SIEMENS

siemens.com/rail-electrification

Sitras LCU

Local charging unit for railway vehicle operation without overhead contact line

The local charging unit Sitras® LCU quickly recharges mobile or hybrid energy storage systems on railway vehicles.
The Sitras LCU may be placed at stations or stops, or may be integrated into traction substations.
Recharging takes place during dwell time.

Features

- High charging currents for charging during typical dwell times
- Concept for highest safety and availability of the complete system for operating without overhead contact line
- Based on proven products of railway electrification (Sitras-family)
- Integrated auxiliary power supply for the station / stop
- Project specific dimensioning, also for the compact type Sitras LCU-C without auxiliary power supply

Technical data *		
Input voltage (tolerances acc. to EN 50163)	[V DC]	750
Operating voltage for full charging power	[V DC]	750...900
Charging current	[A]	1,000
Charging time, e.g. a storage with 3.2 kWh	[s]	20
Auxiliary power supply for station	[kW]	30
Permissible ambient temperature	[°C]	-5...+50
Maximum operating height above sea level	[m]	1,000
Permissible environmental data acc. to EN 50124		PD4A
Dimensions of container and cable cellar **		
– Length	[mm]	4,300
– Width	[mm]	1,600
– Height	[mm]	2,800 + 750

* other values available on request
** inner dimensions plus wall thickness; dimensions may vary acc. to project specific layout

Components

The Sitras LCU comprises the following main components:

- LCU-container with switchgear and diodes, fault protection and auxiliary power supply
- overhead conductor rails,
- cable connections to DC traction substations.

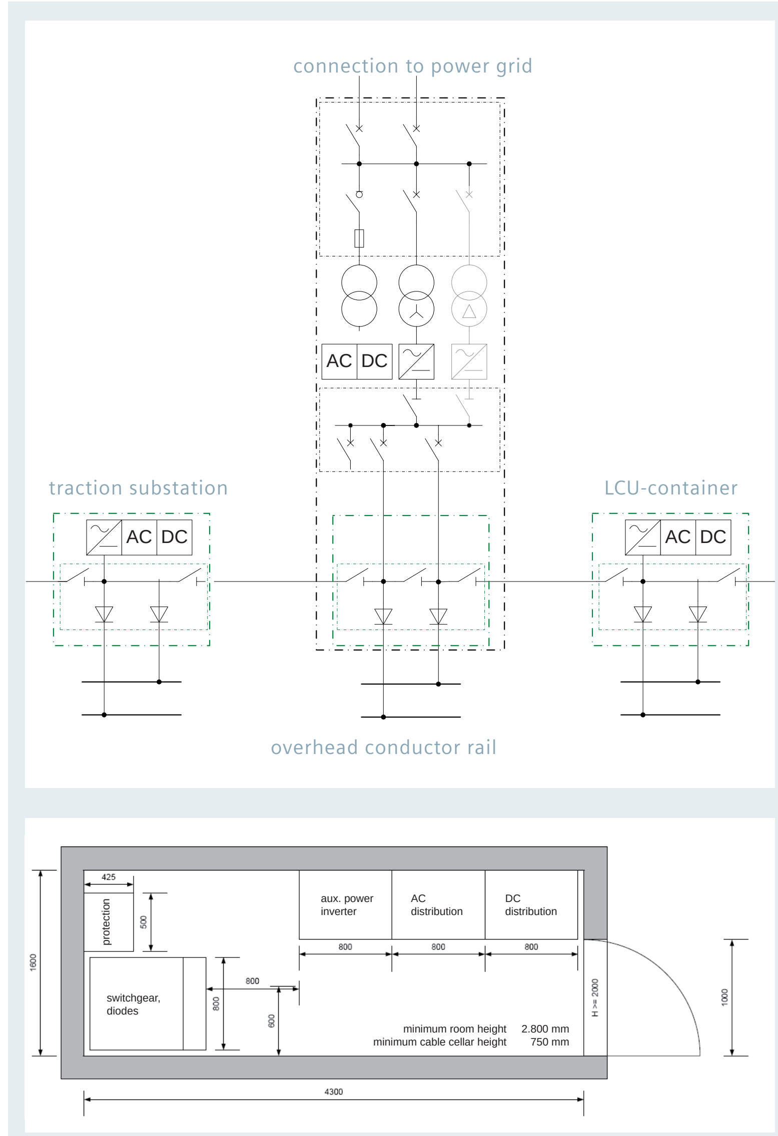
Operation

The LCU overhead conductor rails are always energized, except in case of faults. In case of failures, local control devices within the LCU and central devices in the traction substations reconfigure the system arrangement. Sitras LCU operates without active current control. The charging currents are regulated by the vehicles according to their demands.

Mechanical Design

The switchgear / diode cabinet is based on components of the compact switchgear Sitras CSG. Short circuit protection is guaranteed by Sitras PRO devices inside the LCU-container. The configuration control is realized by the station control system Sitras SCS in the traction substations. Touch voltage protection is handled by the compact short-circuiting device Sitras SCD-C. All equipment is mounted in prefabricated containers. A project dependant integration into customer's rooms is possible. The overhead conductor rails Sicat SR consist of aluminum with copper wire.

Overhead conductor rail Sicat SR



Schematic diagrams

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Product Information / Version 1.0.1 / No. A6Z00031550155

EcoActive Technologies

MITRAC Energy Saver

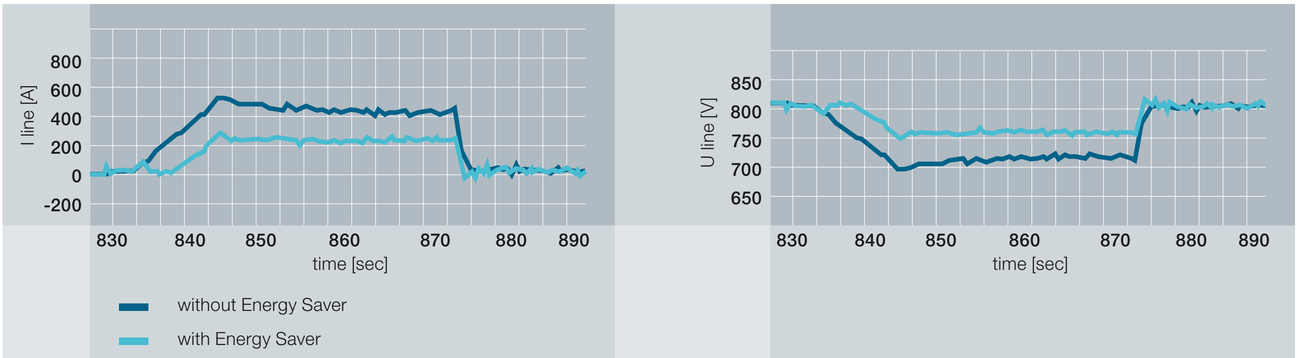
When a vehicle brakes, energy is released. To date, considerable energy has been lost in hot air. The challenging alternative is to store the braking energy on the train and use it during acceleration or autonomous operation of the vehicle.

The solution – Bombardier's MITRAC Energy Saver sets new standards

The *BOMBARDIER* MITRAC** Energy Saver works by charging up storage devices with electrical energy released when braking. The system is based on high-performance double layer capacitor technology (ultracapacitors) which allows frequent starting and braking. The stored energy can be used in many ways resulting in various benefits:

Energy savings and power supply optimization

Resources need to be deployed and utilized efficiently, in a manner that is easy on the environment – and today's rail transport systems are no exception. Environmental awareness plus reduced operating costs are now major considerations in procuring advanced rail vehicles for public transport. The benefits to customers are obvious.



Power supply optimization with MITRAC Energy Saver

The *MITRAC* Energy Saver can help reduce the energy consumption of a light rail or metro system by up to 30%! Moreover, lower peak current demand means that fewer substations are needed and they can be further apart, which reduces infrastructure investment. Using *MITRAC* Energy Saver for diesel multiple units allows energy savings by even up to 35%! Alternatively, the stored energy can be used as performance booster: the *MITRAC* Energy Saver enhances the performance of a vehicle by adding extra power during acceleration.

Performance boosting

The additional power from the *MITRAC* Energy Saver can be used to boost the vehicle's speed when line current or engine power are limited. Assuming e.g. 30% power from the Energy Saver could result in 30% higher power while keeping the same line current demand. This extra power results in additional tractive effort and allows significantly higher train acceleration. Thus, the Energy Saver compensates the disadvantage of the usually limited power of the diesel engines or increases the throughput capacity of a light rail or metro system.

Catenary free operation

The *MITRAC* Energy Saver is also the ideal solution if sections without a catenary are desired (e.g. for aesthetic reasons). The *MITRAC* Energy Saver enables catenary free operation for short distances and as a part of the *BOMBARDIER* PRIMOVE** solution also for longer distances. Additionally, the storage system makes it possible to continue operation in case of maintenance work or power failures in the grid. This can be crucial especially for rescue operations in tunnels to reach the next station allowing save evacuation of the passengers.

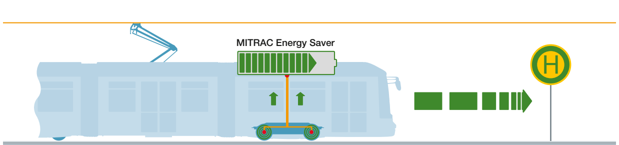
Benefits of the *MITRAC* Energy Saver:
- Energy savings
- Power supply optimization, reducing infrastructure investment
- Catenary free operation
- Performance boosting

How does the MITRAC Energy Saver work?

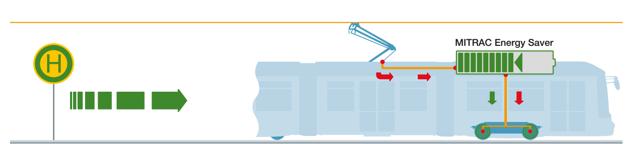
The *MITRAC* Energy Saver stores the energy released when braking and uses this energy during the next acceleration of the vehicle.This additional energy lowers current demands from the network, yet the traction effort stays the same. Measurements during acceleration up to 50 km/h show a reduction of the peak power demand by up to 50% as illustrated in the diagram above.

The technology behind

The most challenging operating conditions for storage devices on board of traction vehicles are high number of load cycles during the vehicle lifetime, relatively short charge and discharge times as well as high charge and discharge power values. In contrast to high-maintenance, flywheel-based mechanical energy storage systems, the *MITRAC* Energy Saver operates on a purely electrical basis.



Storing energy while braking



Using stored energy during acceleration

The MITRAC Energy Saver is available as a standard technical option to the new BOMBARDIER* FLEXITY* 2 light rail vehicle platform

The *MITRAC* Energy Saver solution is based on double-layer capacitors with a long service life and ten times higher performance than conventional batteries. High-performance storage cells are connected in series to create a *MITRAC* storage unit. They store the electrical brake energy with relatively low losses.

Proven technology

A prototype light rail vehicle fitted with *MITRAC* Energy Saver technology completed a four year trial period. It has been successfully tested in the system of the public transportation operator in Mannheim, Germany starting in 2003. The vehicle was in daily revenue service. The energy storage system fitted on the roof of the vehicle, proved to be an efficient and reliable energy saving technical solution. Encouraged by the success of the trial, the German operator Rhein-Neckar-Verkehr GmbH (RNV) ordered 49 *MITRAC* Energy Saver for nineteen light rail vehicles.

How much energy does it really save?

As the trial of the MITRAC Energy Saver proved, the energy savings reach up to 30% of the traction energy or 20% of the total energy demand. In consideration of the fact that the yearly energy cost for the operation of a LRV accounts around 30,000 Euro and approximately 150,000 Euro for a metro, these figures mean a high saving potential for the operators.

Beginning of 2009, RNV won the innovation prize of the State of Baden-Wurttemberg in Germany for deploying the *MITRAC* Energy Saver on their new fleet and thereby making an important contribution to climate-friendly mobility.

MITRAC Energy Saver provides performance boosting for diesel electric multiple units (DMU´s)

MITRAC Energy Saver

MITRAC Energy Saver – Applications

The *MITRAC* Energy Saver is an important contribution to a more sustainable transport system, enhancing the already established environmental advantage of public rail transport not only for light rail vehicles but also for metro systems and diesel electric multiple units. The energy saving potential is exceptionally high when the line receptivity is low and the Energy Saver is used frequently, thus if there are short distances between the stops.

The proven energy savings of 30% by the light rail vehicle prototype and the corresponding emission reduction is in line with various local and global energy saving programs set up by e.g. the European Union and major railway operators. The on board energy storage is one of the main future technologies to increase competitiveness of public transport systems by making them more economic and environmentally friendly.

Technical data

	MITRAC Energy Saver Unit		
Application	LRV 2003	LRV 2008	DMU
Installed energy (kWh)	1	1	1,17
Max output power (kW)	300	300	100
Cooling	forced air cooling	forced air cooling	natural convection cooling
Weight (kg)	477	428	466
Dimensions (mm)	1900x950x455	1700x680x450 (partly 550)	1800x1500x250
Typical application	2 Boxes for 30m LRV 2 kWh, 600 kW	2 Boxes for 30m LRV 2 kWh, 600 kW	6 Boxes for 4 car DMU 7 kWh, 600 kW

Reference projects

MVV Verkehr AG, light rail system
Mannheim, Germany
1 *MITRAC* Energy Saver prototype

Rhein-Neckar-Verkehr GmbH (RNV)
Mannheim, Germany
49 *MITRAC* Energy Saver for 19 light rail vehicles

ECO4 – Energy, Efficiency, Economy and Ecology
The *MITRAC* Energy Saver forms part of Bombardier's *ECO4 environmentally friendly technologies. Addressing the growing challenges among operators to reduce Energy consumption, improve Efficiency, protect the Ecology while making sense Economically, *ECO4* is the concrete validation of Bombardier's declaration – *The Climate is Right for Trains**.**

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BOMBARDIER

Next generation propulsion

and

Energy storage in railway vehicles





Michael Steiner – FEPPCON May 2004

BOMBARDIER
Une expérience extraordinaire

- Research in Energy Saving Technology
- Energy Storage Technology Options
- *Bombardier* Mitrac** Energy Saver Solution
- MVV Stadtbahn – The Energy Saving LRV
- Benefits and Vision for the Future
- Other applications

*Trademark(s) of Bombardier Inc. or its subsidiaries

BOMBARDIER
Une expérience extraordinaire

Research in Energy Saving

- **Environmentally sound use of resources**
  - Existing resources must be used effectively and environmental friendly
- **Public and private operators under cost pressure**
  - Energy costs per Light Rail Vehicle about 30‘000 €/year
  - Energy costs of a Diesel Multiple Unit in the range of:
    - 280’000 €/year (Germany: @0,75€/liter, 250’000km/a, 1,5 liter/km)
    - 75’000 €/year (wo tax: @0,2€/liter, 250’000km/a, 1,5 liter/km)
- **At Bombardier we are also continuously investing in improving the energy use of our vehicles.**
  Our short- and middle-term solution is:
  - Storage of Brake-Energy
  - 1999 started as research topic “alternative energy supply”

Energy Storage Technology Options

- **Batteries:**
  - Problem of loading cycles: the many starting and braking operations would require replacement of batteries after only a short time
  - Starting and braking power too high for batteries

- **Flywheel Storage:**
  - Overall height of units with this solution makes it virtually impossible to install on low-floor LRV
  - Costs and safety aspects when mounted on vehicles

- **UltraCaps (Double-Layer Capacitors)**
  - Further improved capacitor with a very high energy storage capacity
  - UltraCaps are ideal for "on-vehicle storage of braking energy" applications

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Energy storage technology - UltraCaps

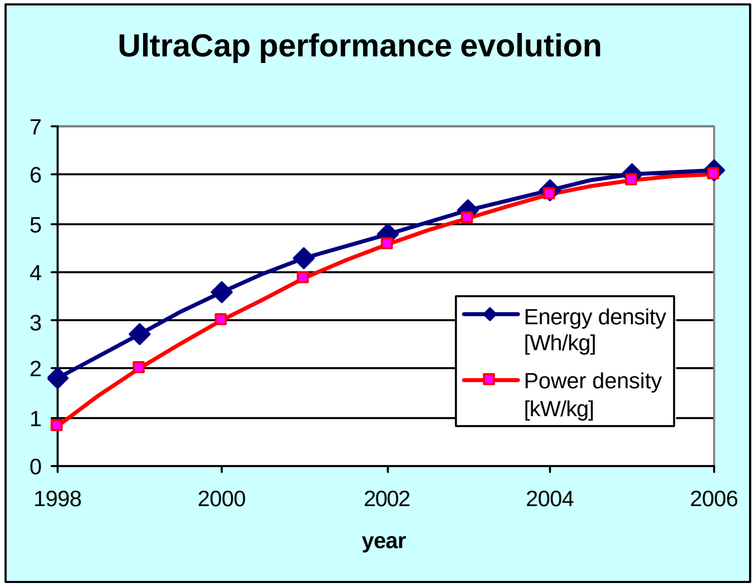
- **double layer capacitors, UltraCaps, SuperCaps, ...**
- **Technically mature: 5 years ago the storage would have been 5 times heavier**

Single cell:

2,5 V

160 in series:

400V



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- Research in Energy Storage Technology
- Energy Storage Technology Options
- ***Bombardier Mitrac* Energy Saver Solution**
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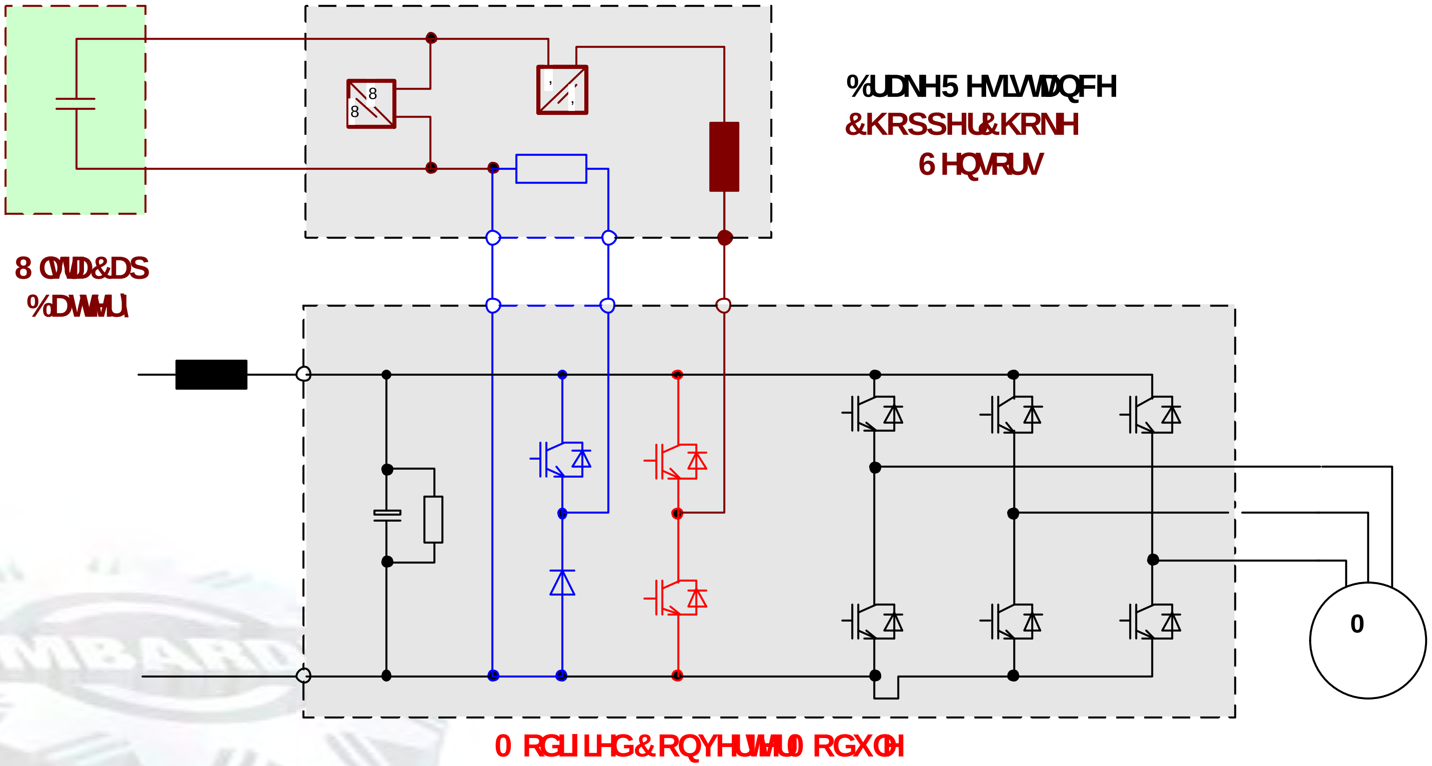
Une expérience extraordinaire

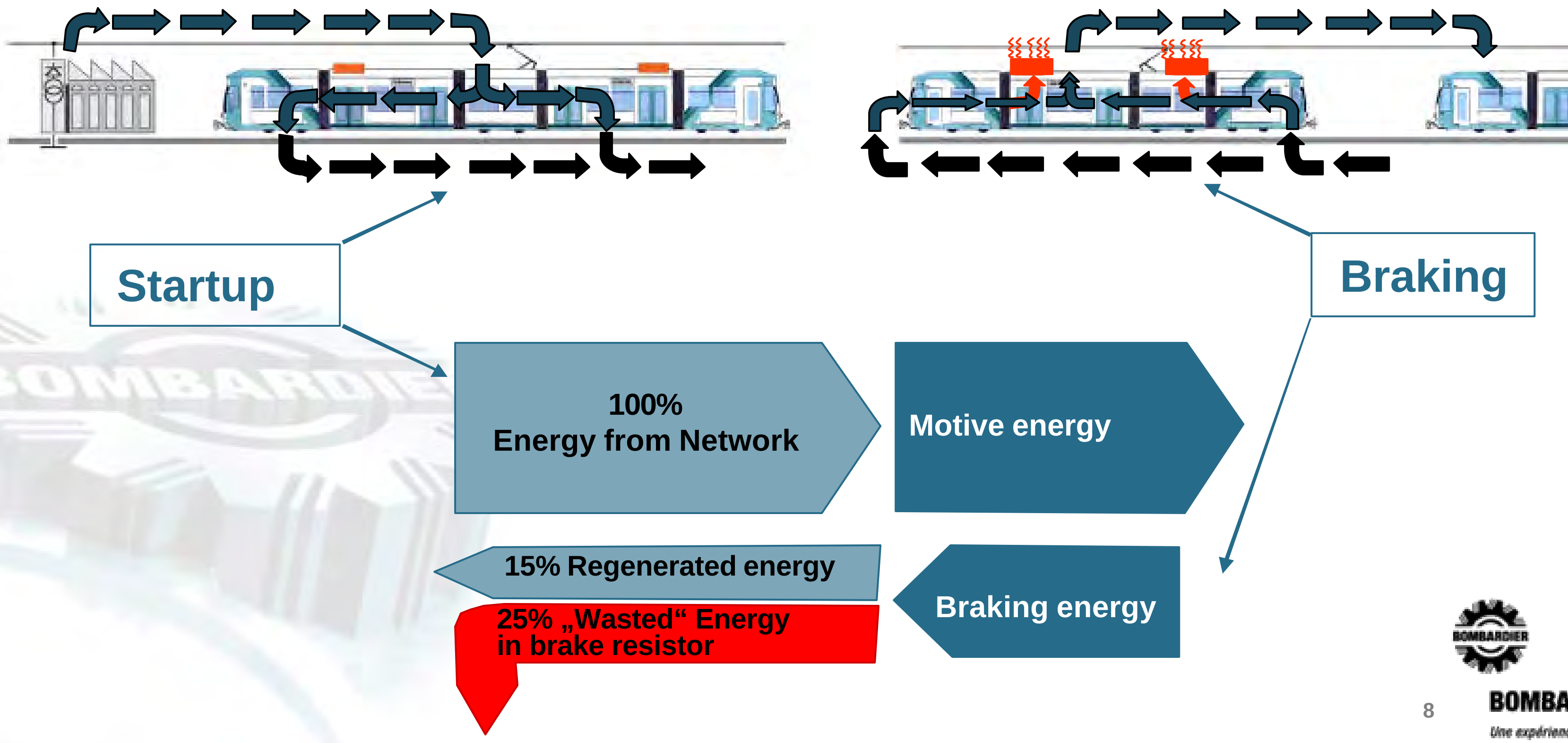
Circuit topology *Mitrac Energy Saver*



Conventional modern Light Rail Vehicles:

Braking energy

- Only around 15% of total input energy is recuperated in braking mode
- Around 25% of input energy is burned in brake resistors



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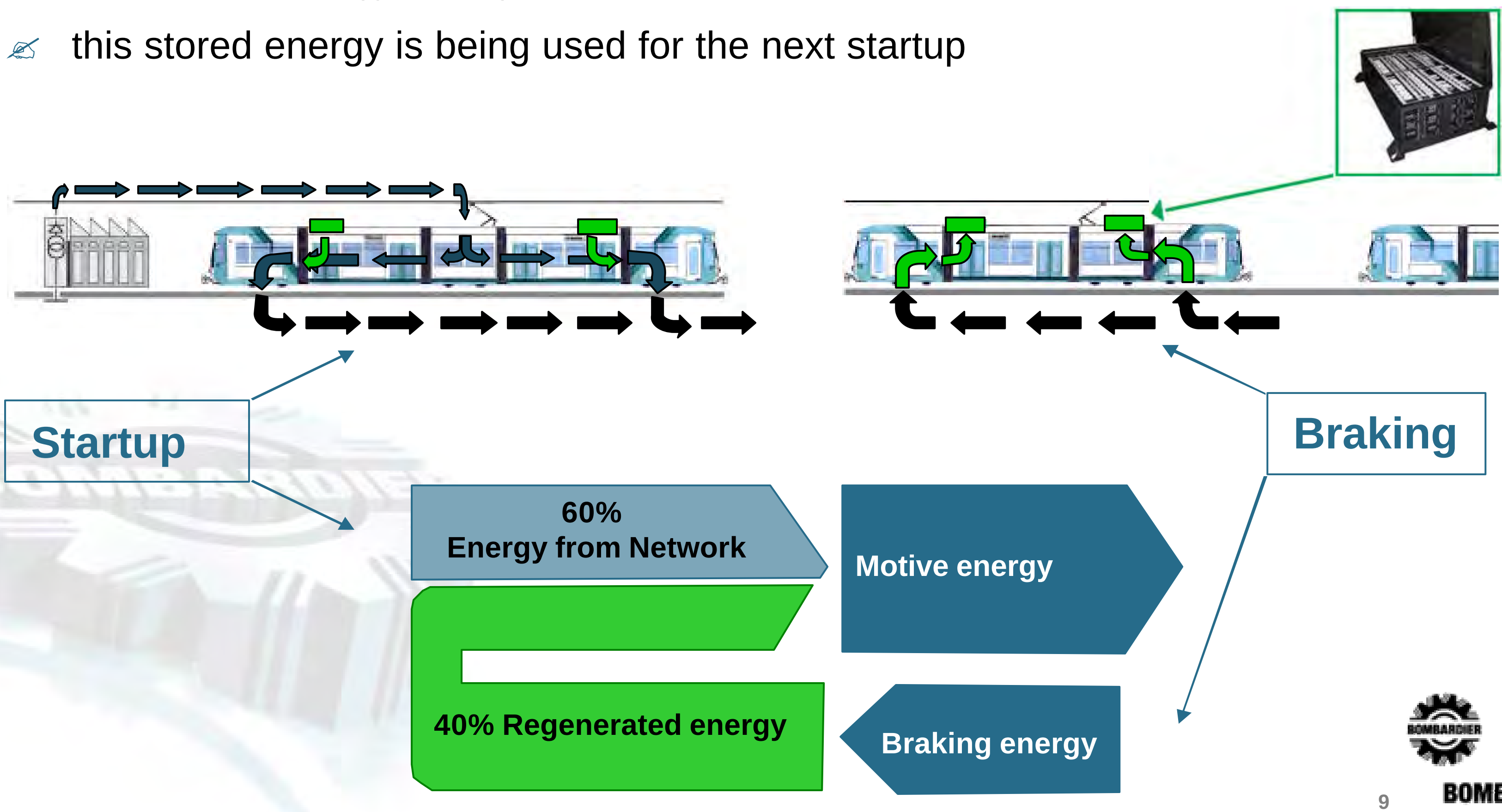
Mitrac Energy Saver Solution

Energy storage on board of vehicle

- Around 40% of input energy is recuperated in braking mode and fed back to the energy storage
- this stored energy is being used for the next startup



Mitrac Energy Saver Solution

Additionally: reduction of losses in contact wire

- The energy storage device reduces network current
- Lower network current generates significantly lower losses in contact wire ($P_V=R*I^2$)

Energy saving: **>5% in contact wire** **25% in vehicle**

Total Energy Saving: 30%
compared to a modern LRV

- Research in Energy Storage Technology
- Energy Storage Technology Options
- *Bombardier Mitrac* Energy Saver Solution
- **MVV Stadtbahn – The Energy Saving LRV**
- Benefits and Vision for the Future
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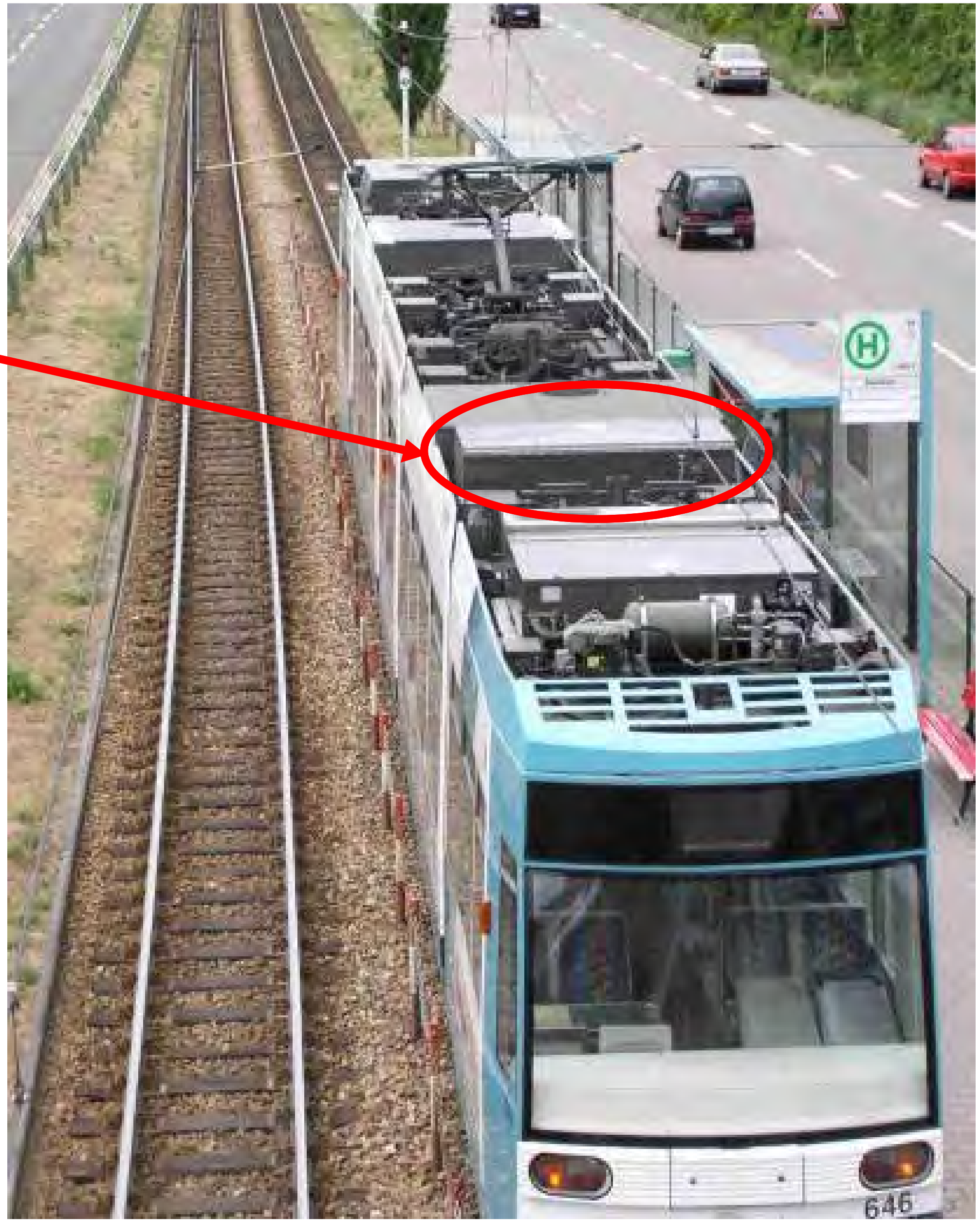
MVV Stadtbahn - The Enegy Saving LRV



Weight: approx. 450 kg

Volume: 1900 x 950 x 455 mm

The test vehicle is equipped with one of two planned energy storage containers.

MVV LRV - The Energy Saving LRV

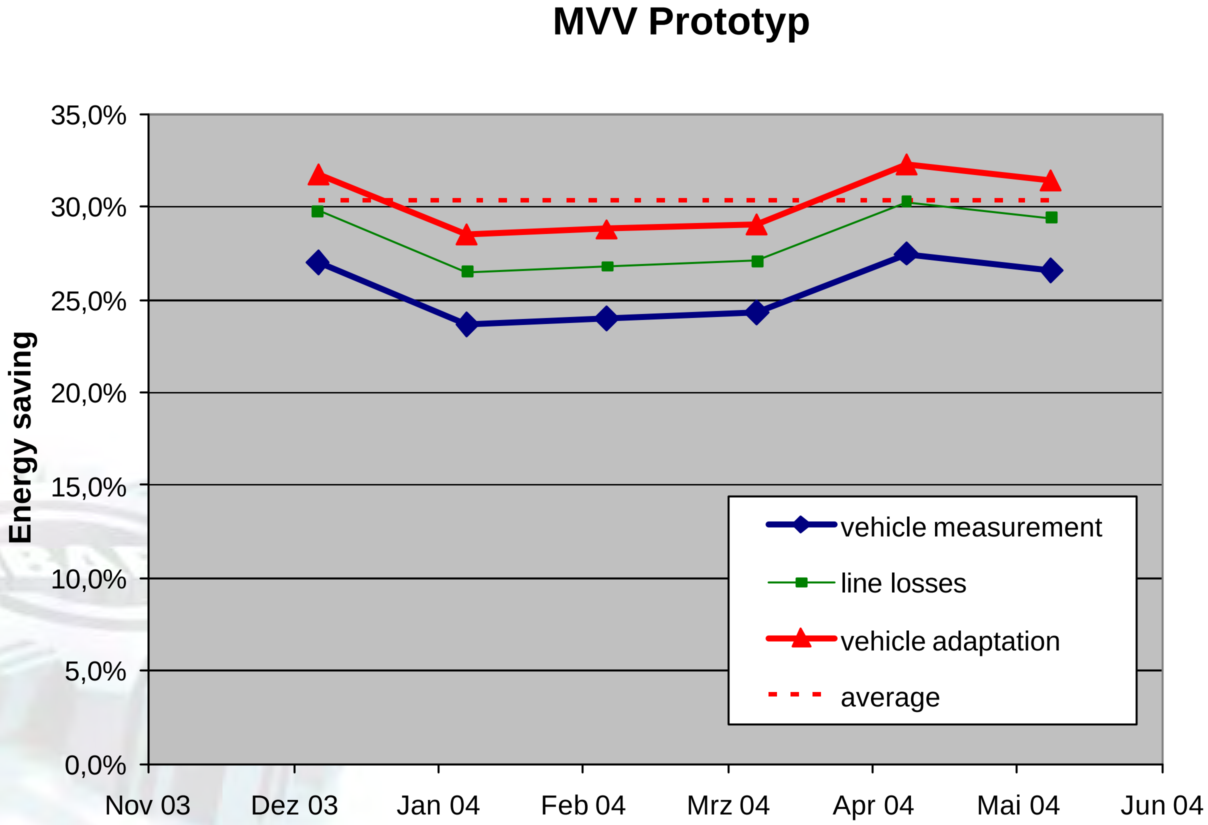
- Press event on 5th September 2003
- Since 5th September the vehicle is in revenue service
- good experience with new technology
- no failures in 9 month

- In revenue service:
    - Experience should be gained with new technology
    - Achievement of targets should be demonstrated
    - Day-to-day operational ability should be demonstrated

MVV LRV - The Energy Saving LRV

Measurements on energy savings

- **between 28% and 32% depending on the climatic conditions**



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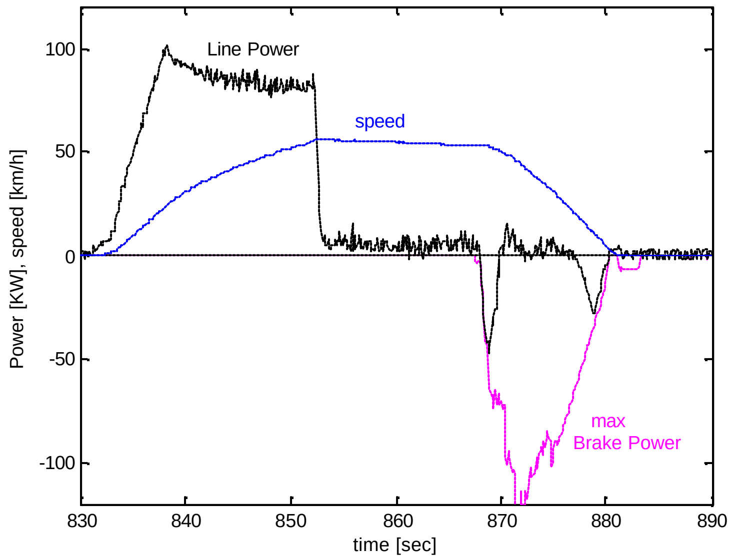
„MVV Stadtbahn“ - The Energy Saving LRV

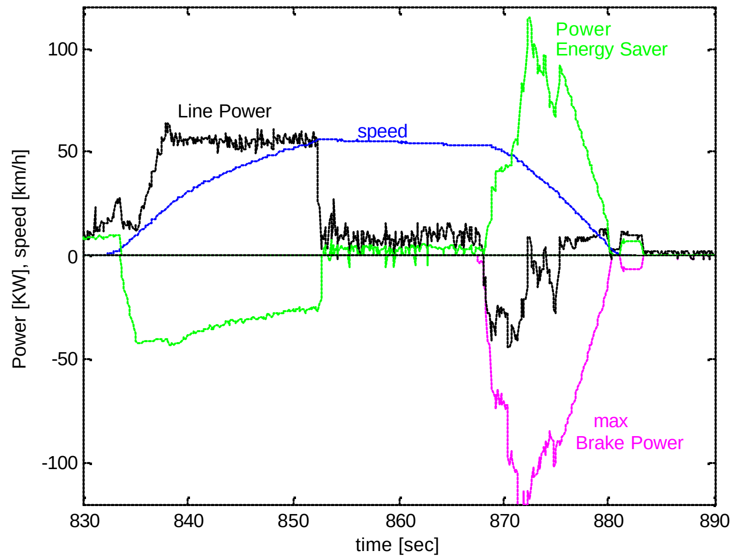
Example: Measurement 28th August

- **The energy consumption could be reduced to 66% at high speeds**
- **the peak power demand could be reduced to 60%**

Without Energy Saver

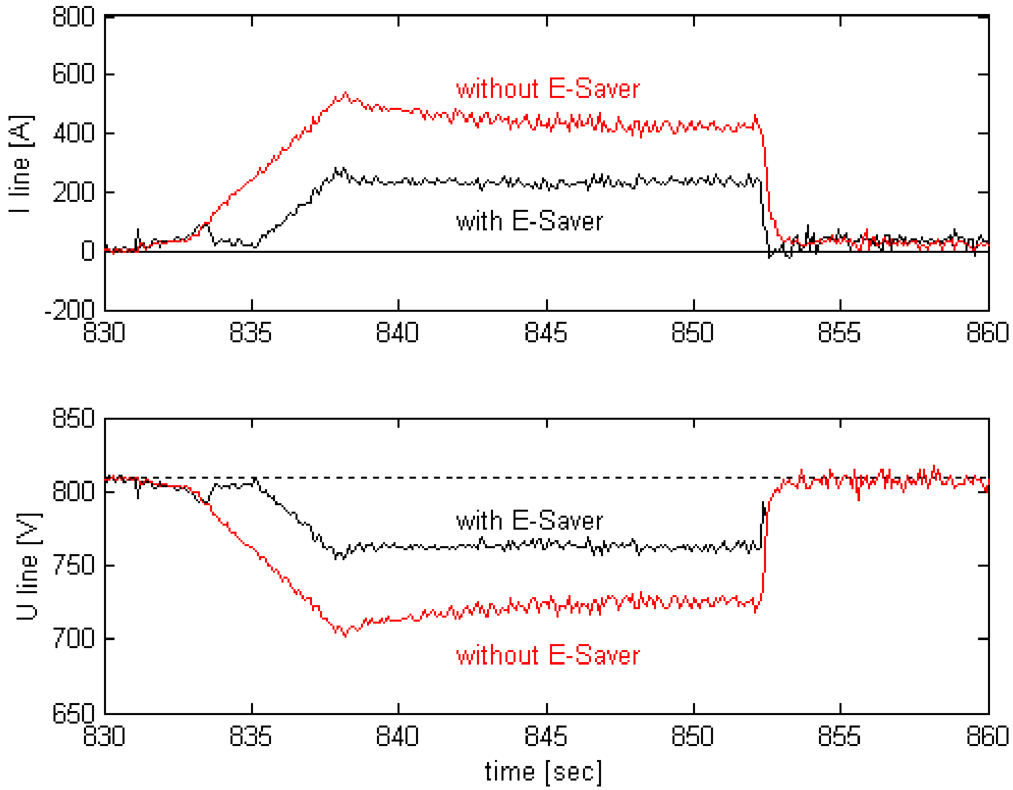


With Energy Saver



„MVV Stadtbahn“ - The Energy Saving LRV

- **With Mitrac Energy Saver the power demand from the line could be drastically reduced**
- **This reduces the voltage drop on the line as well**
- **leading to options:**
  - new lines: less substations (distance between substations increasable)
  - more vehicles in existing lines
  - reduction in cabling cross section, ...
  - on weak lines vehicles will not run in power limits



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Une expérience extraordinaire

- Research in Energy Saving Technology
- Energy Storage Technology Options
- *Bombardier Mitrac* Energy Saver Solution
- MVV Stadtbahn – The Eneergy Saving LRV
- **Benefits and Vision for the Future**
- Other applications

Drawbacks of the *Mitrac* Energy Saver Solution

- **Energy storage requires space on the vehicle**
- **Additional weight ~ 2%**
  - taken into account at energy consumption
- **Additional costs**
  - price drops of UltraCaps have to be taken into account

Benefits of the *Mitrac* Energy Saver Solution

- **Up to 30% Energy saving**
- **Up to 50% Reduction in peak power to be supplied by network**
- **Up to 50% Reduction in voltage drop via contact wire**
  - Depending on the application, following benefits could be used:
    - No limited acceleration in weak networks, therefore journey time reduction
    - Fewer substation in the case of new systems or more vehicles in existing networks
    - Reduced cross section of overhead wiring, feeder cable, ...
- **Operation in sections of roads with no electric power**
  - Section can be cleared to next station in the event of power loss
  - Operational cases: disconnector journeys, icy overhead lines
  - Journeys in the depot or workshop

Catenary free operation

- **Some cities need to operate at least some sections of roads with no overhead line:**
  - It is difficult to obtain approval for the installation of overhead lines in front of historical buildings
  - In such cases, this solution makes the introduction or reintroduction of a light rail system much easier

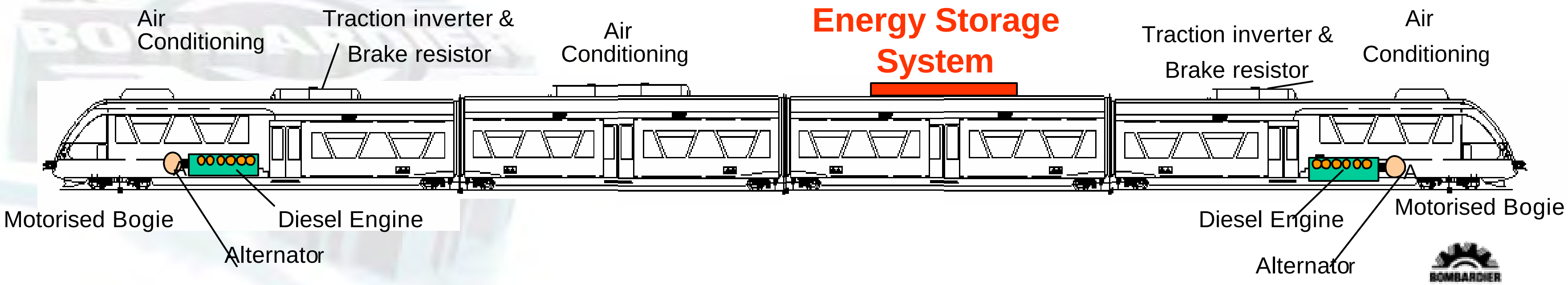
- Research in Energy Saving Technology
- Energy Storage Technology Options
- *Bombardier Mitrac* Energy Saver Solution
- MVV Stadtbahn – The Eneergy Saving LRV
- Benefits and Vision for the Future
- **Other applications**

Diesel-Multiple Units with energy storage

- **Benefits of energy storage for DMUs:**
  - energy savings (high fuel costs, e.g. in Germany ~0,75 Euro/l)
  - additional power for acceleration
  - Soft issues: emissions, noise, switched off diesel in tunnels and stations

- **Add. power to reach same performance of 3car and 4car unit**
- 3car unit (2*662kW) 10,6 kW/t
- 4car unit without ES (2*662kW) 8,2 kW/t
- 4car unit with ES 9-12 kW/t

  e.g. DEMU with ES Energy Storage (9kWh, 3.5t)



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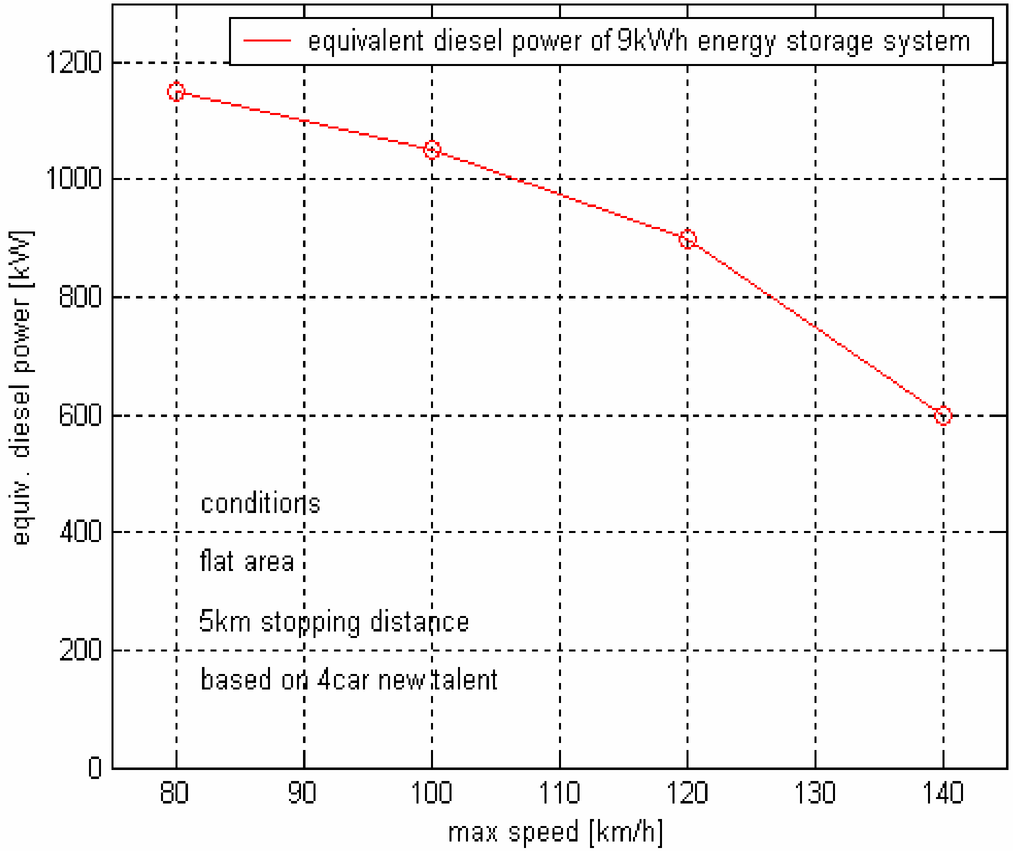
Une expérience extraordinaire

DMU vehicles with energy storage systems

Equivalent diesel power of a 9kWh energy storage:

✍ mainly influenced by maximum operational speed



Diesel-Multiple Units with energy storage

Benefits for Diesel Multiple Units:

- ✍ **Decreased energy costs & emissions** **(by 25...40%)**
- ✍ **Possibility to switch off the Diesel**
  - in stations (reduced noise and emissions)
  - in tunnels (emissions)
- ✍ **Additional power from energy storage**
  - Reduction of installed diesel power (e.g. only 1 diesel engine)
  - Longer trains with same performance by additional car with energy storage
  - Flexibility to adapt to applications with limited weight impact

Next generation propulsion

and

Energy storage in railway vehicles

Michael Steiner – FEPPCON May 2004

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Une expérience extraordinaire

- Overview on mid term propulsion developments
  - Evolution of IGBTs and Converter
  - Multisystem Converter (cross boarder operation)
  - Speed sensorless drives
  - Medium frequency technology

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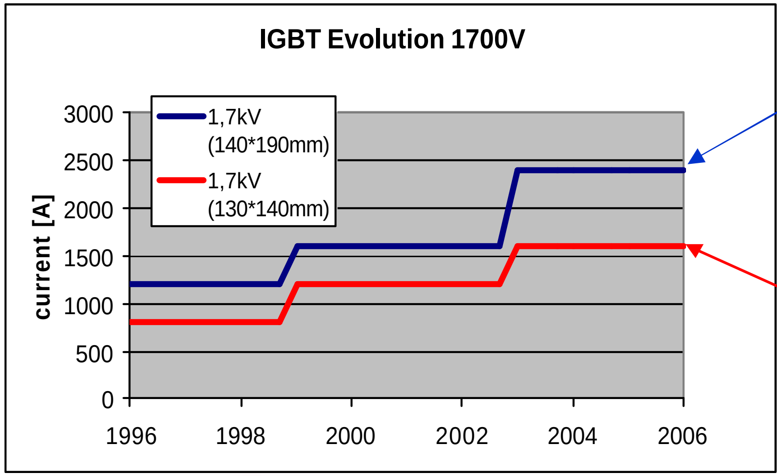
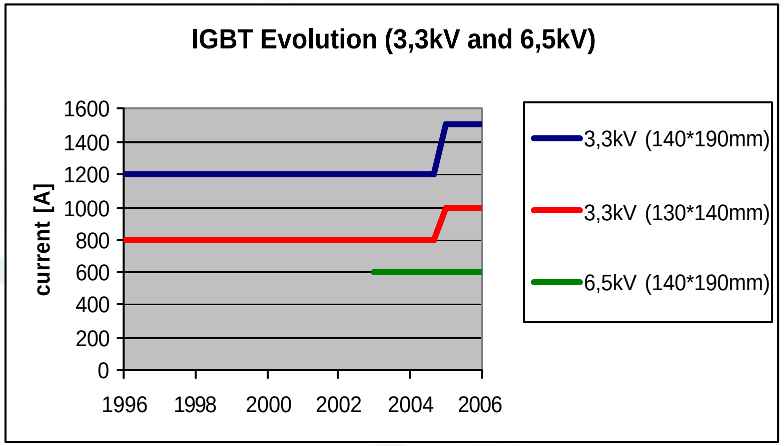
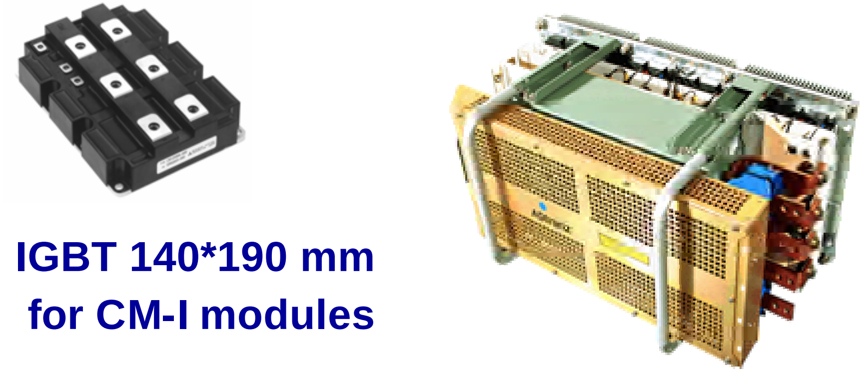
Une expérience extraordinaire

Evolution of IGBTs and Converter

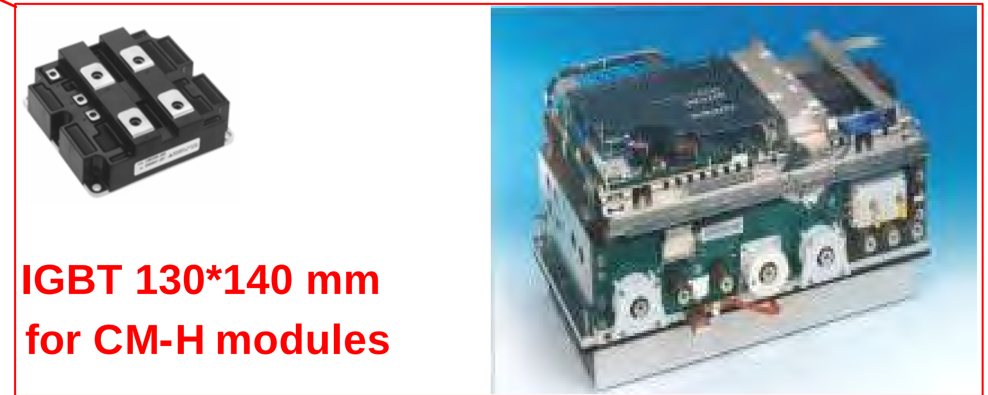
Technology Roadmap IGBTs: Increased current rating over time







IGBT 140*190 mm for CM-I modules



IGBT 130*140 mm for CM-H modules

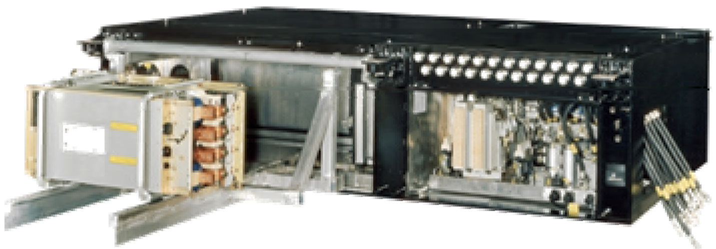
Evolution of IGBTs and Converter

Evolution of semiconductors leads to increasing converter power

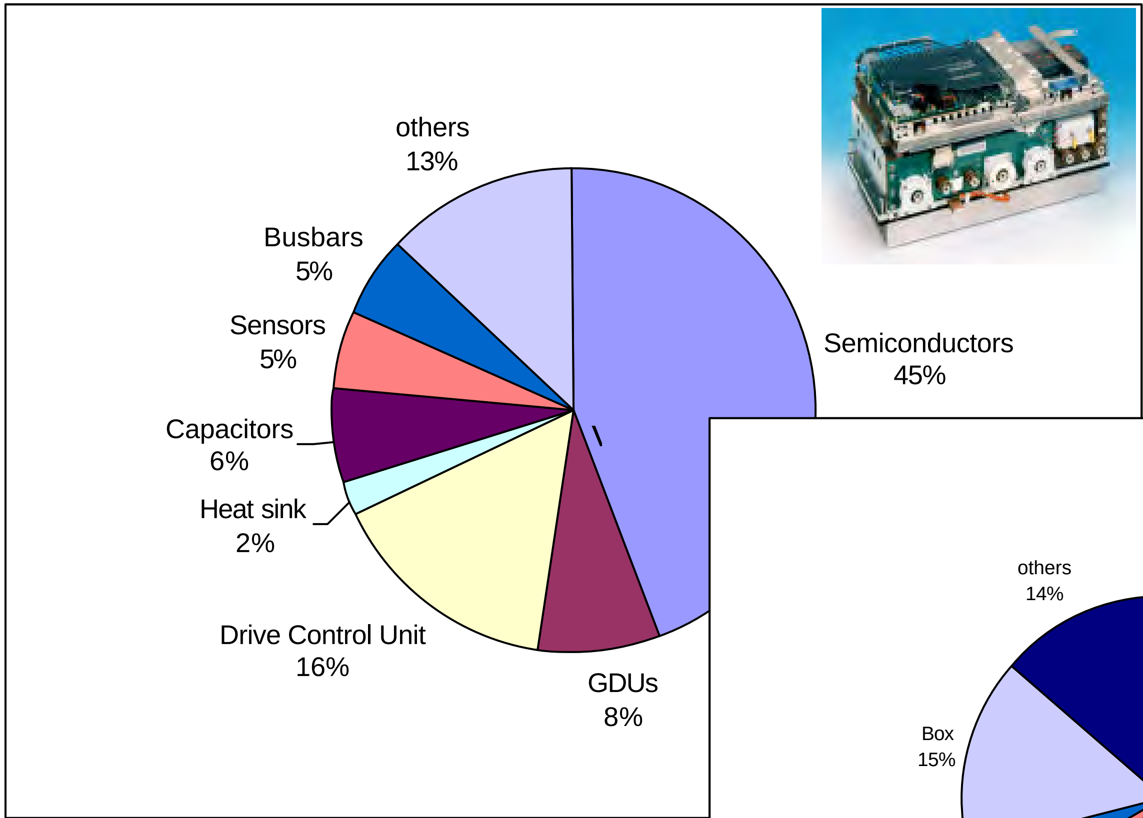
- **Light Rail Vehicle with 2 motors per converter**

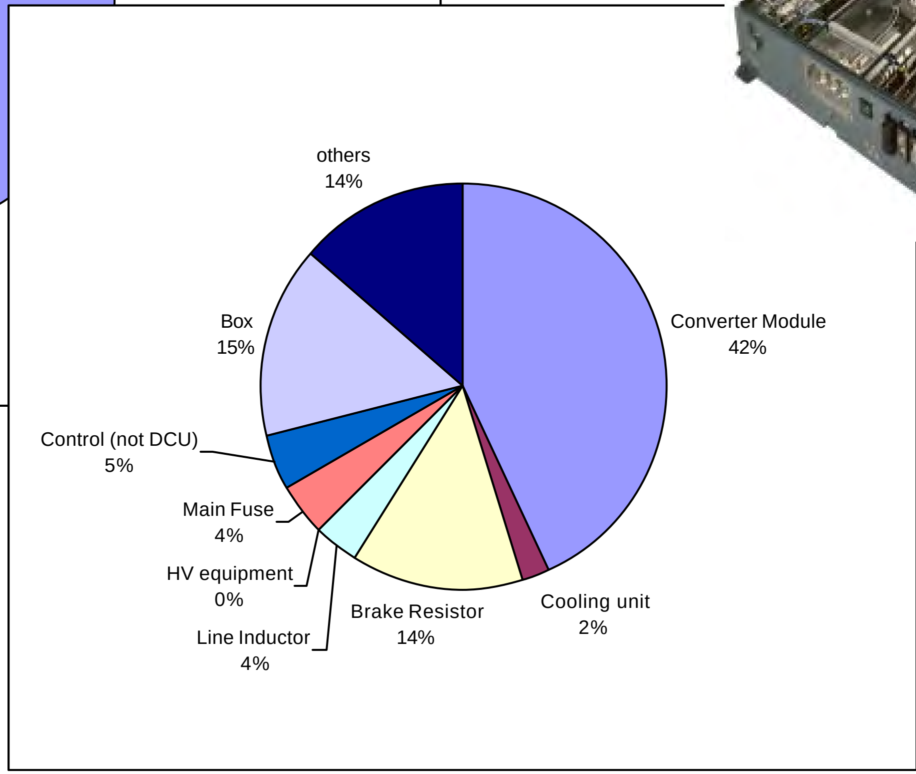
Flexity Outlook Eskisehir

- **Metros/Regional trains with 4 motors per converter**



Cost distribution of converter

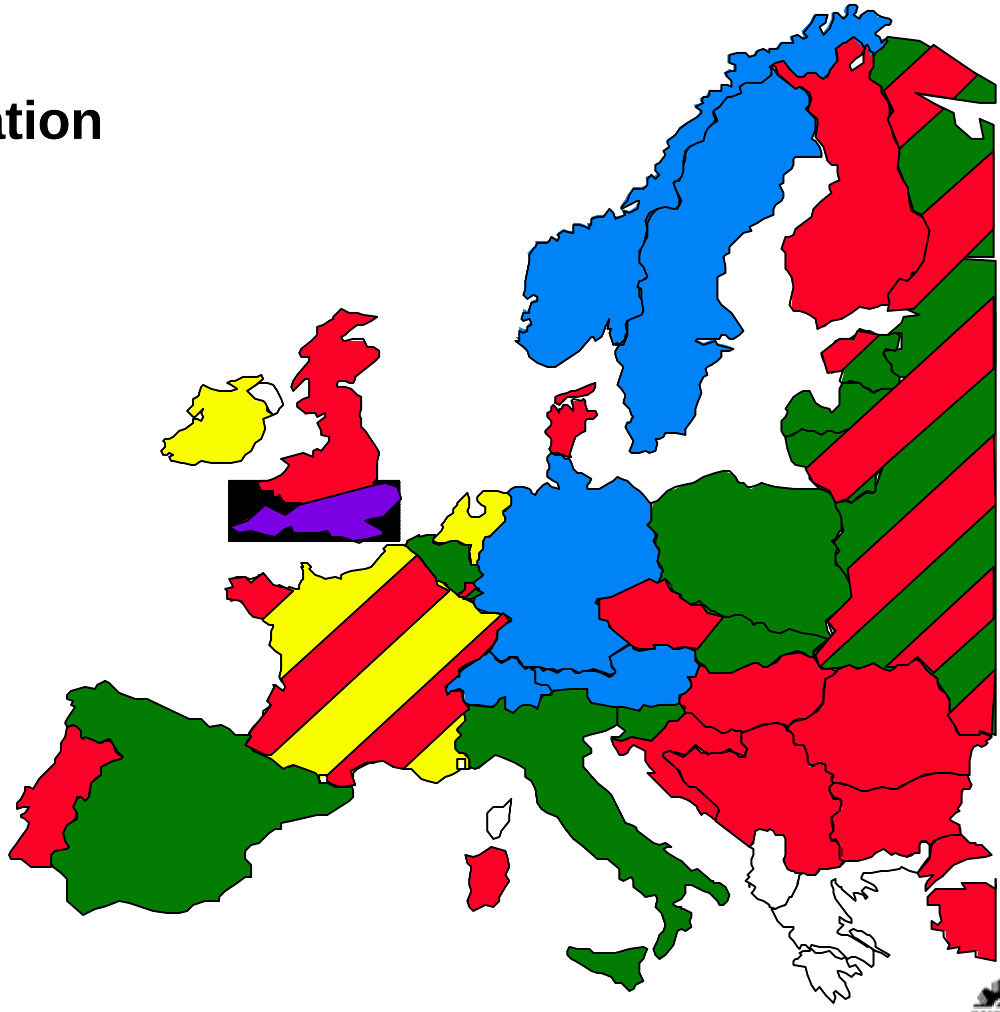




Multisystem Converter (cross boarder operation)

Multisystem Converter

- **cross boarder operation**
- **using 6,5kV IGBTs**



Catenary voltages:

AC 25kV / 50Hz

AC 15kV / 16.7Hz

DC 3kV

DC 1.5kV

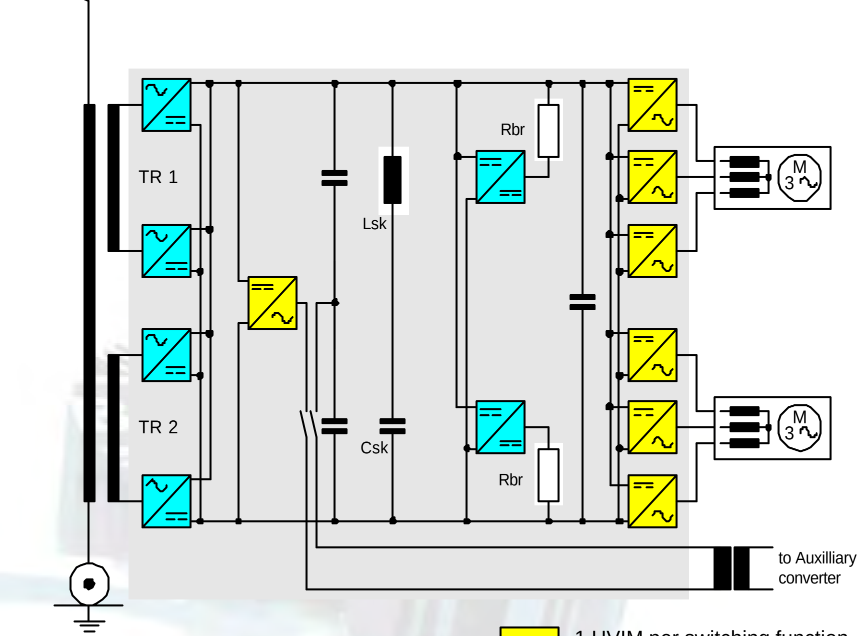
DC 600-1200V

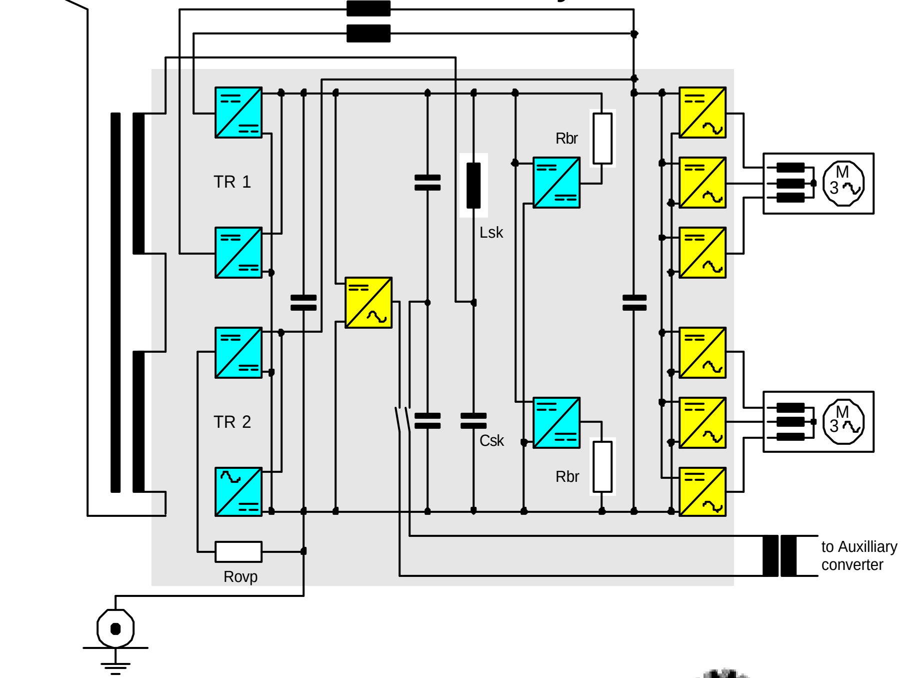
Multisystem Converter (cross boarder operation)

Multisystem Converter using 6,5kV IGBTs

AC 15/25kV
- 4 quadrant converter
- controlled 2.8kV DC-link
- 50 % redundancy

3kV DC
- step down chopper
- controlled 2.8kV DC-link
- 50 % redundancy





1 HVIM per switching function

2 HVIM in parallel per switching function

3 HVIM in parallel per switching function

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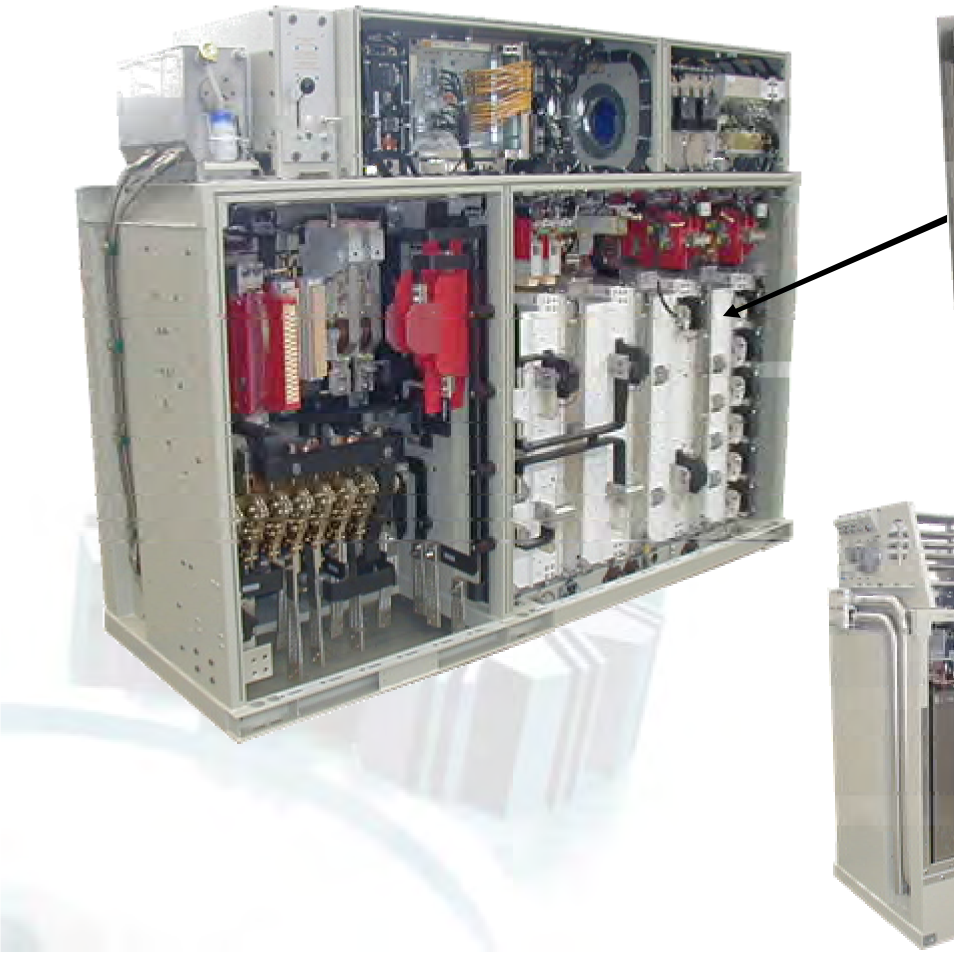
Une expérience extraordinaire

Multisystem Converter (cross boarder operation)

Mitrac TC3300 Multisystem converter

- CM-M Converter Module



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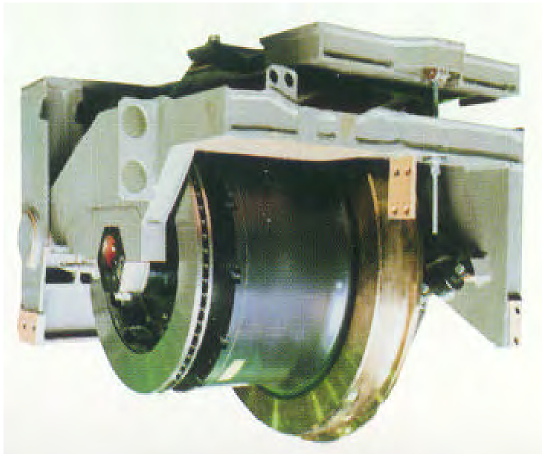
Une expérience extraordinaire

Speed sensorless drives

Speed sensorless control of IM

- limited zero speed
  - **in 2000 applied in Helsinki tram by Bombardier**
    - **using a hub motor**
  - **Siemens presented on the EPE 2003 applications for LRVs, Metros and regional trains**



- full zero speed
  - **Research topic**

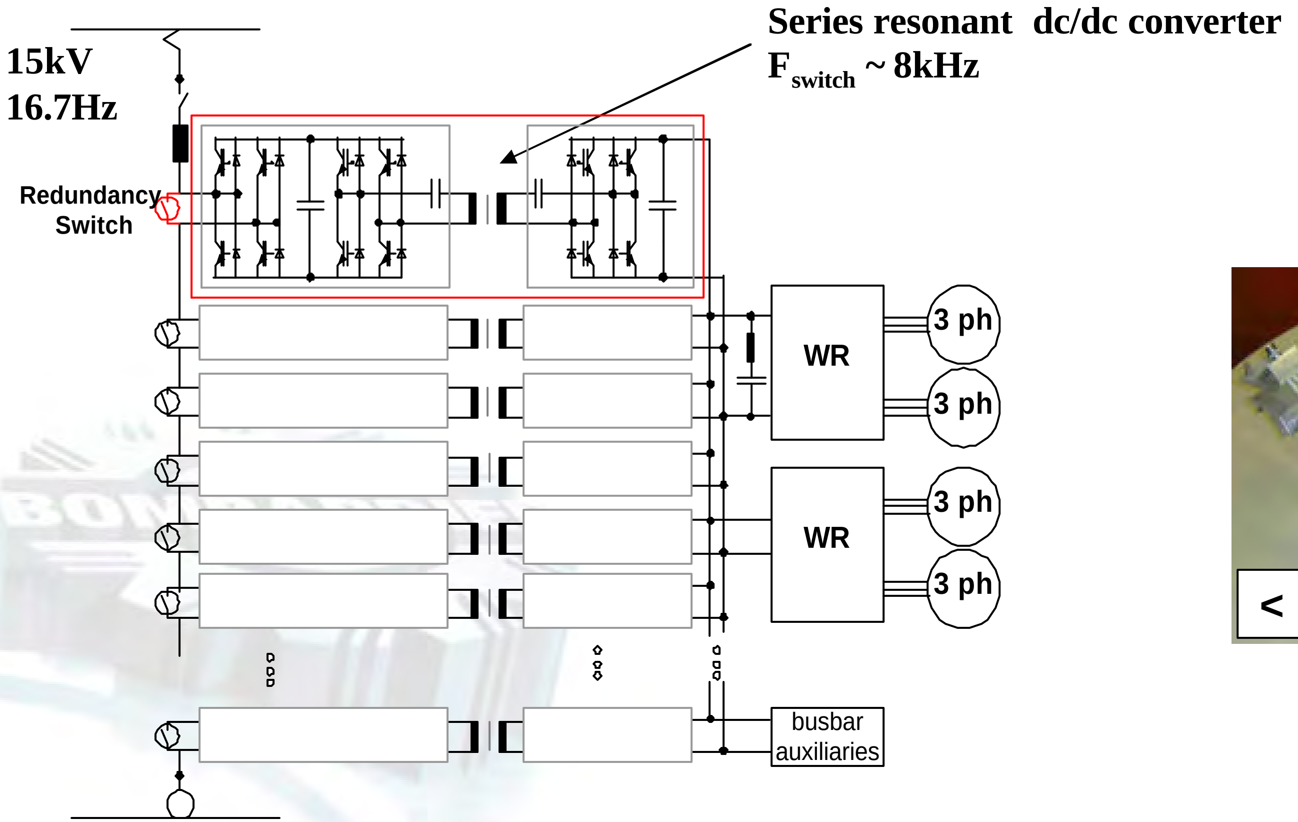
BOMBARDIER

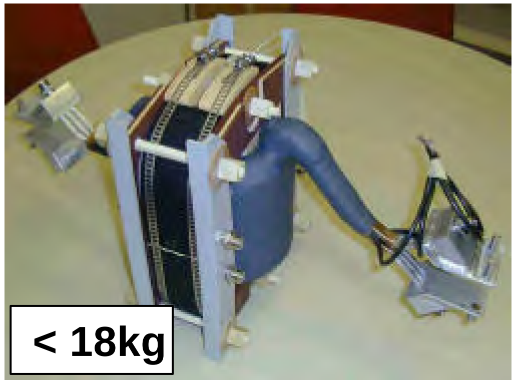
Une expérience extraordinaire

Medium frequency technology

MFT (Medium Frequency) Topology to replace the bulky main line transformer

- AC-MFT uses "electronic dc-transformers" with a considerable higher frequency of about 10 kHz





Medium frequency technology

High Speed Trains

- Conventional transformer for this application are on the technical limit (e.g. ICE3):
  - maximum power with this height limit is achieved
  - very high losses of 10...12% at maximum power (50% reduced losses with MFT)
  - weight could be decreased by 30%

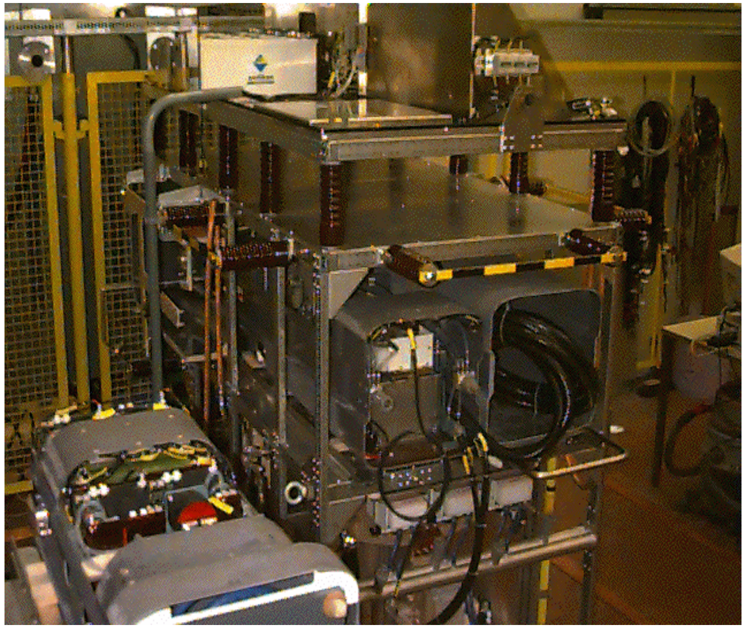
Other vehicles of interest

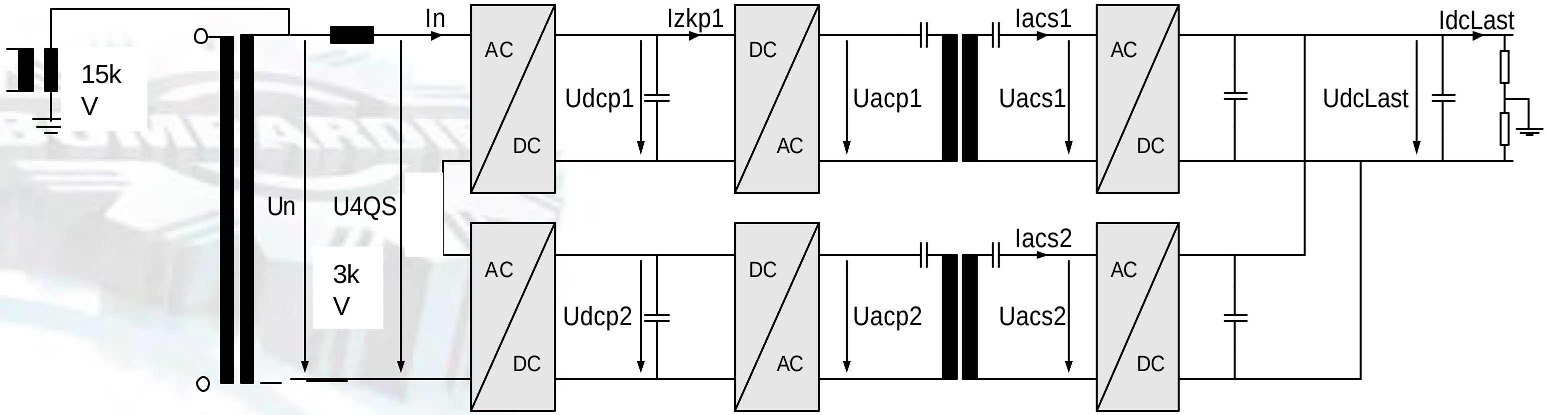
- “When weight is a problem, specially at higher power”
  - Low floor EMUs, Double Decker EMU, Multisystem Powerheads
- “Limited benefits when weight and transformer height is no issue”
  - Locos, Single system Powerheads, Single System Regional trains

Medium frequency technology

Feasibility approved

- **by e.g. high voltage lab test with two line converter modules**
- **Due to high project costs we did not develop a product without order**



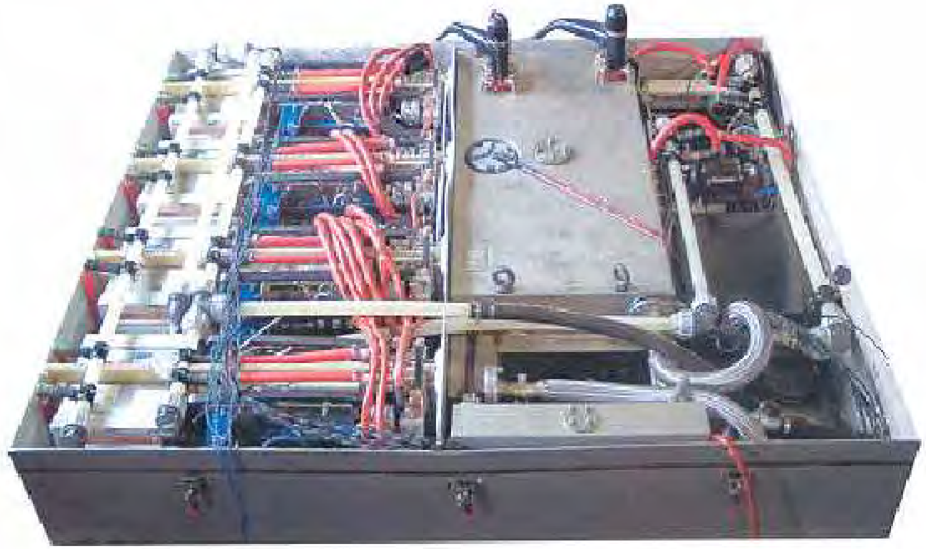


BOMBARDIER
Une expérience extraordinaire

Medium frequency technology

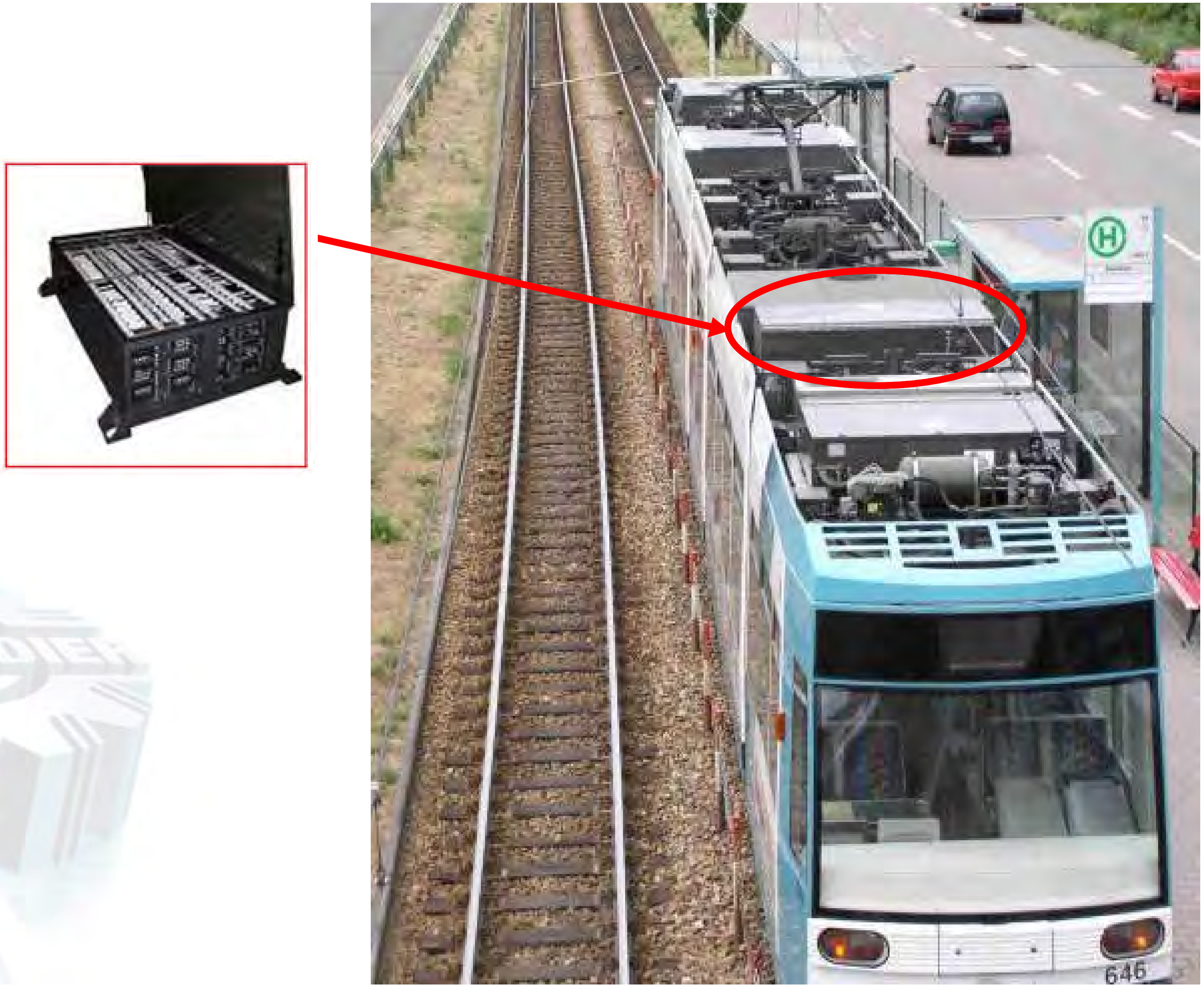
Competitors

- Siemens worked on superconducting transformer (and MFT ?)
  - **similar benefits as MFT (weight, losses)**
- Alstom LHB build a prototype “e-transformer”
  - **very much the same as the MFT**
  - **planned for tests on LIREX (“experimental train”) in end 2004**



source: Eisenbahn Revue 8-9/2003

Thank you for your attention !



The New Seattle Streetcar With Onboard Energy Storage

Ethan Melone

Seattle Department of Transportation

Streetcar Project Manager, Seattle WA

Denny Porter / Jason Krause

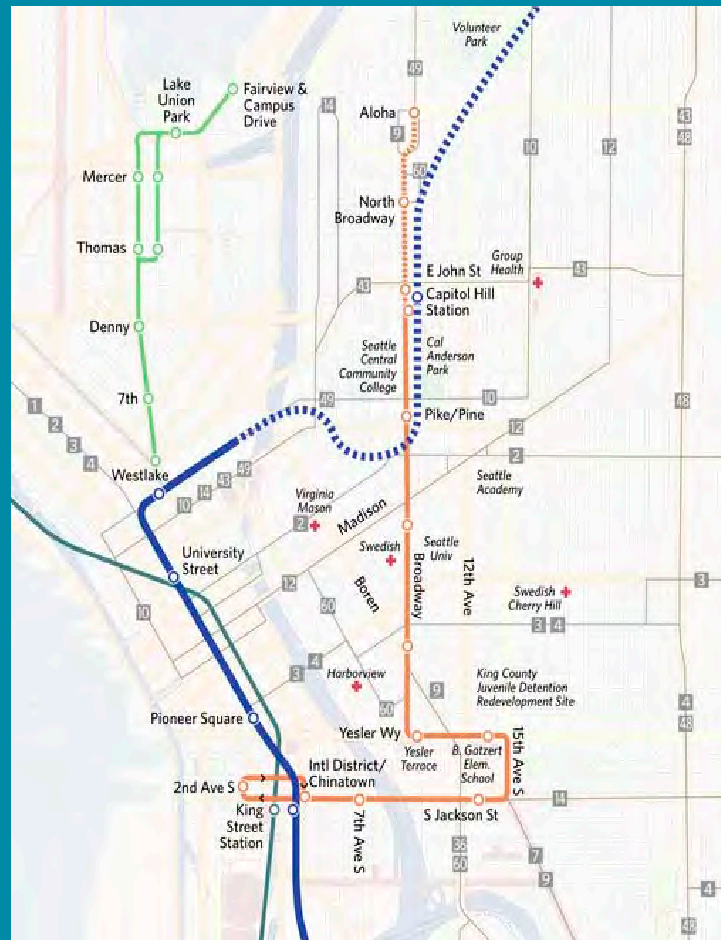
LTK Engineering Services, Consultants, Portland OR

Overview

- First Hill Streetcar Project
- Wireless Operation Study
- Procurement Process
- Vehicle Description
- Schedule

First Hill Streetcar Project (FHSC)

Downtown Seattle Rail Transit



FHSC Alignment

- 2.5 miles double track
  - Average grade 2.4%
  - Maximum grade 9.0%
  - Sustained grade 3.4%
- Uphill outbound
- Downhill inbound
- In-street running
- 10 passenger stations

Wireless Operation Study

Why Wireless Operation?

- Mitigate or reduce potential conflicts
  - Electric trolley bus (ETB) overhead wires
  - New streetcar OCS

- Preserve opportunity for aesthetic mitigation of future streetcar routes

- Provide emergency recovery capability

Purpose of Study

- What is the state-of-the-art in wireless technology?
- What parameters affect sizing and capability of the hardware?
- What onboard hardware is required?
- Where are the most challenging locations?
- What locations benefit the most?
- How feasible is it?

Study Methodology

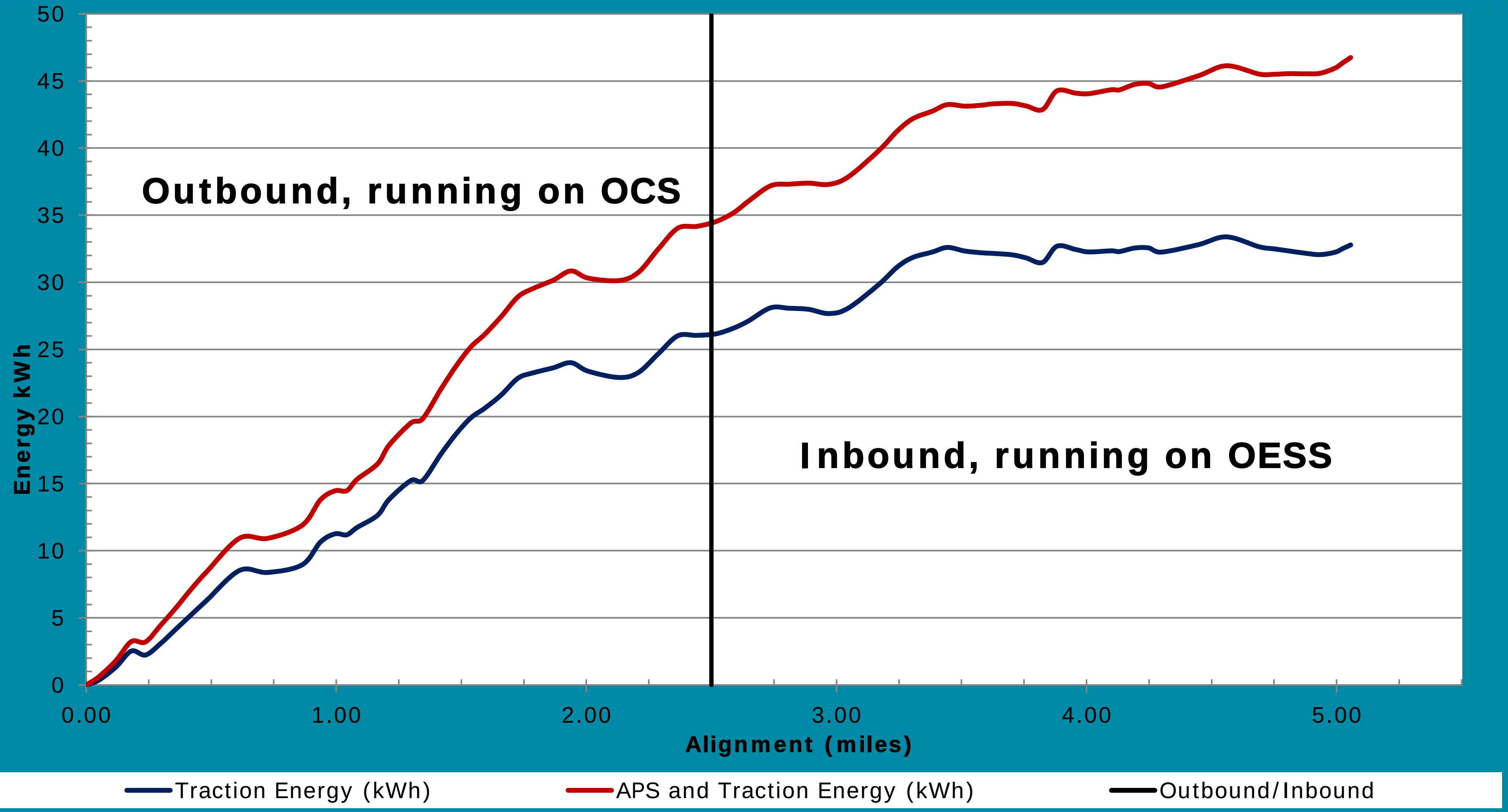
- Research
  - Current active wireless operations
  - Prototype vehicles
  - OESS types
    - Battery
    - Capacitor
    - Combination
  - OESS charging technologies
  - Industry literature

- Characterize intersections
  - Difficulty in introducing streetcar overhead wire

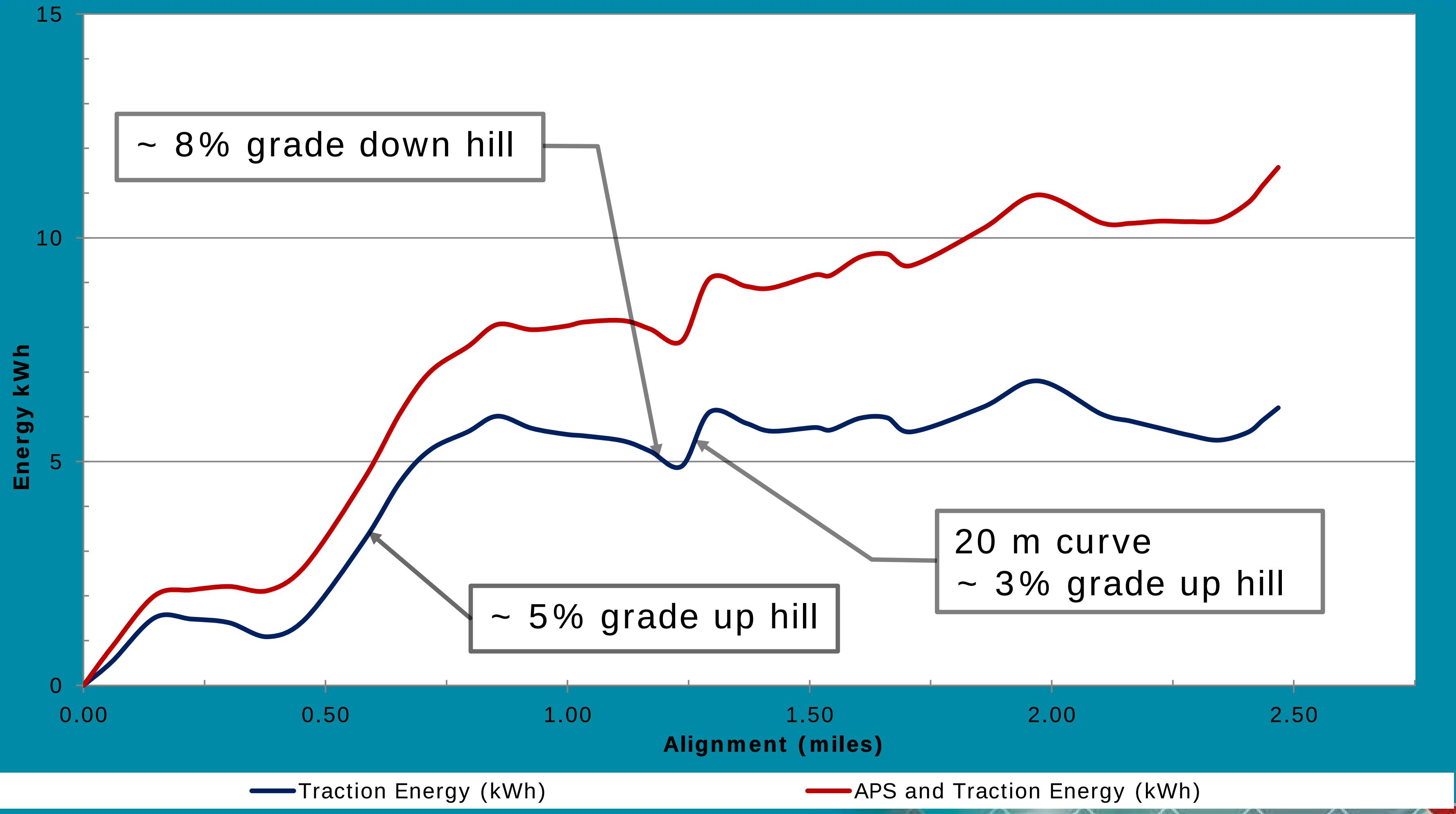
Study Methodology

- Developed alignment energy profiles as a function of performance parameters
  - Acceleration rate
  - Auxiliary power load (HVAC)
- Combined the intersection analysis with the energy profiles identifying favorable areas for wireless operation

Example Energy Profile
AW2 Vehicle, Round Trip



Example Wireless Profile
AW2 Vehicle, Inbound



Conclusions

- Wireless operation is an emerging technology, being tried in several places
- Performance requirements significantly affect feasibility of wireless operation
  - Alignment profile
  - Duty cycle
    - Charging and discharging OESS
    - Acceleration rate
  - OESS technology
  - OESS life
- Operation should be from Station-to-Station
- OESS voltage at least 500 Vdc

Conclusions

- First Hill Streetcar alignment appears feasible for wireless operation
- Desirable wireless regions
  - Outbound
    - Pioneer Square Terminus to Jackson and 5th
    - Broadway and Pine to the Capitol Hill Terminus
  - Inbound
    - Jackson and 7th to the Pioneer Square Terminus
- Possible wireless region
  - Complete Inbound route
    - Large up hill grade in beginning of region

Procurement Process

Vehicle Procurement Approach

- 6 cars
- Two step best value—RFP and RBAFO
- Quantitative assessment
- Technical 60%
  - Vehicle description
  - OESS
  - Management approach
  - Schedule
  - Qualifications
  - Buy America capability

Price 40%

6 Vehicles
System support
Spare parts
Option vehicles
Option services

Vehicle Procurement Schedule

• Issue RLOI	June 2010
• Issue RFP	March 2011
• Receive proposals	June 2011
• Evaluate/rank proposals	June 2011
• Meet with Proposers	July 2011
• Issue Request for BAFO	August 2011
• Receive BAFOs	October 2011
• Evaluate/rank BAFOs	October 2011
• Issue Notice of Intent to Award	October 2011
• Issue NTP	March 2012

RFP
Reevaluating Wireless Operation

- The first step (RFP) produced proposals in excess of the vehicle procurement budget

- Key Factors
  - Cost of the Onboard Energy Storage System
  - Excessive wear on equipment due to having 3 wireless regions
    - 2 Outbound
    - 1 Inbound

RBAFO

- Added alternate extended wireless region
  - Inbound line completely wireless
- Permitted two separate BAFOs
  - Conventional car
  - OESS car
- Evaluation involved selecting
  - Best value Conventional
  - Best value OESS
  - Determining the best value overall

BAFO Results

- OESS
  - Inekon Group
  - KinkiSharyo
  - Oregon Iron Works

  Conventional
  - Inekon Group
  - Oregon Iron Works

- Contract awarded to Inekon Group (IG) of Czech Republic
  - $26.7M
  - 6 OESS cars
  - System support, spare parts, etc.

Wireless Requirements

- Wireless segment is entire inbound route
  - 2.5 miles
  - Predominately downhill

- Performance requirements are reduced
  - Acceleration rate 1.34 m/s^2 (AW2)
    - Rate rolls off at 12 km/h
  - Maximum speed at least 32 km/h
  - HVAC, ventilation only
    - Currently, looking into adding AC and heating

Wireless Requirements

- Recharging occurs
  - Pantograph is connected to the OCS
  - OESS mode, during regenerative braking
- OESS safety
  - OESS is interlocked with the pantograph
  - Pantograph status, up/down, is communicated to the wayside
  - NFPA-130 requirements
  - OSHA requirements

Vehicle Description

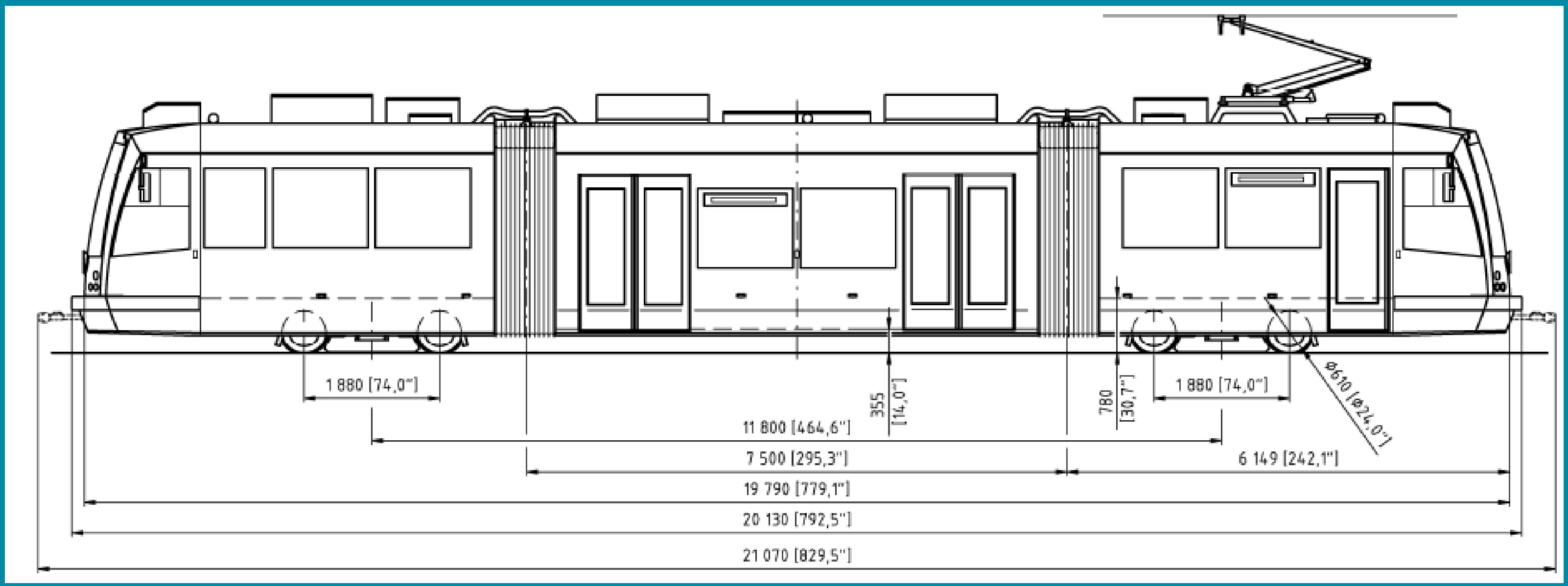
IG Vehicle Overview

- Based on existing SLU design
- 50% low floor, three car sections, two trucks
- 66 ft in length
- 30 seats
- Welded steel construction, bonded stainless steel side cladding, FRP front end
- 69,000 lbs AWO estimated
- Liquid cooled, microprocessor-controlled AC inverter
- Onboard energy storage system (OESS)
- Hydraulic brakes
- Coil spring secondary suspension
- Bridgeplates, for ADA accessibility

Major Suppliers

• Carbody	Inekon (Ostrava)
• Truck frames	
• Final assembly first car	Inekon (Ostrava)
• Final assembly cars 2-7	Pacifica (Seattle)
• Propulsion	ABB
• OESS	ABB/SAFT
• Network	ABB/Selectron
• Friction brakes	Knorr
• Doors	Bode
• HVAC	Meran

General Arrangement



VEHICLE WEIGHT TABLE

LOADING	No. OF PASSENGER	VEHICLE WEIGHT [kg]
AW0	0	30 700±5%
AW1	30 + OPERATOR	32 870
AW2	113 + OPERATOR	38 680
AW3	155 + OPERATOR	41 620
AW4	167 + OPERATOR	42 460

No. OF SEATS 30

STANDEE AREA .... 20,9 m^2

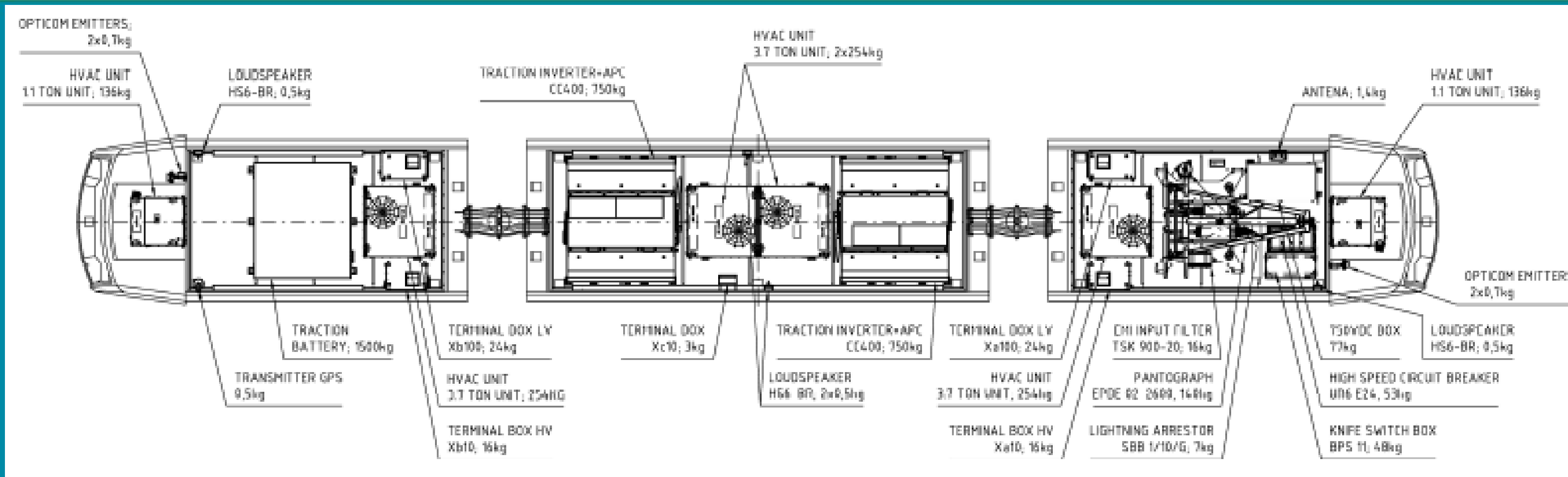
MAXIMUM WIRE HEIGHT .... 6250 mm [246.1"]

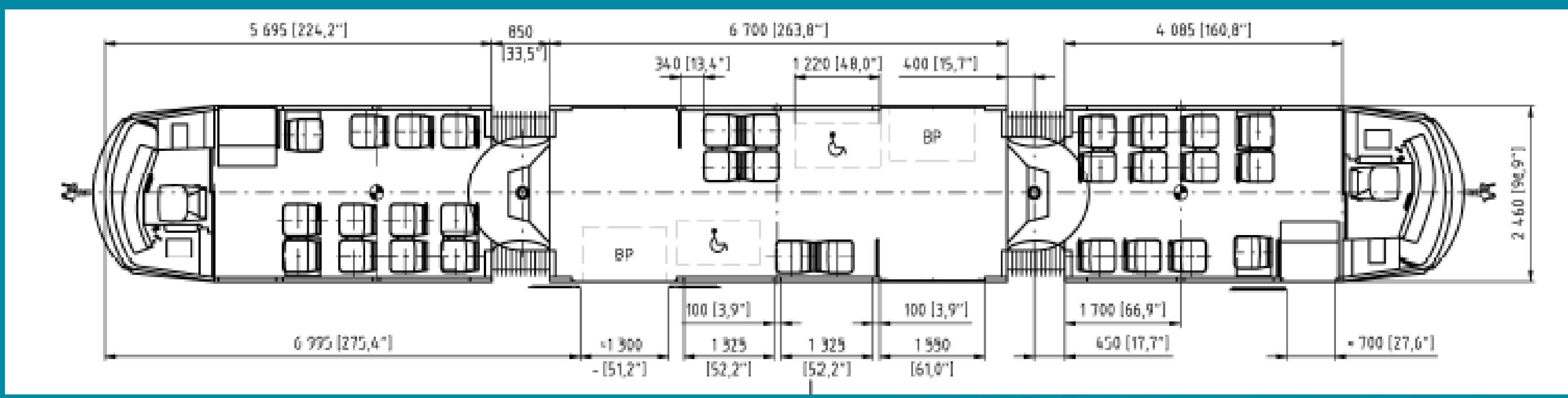
PANTOGRAPH MINIMUM OPERATING HEIGHT ... 3960 mm [155,9"]

WHEELCHAIR PLACE .... ♿

BRIDGEPLATE .... BP

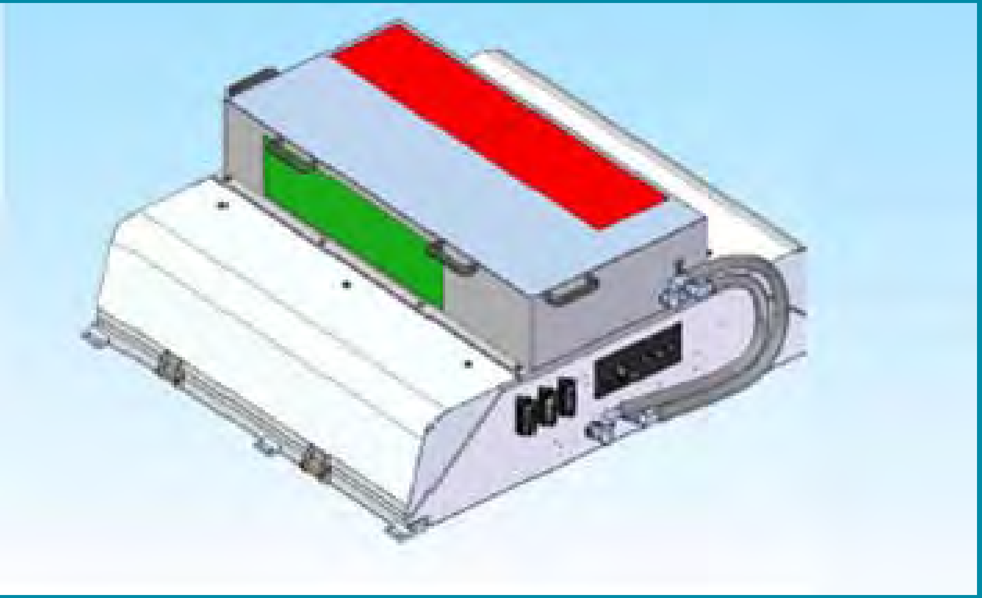
General Arrangement





Unitized Propulsion Inverter

- 2 Traction inverters
- OESS charger
  - Integrated into Traction Inverter
- 1 Auxiliary converter
- 1 LVPS
  - Battery charger
- Braking resistors
- Liquid cooled
  - Traction inverter
  - Auxiliary converter
  - LVPS



Schedule

Schedule Highlights

• NTP	March 2012
• Start carshells	November 2012
• Start final assembly car 1	March 2013
• Compression test car 2	February 2013
• Combined propulsion/OESS test	February 2013
• Ship carshell 2 to Pacifica	April 2013
• Ship car 1 to SDOT	December 2013
• Ship car 2 to SDOT	February 2014
• Ship cars 3-7 to SDOT	March to June 2014

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