Shift2Rail

FFL4E
Future Freight Loco for Europe

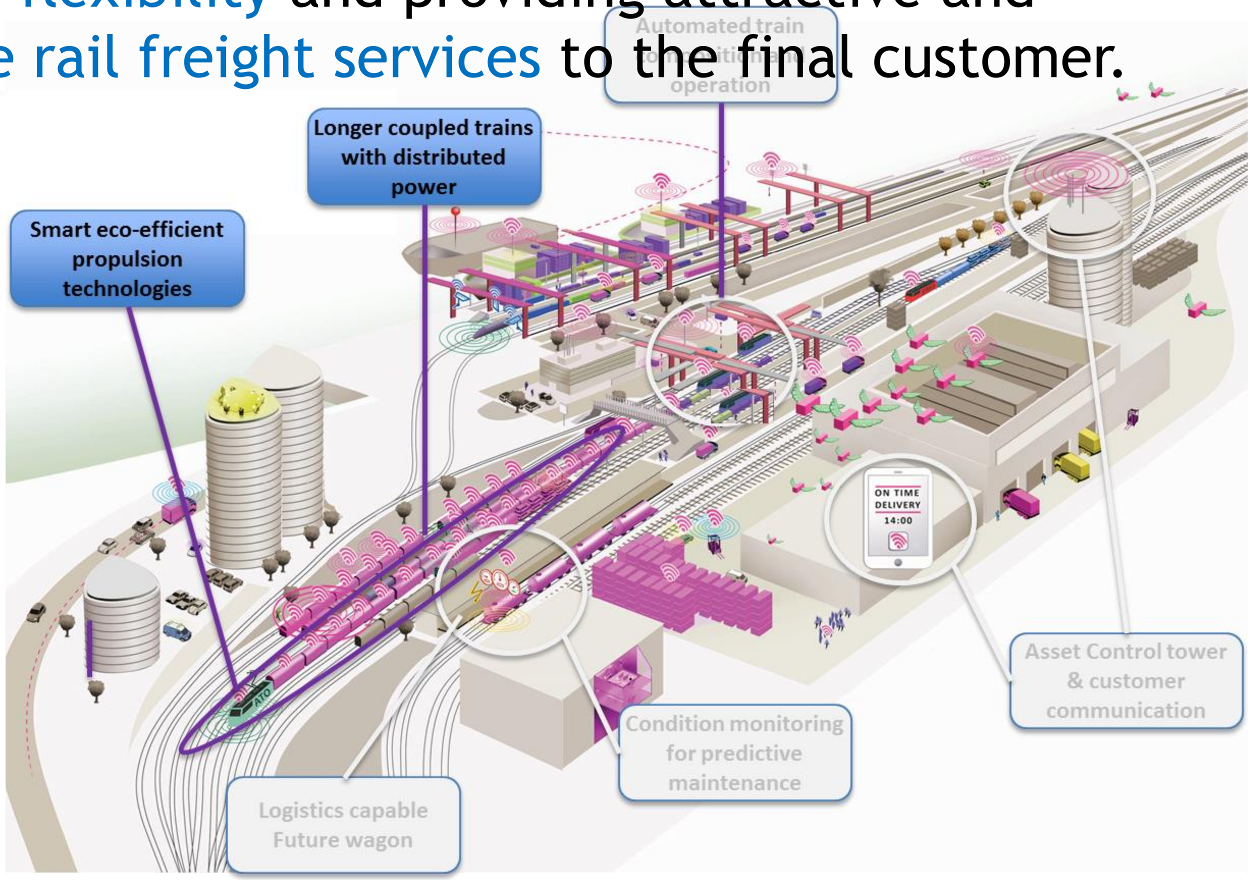
Shift Freight to Rail: Midterm Event for S2R Projects
Vienna, 18.04.2018

FFL4E - Agenda

- Introduction
- Future freight locomotive
- Full electric last mile propulsion
- Long trains
- Summary and Outlook

FFL4E - Contribution to IP5 vision

- The FFL4E aims at developing key technologies for future energy efficient freight locomotives, allowing highest operational flexibility and providing attractive and competitive rail freight services to the final customer.

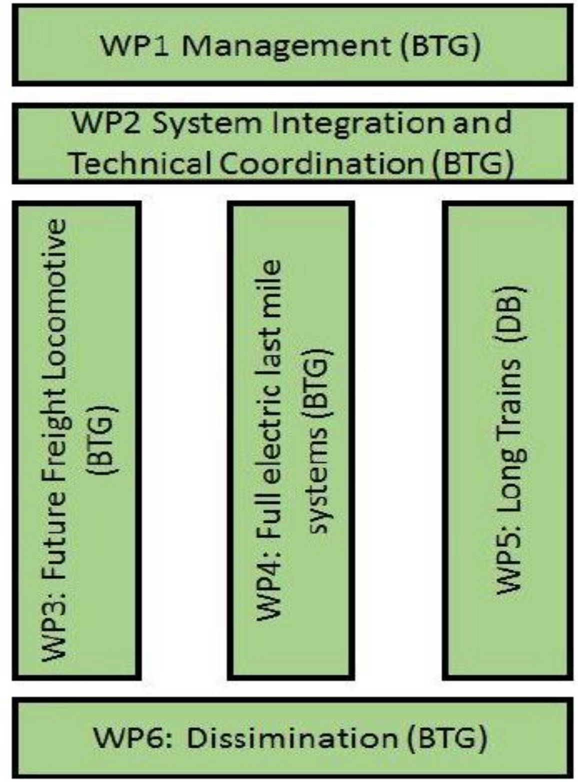


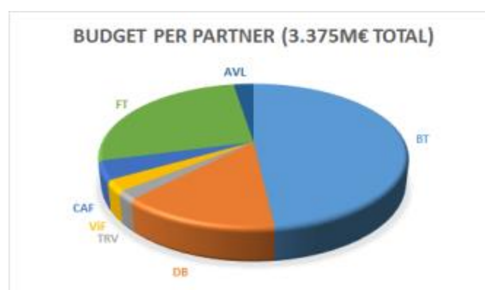
FFL4E - Objectives

- **Extreme flexibility:** operation on non-electrified and electrified lines without the need of changing the locomotive. This requires hybrid propulsion technologies, and includes last mile propulsion systems
- **Competitive rail freight services:** Remote control for distributed power, thus, allowing the increase of the train length up to 1,500 m and consequently improving the cost efficiency of rail transport. This includes also technologies that reduce LCC (e.g. low wear locomotive bogie)
- **Energy efficiency:** Recuperation of braking energy as much as possible, store it onboard and reuse it whenever required, for traction purposes, for peak shaving or to supply auxiliaries and others

FFL4E – Project Structure

- FFL4E is structured as follows:
  - 2 WPs for Management and Coordination
  - 3 technical WPs
  - 1 WP for dissemination
- FFL4E is being led by: Bombardier Transportation
- Project Partners are:
  - Bombardier Transportation
  - Faiveley Transport Italia
  - Trafikverket
  - Deutsche Bahn
  - CAF Power & Automation
  - VVA
  - AVL List





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FFL4E – Future Freight Loco (1/3)

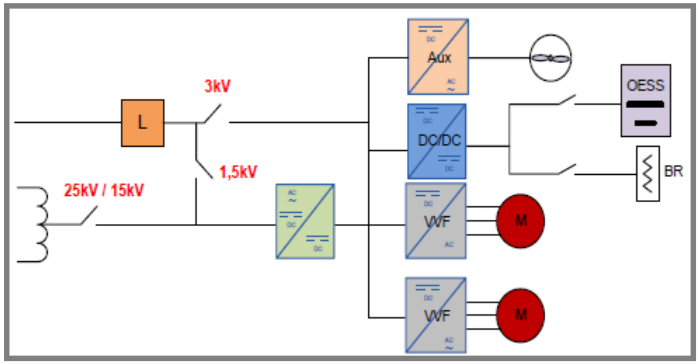
- S2R FFL4E project studies the hybridization of propulsion system to further increase the functionality of electric locomotives

- Focus is on powerful energy storage systems that will allow:
  - Last mile run
  - Peak shaving
  - Backup mode
  - Energy Efficiency
  - Power Boost
  - Electric Mode

- FFL4E studies also how to decrease wear on powered locomotive bogies by means of radial steering systems

FFL4E – Future Freight Loco (2/3)

- Analysis of the key performance figures of existing locomotives and their commercial use
- Focus on Last Mile Run
- Modelling of a locomotive traction chain in simulation tool



- Real Track profiles, connecting towns with industry companies in Europe, used for simulation and calculation of OESS size:
  - TP1: Bruck an der Mur – Paper Mill in Gratkorn
  - TP2: Zeltweg – Pöls
  - TP3: Bruck an der Mur – Magna Steyr in Graz
  - TP4: Lüneburg – Hamburg

FFL4E – Future Freight Loco (2/3)

- Simulation with AVL Cruise M simulation tool
- For the given system architecture and for different real track profiles, the ideal OESS size was evaluated.

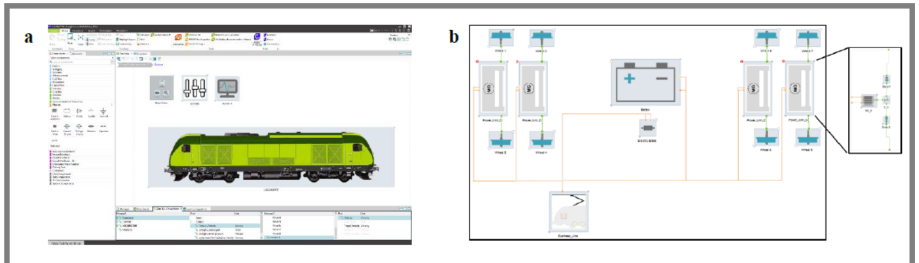
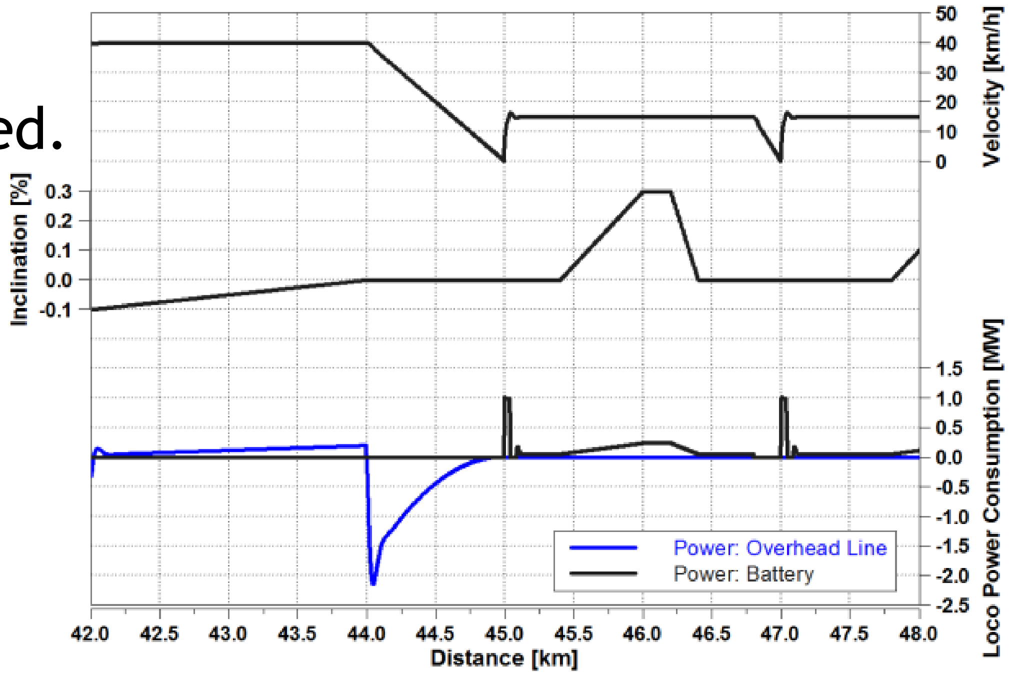


Fig. 2 (a) (b) Simulation model overview of a BoBo Hybrid Electric Multi-System locomotive on CRUISE M.



FFL4E – Future Freight Loco (3/3)

➢ Summary of OESS for the various use cases analysed:

Table 2. OESS characteristics of a hybrid electric freight locomotive for Last Mile application in four different track profiles.

	Track profile and OESS characteristics				
Track profile	Track profile	TP1	TP2	TP3	TP4
	Distance with battery [km]	10	14.5	11.8	7
	Altitude [m]	2	114	1	0
	# of stops [-]	3	-	1	3
	Train load and locomotive weight [t]	1500	←	←	←
OESS charac.	Battery power max. (incl. aux. & losses) [MW]	1.2	1.2	1.2	1.2
	Battery traction power max. [MW]	1	1	1	1
	Battery size – Energy point [kWh]	190 (6.3 C-rate)	1095 (1.1 C-rate)	180 (6.7 C-rate)	145 (8.3 C-rate)
	Battery size – Final [kWh] at 5.0 -Crate	240	1095 (1.1 C-rate)	240	240
	Battery size – Final [kWh] at 2.5 C-rate	480	1095 (1.1 C-rate)	480	480

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FFL4E – Full ele. LM propulsion (1/3)

- Last Mile (LM) Propulsion System for Railway Applications first proposed by Bombardier Transportation few years ago, was a disruptive and successful innovation
- Today, small diesel engines with 200-300kW
- Next generation: hybrid approaches or full electric solutions, with following added value:
  - Increase in tractive power
  - Emission free operation over a certain distance
  - Energy recuperation into battery
  - Environmental friendly recharging of the battery from the catenary

FFL4E – Full ele. LM propulsion (2/3)

- Analysis done in WP3 (Future Freight Locomotive) summarizes
  - Ideal battery size: 500kWh
  - Ideal battery power: 1MW
- Selected architecture:
  - A given number of smaller building blocks, e.g. 50kWh, arranged in parallel strings, each with an own BMS, TCU and DC/DC converter
- Advantages of this approach:
  - Balancing simpler
  - Higher safety
  - Lower maintenance efforts
  - Better adaption to the various customer needs (including retrofit)

FFL4E – Full ele. LM propulsion (3/3)

- FFL4E is developing the demonstrator
- Main components are:
  - The Bombardier water cooled Primove Li-ion battery (nMNC)
    - 49kWh, 127kW continuous, 400kW peak (20s)
    - 440 mm x 1780 mm x 610 mm, 667 kg
  - One dedicated thermal conditioning unit
  - One DC/DC converter
  - Integration into one sealed cubicle
    to be placed in the machine room

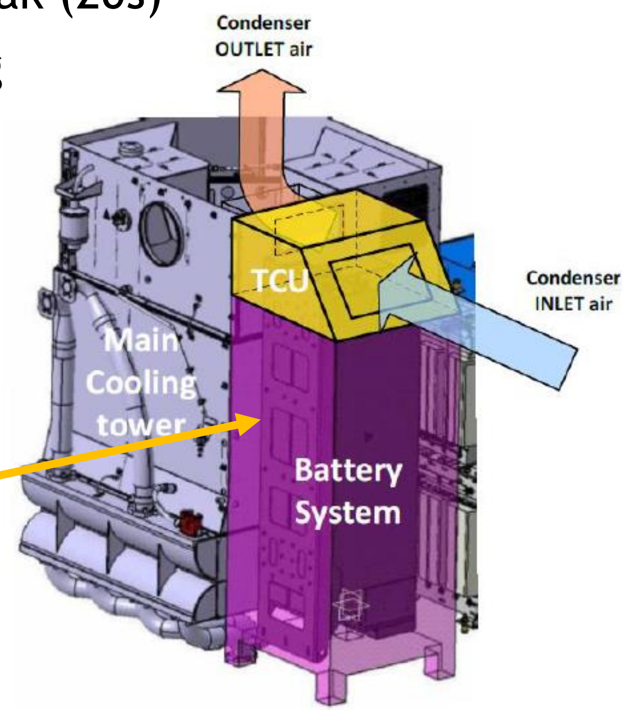

Figure 5: Battery cubicle with air flow of the TCU

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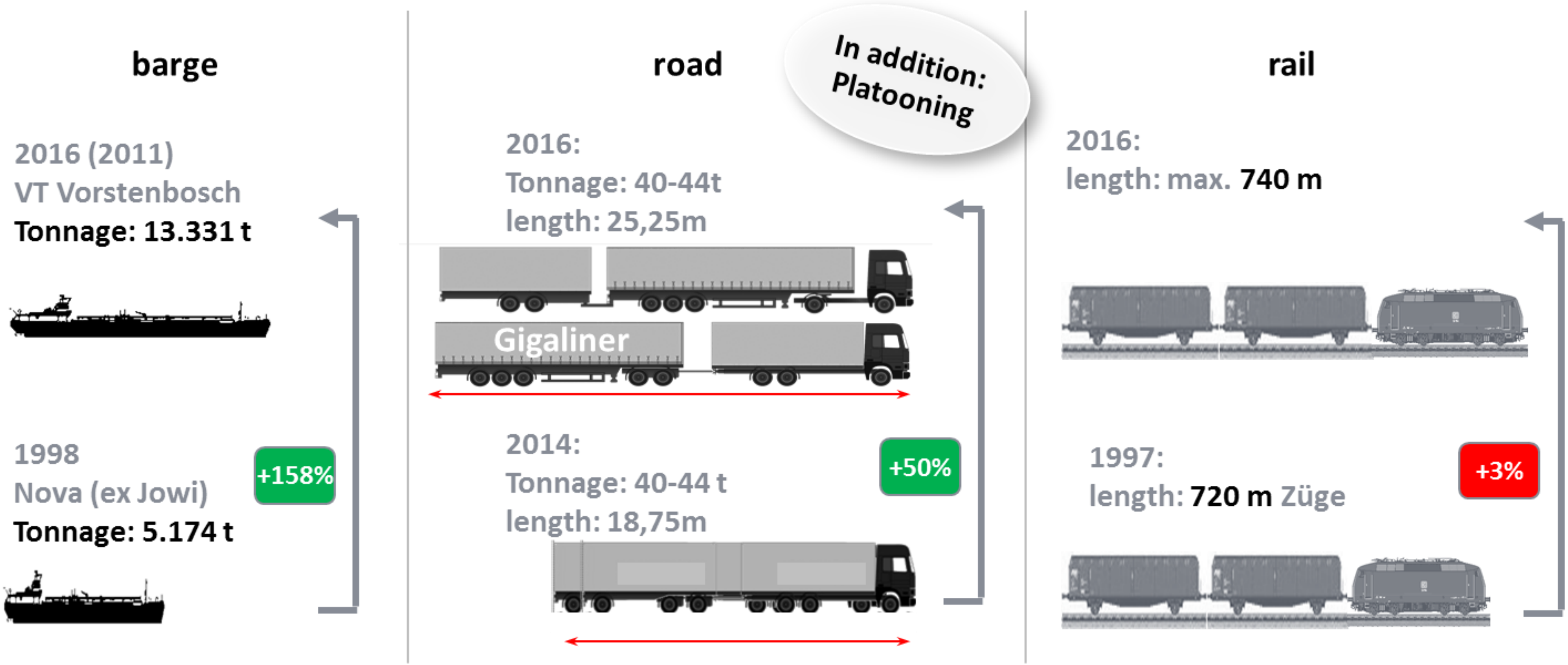
FFL4E – Long Trains (1/7)

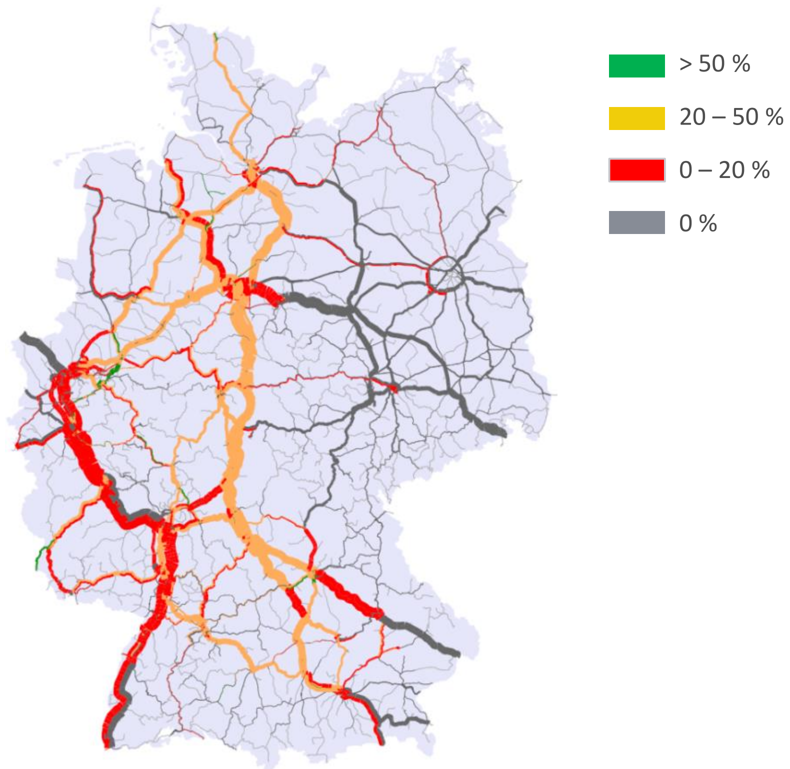
- Rail lags behind road and barge concerning transport efficiency



FFL4E – Long Trains (2/7)

- Currently only a small percentage of freight trains runs with the maximum train length of 740 m

Percentage freight trains ≥ 700m train length



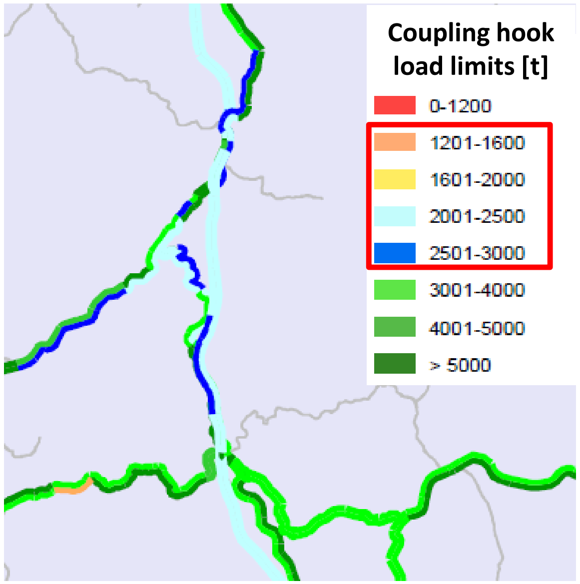
Main reasons for small train lengths

- **Infrastructure** is not prepared for 740 m trains (mainly due to overtaking stations)
- **Missing technology for Distributed Power**
  -> max. loads of trains are restricted to coupling hook load limits

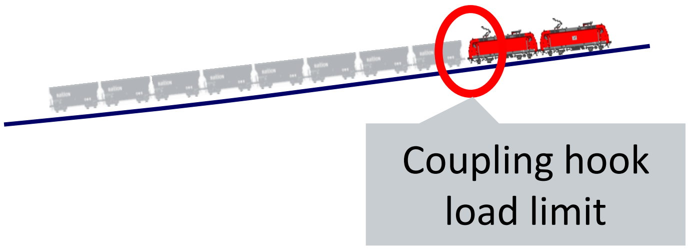
FFL4E – Long Trains (3/7)

- Gradients of infrastructure restricts maximum train loads significantly

Coupling hook load limits due to gradients of infrastructure



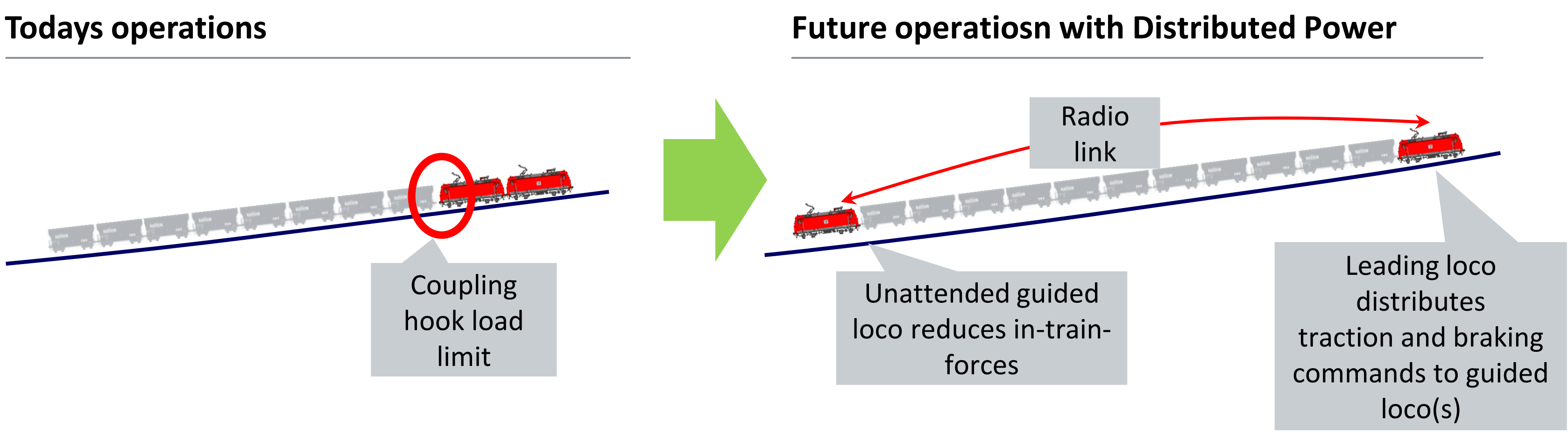
Restrictions for todays operation



- The gradients of infrastructure restricts max. train loads
- Esp. for heavy load trains (coal, mineral oil…) load restrictions lead to short trains of 400 - 500 m

FFL4E – Long Trains (4/7)

- Distributed Power enables RUs to run heavier and longer trains

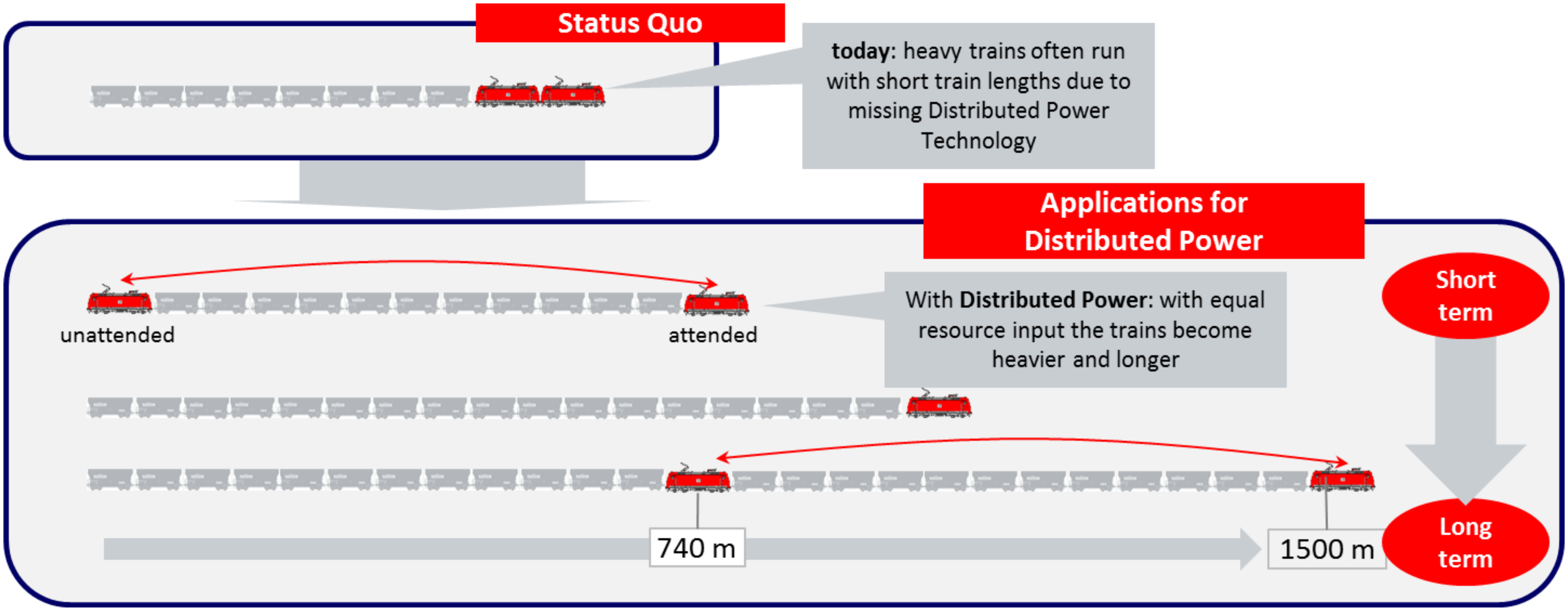


- Coupling hook load limits restricts max. load of freight trains

- Distributed Power reduces in-train-forces
- Distributed Power enables RUs to run much heavier and longer trains using the same resources
- No Infrastructure adaptations needed

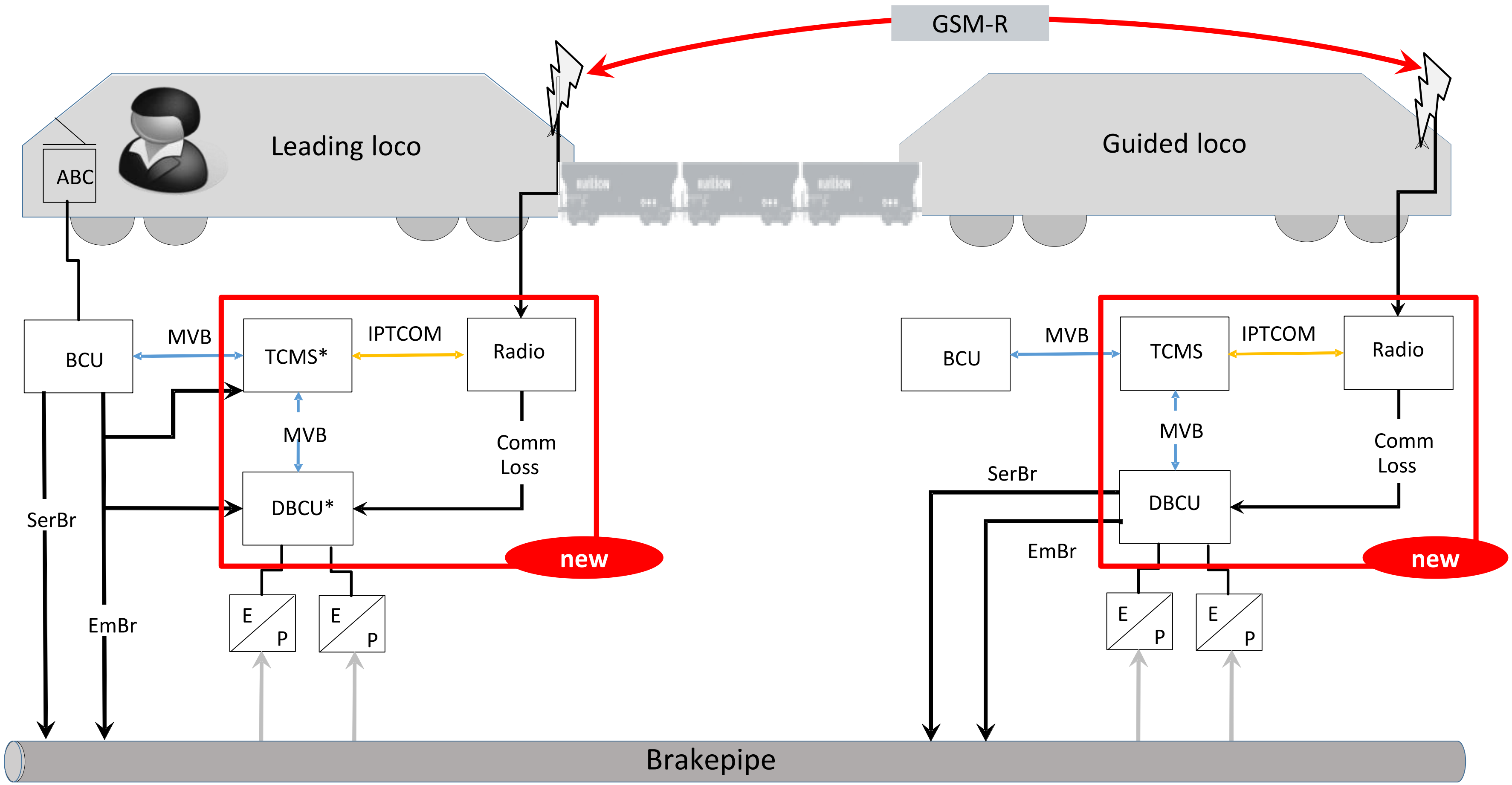
FFL4E – Long Trains (5/7)

- Distributed Power opens the path to 1,500 m long trains



FFL4E – Long Trains (6/7)

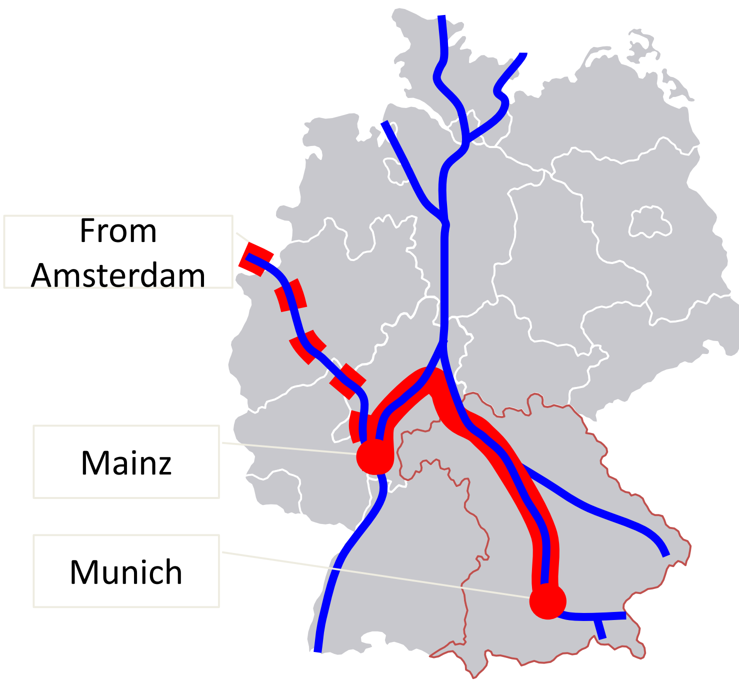
➢ FFL4E develops Distributed Power technology for the European market



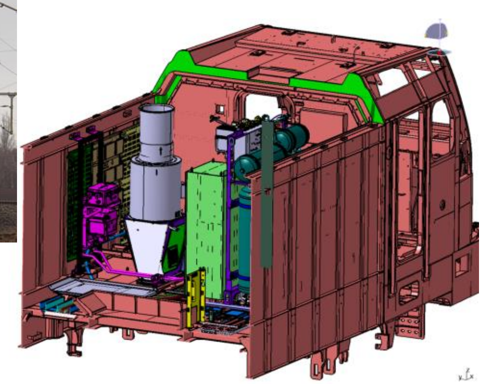
*TCMS:Train Control Management System, DBCU: Distributed Brake Control Unit

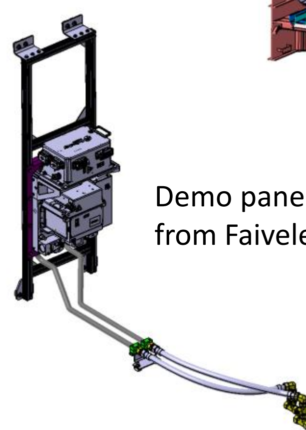
FFL4E – Long Trains (7/7)

- Distributed Power will be demonstrated on a coal train Amsterdam - Munich



Demo train Amsterdam - Munich





Demo panel and SIL4 computer from Faiveley Italy

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FFL4E – Summary and Outlook

- FFL4E is developing two demonstrators:
  - Full Electric LMB
  - Radio Remote Control for Distributed Power

- FFL4E is literally addressing the KPIs stated in the MAAP:
  - Increase of Energy efficiency
  - Increase of competitiveness
  - Doubling of capacity

- After some initial problems, work proceeding well

Thank you for your attention

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FFL4E - Contribution to IP5 vision

FFL4E Future Freight Locomotive For Europe