

APS 2100

11:20

+++ Have a good journey +++

Bern HB – Berlin Hbf – Stuttgart Hbf

Future

1

2

3

4

5

6

7

8



Digitale Schiene Deutschland



Advanced Protection System



APS; APS in RCA architecture



Abstractions



Block centric/train centric



Hybrid operation



Built-in migration



Backup





BLÖCKE WAREN GESTERN – ÜBER DIE CHANCEN EINER ZUGENTRISCHEN LST

# Advanced Protection System (APS)

FRANK SKOWRON, DB NETZ AG

DMG-SEMINAR – STUTTGART, 28.09.2023



**RCA**  
Reference CCS  
Architecture



# → **Digitale Schiene Deutschland**

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

## Expectations on the railway system

Modal shift to railway is key to **reduce CO<sub>2</sub>** 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**

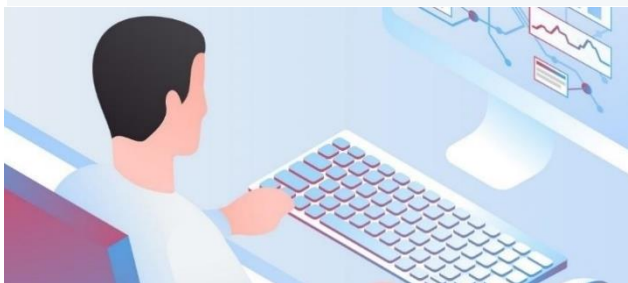
# Key innovations are being implemented in all main areas of the rail system and create new opportunities



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

## DBS Target Picture



### BASIS DIGITALIZATION OF INFRASTRUCTURE

ETCS L2 & Digital Interlockings (DSTW)  
+ additional features/improvements



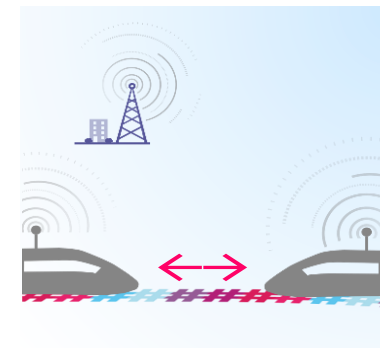
### HIGHLY AUTOMATED DRIVING

- 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



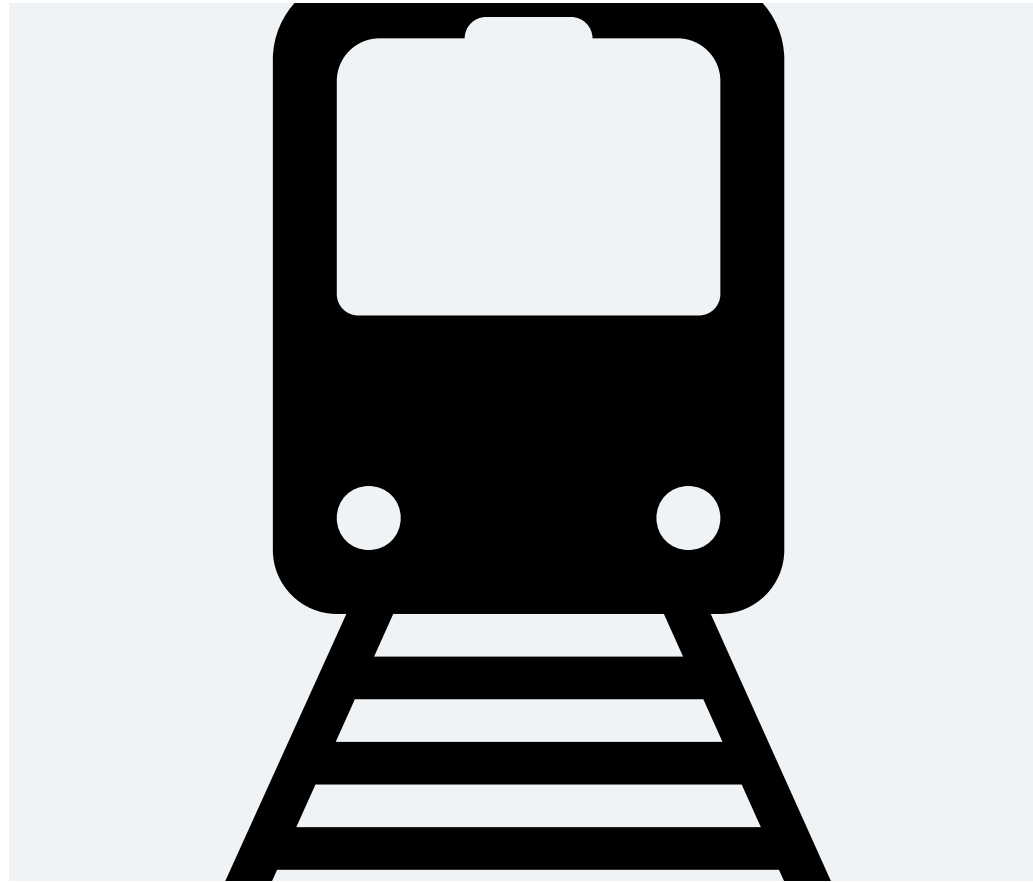
### ADVANCED DIGITAL INFRASTRUCTURE

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

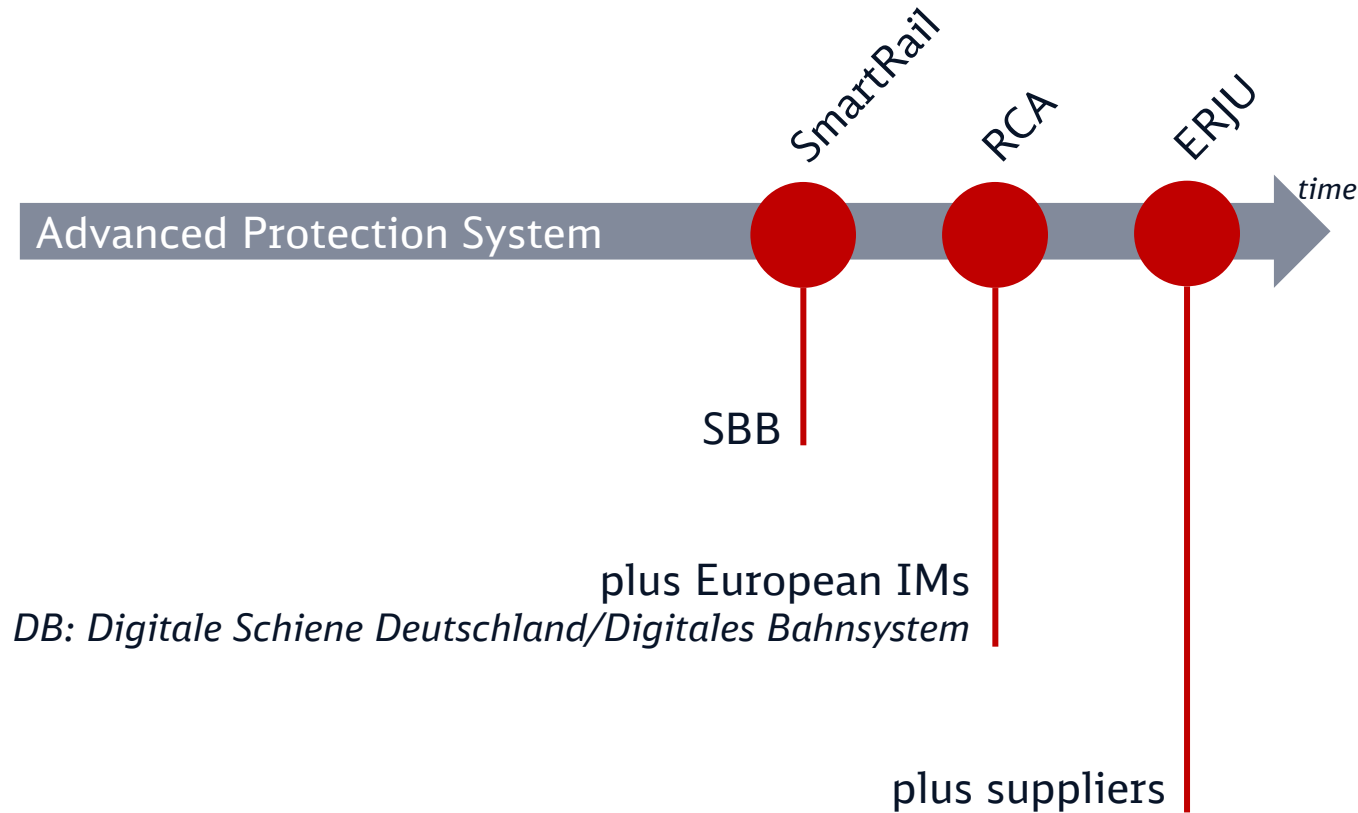


### INTELLIGENT PLANNING AND DISPATCHING

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



→ **Advanced  
Protection  
System**



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





Berlin Hbf

Image by Ansgar Koreng – Own creation, CC BY 3.0,  
[https://commons.wikimedia.org/wiki/File:Berlin\\_Hauptbahnhof\\_Ostseite\\_HDR.jpg](https://commons.wikimedia.org/wiki/File:Berlin_Hauptbahnhof_Ostseite_HDR.jpg)

→ **APS**

# **APS in RCA Architecture**

# What is APS (1)?

1

Function ***route protection*** (today task of interlocking)

2

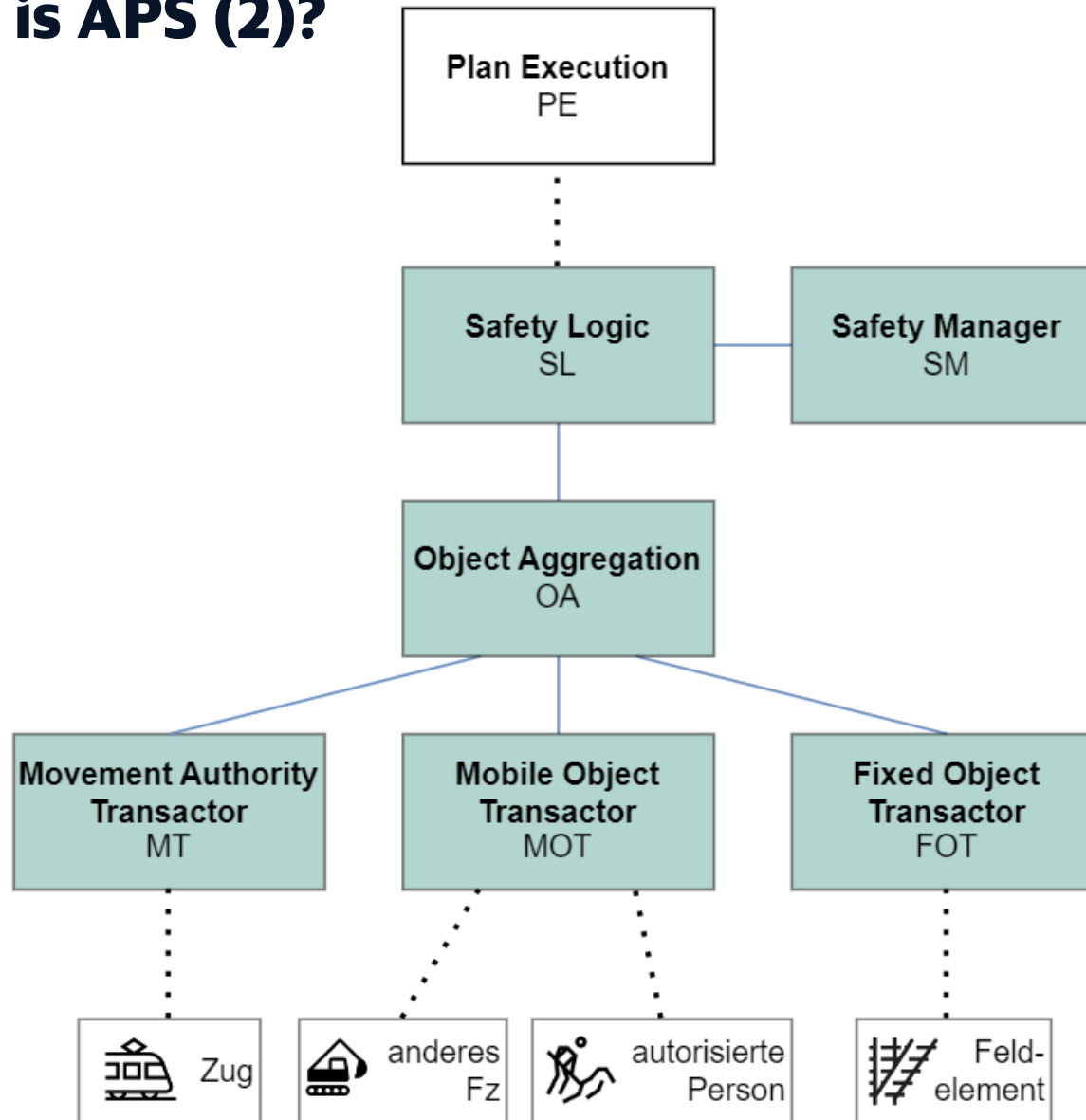
Function trackside ***train control*** (today task of RBC)

!

3

**Train-centric** approach (unlike interlocking)

# What is APS (2)?



## Receives

- Field Element state change commands
- Movement Permission requests

## Grants/Rejects requests

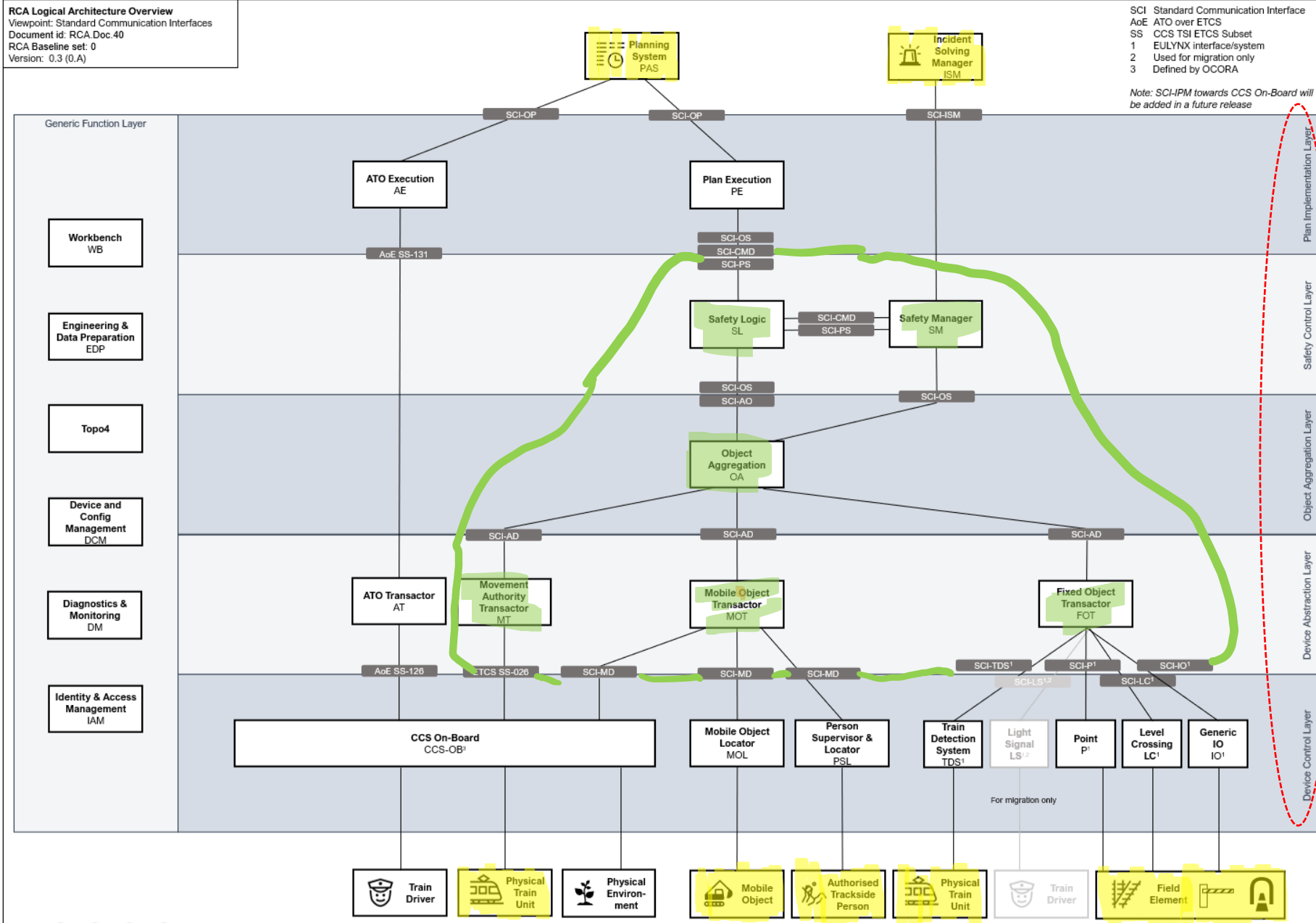
## Controls

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

## Reports states of

- Field elements
- Movable objects
- Movement permissions

# RCA Candidate Architecture – APS Scope & Interfaces



## Layers

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

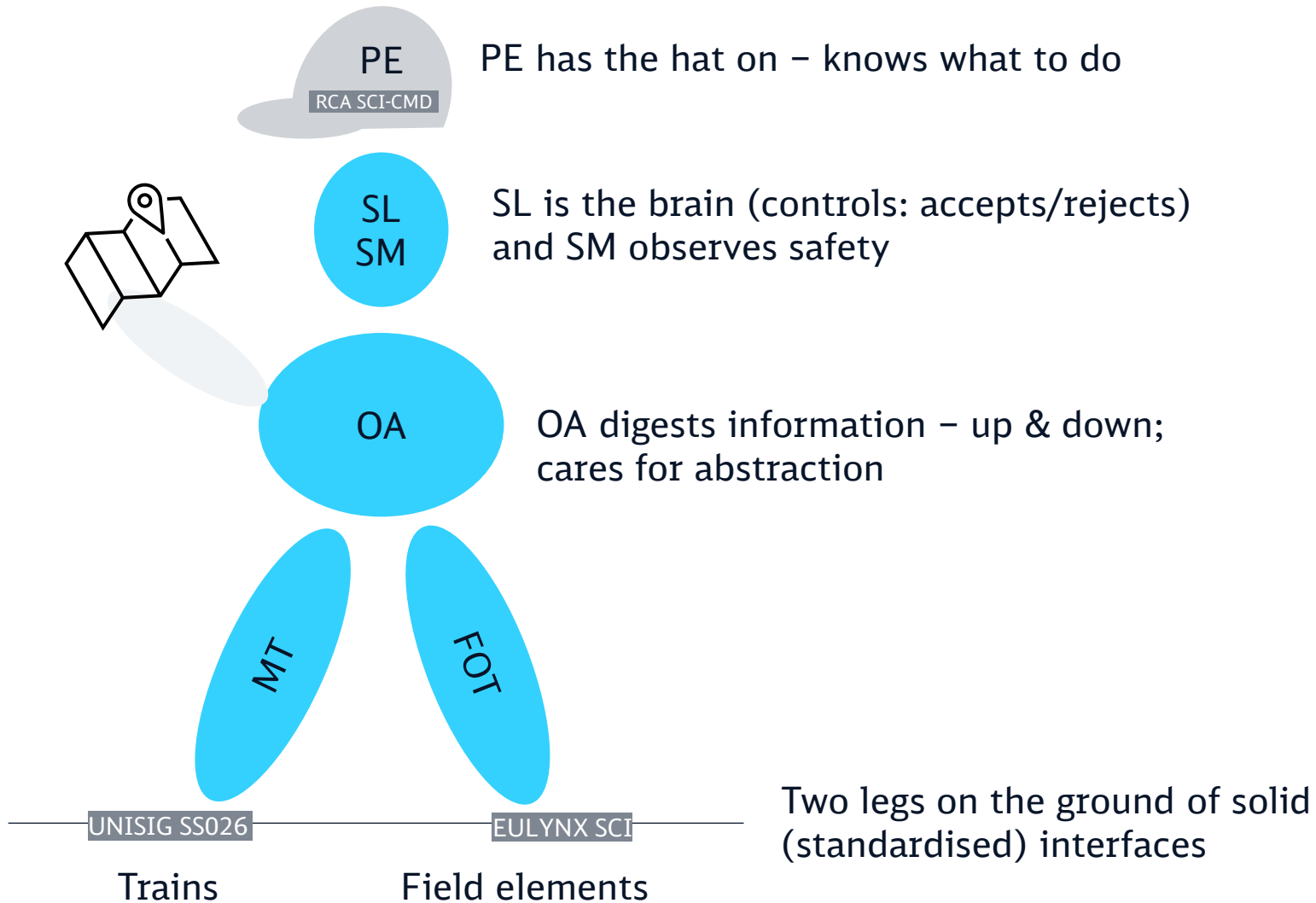
## Benefits

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

## Challenge

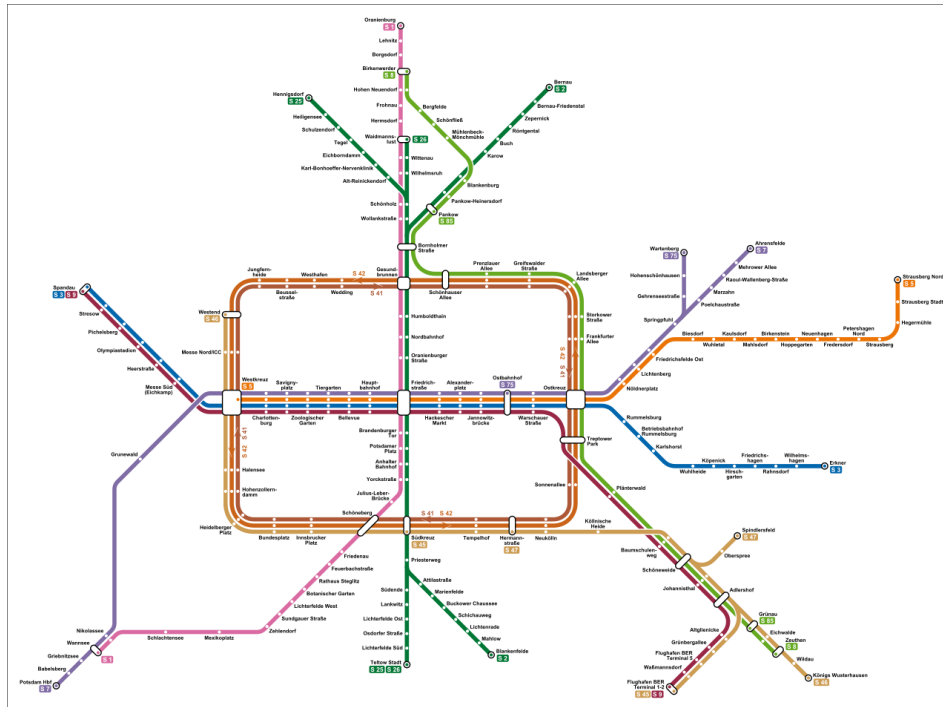
- Integration

# RCA Candidate Architecture – The APS stickman (informal)



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

(trackworkers, maintenance vehicles)

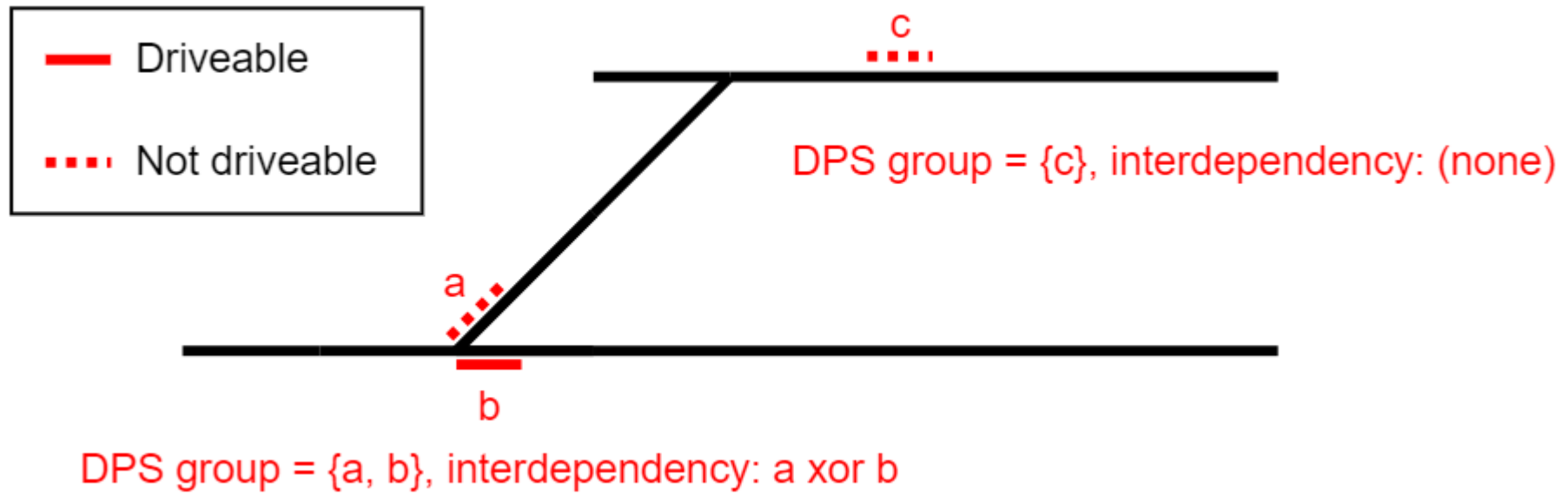


→ **Abstractions**

## Movement Permission (MP)

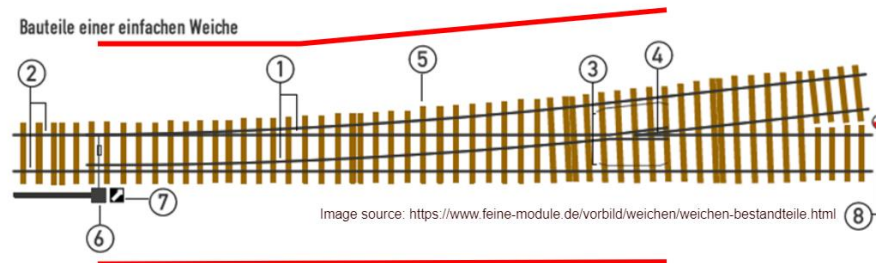
End of Track   Occupied Track   Balise Group   Movement Permission Extent   Risk Buffer

# Abstraction – Driveability (Drive Protection Section DPS)



## Examples for DPS

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

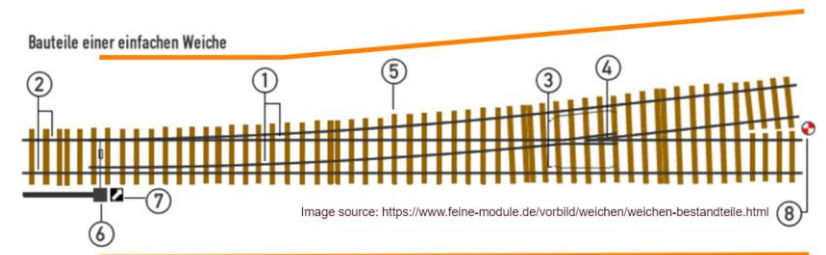


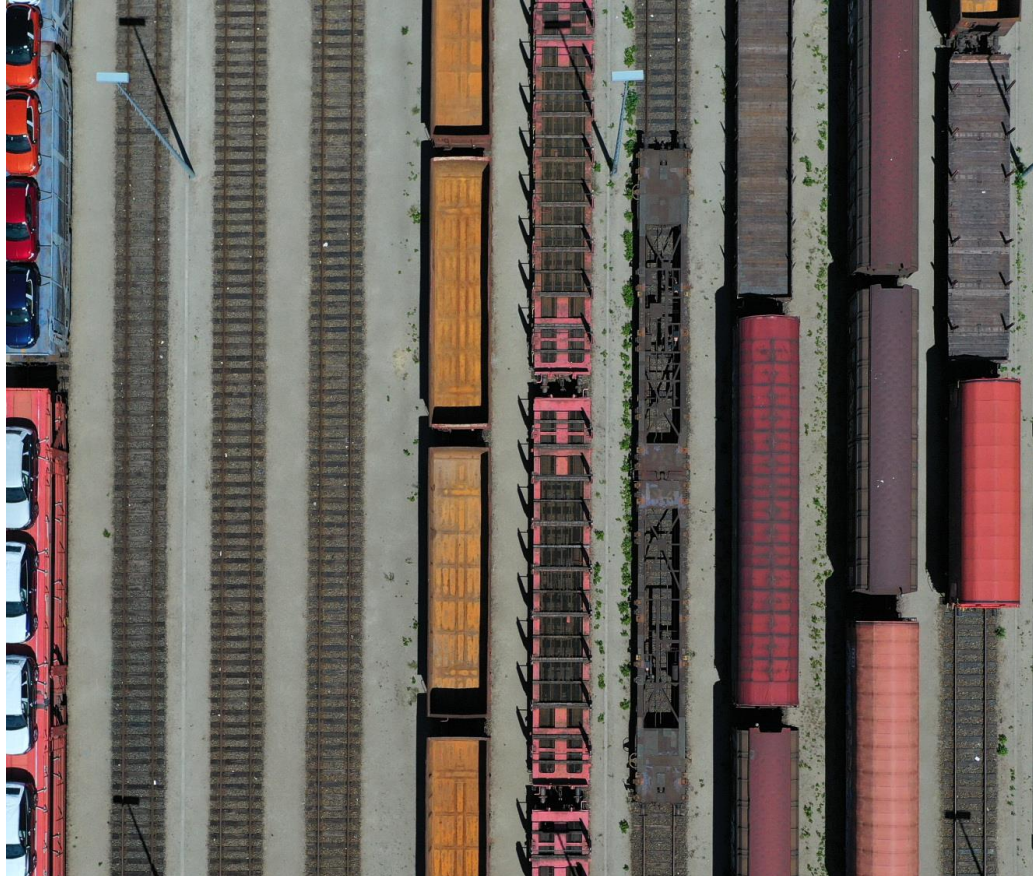


# Abstraction: Gauge clearance (Allocation Section AS)



AS group = {a, b}, interdependency:  $a \text{ xor } b$





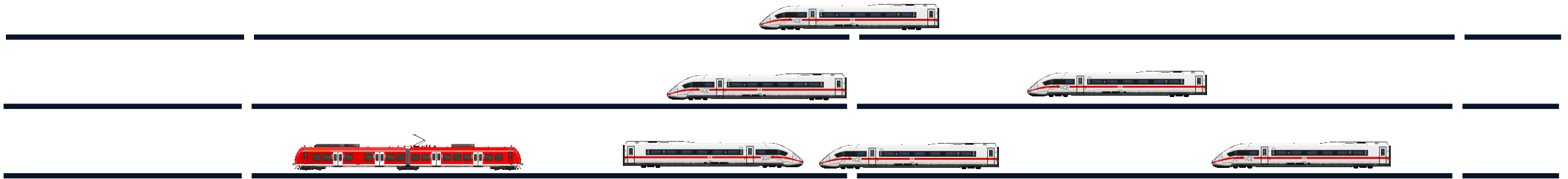
→ **Block-centric  
vs  
Train-centric  
approach**

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

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



... it can be any of these exemplary situations in reality



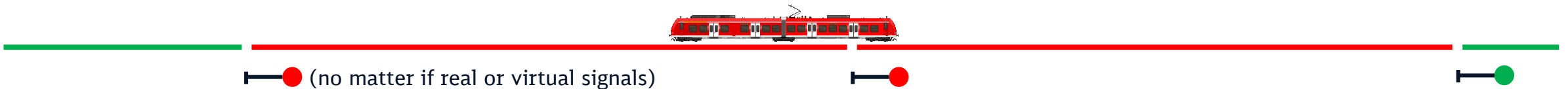
which means the interlocking view is not oriented to the business object (train) but to **auxiliary objects** (blocks/occupations) which suppresses essential information

# 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

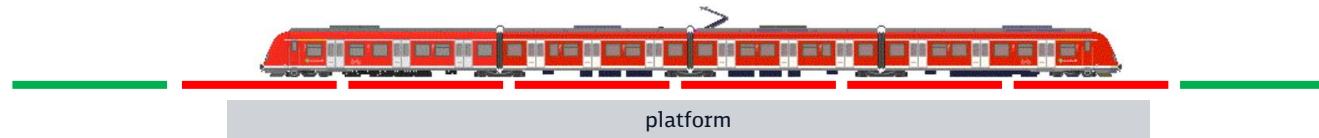


where, when the interlocking can't report a qualified signal stop to the RBC, the RBC cannot *directly* conclude whether the signal was closed triggered by the passing train itself (regular situation) or a preceding train (hazard).

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

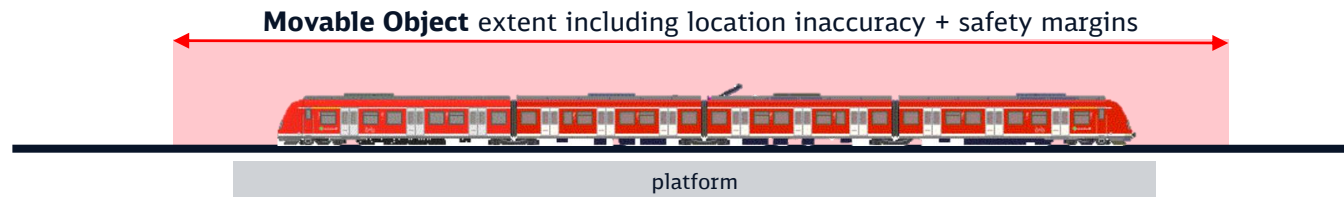
# From block-centric view to train-centric view: **Real business object** **Digitale Schiene** ##### Deutschland

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

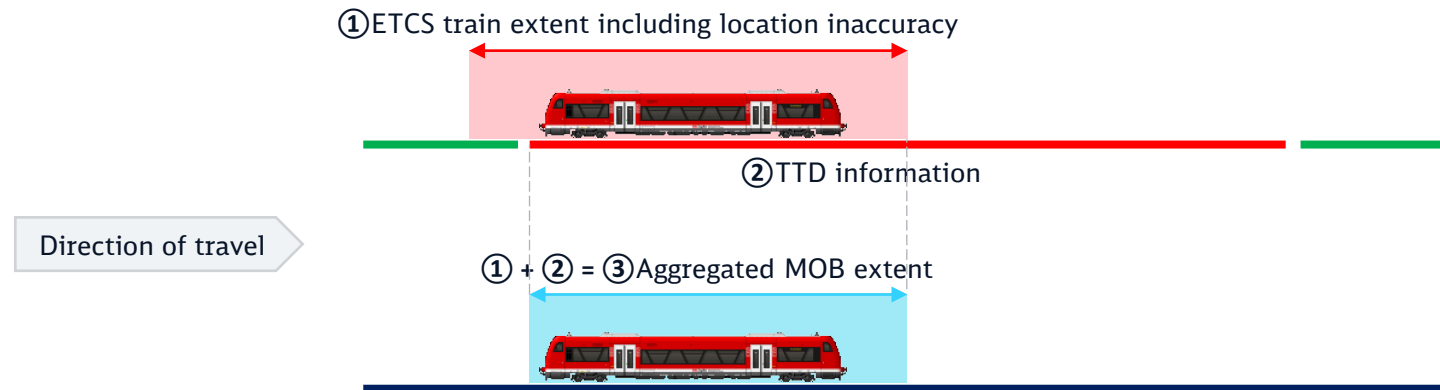
In **train-centric** view, all this is already built-in.



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

# Still trackside train-detection equipment (TTD)?

- 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

Image by Kecko – Own creation, CC BY 2.0,  
<https://www.flickr.com/photos/kecko/50259058731/in/photostream/>

→ **Hybrid  
operation**

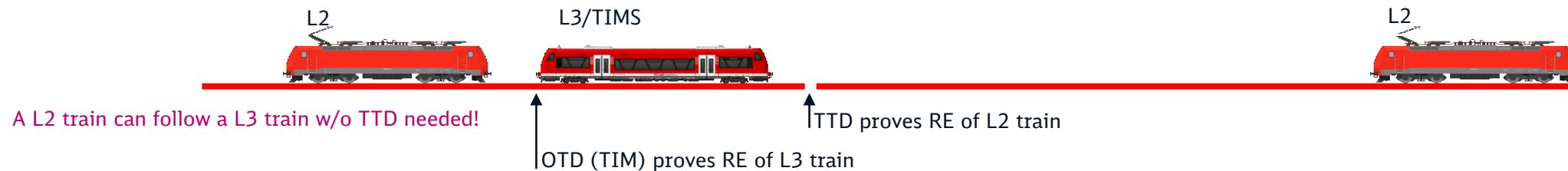
# Hybrid/mixed operation (migration)

- 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

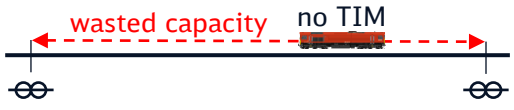
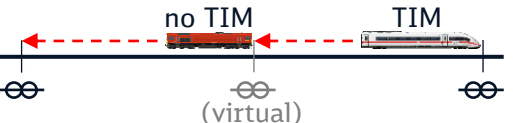


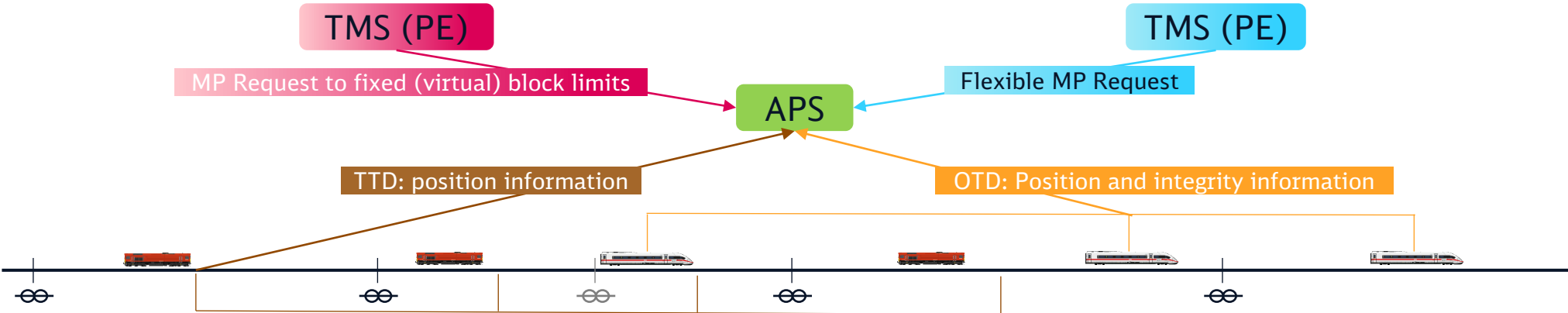


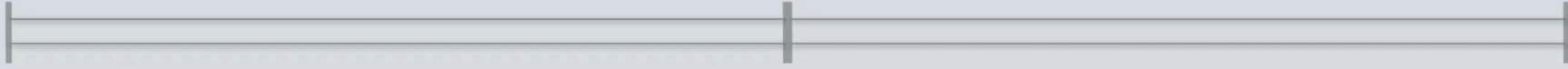
➔APS supports mixed L2/L3 operation from the beginning

(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

	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	<div><div>TMS (PE)</div><div>MP Request to fixed (virtual) block limits</div><div>TMS (PE)</div><div>Flexible MP Request</div><div>APS</div><div>TTD: position information</div><div>OTD: Position and integrity information</div></div>			
No blocks! TTD only for localisation support!				

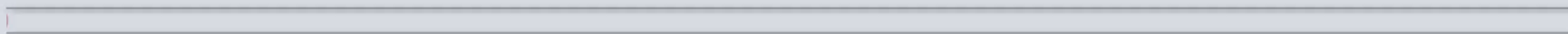


(Video)

Fixed Block

# Full moving block

(Video)



# Hybrid virtual fixed block



# Hybrid moving block

Fixed block

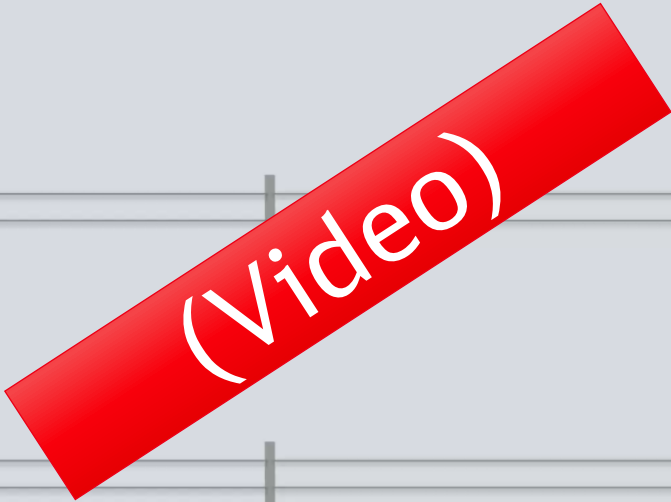
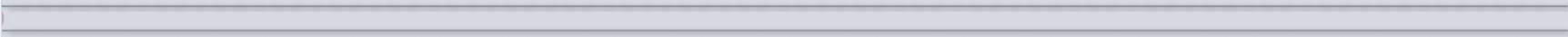


Hybrid virt.  
fixed block



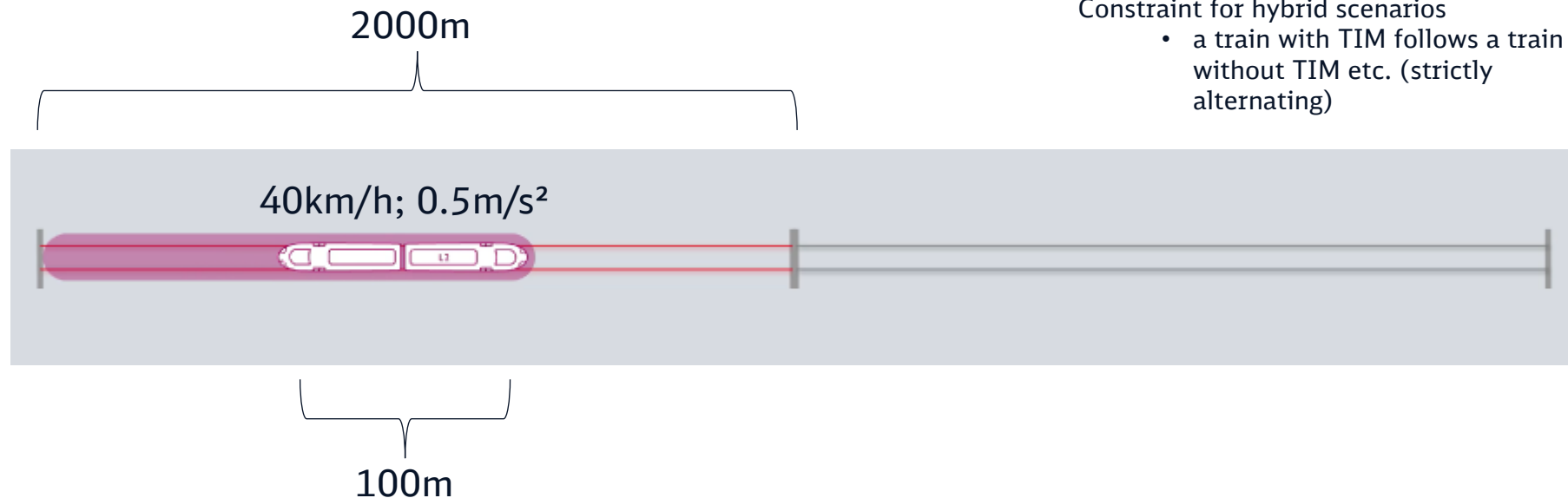
Hybrid  
moving block

Full moving  
block



# Comparison of signalling principles (video)

	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)



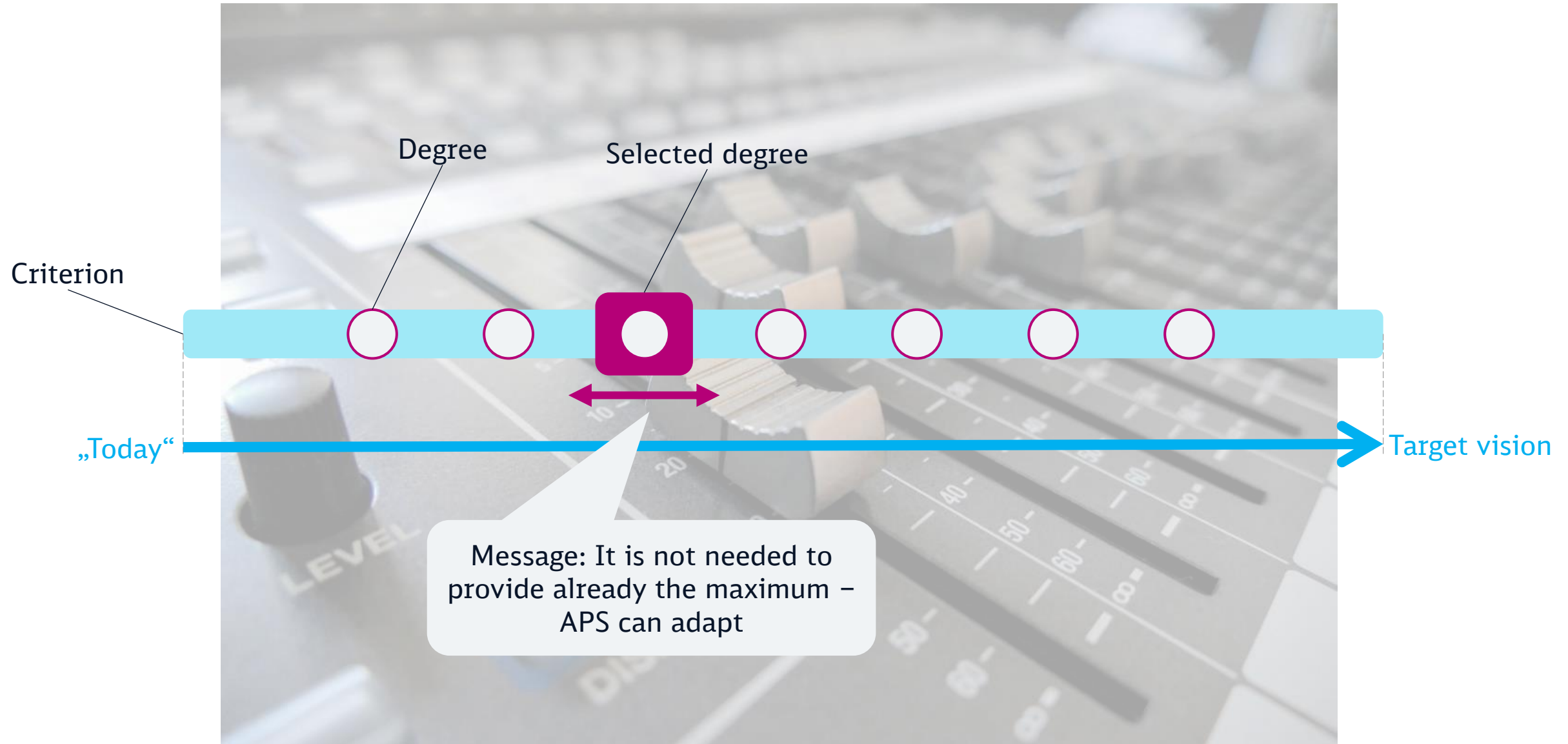
Image by Hans-Jörg Aleff

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→ **A step too big?**

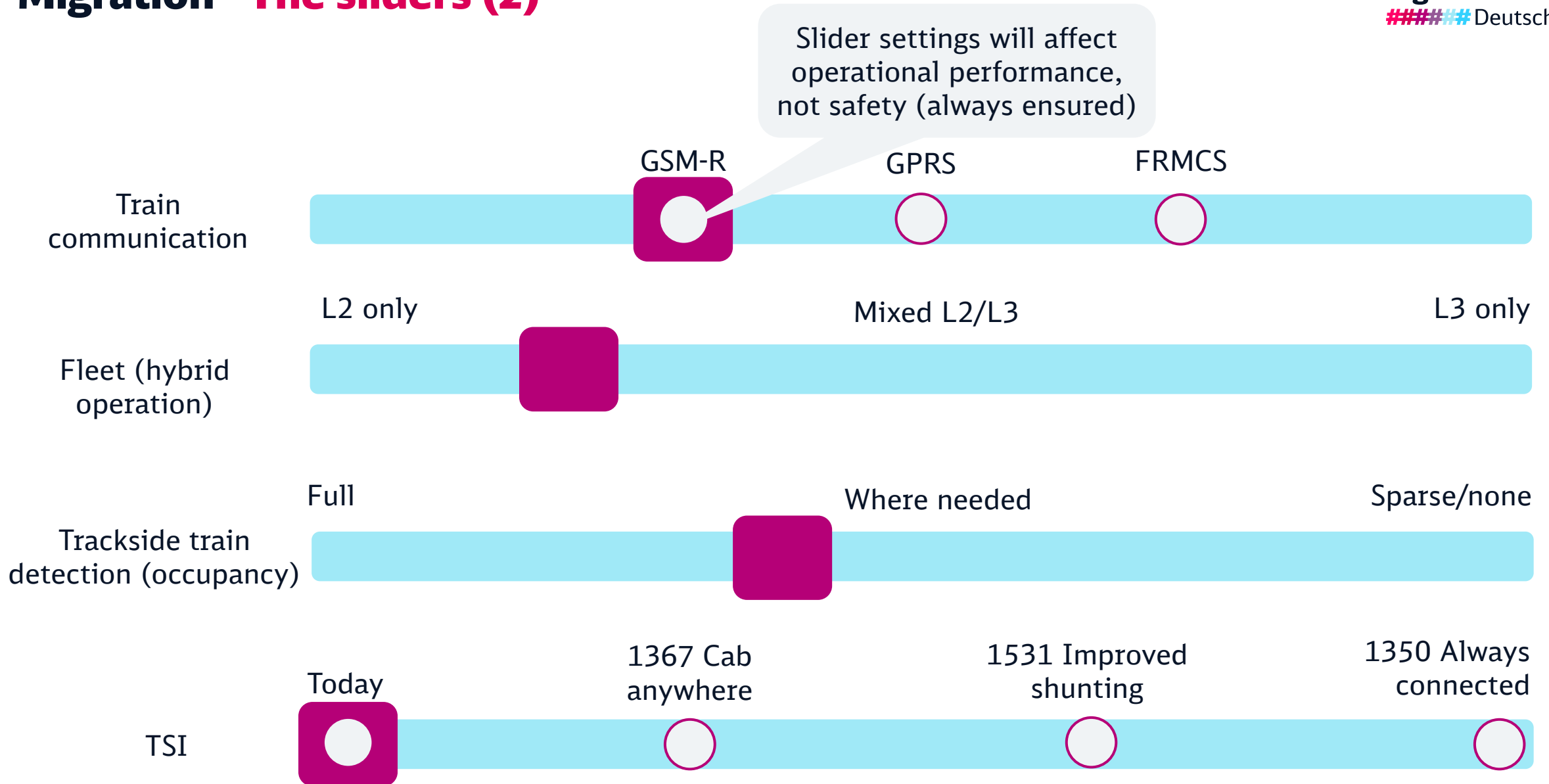
**Built-in  
migration!**

# Migration - The sliders (1)





# Migration - The sliders (2)

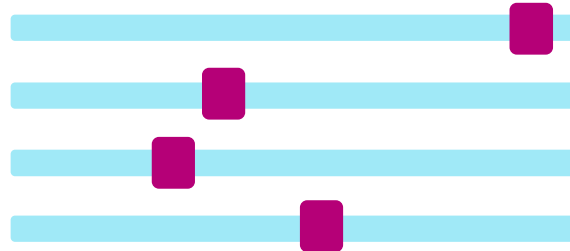


Examples. APS will serve them all – environment-driven

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



According to needs, line,  
and feature availability



Target vision



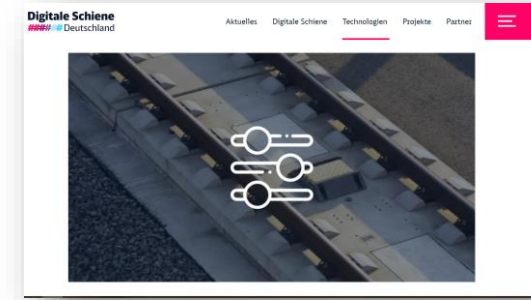
Sliders are influenced by  
external factors (e.g.  
infrastructure or fleet) and APS  
can *dynamically* adapt – **no**  
**APS sw adaptation** needed!

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 Raxbachn (Schmalspurig)										
Alle Züge nur 3. Klasse										
Station	1	3	5	7	9	11	13	15	17	19
Wien Südb.	6.05	7.35	8.65	9.95	11.25	12.55	14.25	15.55	17.25	18.55
W. Neustadt	6.10	7.40	8.70	10.00	11.30	12.60	13.90	15.20	16.50	18.20
Payerbach-Reichenau	6.15	7.45	8.75	10.05	11.35	12.65	13.95	15.25	16.55	18.25
Mürzzuschlag	6.20	7.50	8.80	10.10	11.40	12.70	14.00	15.30	17.00	18.30
Payerbach-Reichenau	6.25	7.55	8.85	10.15	11.45	12.75	14.05	15.35	17.05	18.35
Payerbach-Hirschwang	6.30	8.00	8.90	10.20	11.50	13.20	14.50	15.80	17.10	18.40
Payerbach-Lokalb.	6.35	8.05	8.95	10.25	11.55	13.25	14.55	15.85	17.15	18.45
Payerbach-Ort PH X	6.40	8.10	9.00	10.30	12.00	13.30	14.60	15.90	17.20	18.50
Kurhaus Raxbach PH X	6.45	8.15	9.05	10.35	12.05	13.35	14.65	15.95	17.25	18.55
Reichenau (Rax)	6.50	8.20	9.10	10.40	12.10	13.40	14.70	16.00	17.30	19.00
Hirschwang PH X	6.55	8.25	9.15	10.45	12.15	13.45	14.75	16.05	17.35	19.05
Hirschwang	7.00	8.30	9.20	10.50	12.20	13.50	14.80	16.10	17.40	19.10
Fabrik PH X	7.05	8.35	9.25	10.55	12.25	13.55	14.85	16.15	17.45	19.15
Windbrücke Raxbach PH	7.10	8.40	9.30	11.00	12.30	14.00	15.30	16.60	17.90	19.20
Windbrücke Raxbach	7.15	8.45	9.35	11.05	12.35	14.05	15.35	16.65	17.95	19.25
Teilstation Raxbach	7.20	8.50	9.40	11.10	12.40	14.10	15.40	16.70	18.00	19.30
Wien Südb.	7.25	8.55	9.45	11.15	12.45	14.15	15.45	16.75	18.05	19.35
W. Neustadt	7.30	9.00	9.50	11.20	12.50	14.20	15.50	16.80	18.10	19.40
Payerbach-Reichenau	7.35	9.05	9.55	11.25	12.55	14.25	15.55	16.85	18.15	19.45
Mürzzuschlag	7.40	9.10	10.00	11.30	13.00	14.30	15.60	16.90	18.20	19.50
Payerbach-Reichenau	7.45	9.15	10.05	11.35	13.05	14.35	15.65	16.95	18.25	19.55
Payerbach-Hirschwang	7.50	9.20	10.10	11.40	13.10	14.40	15.70	17.00	18.30	20.00
Payerbach-Lokalb.	7.55	9.25	10.15	11.45	13.15	14.45	15.75	17.05	18.35	20.05
Payerbach-Ort PH X	8.00	9.30	10.20	11.50	13.20	14.50	15.80	17.10	18.40	20.10
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Hirschwang PH X	8.15	9.45	10.35	12.05	13.35	15.05	16.35	17.65	18.95	20.25
Hirschwang	8.20	9.50	10.40	12.10	13.40	15.10	16.40	17.70	19.00	20.30
Fabrik PH X	8.25	9.55	10.45	12.15	13.45	15.15	16.45	17.75	19.05	20.35
Windbrücke Raxbach PH	8.30	10.00	10.50	12.20	13.50	15.20	16.50	17.80	19.10	20.40
Windbrücke Raxbach	8.35	10.05	10.55	12.25	13.55	15.25	16.55	17.85	19.15	20.45
Teilstation Raxbach	8.40	10.10	11.00	12.30	14.00	15.30	16.60	17.90	19.20	20.50
Wien Südb.	8.45	10.15	11.05	12.35	14.05	15.35	16.65	17.95	19.25	20.55
W. Neustadt	8.50	10.20	11.10	12.40	14.10	15.40	16.70	18.00	19.30	21.00
Payerbach-Reichenau	8.55	10.25	11.15	12.45	14.15	15.45	16.75	18.05	19.35	21.05
Mürzzuschlag	9.00	10.30	11.20	12.50	14.20	15.50	16.80	18.10	19.40	21.10
Payerbach-Reichenau	9.05	10.35	11.25	12.55	14.25	15.55	16.85	18.15	19.45	21.15
Payerbach-Hirschwang	9.10	10.40	11.30	13.00	14.30	15.60	16.90	18.20	19.50	21.20
Payerbach-Lokalb.	9.15	10.45	11.35	13.05	14.35	15.65	16.95	18.25	19.55	21.25
Payerbach-Ort PH X	9.20	10.50	11.40	13.10	14.40	15.70	17.00	18.30	20.00	21.30
Kurhaus Raxbach PH X	9.25	10.55	11.45	13.15	14.45	15.75	17.05	18.35	20.05	21.35
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Hirschwang PH X	9.35	11.05	11.55	13.25	14.55	15.85	17.15	18.45	20.15	21.45
Hirschwang	9.40	11.10	12.00	13.30	15.00	15.90	17.20	18.50	20.20	21.50
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Windbrücke Raxbach	9.55	11.25	12.15	13.45	15.15	16.05	17.35	19.05	20.35	22.05
Teilstation Raxbach	10.00	11.30	12.20	13.50	15.20	16.10	17.40	19.10	20.40	22.10
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Mürzzuschlag	10.20	11.50	12.40	14.10	15.40	16.30	17.60	19.30	21.00	22.30
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Payerbach-Lokalb.	10.35	12.05	12.55	14.25	15.55	16.45	17.75	19.45	21.15	22.45
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Kurhaus Raxbach PH X	10.45	12.15	13.05	14.35	16.05	16.55	17.85	19.55	21.25	22.55
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Hirschwang PH X	10.55	12.25	13.15	14.45	16.15	17.05	17.95	20.05	21.35	23.05
Hirschwang	11.00	12.30	13.20	14.50	16.20	17.10	18.00	20.10	21.40	23.10
Fabrik PH X	11.05	12.35	13.25	14.55	16.25	17.15	18.05	20.15	21.45	23.15
Windbrücke Raxbach PH	11.10	12.40	13.30	15.00	16.30	17.20	18.10	20.20	21.50	23.20
Windbrücke Raxbach	11.15	12.45	13.35	15.05	16.35	17.25	18.15	20.25	21.55	23.25
Teilstation Raxbach	11.20	12.50	13.40	15.10	16.40	17.30	18.20	20.30	22.00	23.30
Wien Südb.	11.25	12.55	13.45	15.15	16.45	17.35	18.25	20.35	22.05	23.35
W. Neustadt	11.30	13.00	13.50	15.20	16.50	17.40	18.30	20.40	22.10	23.40
Payerbach-Reichenau	11.35	13.05	13.55	15.25	16.55	17.45	18.35	20.45	22.15	23.45
Mürzzuschlag	11.40	13.10	14.00	15.30	17.00	17.50	18.40	20.50	22.20	23.50
Payerbach-Reichenau	11.45	13.15	14.05	15.35	17.05	17.55	18.45	20.55	22.25	23.55
Payerbach-Hirschwang	11.50	13.20	14.10	15.40	17.10	18.00	18.90	21.00	22.30	24.00
Payerbach-Lokalb.	11.55	13.25	14.15	15.45	17.15	18.05	18.95	21.05	22.35	24.05
Payerbach-Ort PH X	12.00	13.30	14.20	15.50	17.20	18.10	19.00	21.10	22.40	24.10
Kurhaus Raxbach PH X	12.05	13.35	14.25	15.55	17.25	18.15	19.05	21.15	22.45	24.15
Reichenau (Rax)	12.10	13.40	14.30	16.00	17.30	18.20	19.10	21.20	22.50	24.20
Hirschwang PH X	12.15	13.45	14.35	16.05	17.35	18.25	19.15	21.25	22.55	24.25
Hirschwang	12.20	13.50	14.40	16.10	17.40	18.30	19.20	21.30	23.00	24.30
Fabrik PH X	12.25	13.55	14.45	16.15	17.45	18.35	19.25	21.35	23.05	24.35
Windbrücke Raxbach PH	12.30	14.00	14.50	16.20	17.50	18.40	19.30	21.40	23.10	24.40
Windbrücke Raxbach	12.35	14.05	14.55	16.25	17.55	18.45	19.35	21.45	23.15	24.45
Teilstation Raxbach	12.40	14.10	15.00	16.30	18.00	18.50	19.40	21.50	23.20	24.50
Wien Südb.	12.45	14.15	15.05	16.35	18.05	18.55	19.45	21.55	23.25	24.55
W. Neustadt	12.50	14.20	15.10	16.40	18.10	19.00	19.50	22.00	23.30	25.00
Payerbach-Reichenau	12.55	14.25	15.15	16.45	18.15	19.05	19.55	22.05	23.35	25.05
Mürzzuschlag	13.00	14.30	15.20	16.50	18.20	19.10	20.00	22.10	23.40	25.10
Payerbach-Reichenau	13.05	14.35	15.25	16.55	18.25	19.15	20.05	22.15	23.45	25.15
Payerbach-Hirschwang	13.10	14.40	15.30	17.00	18.30	19.20	20.10	22.20	23.50	25.20
Payerbach-Lokalb.	13.15	14.45	15.35	17.05	18.35	19.25	20.15	22.25	23.55	25.25
Payerbach-Ort PH X	13.20	14.50	15.40	17.10	18.40	19.30	20.20	22.30	24.00	25.30
Kurhaus Raxbach PH X	13.25	14.55	15.45	17.15	18.45	19.35	20.25	22.35	24.05	25.35
Reichenau (Rax)	13.30	15.00	15.50	17.20	18.50	19.40	20.30	22.40	24.10	25.40
Hirschwang PH X	13.35	15.05	15.55	17.25	18.55	19.45	20.35	22.45	24.15	25.45
Hirschwang	13.40	15.10	16.00	17.30	19.00	19.50	20.40	22.50	24.20	25.50
Fabrik PH X	13.45	15.15	16.05	17.35	19.05	19.55	20.45	22.55	24.25	25.55
Windbrücke Raxbach PH	13.50	15.20	16.10	17.40	19.10	20.00	20.50	23.00	24.30	26.00
Windbrücke Raxbach	13.55	15.25	16.15	17.45	19.15	20.05	20.55	23.05	24.35	26.05
Teilstation Raxbach	14.00	15.30	16.20	17.50	19.20	20.10	21.00	23.10	24.40	26.10
Wien Südb.	14.05	15.35	16.25	17.55	19.25	20.15	21.05	23.15	24.45	26.15
W. Neustadt	14.10	15.40	16.30	18.00	19.30	20.20	21.10	23.20	24.50	26.20
Payerbach-Reichenau	14.15	15.45	16.35	18.05	19.35	20.25	21.15	23.25	24.55	26.25
Mürzzuschlag	14.20	15.50	16.40	18.10	19.40	20.30	21.20	23.30	25.00	26.30
Payerbach-Reichenau	14.25	15.55	16.45	18.15	19.45	20.35	21.25	23.35	25.05	26.35
Payerbach-Hirschwang	14.30	16.00	16.50	18.20	19.50	20.40	21.30	23.40	25.10	26.40
Payerbach-Lokalb.	14.35	16.05	16.55	18.25	19.55	20.45	21.35	23.45	25.15	26.45
Payerbach-Ort PH X	14.40	16.10	17.00	18.30	20.00	20.50	21.40	23.50	25.20	26.50
Kurhaus Raxbach PH X	14.45									

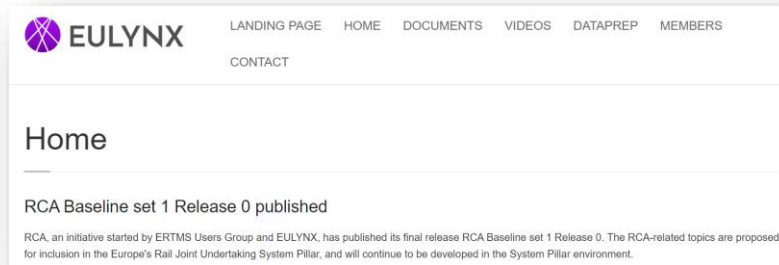
# Further reading

<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



A decorative pattern of small grey dots arranged in a grid, forming a large 'L' shape that frames the left and bottom edges of the central text area.

# **Digitale Schiene**

**##### Deutschland**