitalisation of rail



Elemente	Beschreibung
1 Digitale Infrastruktur	Digitale und tagesaktuelle Darstellung der zur Verfügung stehenden Infrastruktur
2 Digitaler Fahrplan	Automatisierte und industrialisierte Fahrplan-erstellung (Projekt DigiKap, M31)
3 Digitaler Betrieb I	Decision Support System für Betriebsdisposition
4 Digitaler Betrieb II	Überführung der Optimierungsverfahren des digitalen Fahrplans in die Betriebsdisposition
5 Realtime Rescheduling	Echtzeit-Simulation und -Planung des Betriebsgeschehens durch Beschleunigung der Optimierungsverfahren
6 Fahrempfehlung Tfz	Übermittlung des gemäß Dispositionsent-scheidungen zu fahrenden Geschwindig-keitsprofils auf die Lok
7 Fahrempfehlung Stellwerk	Direkte Umsetzung der Dispositionsentschei-dungen auf dem Stellwerk ohne Zwischen-schnittstelle Fahrdienstleiter
8 Aut. Train Operations	Direkte Umsetzung der Dispositions-entscheidungen auf der Lok ohne Zwischenschnittstelle Triebfahrzeugführer

Herstellung Datenverfügbarkeit | Optimierung Entscheidungsfindung | Optimierung Entscheidungsumsetzung

Click&Ride – six steps from train path request to the train path and timetable