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für Verkehr und
digitale Infrastruktur

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„Development of a concept for the EU-wide migration to a Digital Automatic Coupling System (DAC) for Rail Freight Transportation“

Final Presentation on 29 June 2020 in Berlin

On behalf of the German Ministry of Transport and Digital Infrastructure (BMVI)

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Essential content of the study

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WP 1: Market overview / State of the art

- Retrofitting requirements for wagons/locomotives, costs of migration to the DAC, potential benefits of the DAC
- State of the art – DAC
- National and EU-wide legal framework – DAC
- Standards for electrical power and data supply

WP 2: Migration concept

- Sector-wide process for agreement of a single DAC type
- Parallel operation of DAC/SC
- Organisation model for DAC roll-out
- Financing/Cost distribution model

WP 3: Recommendations for action

- Development of a migration roadmap for the DAC
- Identification of barriers to implementation and proposals to remove them

Duration of the study: June 2019 to June 2020

Contractor:

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Subcontractor:

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More than 50 interviews with national and international stakeholders

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- DG Move
- ERA
- Shift²Rail
- CER
- UIC
- UIP
- UIRR

- Mercitalia

- ZSSK Cargo

More than 700 Mio. to. of freight volume and 380,000 wagons

- CD Cargo

- Aspöck
- GATX
- ÖBB
- Rail Cargo Austria
- VPI Austria

- Trafikverket
- Dellner
- Green Cargo

- CAF

- PKP Cargo

- Faiveley Transport Schwab
- SBB Cargo
- VAP
- Wascosa

- Amsted Rail
- Miner

- AUTF
- Ermewa
- Fret SNCF
- LAF
- Touax
- Wabtec

- Grup Feroviar Roman

- BMVI
- EBA
- Allianz pro Schiene
- Axtone
- BASF
- DB Cargo
- DB System-technik
- DB AG
- Waggonbau Niesky
- GATX Rail Germany
- Knorr-Bremse
- MEV
- NEE
- R. Bosch
- Siemens
- VDI
- VDV
- Voith
- VPI
- VTG
- Waggon-bau Graaff

Agenda

A DAC as a building block for digitization and automation in RFT

B Quantity Structure, Cost and Benefit Estimate for Migration of DAC

C Challenges for Migration of DAC

D Roadmap DAC

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Automatic couplers have been introduced wordwide since the 19th century – but not so in Europe

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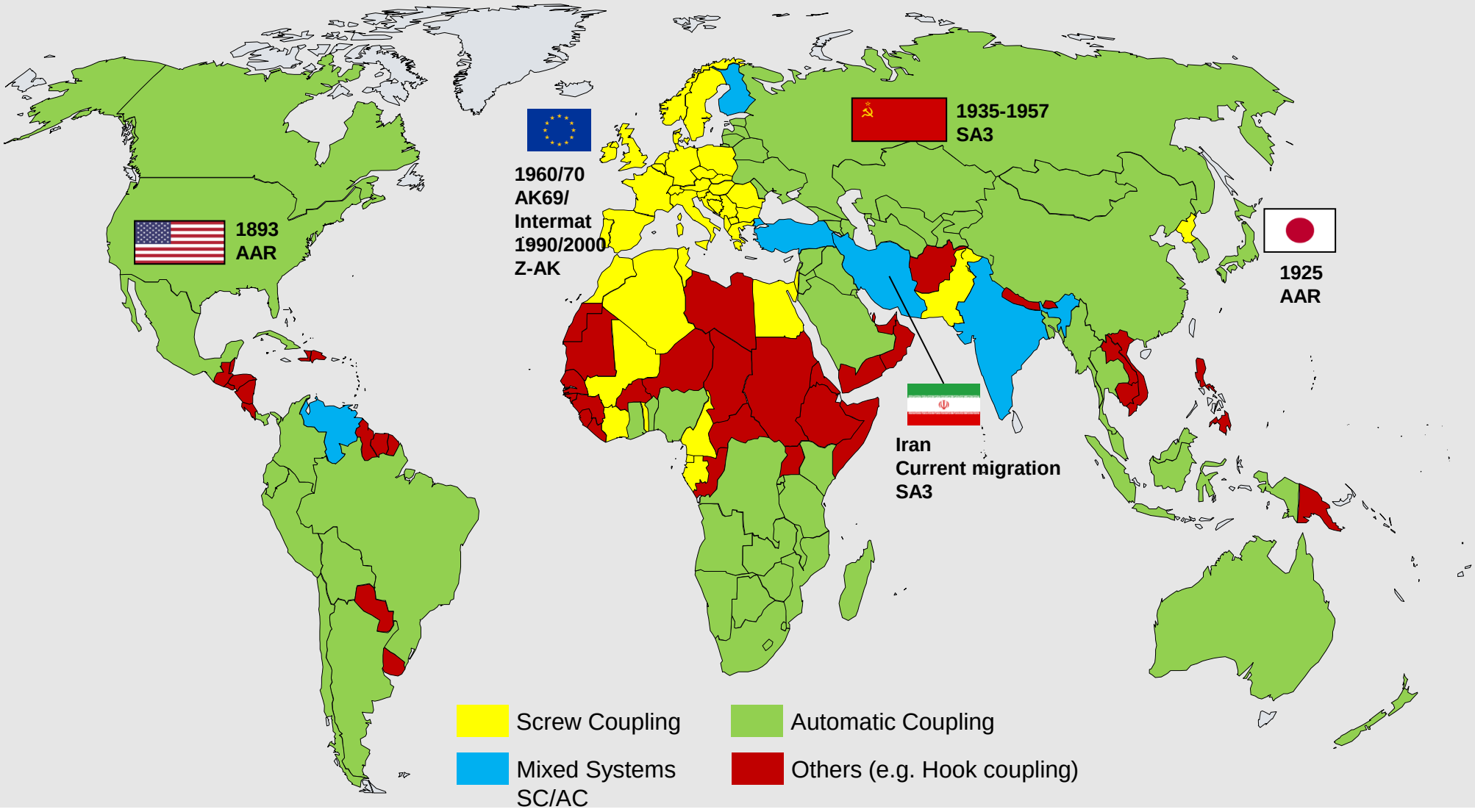

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In the meantime, however, the framwork conditions in European RFT have changed significantly

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Early 20th century

Automatic coupling (AC) for reducing shunting accidents

Late 20th century

AC for increasing productivity in shunting operations

21st century

Digital automatic coupling (DAC) as a prerequisite for the automation and digitisation of RFT in Europe

With the growth of digitisation and automation in rail operations, many applications that will allow stakeholders to significantly increase the attractiveness and productivity of rail freight transport are currently being developed. For these to be implemented, the following requirements must be met:

Sufficient electrical power supply + **Secure data communications** + **Automatic coupling/decoupling** = **Digital automatic coupling (DAC) with power and data line**

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The introduction of a Type 4 Digital Automatic Coupling is being pursued by the Rail Freight Sector

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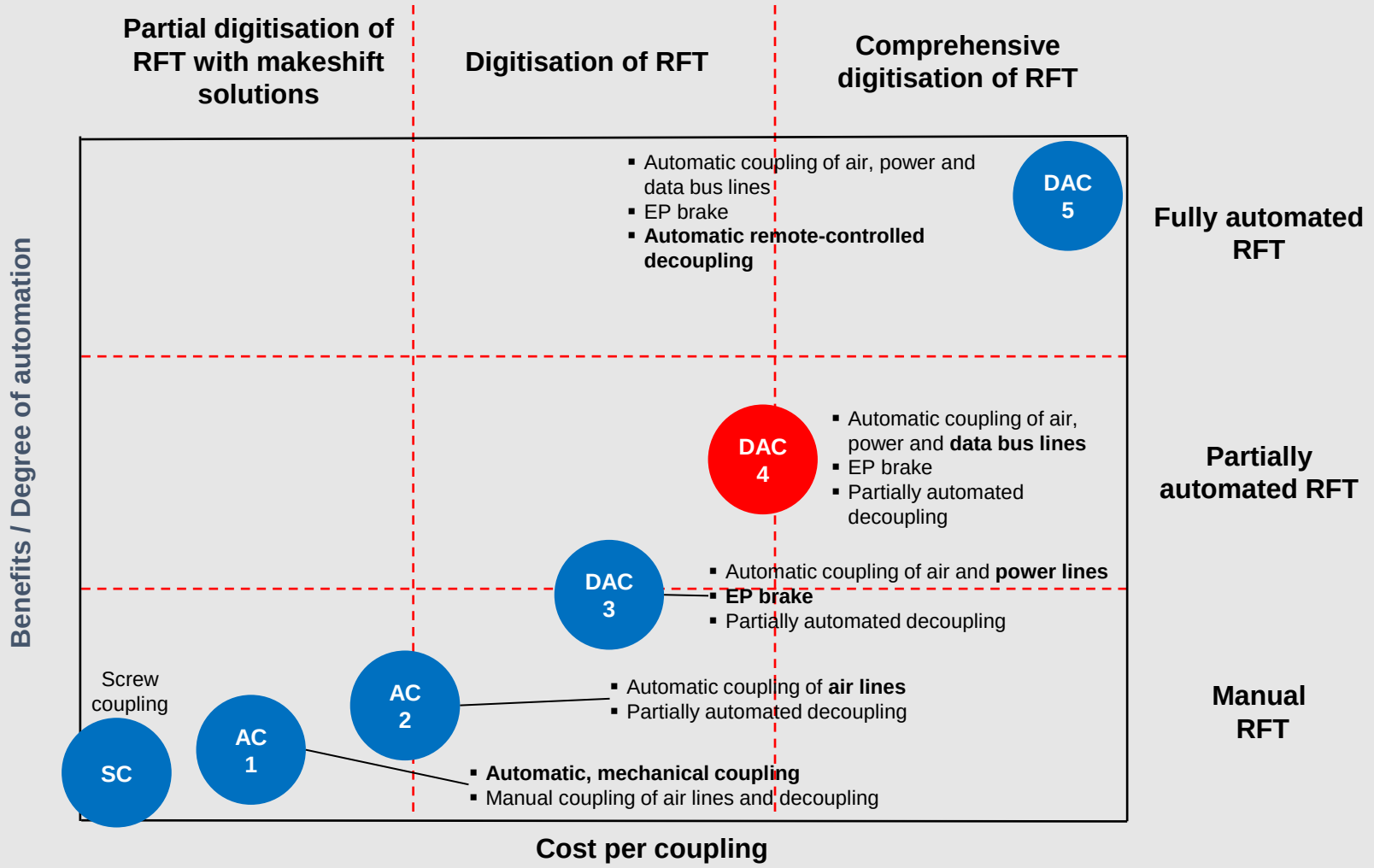

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The DAC for RFT holds great potential especially for RIU, RU, wagon keepers and shippers

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	Railway infrastructure undertakings (RIU)	Railway undertakings (RU)	Wagon keepers	Shippers
Increase in efficiency	Increase in track capacity due to longer, heavier, faster trains, increase in marshalling yard capacity	Reduction in shunting work; longer, heavier, faster trains, increase in system speed	Reduction in maintenance costs for wheelsets/buffers	Higher payload per wagon/train; increased attractiveness of RFT for modal shift
Enabler function for automation of RFT	Train integrity test as pre-requisite for ETCS Level 3	Automated railway operation, e.g. automatic brake test, wagon order, monitoring of components,…	Increased wagon availability due to predictive maintenance	Increased attractiveness of RFT due to telematics and automation
Safety, noise, energy	Increased protection against derailment	Occupational safety during shunting, derailment protection, reduction of noise emission	Increased protection against derailment, reduction of noise emissions	Occupational safety during shunting in the siding

A total of 28 Use Cases have been developed.

DAC as a building block for the digitization and automation of RFT

Automation components for intelligent freight trains – DAC as an essential building block

2 Automatic brake test

1 Telematics and sensors

3 Automatic registration of wagon order

DAC including energy and data management

7 Electro-pneumatic brake (EP brake)

4 Automatic train integrity test

6 Condition-based maintenance (CBM)

5 (Partially) automated technical wagon inspection

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RFT with huge international transport volumes – here RFT-exports/imports for Germany

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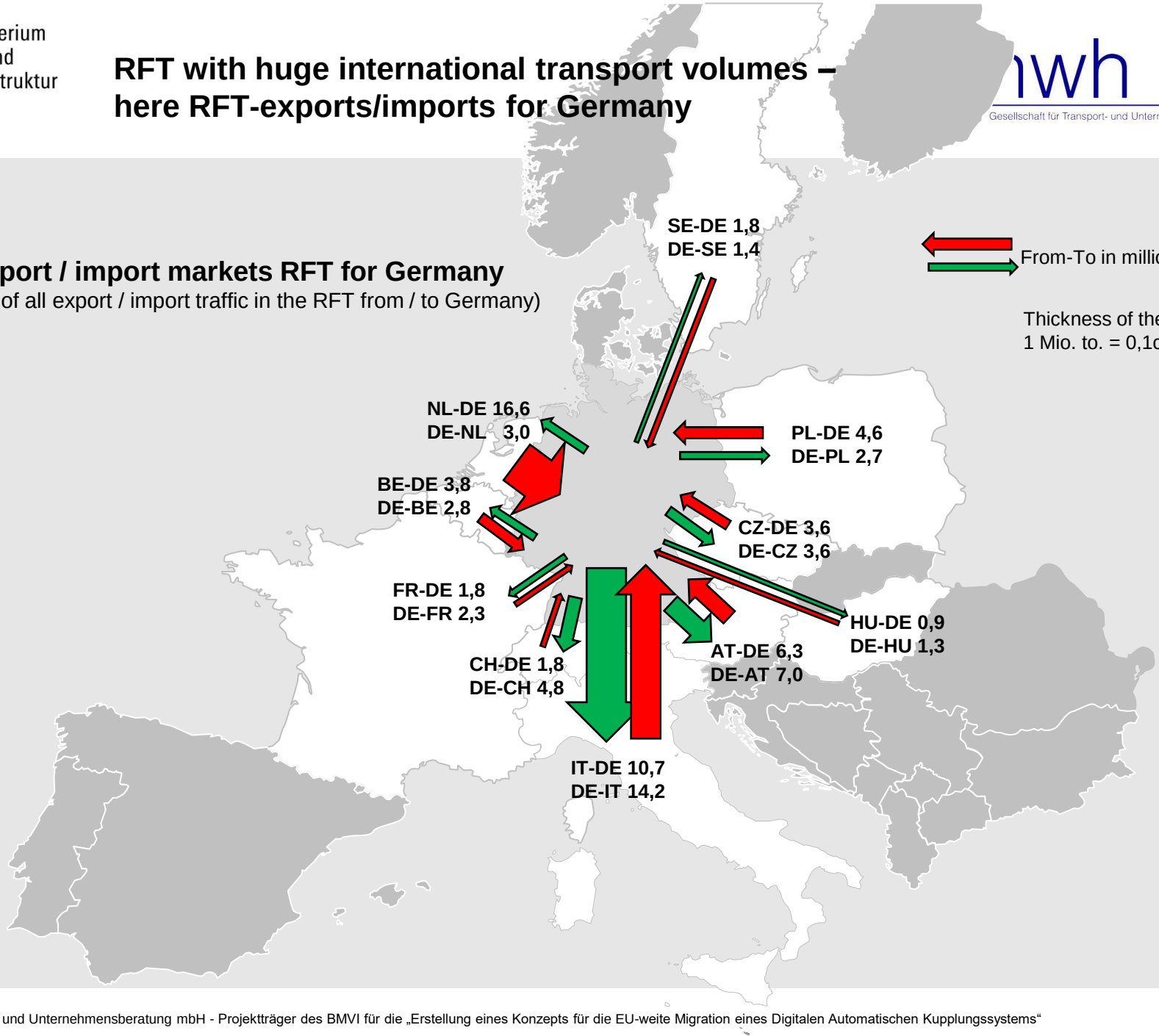
TOP 10 export / import markets RFT for Germany

(approx. 94% of all export / import traffic in the RFT from / to Germany)



Source: destatis 2017

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The introduction of a DAC must be done at EU-level

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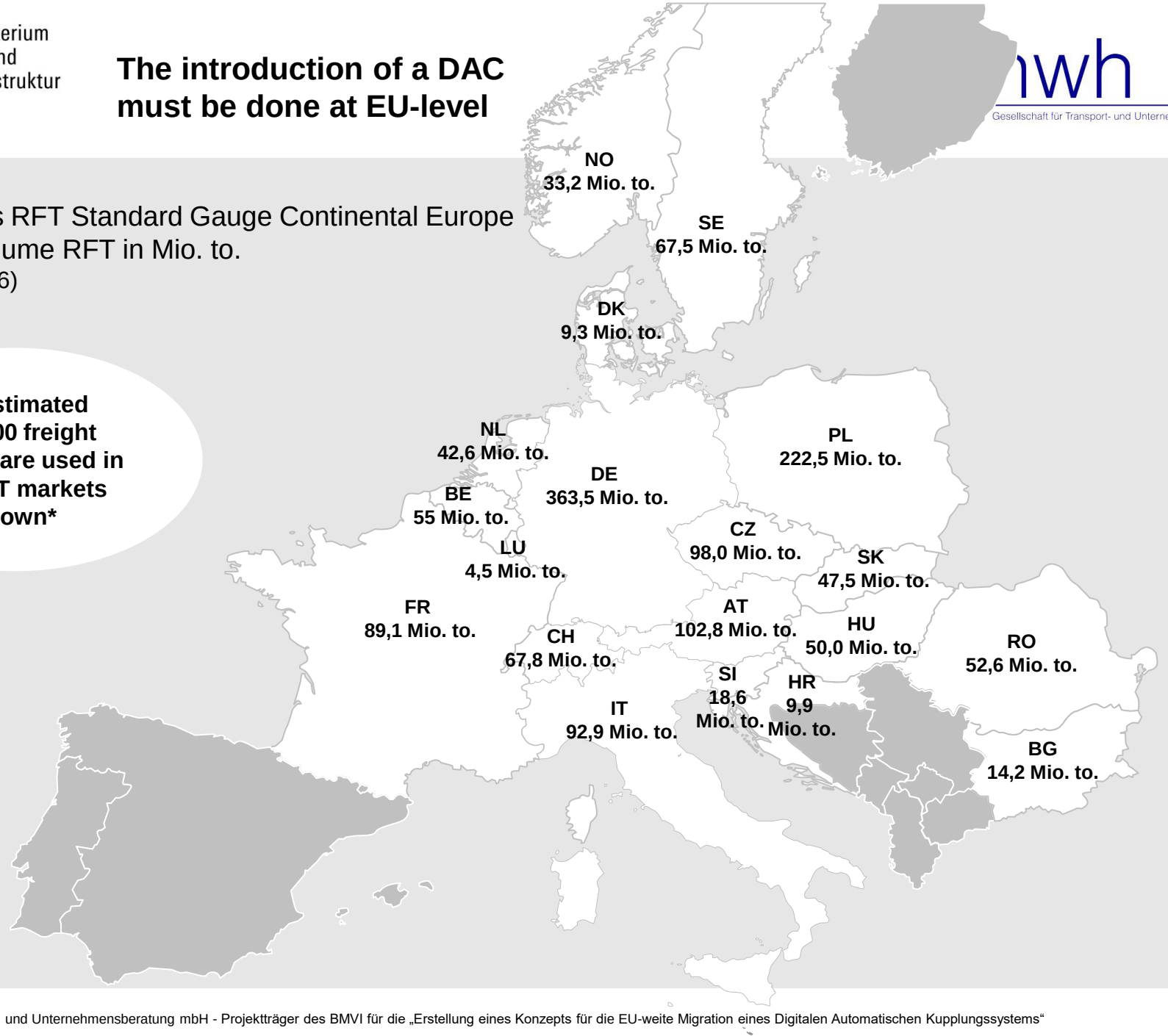
TOP markets RFT Standard Gauge Continental Europe
Transport volume RFT in Mio. to.
(Eurostat | 2016)

An estimated 477.000 freight wagons are used in the RFT markets shown*



Agenda

A **DAC as a building block for digitization and automation in RFT**

B **Quantity Structure, Cost and Benefit Estimate for Migration of DAC**

C **Challenges for Migration of DAC**

D **Roadmap DAC**

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A DAC-cost/benefit estimate has been developped with following parameters

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No. of freight wagons for conversion

Proportion of freight wagons that can be converted

Age distribution of freight wagons

No. of locomotives for conversion

Procurement costs for DAC and hybrid couplings/Costs of automation components

Conversion costs for DAC and hybrid coupling

No. of new freight wagons built p.a.

Production capacities of DAC manufacturers

Workshop capacities for conversion

Migration period

DAC use cases and assessment of potential

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When migration DAC to EU 27 plus CH, NO, UK between 432,000 and 485,000 wagons should be equipped with DAC

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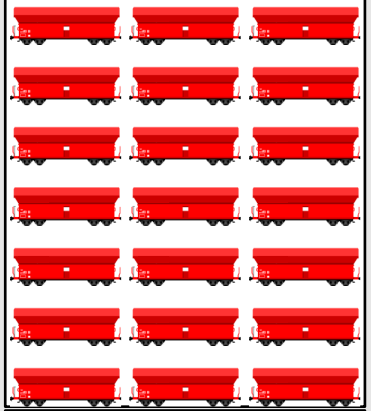
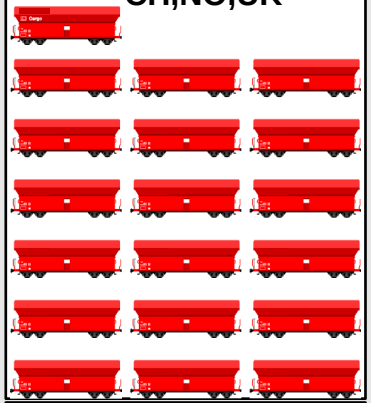
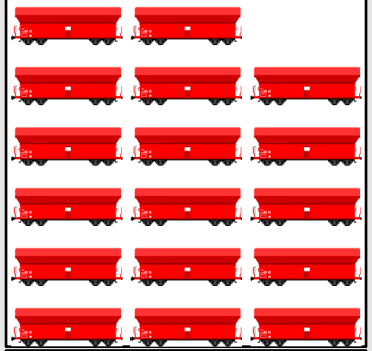
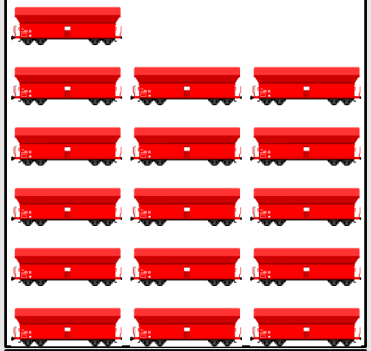
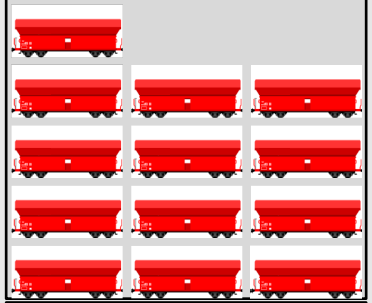
Total freight wagon fleet in the EU 27 plus CH, NO, UK	No. of freight wagons with standard gauge, incl. changeable gauge, in the EU 27 plus CH,NO,UK	Number of freight wagons in the General Contract of Use for Wagons (GCU)	Number of FWs in the GCU that can technically be converted (95% of GCU fleet)	Number of freight wagons that are actually converted (approx. 80% to 90% of the technically convertible FWs in the GCU)
				
712,265	642,287	568,000	540,000	432,000 to 485,000

In addition, approximately 17.000 locomotives were to be equipped with hybrid couplers.

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Procurement costs for a DAC can currently only be estimated – market prices are not yet available

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Procurement costs DAC for freight wagons

- Procurement costs per DAC: € 4,000 to € 5,000
- **Procurement costs DAC per wagon: € 8,000 to € 10,000**

Conversion costs freight wagons

- Working hours per wagon: 16 h
- **Conversion costs per wagon: € 2,500**

Additional costs for automation components

- **Costs per wagon: € 4,000 to € 5,000**

Procurement costs hybrid coupler for locomotives

- Procurement costs per hybrid coupler: € 10,000
- **Procurement costs hybrid coupler per locomotive: € 20,000**

Conversion costs for locomotives

- Working hours per locomotive: 40 h
- **Conversion costs per locomotive: € 5,300**

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Build-up of production and workshop capacities required

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Production capacities worldwide

- Number of new freight wagons (in the markets above) p.a.: appr. 170,000
- Number of automatic coupling systems p.a.: appr. 340.000
- Number of DAC required : 864.000 to 970.000
- Annual need for migration time of 6 years: 144,000 to 162,000 pieces DAC.
- Development of production capacities DAC requires preparation time.
- Early establishment of a DAC standard is recommended.

Workshop capacities across Europe

- Workshops in Europe: 694
- Workload installation per wagon: 16 h
- Workload installation per locomotive: 40 h
- Total workload for migration: 8,4 million h
- Workload p.a.: 1.4 million h

➔ **Approx. 950 workshop personnel additionally required**

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Various scenarios were set up regarding the migration duration - base scenario 6 years

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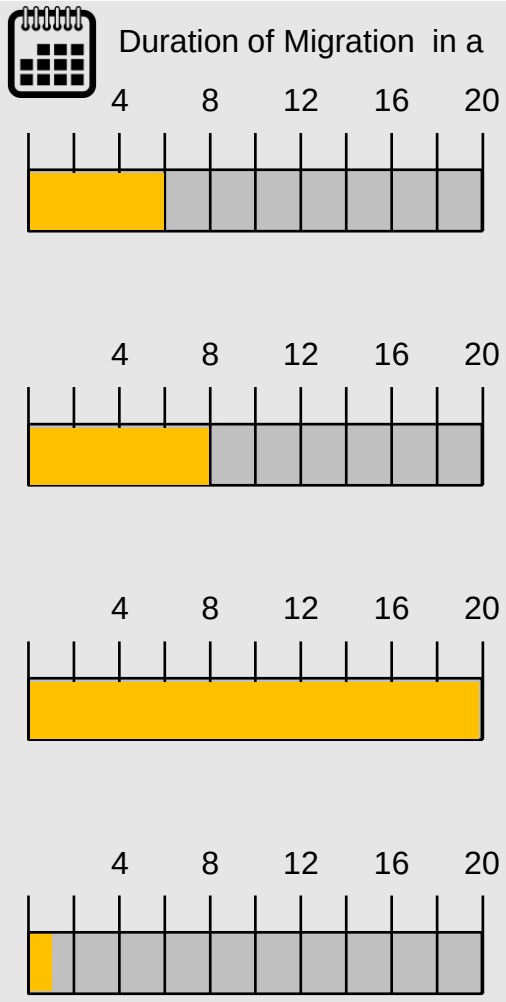
Baseline scenario:
Conversion during revision cycle
Duration of migration 6 years

Scenario 2:
Conversion during extended revision cycle
Duration of migration 8 years

Scenario 3:
Conversion during a long duration of migration
Duration of migration 20 years

Scenario 4:
Conversion during a short duration of migration
Duration of migration 1 year



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Estimated total costs for migration to the DAC in the six-year period

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Estimated DAC migration costs for a migration period of 6 years*	Quantity structure	Cost per wagon/locomotive	Total costs
DAC procurement costs for freight wagons	432,000 - 485,000 freight wagons	€ 8 - 10 thousand	€ 3.3 to 4.7 billion
DAC conversion costs for freight wagons	432,000 - 485,000 freight wagons	€ 2,500	€ 1.0 to 1.1 billion
Procurement and conversion costs for hybrid couplings on locomotives	17,000 locomotives	€ 20,000 procurement € 5,300 conversion	€ 0.43 billion
Total costs of migration to the DAC (Procurement and conversion for freight wagons and locomotives)			**€ 4.7 to 6.2 billion**
Costs for automation components for freight wagons	432,000 - 485,000 freight wagons	€ 4 - 5 thousand	€ 1.7 to 2.4 billion
Total costs of migration to the DAC plus automation			**€ 6.4 to 8.6 billion**

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TOP 10 Use Cases – appr. 80 percent of total benefit of migation to DAC

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Increased efficiency – Effects of the DAC	Safety / Human Ressources / Market Potential	Automation - DAC as Enabler
▪ Reduction of manual shunting work ▪ Increased system speed RFT ▪ Heavier trains ▪ Increase speed by using brake lever position „P“	▪ Increased operational safety ▪ Development of new market segments for RFT	▪ Automatic brake test ▪ Electro-pneumatic brake ▪ Train integrity control ▪ Conditon Based Maintenance

For the EU 27 plus CH, NO, UK, an annual benefit potential from the DAC of at least € 750 million is estimated.

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A challenge during migration is the slow ramp-up of benefits

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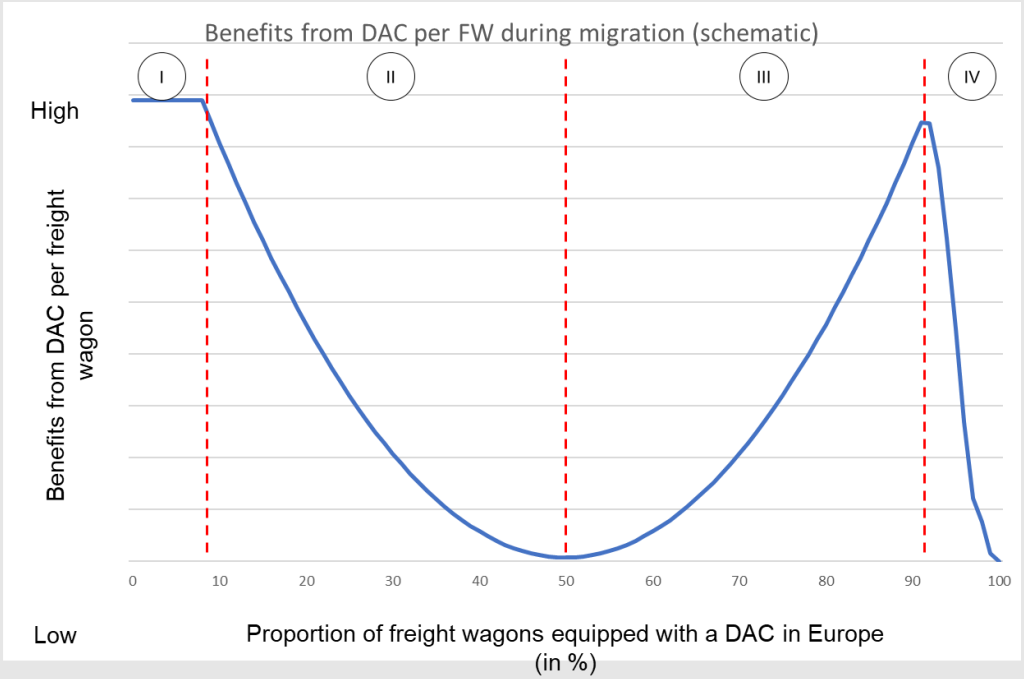

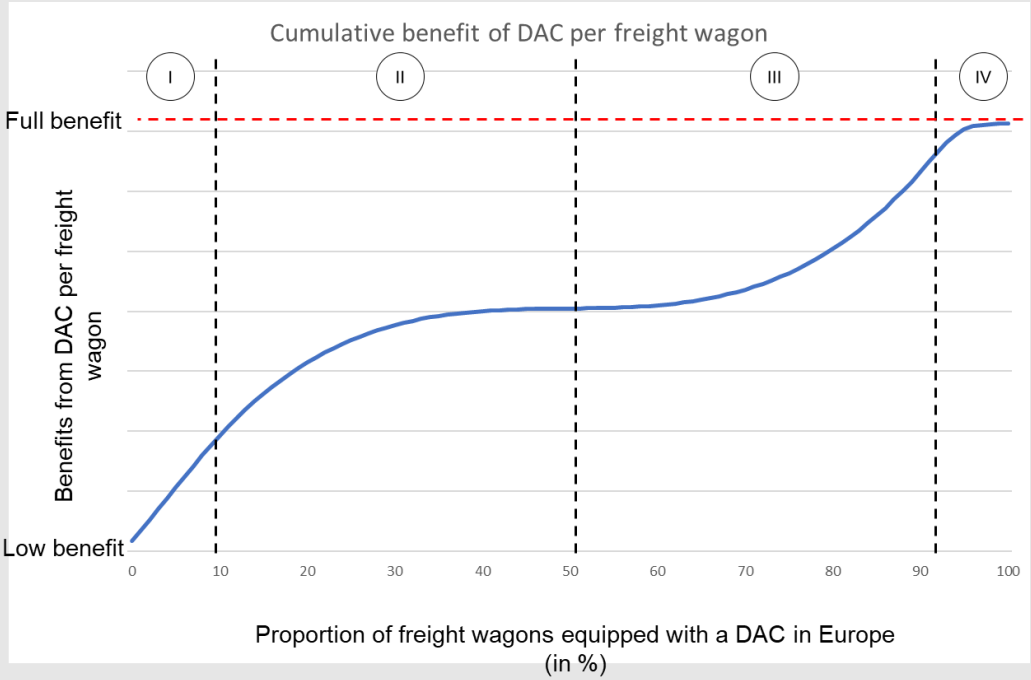

The benefit curve for DAC migration leads to long payback periods and disadvantage the early movers (from phase 2 in the diagram)

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The payback period in the base scenario is 18 years

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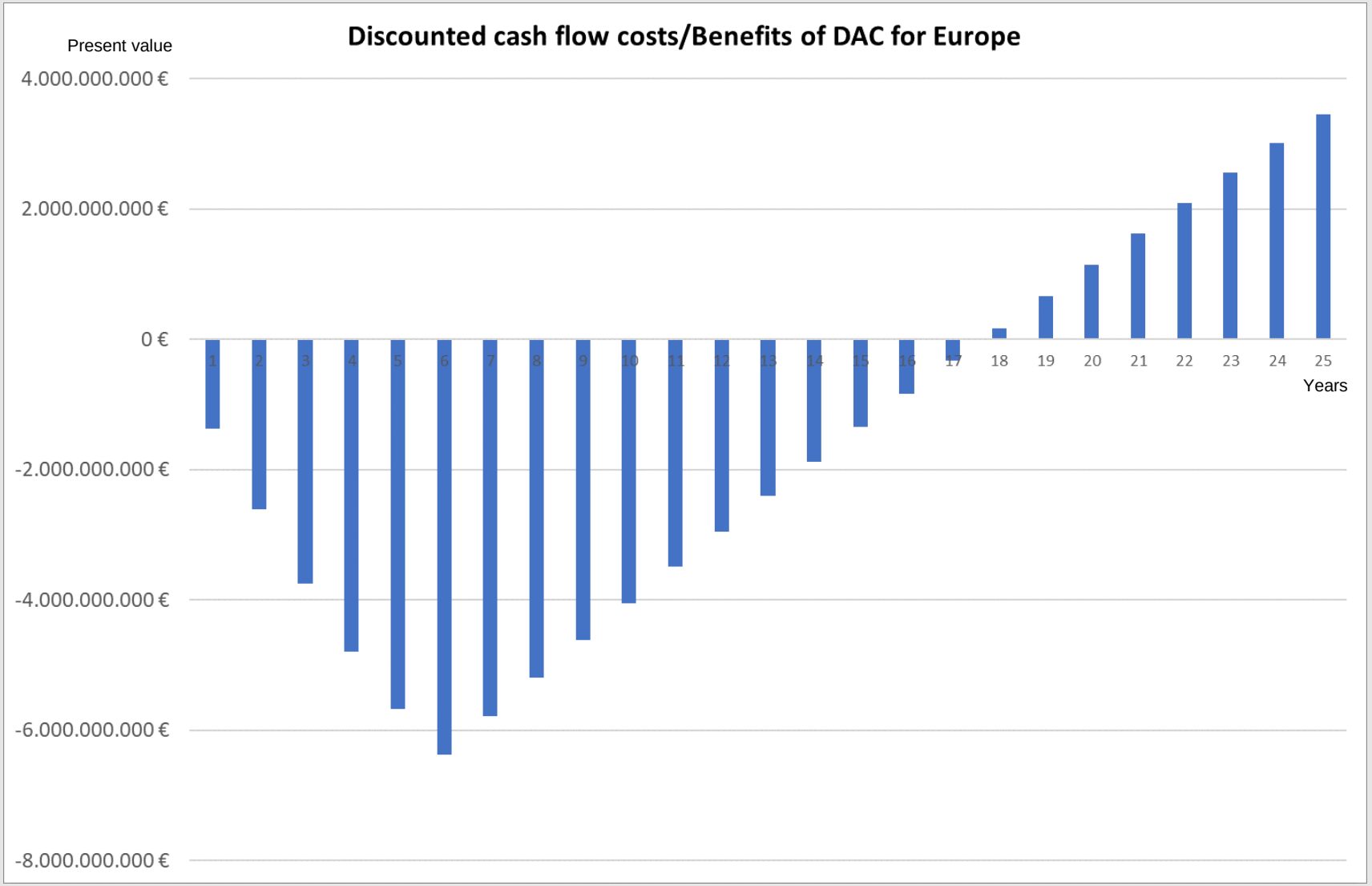

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The migration duration has a major impact on the payback period

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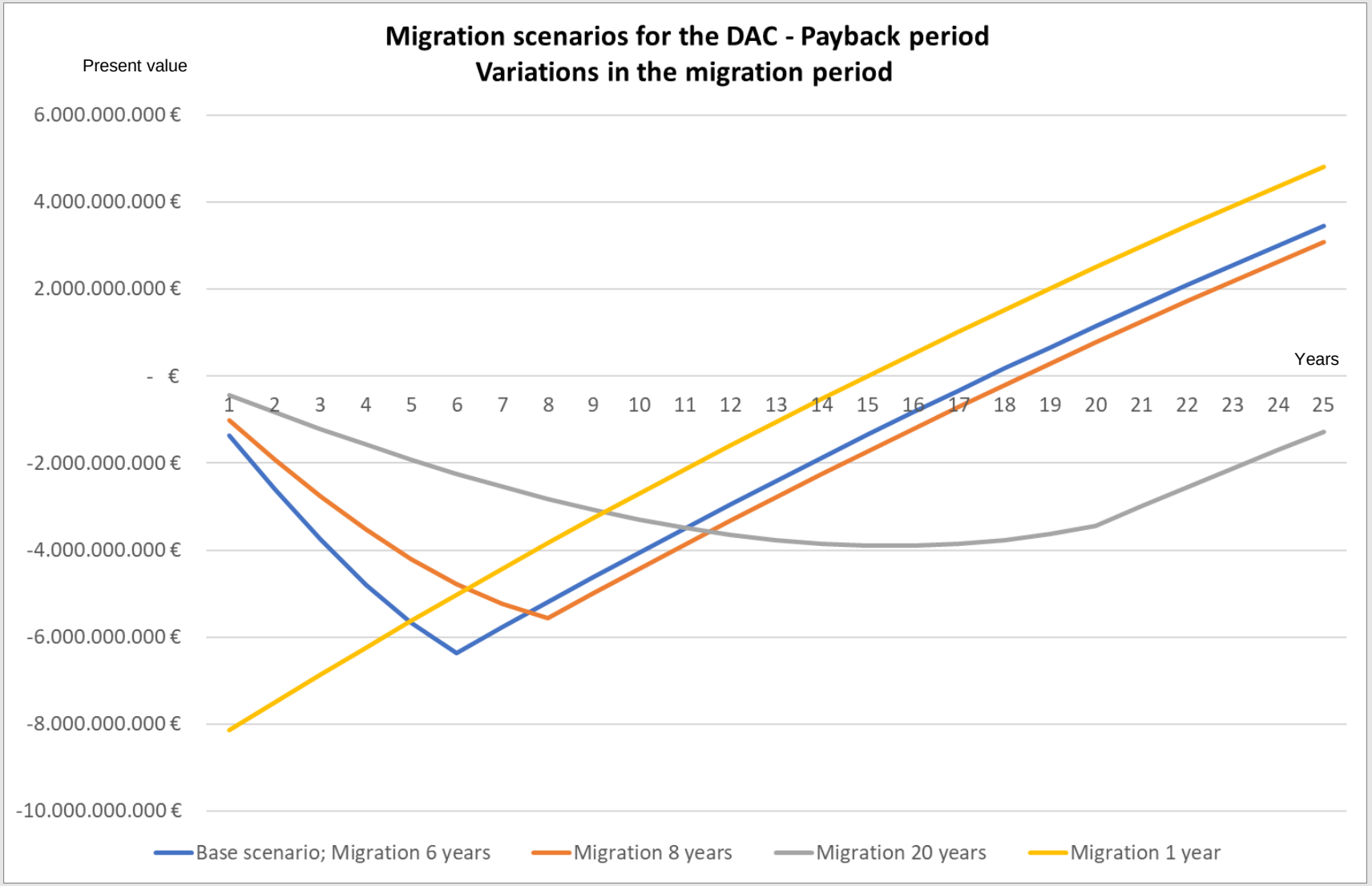
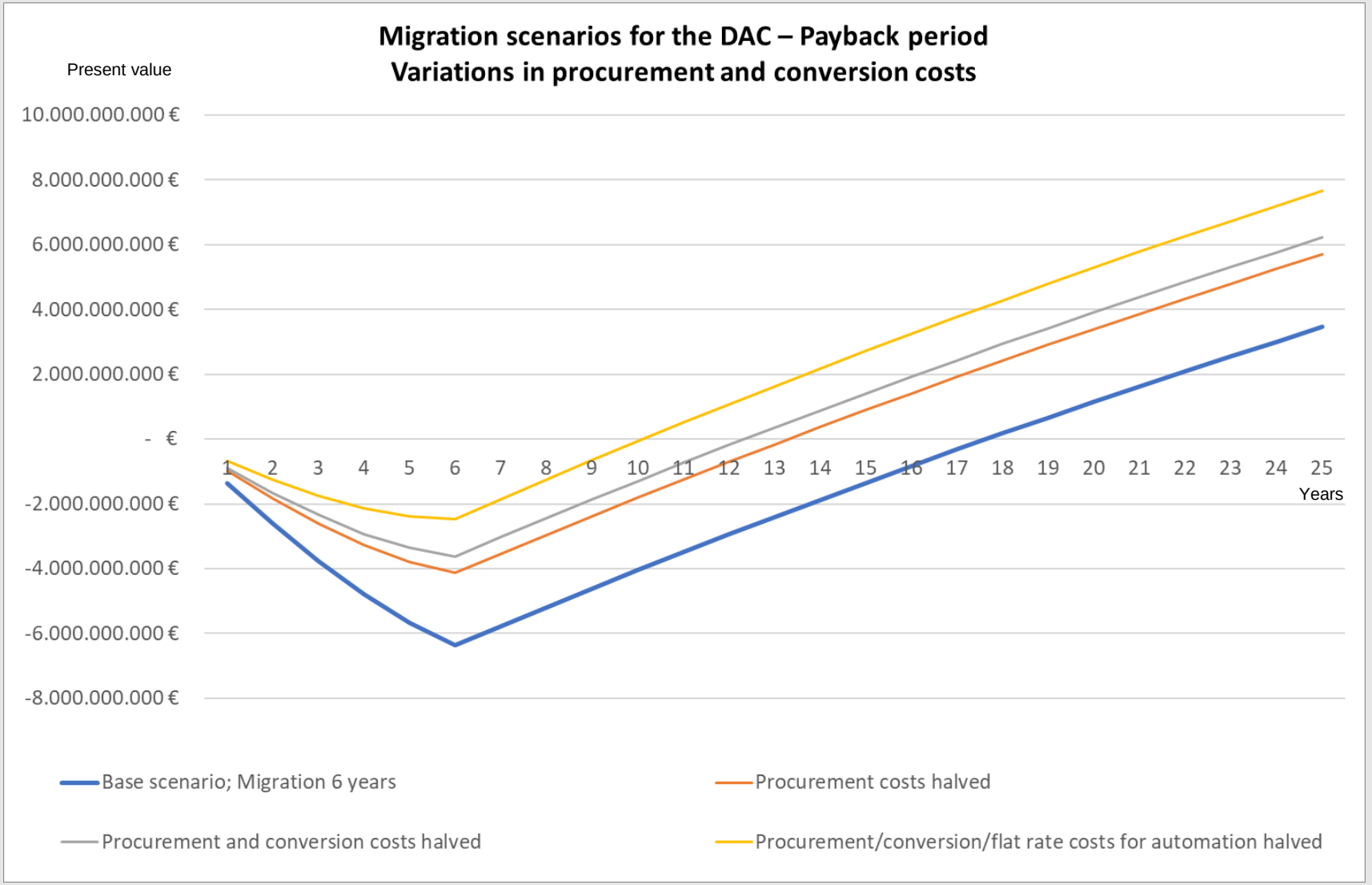


Alternative scenario - nine years of amortization by halving all costs



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Challenges for migration to DAC

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A Technology

1. Standard for the DAC
2. Standard for the electrical power supply
3. Standard for data communication in the train
4. Proof of the reliability/availability of the DAC
5. Approval for the DAC
6. Standard for legal requirements in the transport of hazardous goods, esp. electrical power supply

B Operation

1. Parallel operations of DAC and screw coupling
2. Migration planning regarding the order of freight wagon conversion
3. Non-discriminatory and seamless availability of adapters / coupler wagons

C Financial

1. Proof of the business case for DAC plus further automation elements
2. Long payback period for investment in DAC
3. Unequal distribution of costs / benefits (investment by wagon keepers, benefits mainly for RUs)
4. Financial strength in the sector to make investments in DAC

D Policy

1. European agreement process for the DAC migration
2. Financial support programme for the sector in the DAC migration

E RFT sector

1. Commitments from all relevant stakeholders on the migration to a DAC
2. Organisational structures for migration to the DAC (e.g. European coordination office)

F Industry

1. Market prices for DAC not yet known
2. Production and conversion capacities for the DAC

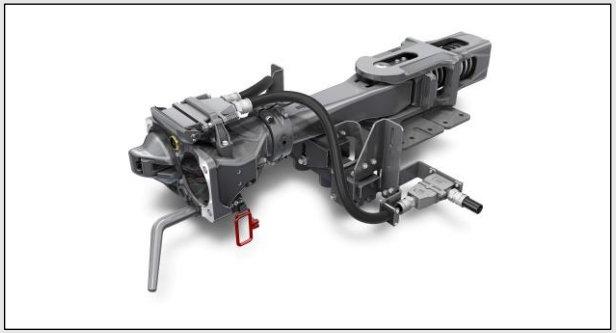
G Personnel

1. Training concept
2. Agreement on DAC with works councils / trade unions still pending

Challenge Technology – Standard DAC

Type Scharfenberg

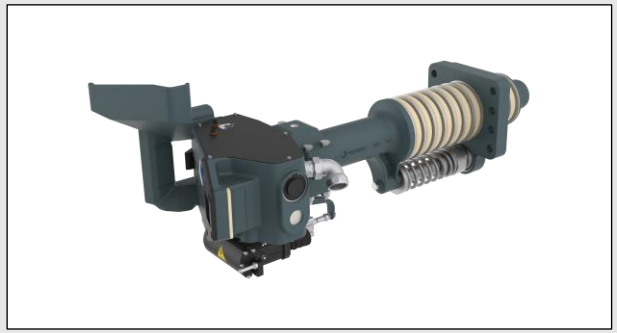
Voith



Dellner

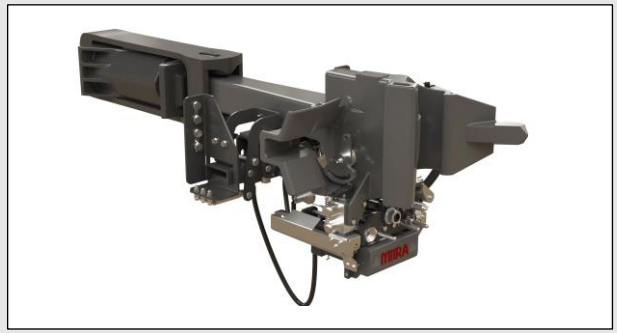
Type Schwab

Wabtec



Type SA3

CAF



<u>Four</u> manufacturers are currently developing

a DAK Type 4 with <u>three</u> different coupling heads.

<u>One</u> coupling type must be selected

on the way to a European standard DAC.

Source photos: Dellner, Voith, Wabtec, CAF

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Challenge Technology – Unification process on standard DAC

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1. Functional requirements / test concept	2. DAC-Tests & Demonstrator	3. Standardization DAC	4. Homologation DAC
▪ DAC-specification ▪ Test concept DAC ▪ Assessment criteria DAC	▪ BMVI-Project „DAC-Demonstrator“ (Summer 2020 – end of 2022) ▪ DAC-Demonstrator Sweden by Trafikverket / Green Cargo (Sep. 2020 – Mar. 2021)	▪ Development of an EU-wide standard for DAC (CEN)	▪ Homologation DAC as Interoperabilty Constituent ▪ Clarification of procedure for retrofitting existing wagons with DAC
DAC-specification and test concept developed by „Industry platform DAC“	**Selection of DAC type by EU-wide panel (to be defined)**	**CEN/TC 256/SC 2 „Rolling Stock Products“**	**TSI-Revision by „Topical Working Group Freight“ of ERA**

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Challenges Technology – Homologation DAC / Retrofitting existing wagons

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Homologation DAC

- Homologation DAC possible via Intermediate Statement of Verification or via Interoperability Constituent (IC).
- For homologation of DAC as IC revision of TSI required.
- Initiation of Topical Working Group Freight by ERA. Objective: TSI revision incl. DAC until 2022.

Retrofitting of existing wagons with DAC

- Avoidance of a renewed „authorisation for placing in service“ for existing freight wagons.
- However, some factors of DAC speak for new authorisation for placing in service.
- Further challenge: checking of existing wagons for absorption of tensile and compressive forces via DAC.
- Consideration of conversion of locomotives with hybrid couplers as well as power and data line.

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Challenge Technology – Reliability and technical design DAC

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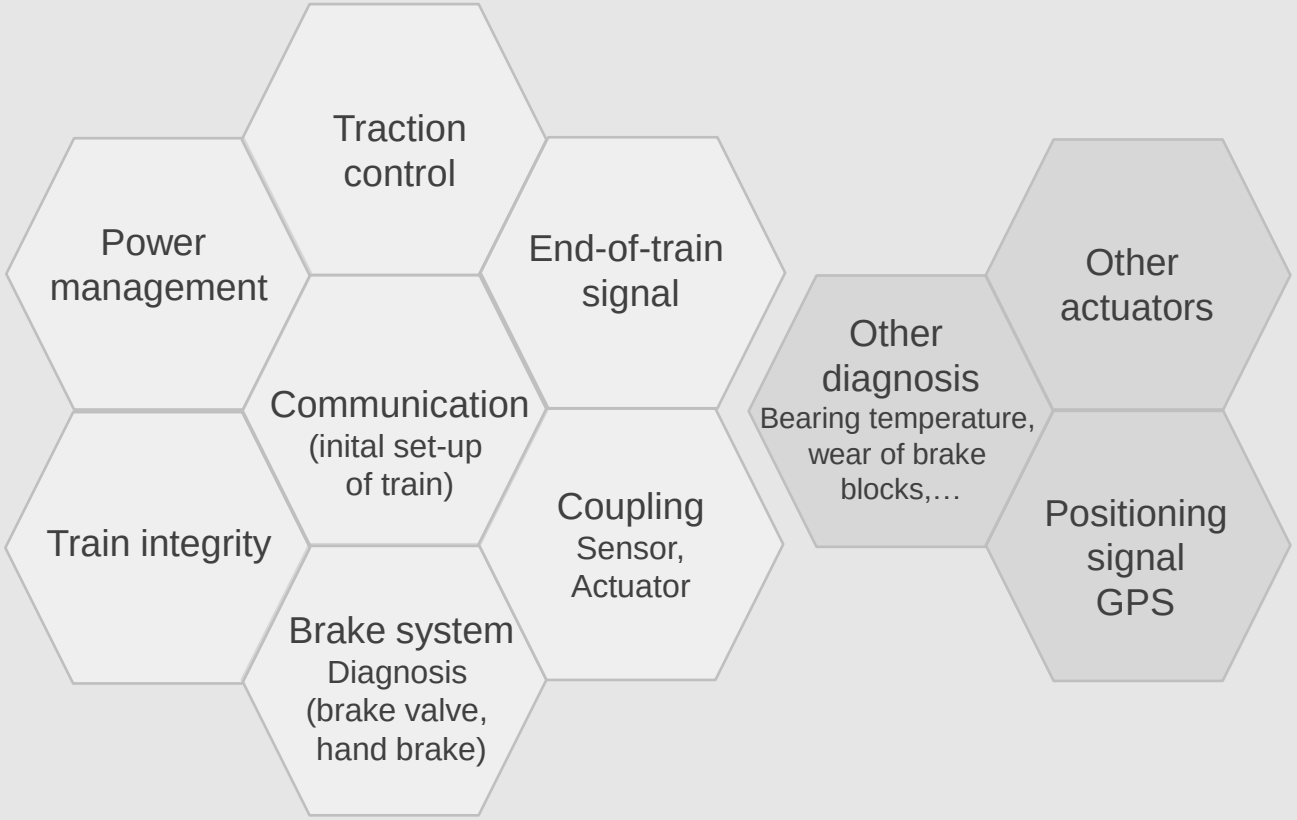
Reliability DAC	▪ Wheather resistance of DAC (ice, dirt,…); ▪ Contact stability of power and data lines; ▪ Requirements on reliability of DAC: Example: 98 percent reliability of DAC will lead to 36 percent reliability of the train (with 50 wagons)!
Technical design DAC	▪ Definition of strength requirements (esp. fatigue strength); ▪ Crash requirements, design of suspension of DAC; ▪ Explosion protection / RID; ▪ Support DAC (crossbeam-, suspension strut-, hoirzontal support); ▪ Upgradeability to DAC type 5.
Operational Handling DAC	▪ Necessity of buffer/joint position (ready for coupling, buffer position, coupled and locked, coupled and unlocked); ▪ Gathering range DAC and possibilities for manual deflection; ▪ Operating controls and device for uncoupling.

Challenge Technology – Standard for electrical power and data line Electrical concept

(Future) applications in intelligent freight trains



Electrical concept:

- Energy requirement of appr. **30 Watt per wagon**;
- Continous powerline with **110 V** and **16 mm²** wire cross section.
- **24 V** electrical system on the wagons with buffer battery;
- Specification for electrical concept developed.

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Challenge Technology – Standard for electrical power and data line Communication concept – three alternatives

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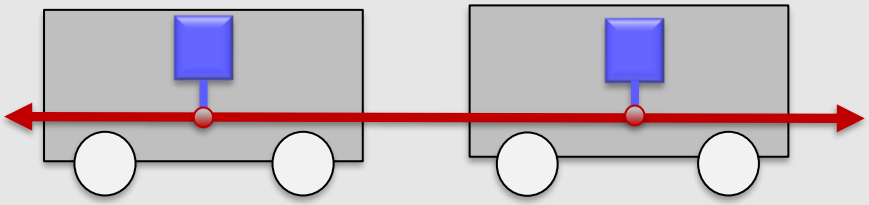
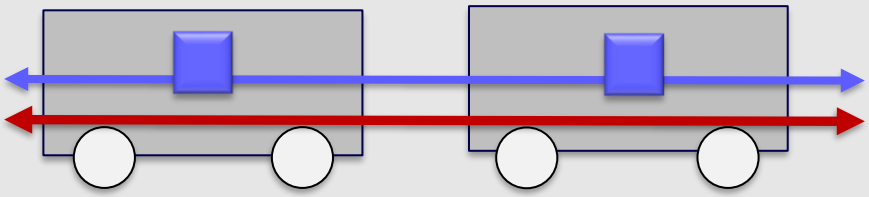
Continous line / Shared Medium

- Based on Powerline technologies;
- No additional contact in coupler head required.



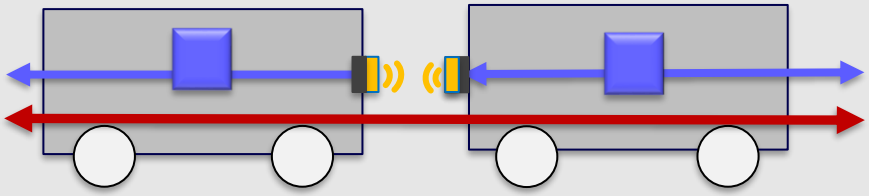
Segmented system with additional data line

- Based on CAN-Technology;
- Additional contacts in coupler head required.



System with change of technology

- Radio transmission (short-range) between wagons (e.g. 433 MHz, 2.4 GHz, 802.15.4-2011)
- No additional contact in coupler head required.



Selection of communication technology only possible through practical testing.
System specifications for all three technoligies have been developed for the testing.

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Challenge Technology – Standard for electrical power and data line Proposal for the further procedure

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Development of sustainable concepts for energy and data management in freight trains

Selection of technology for energy and data communication based on DAC tests and an EU-wide decision process	Development of functional patterns for energy and data communication in demonstrators as well as homologation of electrical and communication system	Development of dedicated components for the electrical and communication system; testing of automation components

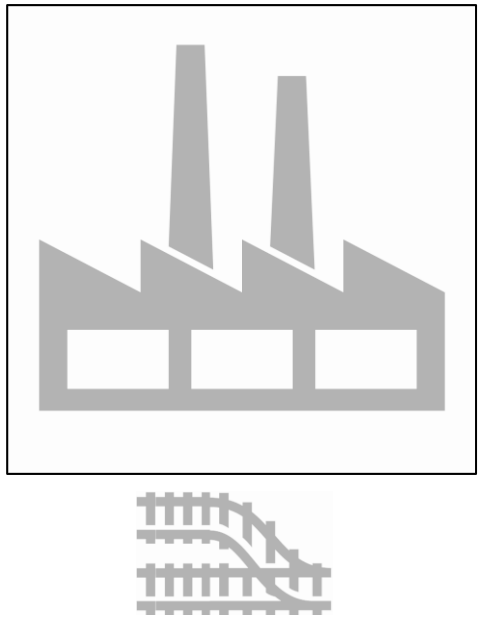
Accompanying: Standardization

Integration of users (RU‘s, wagon keepers,…), suppliers as well as experts for development of an open standard for energy and data management in freight trains required.

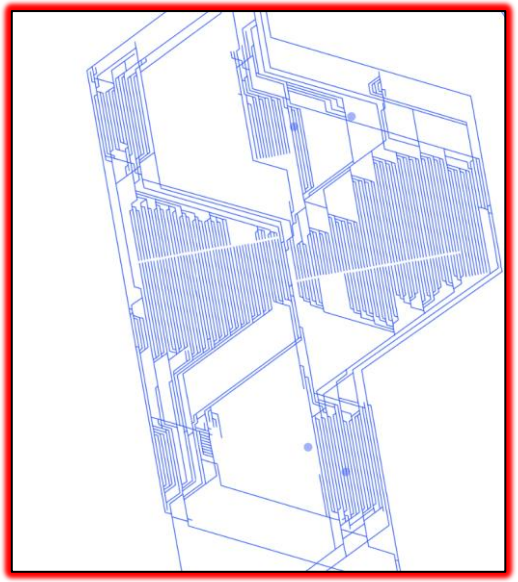
Challenges Operations –
Parallel Operations DAC – Screw Coupling

**DAC and screw coupling are not compatibel –
during migration phase a parallel operations of both couplings has to be ensured.**

Parallel operations in customer sidings

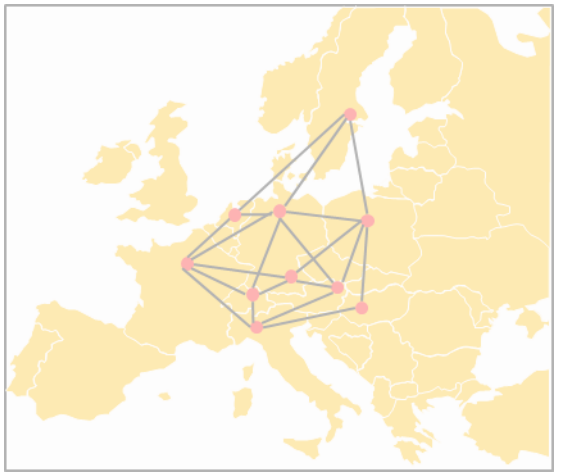


Parallel operations in marshalling yard

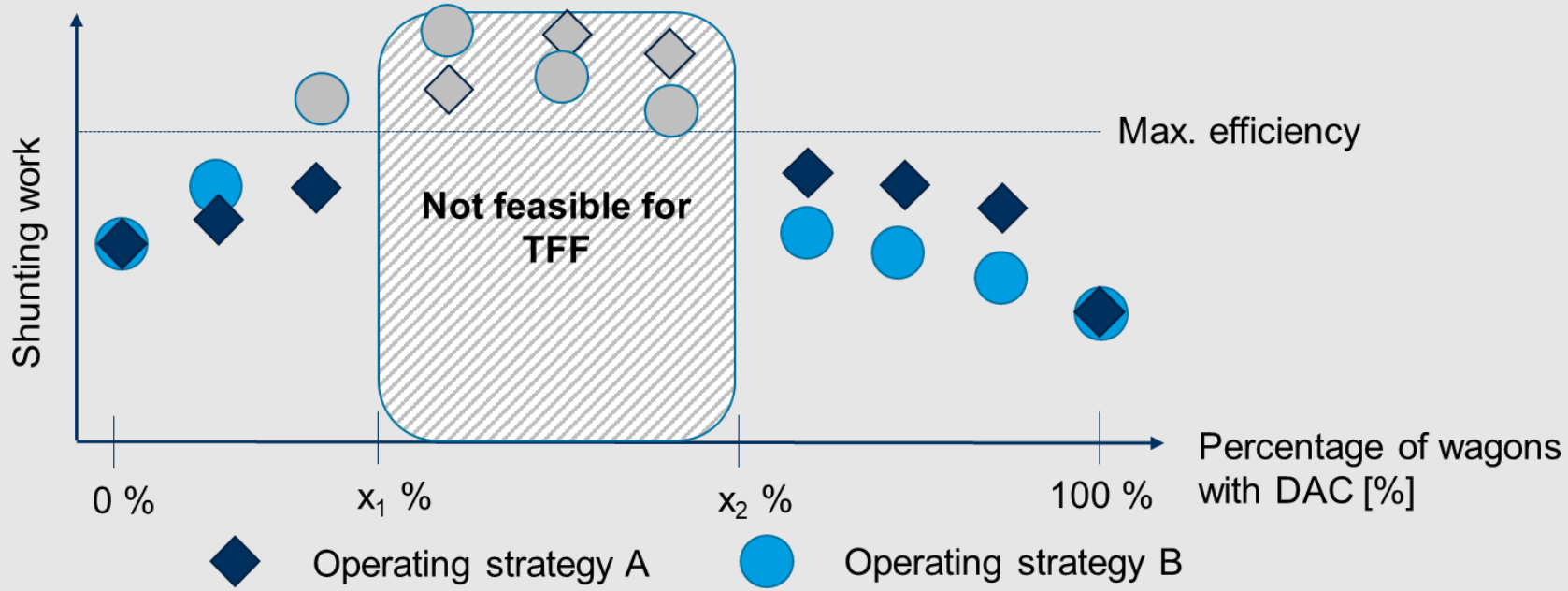


**Detailed analyses by
TU Dresden**

Effects of parallel operations on network



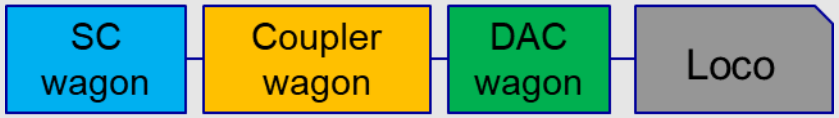
Challenges Operations –
Parallel Operations DAC – Screw Coupling



- Train formation facility (TFF) München Nord over a period of three days with appr. 2.500 freight wagons.
- Simulation of 31 scenarios for two operations strategies - „mixed traffics“ and „separated traffics“.
- Industry-oriented conversion; first automotive wagons, then chemical wagons; subsequently random selection freight wagons for conversion ➔ conversion was largely uncoordinated in the simulations.
- In this respect, a worst case scenario was considered.

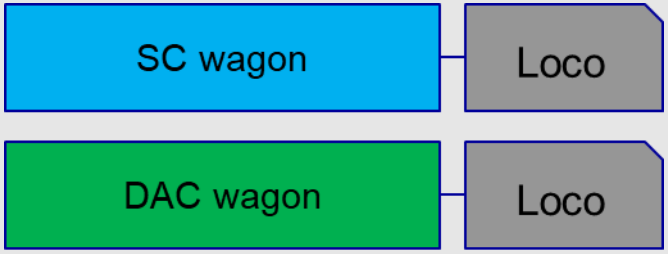
Challenges Operations – Parallel Operations DAC – Screw Coupling

Operating strategy „mixed traffics“



Uncoordinated retrofitting can lead to additional maneuvering costs due to "art-pure" sorting of the freight wagons by coupling type as well as inserting of buffer wagons and thus overloading the capacity of a marshalling yard.

Operating strategy „separated traffics“



Simulation shows that only scenarios for retrofitting the automotive wagons could be solved without additional operational track requirements. However, the marshalling yard‘s capacity limit has already been reached.

Challenges Operations – Parallel Operations DAC – Screw Coupling

Coordination of the migration process

- Duration of migration process
- Definition of a sequence for conversion of wagons

Control of traffic in the network

- Continous adaption of the train frame and the wagon routings to different retrofitting status

Control of processes in marshalling yards

- Capacity investigations and continous adaption of the shunting work plans to changing train structures

Recommendations:

- Migration duration as short as possible;
- Avoidance of uncoordinated migration; analyses of migration sequence (along industries, customers, relations, corridors);
- Further capacity investigations for marshalling yards as well as larger infrastructures (e.g. ports, customer sidings,…);
- Examination of spatial and temporal separation of wagon flows with DAC / Screw Coupler required; possibly continuous adjustment of wagon routing, train structures and shunting work plans necessary.

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Financing challenges

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Financing challenges	Approaches
Investment volume of EURO 6,4 to 8,6 billion	EU-wide funding programme
Earnings situation in European RFT	
Benefits are only realized, when most of the wagons have been converted; early movers are disadvantaged	Open access to financing offers for all stakeholders
Avoidance of negative cash flows during migration period	Deployment DAC with variable usage fee according to conversion status of wagon fleet
Balance-saving refinancing	

Organizational challenges

Technology

- DAC specification,
- DAC tests and demonstrators,
- Selection of standard DAC incl. energy and data concept,
- Homologation DAC,
- Dangerous goods requirements,
- …

Financing

- Business Case DAC,
- Risk profile DAC,
- Adressing investors,
- Financing offers for all stakeholders,
- …

Regulation

- Possible EU-wide funding programme,
- EU-wide standard for DAC (TSI)
- Period for retrofitting a large part of the freight wagons in EU.
- …

Operations

- Standards for operational processes with DAC and further automation components,
- Migration planning,
- Derivation of DAC-quantity structure for industry and workshops,
- …

Coordination

- EU-wide coordination of the various activities for preparation and execution of DAC-migration.

Agenda

A **DAC as a building block for digitization and automation in RFT**

B **Quantity Structure, Cost and Benefit Estimate for Migration of DAC**

C **Challenges for Migration of DAC**

D **Roadmap DAC**

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Roadmap DAC

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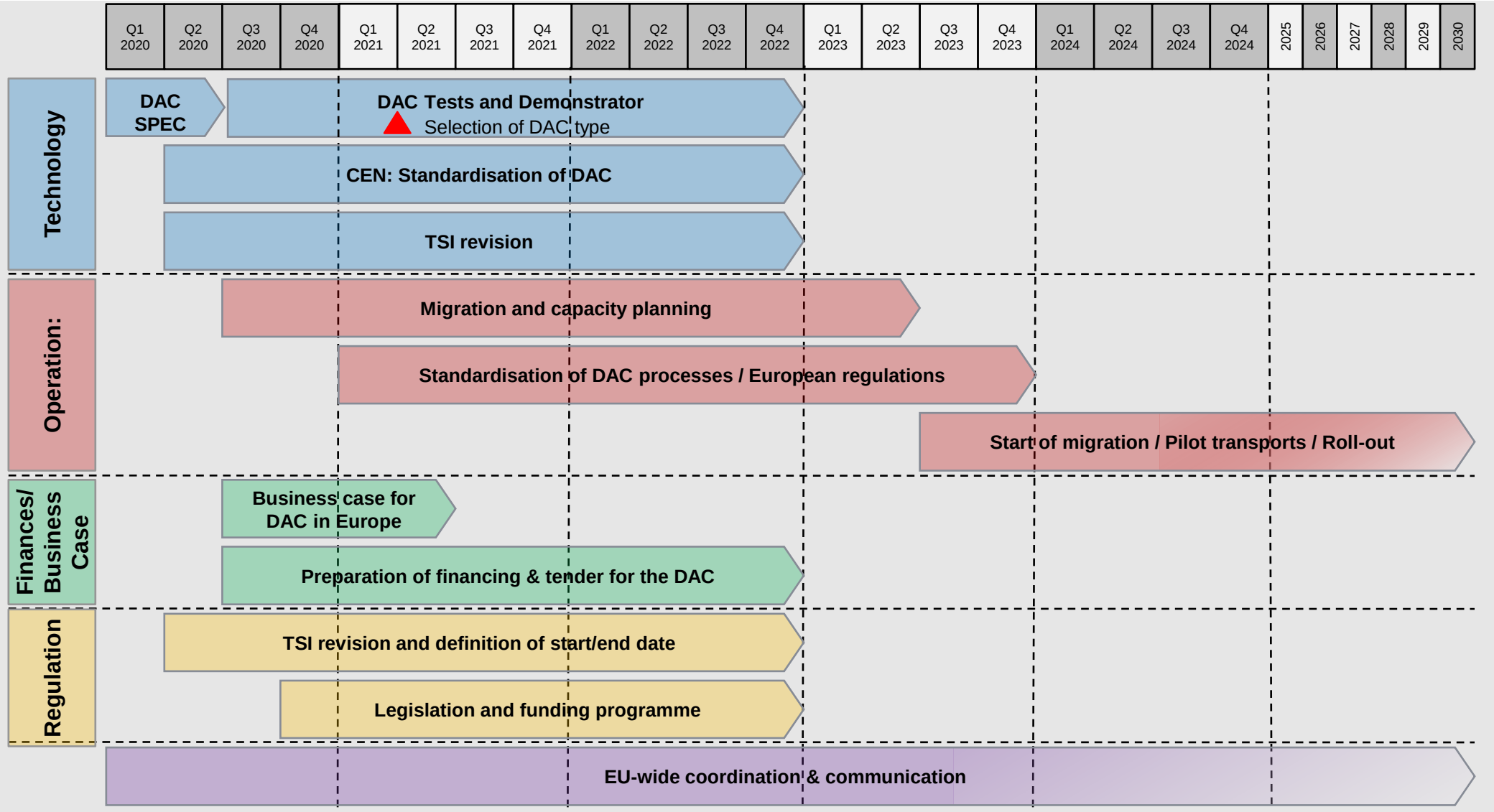

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From the manual world of screw coupling to automated railway operations with DAC

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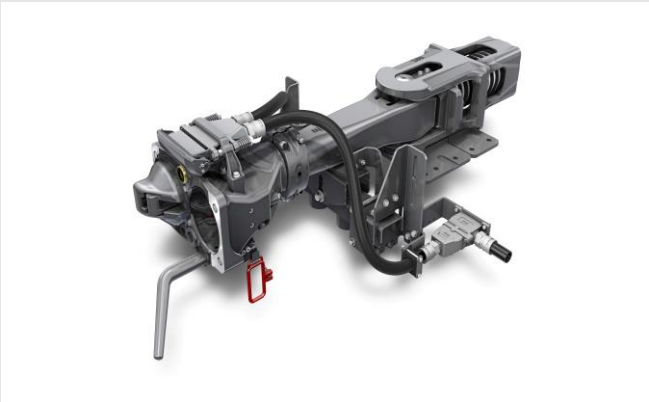


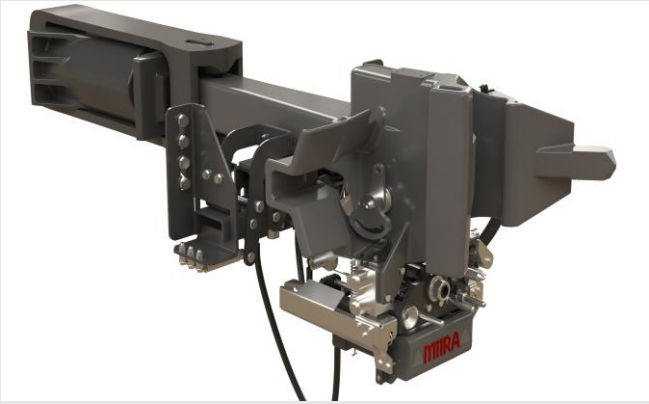


Thank you for your attention.

Source photos: from left top to right bottom: Voith, DAC4EU, Dellner, CAF, Forschungs-Informations-System BMVI, Wabtec