Digitale Schiene
Deutschland

+++ Have a good journey +++

APS 2100

11:20

Bern HB – Berlin Hbf – Stuttgart Hbf

Future

1	2	3	4	5	6	7	8


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Advanced Protection System


APS; APS in RCA architecture


Abstractions


Block centric/train centric


Hybrid operation


Built-in migration


Backup

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ERTMS USERS GROUP

EULYNX

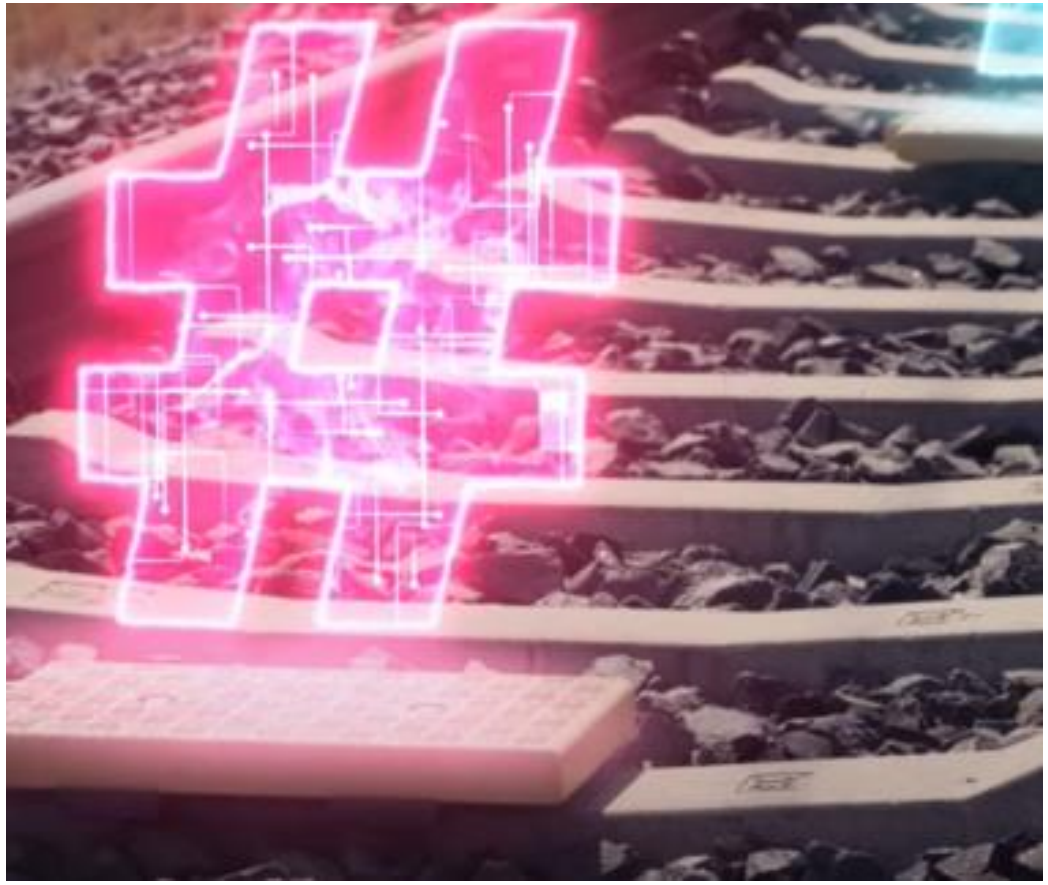
RCA
Reference CCS Architecture

BLÖCKE WAREN GESTERN – ÜBER DIE CHANCEN EINER ZUGENTRISCHEN LST

Advanced Protection System (APS)

FRANK SKOWRON, DB NETZ AG

DMG-SEMINAR – STUTTGART, 28.09.2023



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Government and society expectations require profound technological innovations of the railway system

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Expectations on the railway system

Modal shift to railway is key to **reduce CO_2** emissions in traffic sector

Amount of **rail passengers** expected to **double** by 2030

Share of **freight transport** by rail will **increase** up to 25 %

- We need to **to increase rail capacity by up to 35%**
- Along with the physical expansion, **technological innovation and digitalisation** are the game changers to increase capacity
- Making this lever **available to the rail system** is the mission of **Digitale Schiene Deutschland**

Key innovations are being implemented in all main areas of the rail system and create new opportunities

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DIGITALIZED INFRASTRUCTURE

FULLY AUTOMATED VEHICLES

SMART CONTROL

Target picture for the entire rail system

Trains run **automatically**

Trains driving at **optimal headway**

Intelligent **Traffic management** plans and dispatches trains and routes

Interruptions are **automatically detected** and managed

DSD starts with the base digitalization of the infrastructure and continues with technological advancements

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DBS Target Picture

BASIS DIGITALIZATION OF INFRASTRUCTURE

ETCS L2 & Digital Interlockings (DSTW)

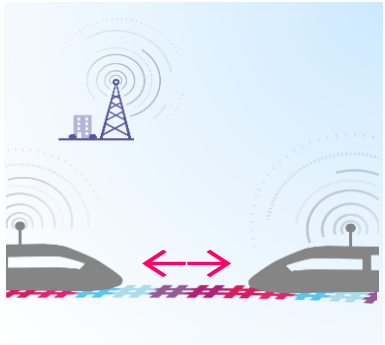
+ additional features/improvements

HIGHLY AUTOMATED DRIVING

- Trains run highly automated (GoA2)
- Important interim development and migration step
- Enabler for other PBs

FULLY AUTOMATED DRIVING

- Trains run fully automated (GoA4)
- Trains monitor their environment
- Trains react on incidents automatically

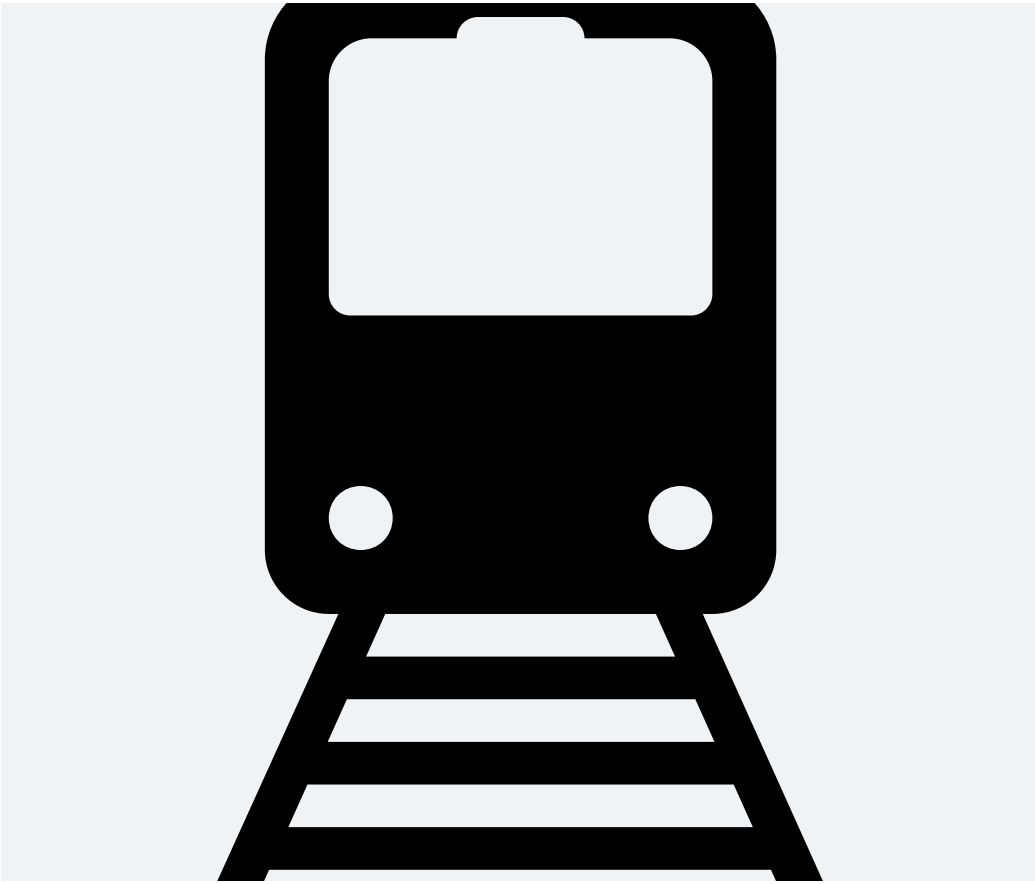


ADVANCED DIGITAL INFRASTRUCTURE

- Novel safety architecture
- Allows driving in optimal headway
- Allows lean infrastructure rollout

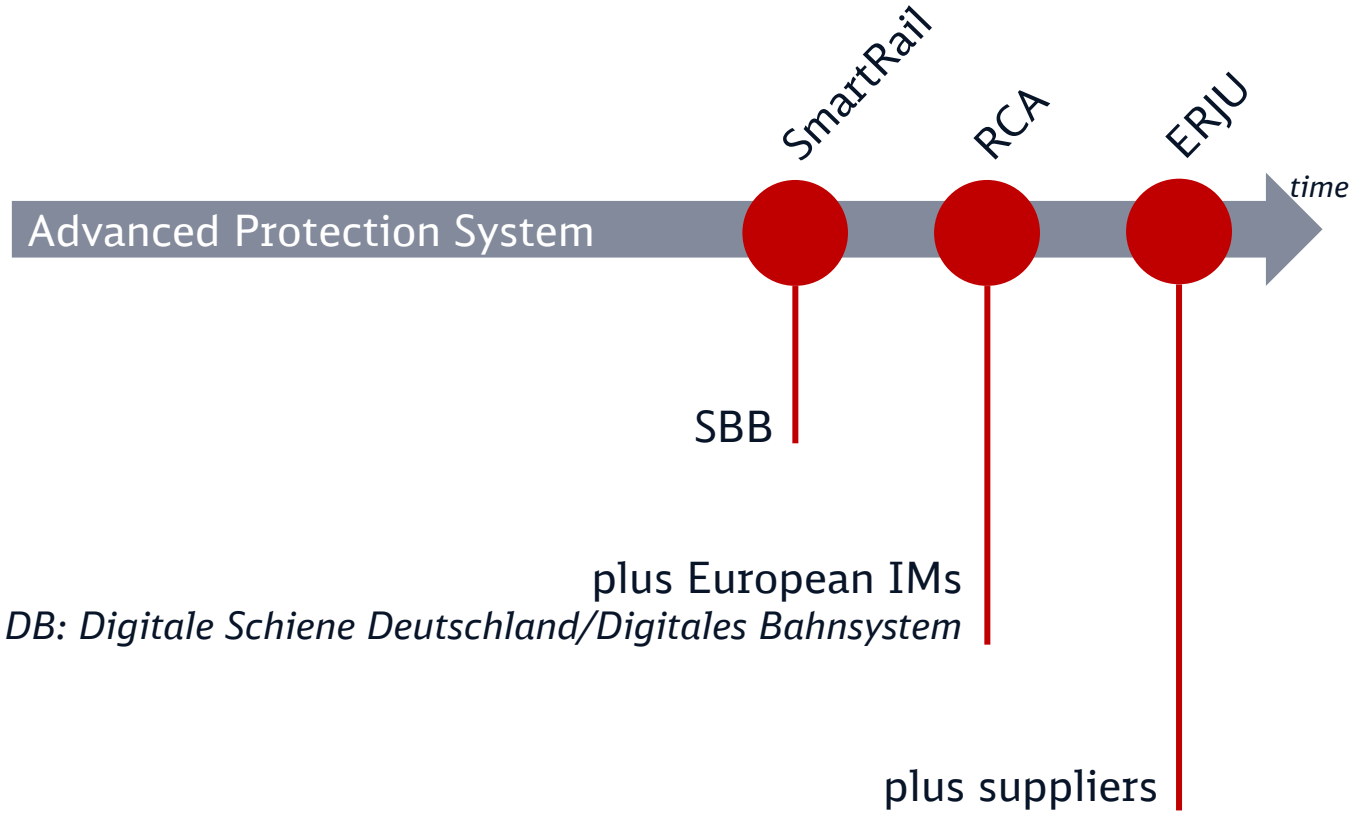
INTELLIGENT PLANNING AND DISPATCHING

- Automated real-time traffic planning and dispatching
- Automated capacity management and scheduling



→ Advanced Protection System

Initiatives



DB: Digitale Schiene Deutschland/Digitales Bahnsystem

Europe's Rail

- System Pillar CCS+
- Innovation Pillar
  - TE Moving Block
  - Demonstrator

Berlin Hbf

→ **APS**

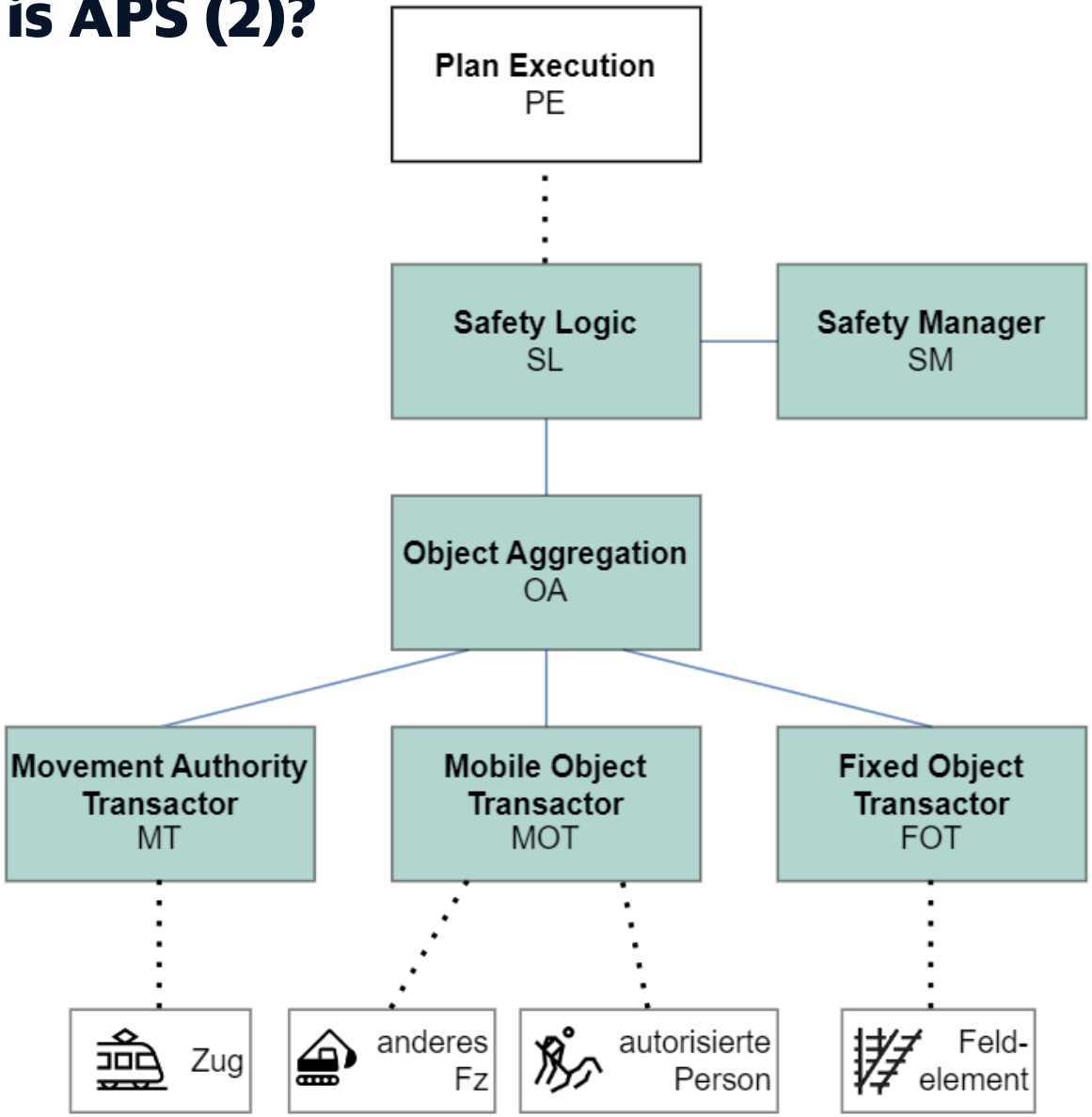
APS in RCA Architecture

What is APS (1)?

1. Function ***route protection*** (today task of interlocking)
2. Function trackside ***train control*** (today task of RBC)
3. **Train-centric** approach (unlike interlocking)

!

What is APS (2)?



Receives

- Field Element state change commands
- Movement Permission requests

Grants/Rejects requests

Controls

- Trains (ETCS)
- Field Elements (EULYNX SCI)

Reports states of

- Field elements
- Movable objects
- Movement permissions

RCA Candidate Architecture – APS Scope & Interfaces

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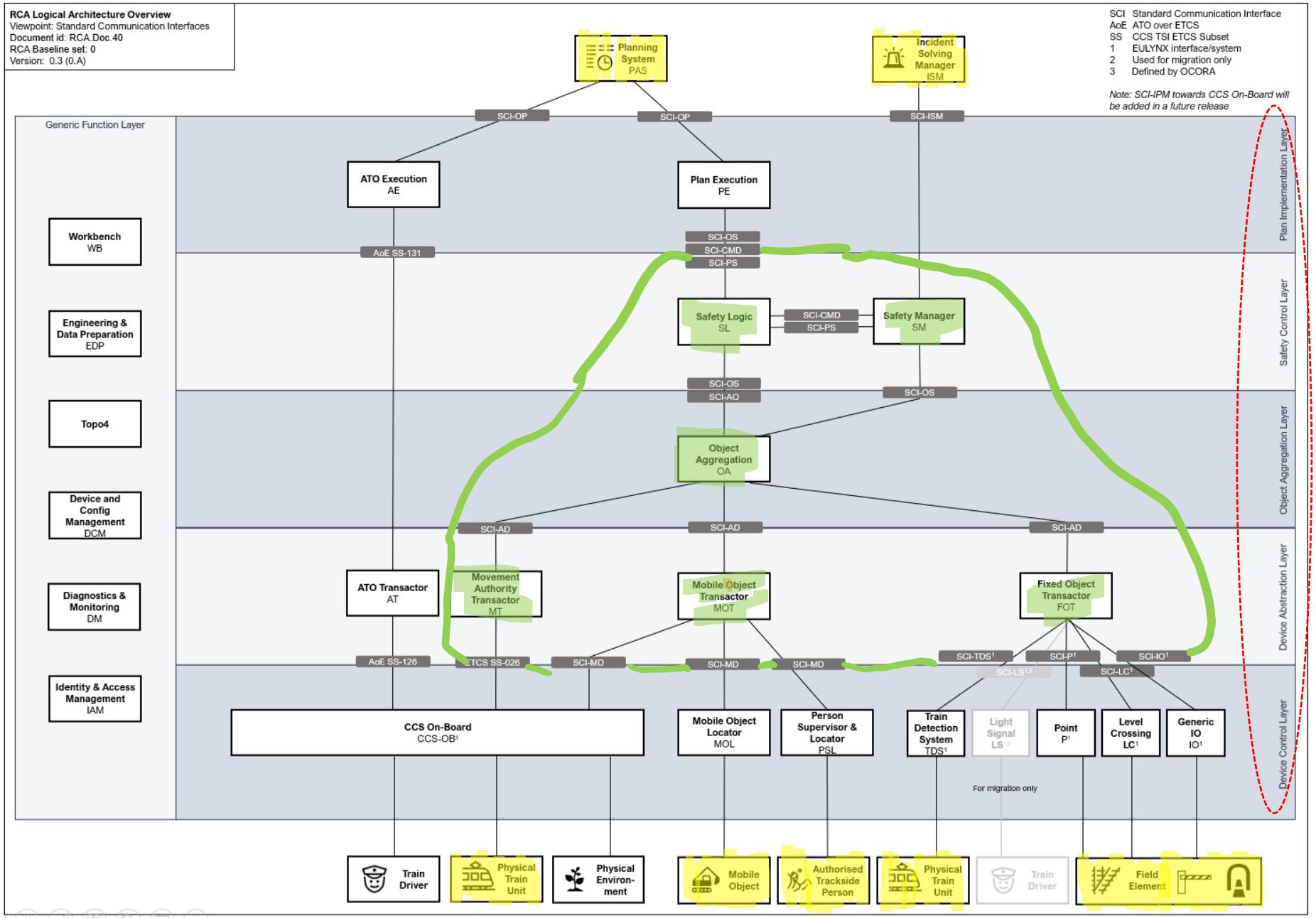

Layers

- Plan Implementation
- Safety Control
- Object Aggregation
- Object Abstraction
- Device Control

Benefits

- Clear responsibilities
- Clear interfaces
- Interchangeability
- Competition, market entry, costs
- Separated life cycles

Challenge

- Integration

RCA Candidate Architecture – The APS stickman (informal)

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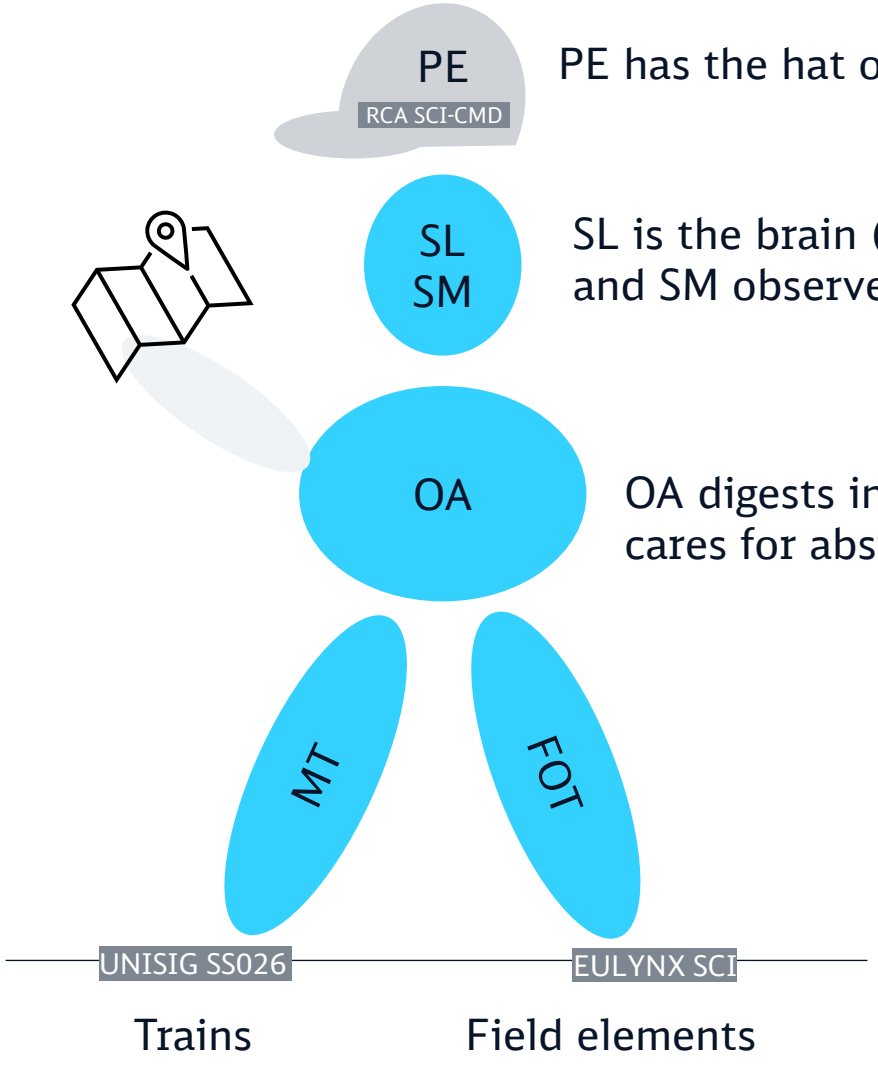


PE has the hat on – knows what to do

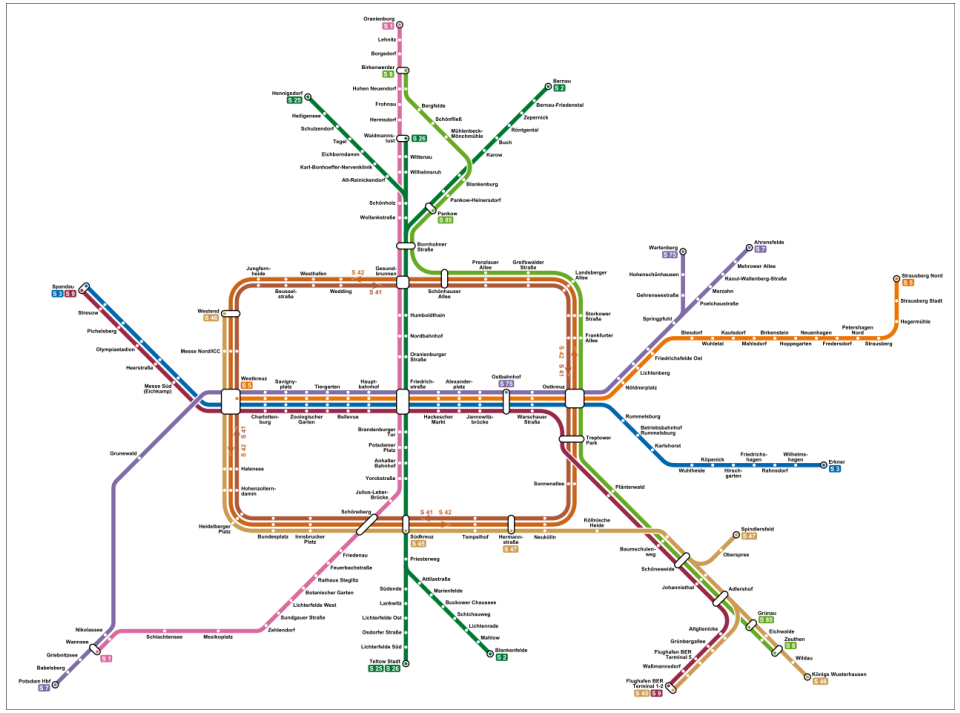
SL is the brain (controls: accepts/rejects) and SM observes safety

OA digests information – up & down; cares for abstraction

Two legs on the ground of solid (standardised) interfaces

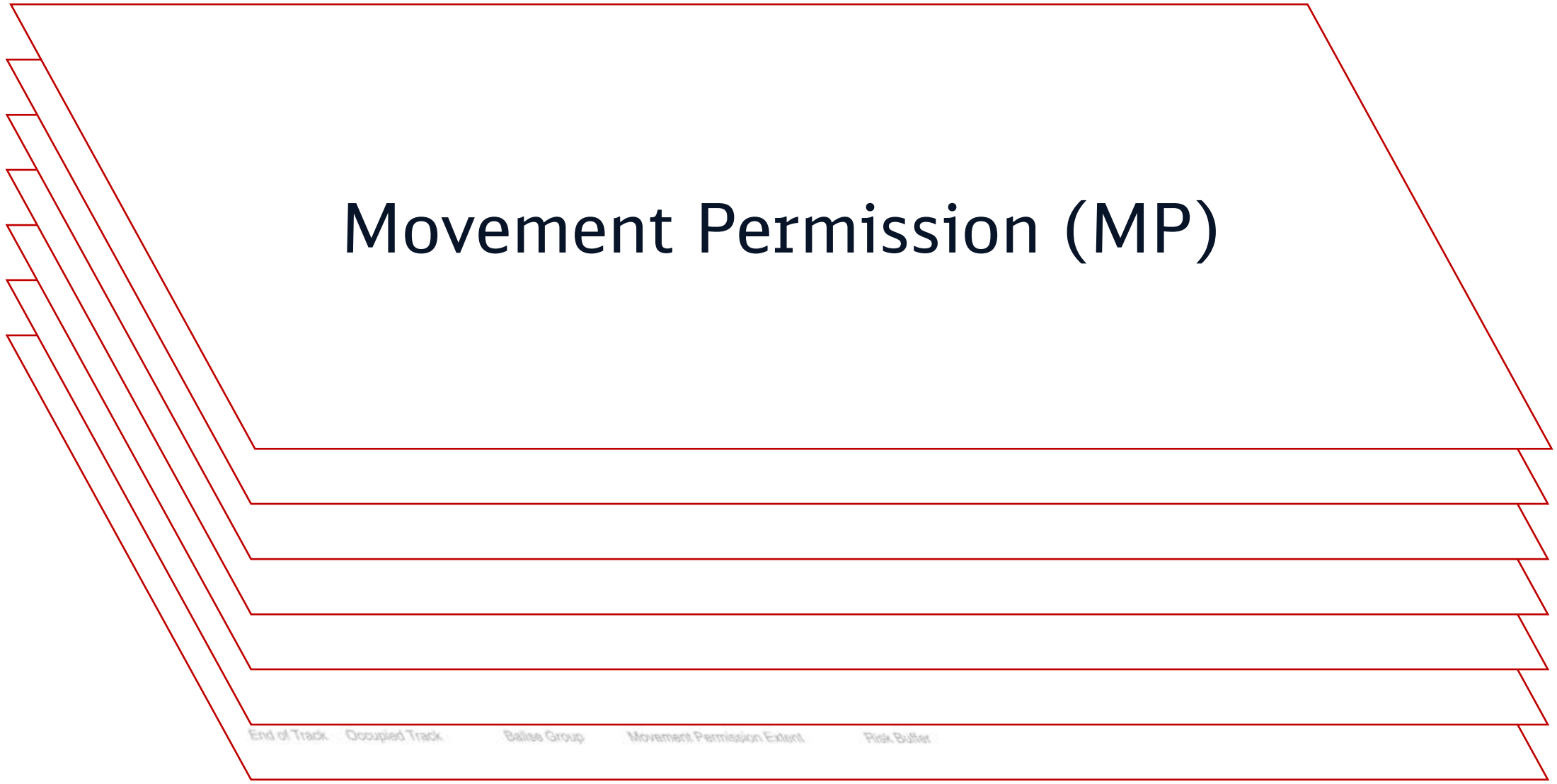
Not shown: the „third leg“ to the non-trackbound movable objects

(trackworkers, maintenance vehicles)

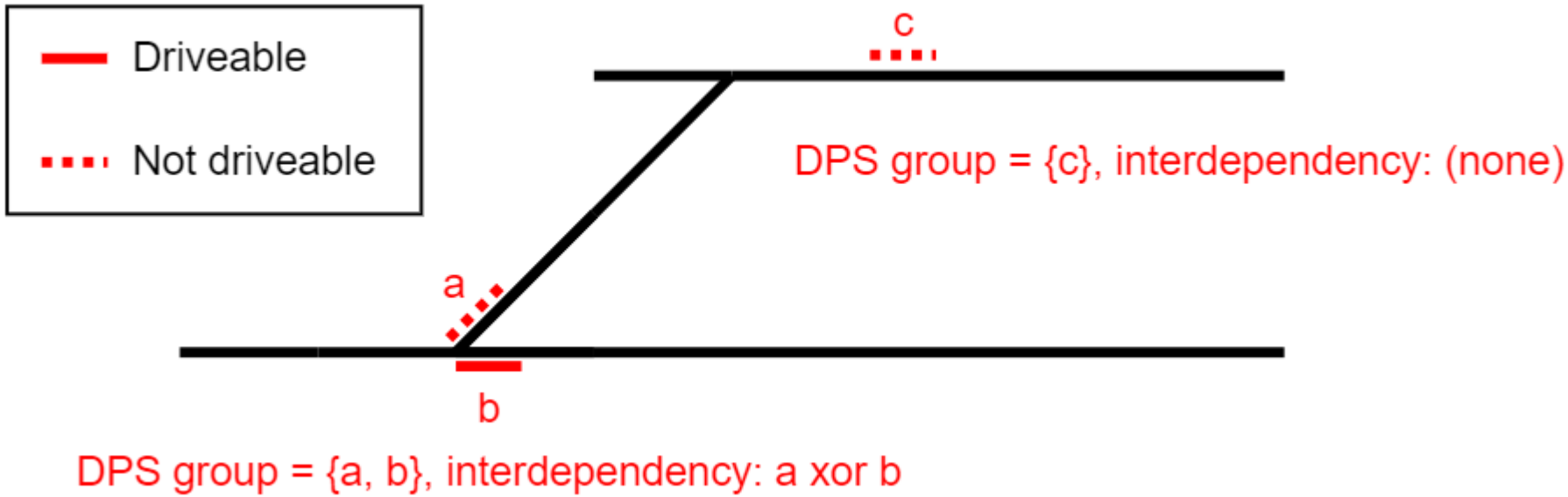


→ Abstractions

Abstractions

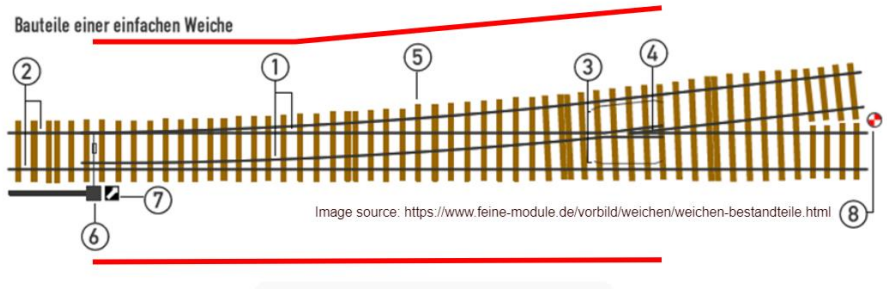


Abstraction – Driveability (Drive Protection Section DPS)



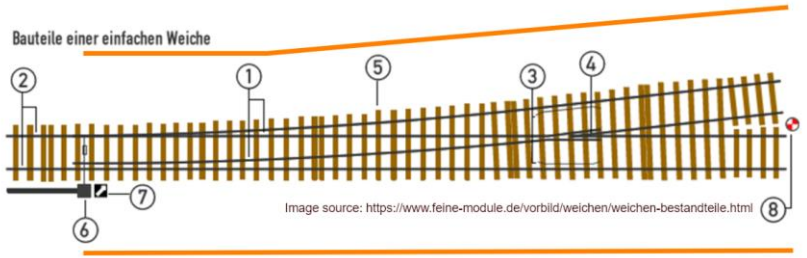
Examples for DPS

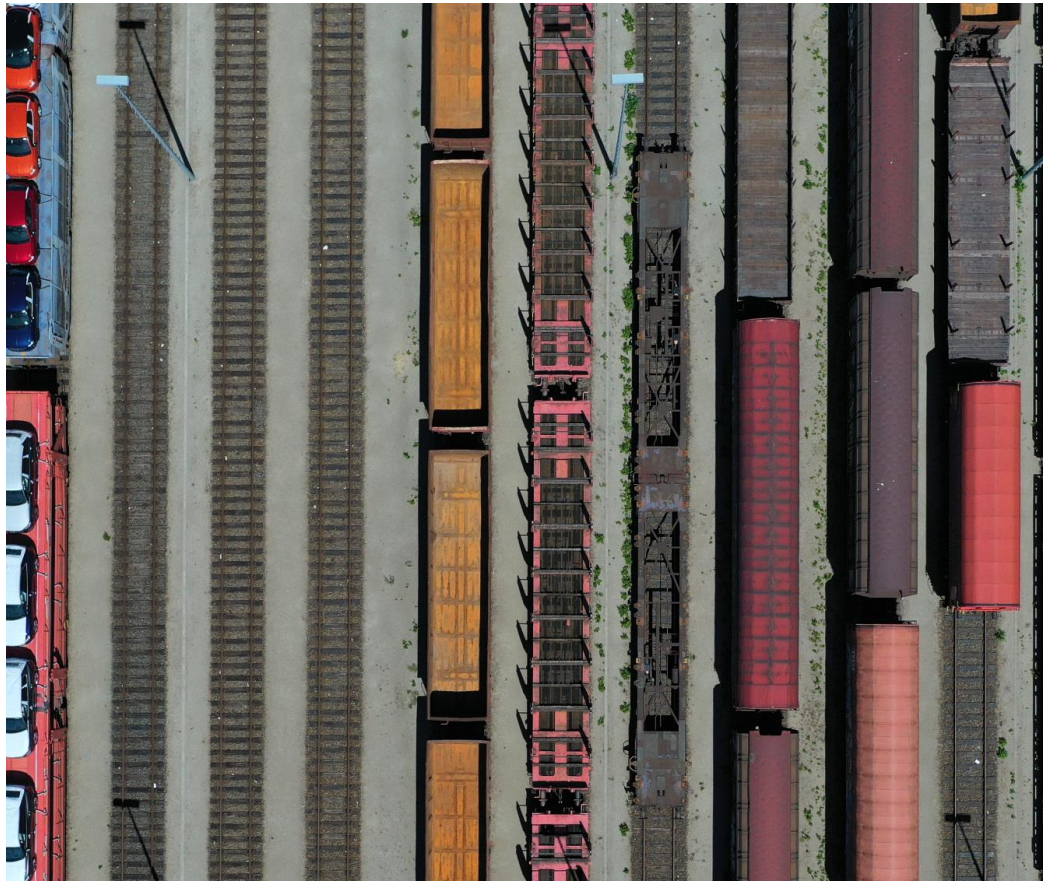
- Point (simple, slip point)
- Derailer
- Level crossing
- Gate
- Movable bridge
- Traverser, turntable



Abstraction: Gauge clearance (Allocation Section AS)

AS group = {a, b}, interdependency: a xor b





→ Block-centric vs Train-centric approach

Block-centric view: Only auxiliary class of objects in focus

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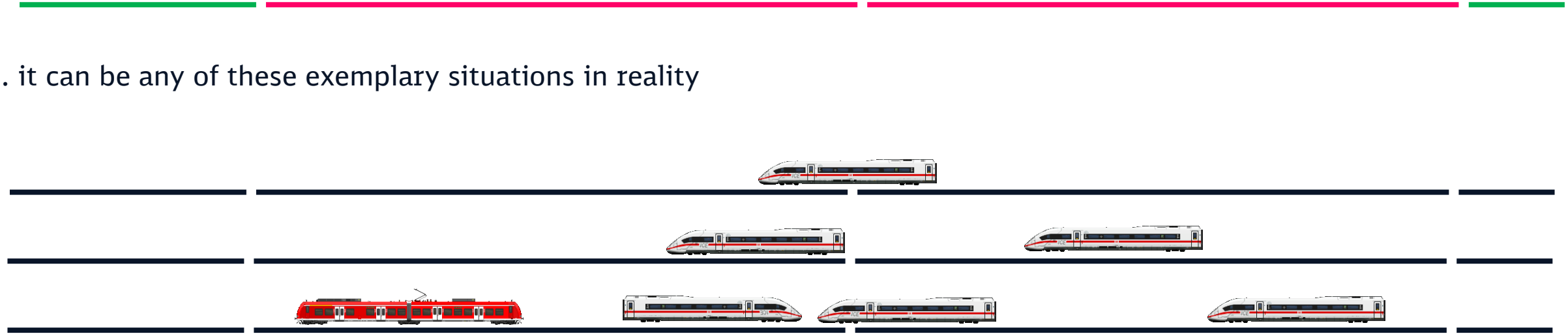
When the interlocking sees this (example: 4 axle counter sections on a straight track)…



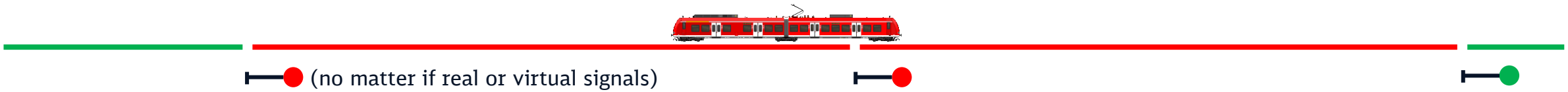
… it can be any of these exemplary situations in reality

which means the interlocking view is not oriented to the business object (train) but to **auxiliary objects** (blocks/occupations) which suppresses essential information

Block-centric view: Supplement by train information (RBC)

With the RBC which knows the business object, both views can be combined

but still the basic functional separation *route protection* and *train control* is in place, consider this example



where, when the interlocking can‘t report a qualified signal stop to the RBC, the RBC cannot *directly* conclude whether the signal was closed triggered by the passing train itself (regular situation) or a preceding train (hazard).

➔ The block-centric view is supplemented by train information but **basic (interlocking) principles still hold** and require complicated technical solutions.

From block-centric view to train-centric view: Real business object

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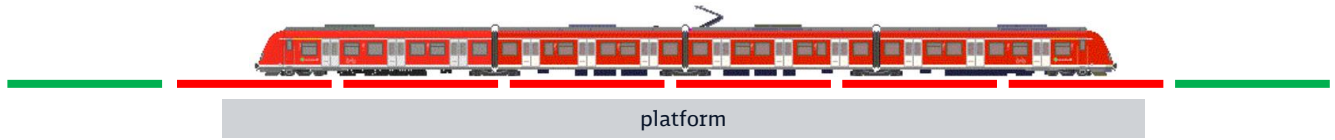
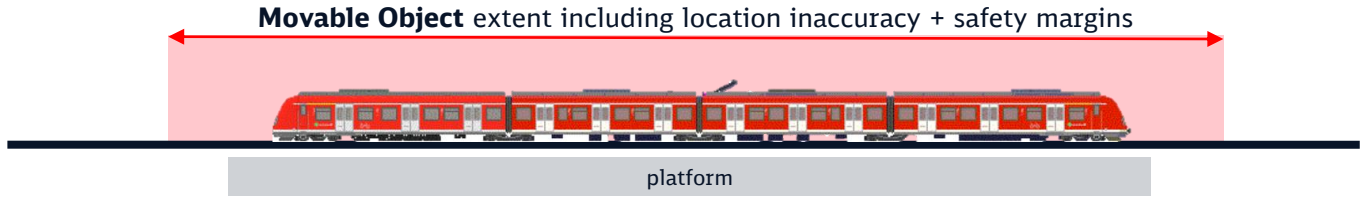
Due to capacity improvement needs, in block-centric approach blocks can be (real or virtually) sub-divided so that a train occupies more than one block section



and if this happens in the terminal station and the train has to turn, the interlocking gets a sequence error (expected release order not fulfilled). → Again the mitigation means complicated technical solutions

In **train-centric** view, all this is already built-in.



→ None of the two examples will cause a change in APS

Still trackside train-detection equipment (TTD)?

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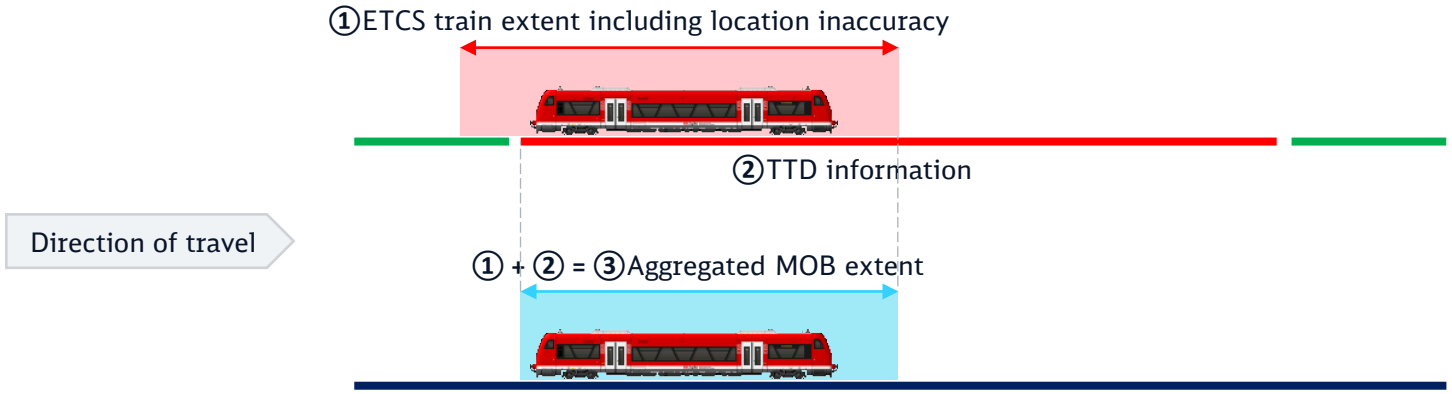
- From the beginning, APS will support TTD
- This is needed anyway for migration scenarios

- But: the role of TTD will change: from the central **signalling** asset to a pure **location** asset
- This will be used for **object aggregation**



➔ Different source of localisation information is aggregated

Hybrid shunting loco RhB Geaf 2/2

→ Hybrid operation

Hybrid/mixed operation (migration)

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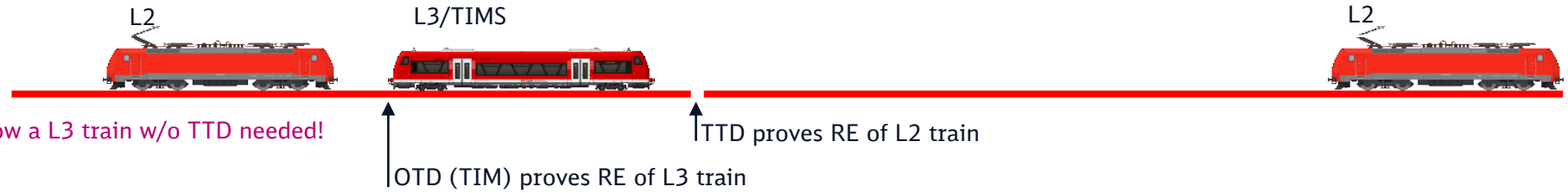
- Train front end (FE) is reported by ETCS train position report in both ETCS L2 and L3
- In ETCS L3, the train rear end (RE) can be deduced from integrity + train length
- For a train to follow safely and closely it is important to clear the RE of the preceding train

- No TTD

- (Full) TTD



➔APS supports mixed L2/L3 operation from the beginning

(This will be needed to cope with different TIM equipment grades during migration, expected to be a long period.)

APS inner train-centric safety logic serves all system types

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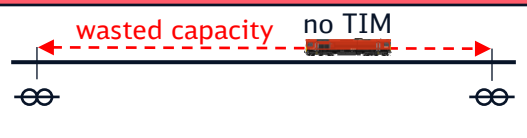
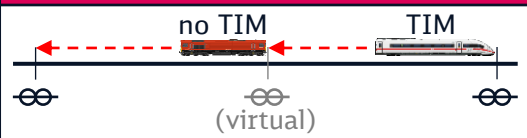
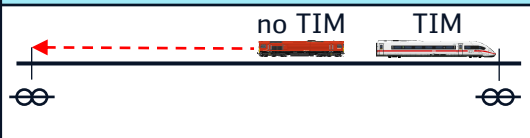
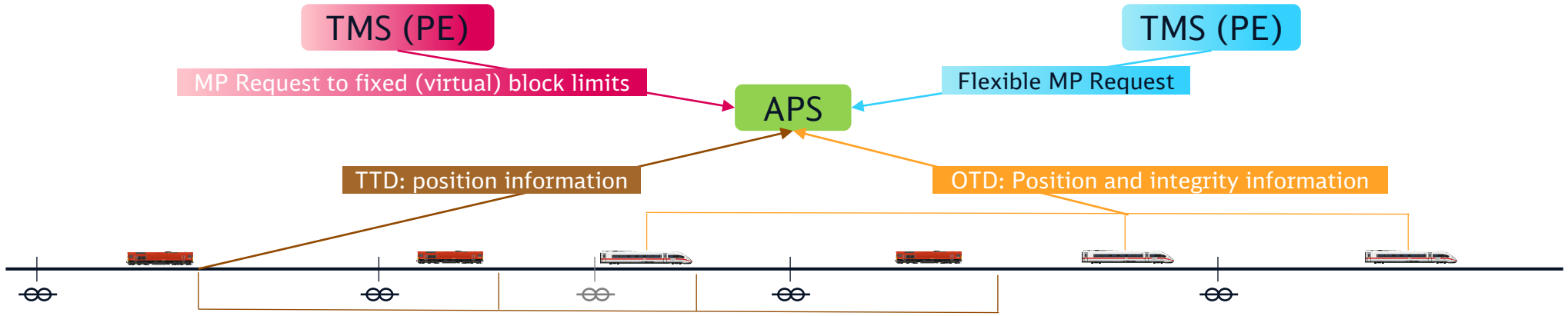
	Fixed block	Hybrid virtual fixed block	Hybrid moving block	Full moving block
				
Rear end located by	TTD	TTD, OTD		OTD
Operation	fixed block		moving block, partially fixed rear end	moving block
TMS view	block-centric		train-centric	
MA target	fixed location		any location	
Same train-centric APS No blocks! TTD only for localisation support!				

Axle counter | TTD: Trackside Train Detection | OTD: On-board Train detection | TIM: Train Integrity Monitoring

(Video)

Fixed Block

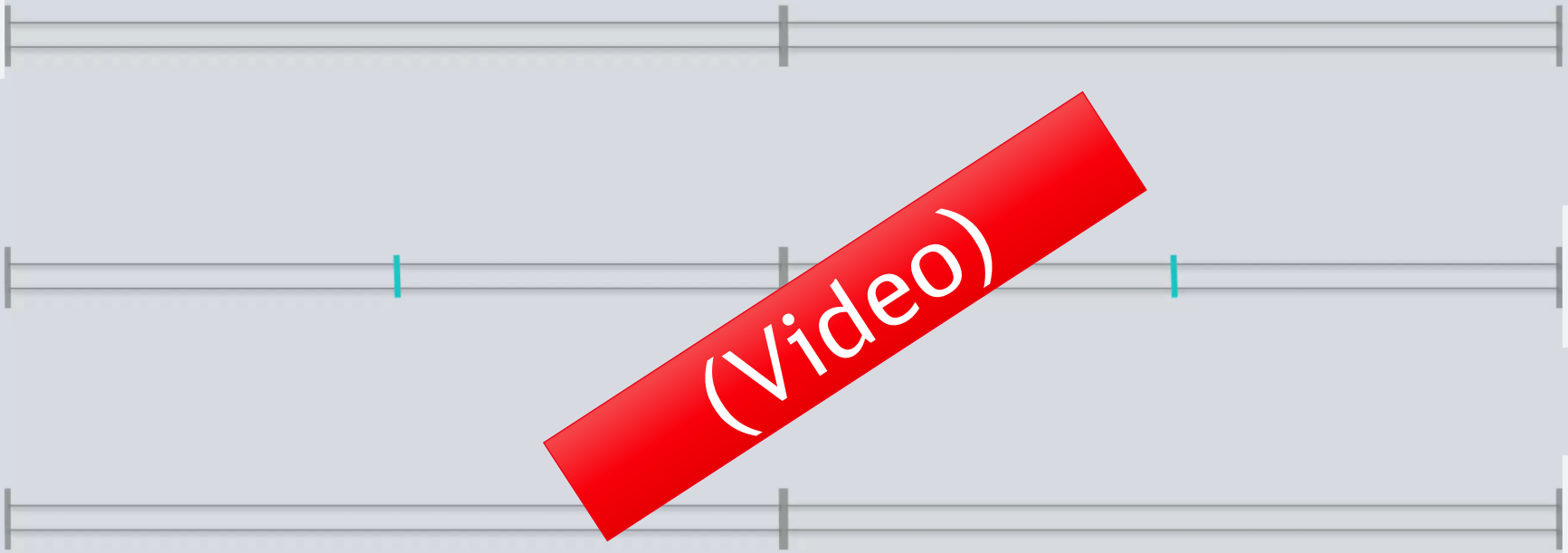
Full moving block

(Video)

Hybrid virtual fixed block

Hybrid moving block

Fixed block



Hybrid virt. fixed block

Hybrid moving block

Full moving block

Comparison of signalling principles (video)

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	Train s/h	Compared to …	
Fixed block	18		
Hybrid virtual fixed block	21	+17%	
Hybrid moving block	27	+50%	+29%
Full moving block	61	+238%	

Constraint for hybrid scenarios

- a train with TIM follows a train without TIM etc. (strictly alternating)

Image by Hans-Jörg Aleff

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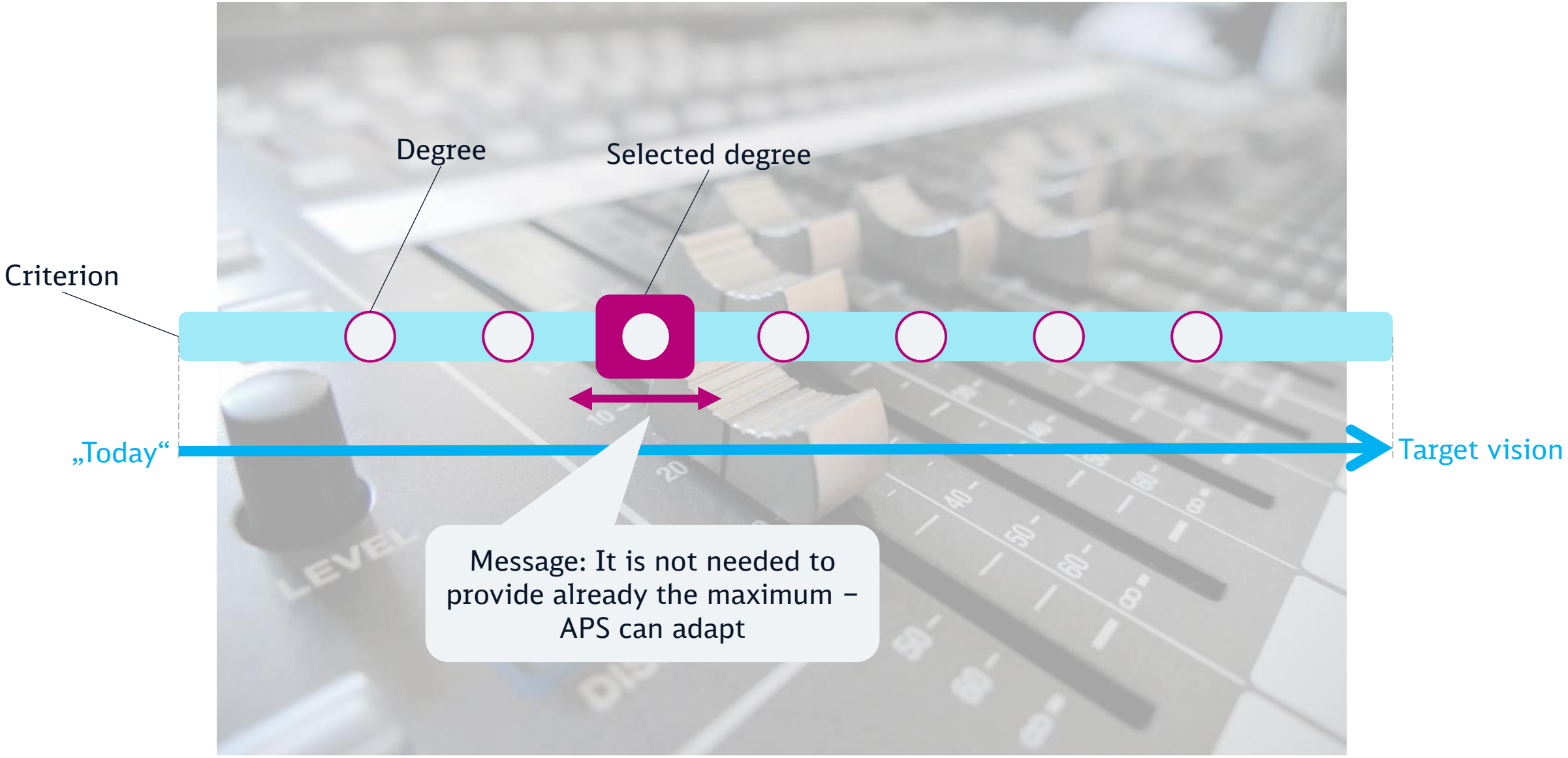
→ A step too big?

Built-in migration!

Migration - The sliders (1)



Migration - The sliders (2)

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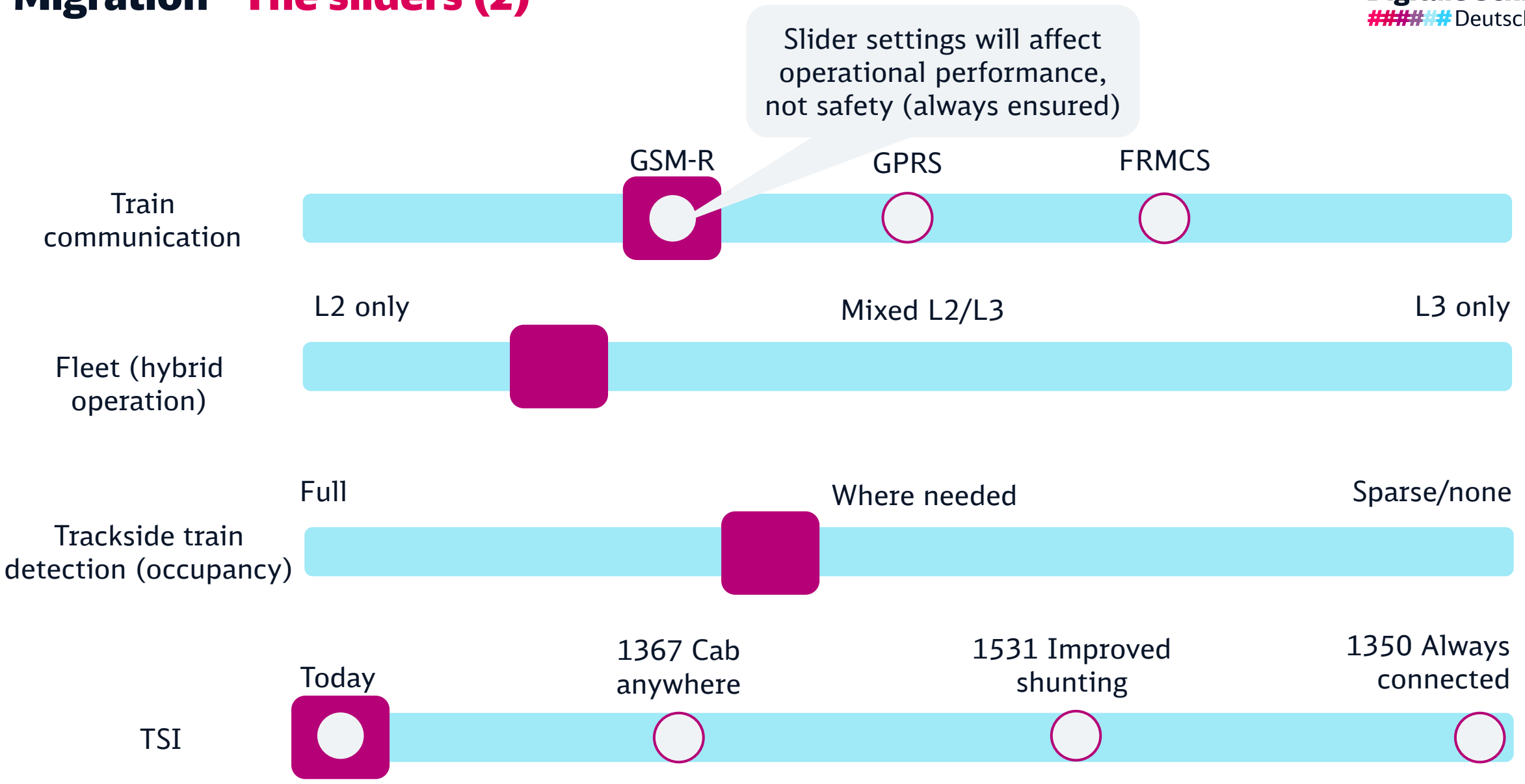

Migration - The sliders (3)

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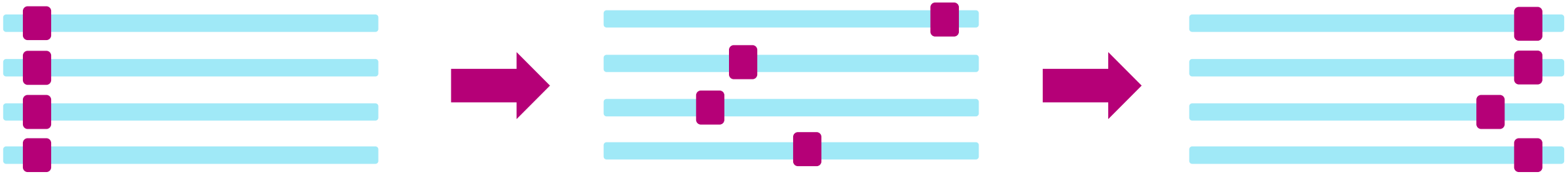
Examples. APS will serve them all – environment-driven

Already suited to replace today‘s CCS = already value!

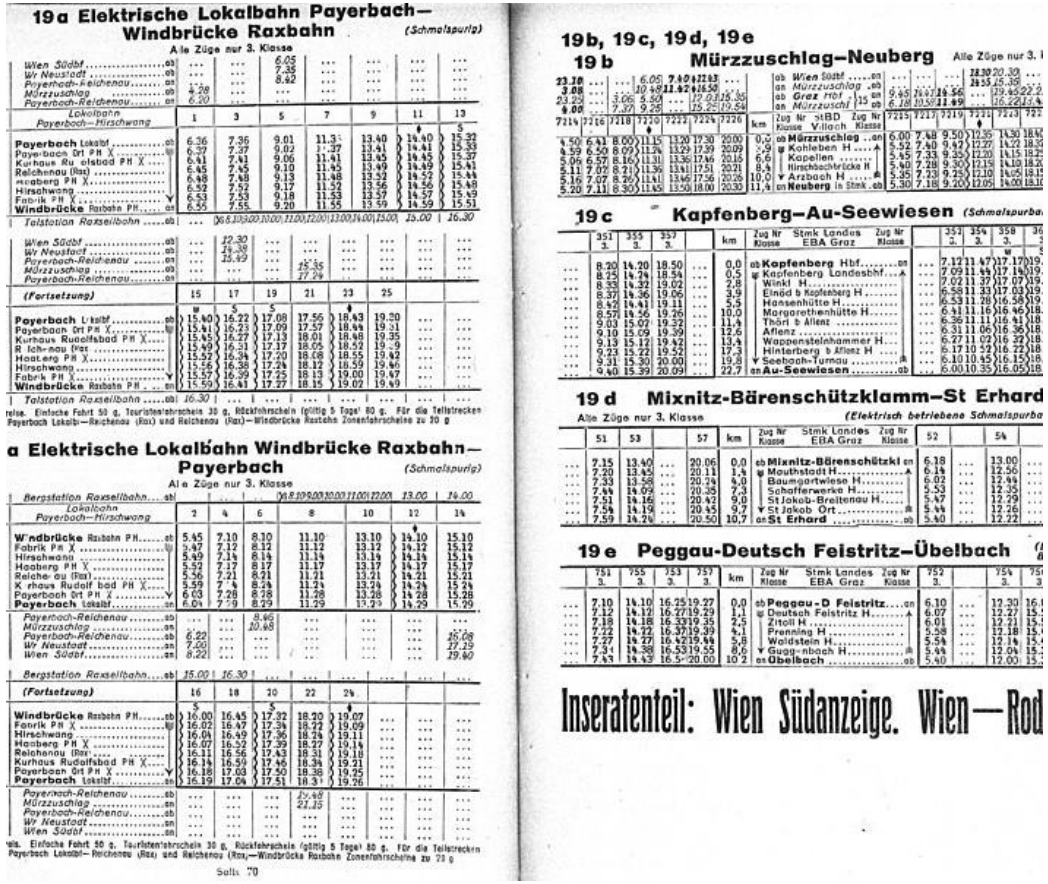
According to needs, line, and feature availability

Target vision



Sliders are influenced by external factors (e.g. infrastructure or fleet) and APS can *dynamically* adapt – **no APS sw adaptation** needed!

Message: **Don‘t fear** the target vision‘s **ambitions** (e.g. *always connected*) – APS will cope with every step within and until.



19a Elektrische Lokalbahn Payerbach—Windbrücke Raxbahn (Schmalspurbahn)

19b, 19c, 19d, 19e

19b Mürzzuschlag–Neuberg

19c Kapfenberg–Au-Seewiesen

19d Mixnitz-Bärenschützklamm–St Erhard

19e Peggau-Deutsch Feistritz–Übelbach

Inseratenteil: Wien Südanzeige. Wien—Rod

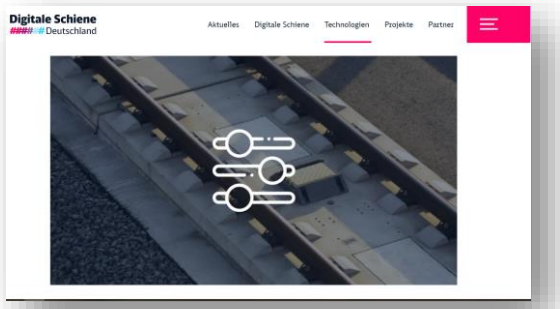
Image by Josef Moser

https://commons.wikimedia.org/wiki/File:Fahrpl%C3%A4ne_H%C3%B6llentalbahn_Neuberg_Th%C3%B6rlerbahn_Breitenauerbahn_%C3%9Cbelbach_1946-47.jpg CC license

→ **Further Reading**

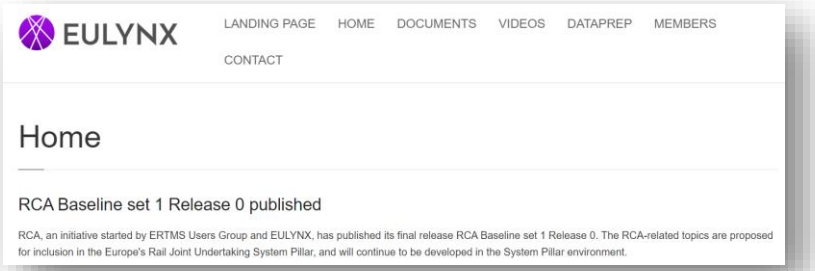
Further reading

https://digitale-schiene-deutschland.de/Advanced-Protection-System



RCA Baseline 1.0 https://public.3.basecamp.com/p/KeehzqFmXv5R2N7tGDjaEokq

- APS-Documents RCA.Doc.##: 51, 52, 61, 62, 63, 67, 68, 79



Der Eisenbahningenieur 11/2022: Blöcke waren gestern – Chancen einer zugzentrischen LST

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