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CSR Locomotive Report
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Class ALP-45DP Locomotive
InnoTrans Megareport, Part 2
In The Birthplace Of The Gravitas
On 18 August 2008 Bombardier was awarded two contracts to build electro-diesels for passenger services in the United States and Canada. One of these, worth 178 million EUR, is for 26 locomotives, with an option clause for 63 more, and is for the New Jersey Transit Corporation (NJT). The other is for Agence Metropolitaine de Transport (AMT) of Montreal, is worth 152 million EUR, and is for 20 such locomotives, with an option clause for ten more.

The American railway network is characterised by few electrified routes for passenger services, while the non-electrified network, used nowadays mainly by freights, is huge. Long distance passenger trains are mostly diesel-hauled, even under the wires, while in suburban areas passengers are often faced with the disadvantage of changing trains, from electric- to diesel-hauled stock, at the end of the local electrified network. Moreover, tunnel safety regulations prohibit underground running with diesel haulage in certain urban areas, such as New York. Local passenger operators, of which NJT is a prime example, are increasingly concerned about the unpopularity and inconvenience of such changes, and efforts are now being made to offer through trains, without a time-consuming change of traction type. The answer is clearly the electro-diesel, either by the 'modernisation' of existing single-track sections and re-signalling, or by using double unit single-track sections and re-signalling. Scheduled to start up in 2012 are urban services on the 51 km route from Montreal to Repentigny and Mascouche, requiring use of part of a Canadian Pacific line that was closed many years ago, and involving construction of an entirely new section of line between Repentigny and Terrebonne. Some of the ALP-45DPs will be employed here, using electric power to traverse almost 5 km long Mount Royal tunnel (on the 25 kV, 60 Hz Deux-Montagnes line) to access Central Station in Montreal. It is also planned to divert the Montreal end of the Blainville-Saint-Jerome line so that it joins the Deux-Montagnes line to pass through Mount Royal tunnel. This will cut journey time to and from the city centre by around 15 minutes, and will enable ALP-45DPs to be used on this route.

### ALP-45DP Design Challenges

The ALP-45DP had to be designed to comply with certain operating requirements laid down by NJT and AMT. These included the limited headroom in the Hudson River and other Northeast Corridor tunnels, which means that locomotive height (excluding the pantograph) must not exceed 4,440 mm. Maximum length was specified as 21,800 mm - with a longer locomotive there would be complications related to front end overhang clearance. Low noise levels and low levels of noxious exhaust emissions (the EPA Tier 3 requirement becomes effective on 1 January 2012) from the diesels were also requested. Maximum axle-load was fixed at 32.6 t, and that with a Bo'Bo' axle arrangement, the latter being the standard, rather than Co'Co', for passenger locomotives in the USA. Another important task was to evenly distribute the weight and to keep the centre of gravity as low as possible to minimise centrifugal forces on curves. To keep the unprung mass as low as possible, the traction motors with gearboxes are suspended from the bogies. In the USA the standard low speed (between 800 and 1,000 rpm) diesel engine would be too heavy for installation in an electro-diesel such as the ALP-45DP. It was thus decided to opt for high speed (1,800 rpm) diesel engines, of the same power rating, but considerably lighter, of more compact dimensions, and thus easier to install. There are two diesel gensets. The chosen diesel power system thus enabled the design of the ALP-45DP to be based on that of the ALP-46A, with bodyside, bogie and electric driveline technology being similar. The diesel prime movers are 12-cylinder Caterpillar 3512C HD models, each with a rating of 1,567 kW and together delivering 3,108 kW at engine shafts. Depending on trainset

![Principal Technical Data]

<table>
<thead>
<tr>
<th>Ambient Temperatures</th>
<th>- NJT Locomotives</th>
<th>- AMT Locomotives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-40 to +60 °C</td>
<td>-40 to +50 °C</td>
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<tr>
<td>Track Gauge</td>
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<tr>
<td>Axle Arrangement</td>
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<td>Operating Voltages</td>
<td>- NJT Locomotives</td>
<td>- AMT Locomotives</td>
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<tr>
<td></td>
<td>25 kV, 60 Hz</td>
<td>25 kV 60 Hz only</td>
</tr>
<tr>
<td></td>
<td>12.5 kV, 60 Hz</td>
<td></td>
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<tr>
<td></td>
<td>12 kV, 25 Hz</td>
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<tr>
<td>Max. Operating Speed</td>
<td>- NJT Locomotives</td>
<td>- AMT Locomotives</td>
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<tr>
<td></td>
<td>201 km/h</td>
<td>161 km/h</td>
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<tr>
<td></td>
<td>Electric NJT</td>
<td>Diesel NJT</td>
</tr>
<tr>
<td></td>
<td>129 km/h</td>
<td>161 km/h</td>
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<td></td>
<td>Diesel AMT</td>
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<tr>
<td>Continuous Tractive Power</td>
<td>Electric</td>
<td>4,000 kW</td>
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<tr>
<td></td>
<td>- Diesel</td>
<td>2 x 1,567 kW</td>
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<tr>
<td>Starting Tractive Effort</td>
<td>- During Recovery</td>
<td>316 kW</td>
</tr>
<tr>
<td></td>
<td>- During Resistor Braking</td>
<td>1,300 kW</td>
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<tr>
<td>Max. Effort Of EDB</td>
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<td>150 kN</td>
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<tr>
<td>Minimum Service Brake Deceleration</td>
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<td>Minimum Emergency Brake Deceleration</td>
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<tr>
<td>Length Over Couplers</td>
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</tr>
<tr>
<td>Distance Between Bogie Centres</td>
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<tr>
<td>Bogie Wheelbase</td>
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<tr>
<td>Wheel Diameter (New/Worn)</td>
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<tr>
<td>Maximum Width</td>
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</tr>
<tr>
<td>Maximum Height Over Rail Top</td>
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</tr>
<tr>
<td>Minimum Curve Radius Negotiable</td>
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</tr>
<tr>
<td>Weight In Working Order</td>
<td>130.6 t</td>
<td></td>
</tr>
<tr>
<td>Maximum Axle Load</td>
<td>32.65 t</td>
<td></td>
</tr>
<tr>
<td>Fuel Tank (Usable Capacity) - NJT Locomotives</td>
<td>6,056 l</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- AMT Locomotives</td>
<td>6,813 l</td>
</tr>
</tbody>
</table>
length and auxiliary power consumption this results in a power rating of up to 2,650 kW at wheel rim. Maximum speed using diesel power is 161 km/h (100 mph). When operating on electrified sections of route the rated power at wheel rim is 4,000 kW (equal if the train heating is on or off). For a limited time a maximum power of 4,400 kW can be delivered. Maximum speed using electric power is 201 km/h (125 mph).

ALP-45DP Design Concept

The design of the ALP-45DPs is essentially based on the TRAXX and ALP-46 locomotives. The front end being similar to that of NJT’s ALP-46s, to ensure that all three ALP types have identical cabs, as far as is possible. The front ends of all three types are of considerably more massive construction, and more robust than those of their European TRAXX cousins, to meet the American FRA crashworthiness standards. But unlike the ALP-46, the ALP-45DP is a single-cab locomotive, the reason for this being that it will usually be coupled to a rake of doubledeck stock.

The ALP-45DP weighs slightly less than the limit of 130.6 t. The locomotive is thus heavier than the 92-tonne Class ALP-46 and ALP-46As. The extra weight results from the two diesel gensets, heavier electrical equipment, and the even more robust bodysHELL design. To counter this burden as much as possible, attention was paid to bodysHELL and underframe design, to ensure that these basic elements were as light as possible. The bodysHELL framework consists of steel box girders, clad in sheet steel panels of various thicknesses of up to 12 mm, and partly up to 25 mm. Whereas the bodysHELL of the ALP-46 weighs about 24 t, that of the ALP-45DP weighs around 29 t.

As far as crashworthiness is concerned, the AAR (S-580 norm) and APTA (American Public Transportation Association) stipulate that the bodysHELL must be capable of resisting end-on compressive forces of up to 3,560 kN. The seven roof sections are made of lightweight welded aluminium structures, and can be removed and refitted very rapidly, thus affording easy access to the machinery spaces.

The ALP-45DP is mounted on FLEXX Power 250 bogies. Wheelset suspension is by means of pairs of helical steel springs, fitted one inside the other (a parallel arrangement) on account of the locomotive’s considerable weight. Wheelset guidance is provided by horizontal links. The wheels and axles are produced by Bonatrans of Bohumín, and assembled at Bombardier’s Siegen works. The secondary suspension is of Flexicoil type, and once again, on account of the weight involved, one coil is fitted inside the other. Transmission of longitudinal forces between the bodysHELL and the bogies is realised via two angle rods, connected to the bodysHELL under the fuel tanks.

The electrical equipment is situated in the centre part of the machinery space and is basically identical for both the NJT and the AMT versions of the locomotive. Here can be found the high voltage and auxiliary equipment (including the high voltage vacuum circuit breaker, the disconnecting switch, the high-voltage arresters, the filters, the auxiliary switches, and the voltage and current measuring devices) and the two MITRAC TC 3360 DP traction converters. The latter are of identical construction, one working independently for each bogie. The converter cubicle houses the four-quadrant converters, DC link capacitors, four inverters for each traction motor, the change-over switches for the different overhead line voltages (three in the case of the NJT version) and for transition to and from diesel operation, together with the control electronics.

For the ALP-45DP ABB of Geneve designed a traction transformer that is 35 % lighter than the earlier version which is installed in the ALP-46, although both types have similar technical requirements. The transformer weighs less than 1 t and is exceptionally compact, to fit between the two fuel tanks. This was achieved by redesigning the auxiliary transformers and by increasing the operational temperature of the oil from 105 to 135 °C. Unlike some other electro-diesel that usually travel only short distances using each type of power and have only one diesel engine, the ALP-45DP is a long distance locomotive with two high power diesels and full power electric propulsion equipment. This means space for other components, such as the traction transformer, is severely reduced.

A FLEXX Power 250 bogie for the ALP-45DP at the Kassel works following delivery from Siegen. Compared with the ALP-46s and ALP-46As, there is twice the number of hydraulic dampers, and the bogie crossbeam is also of more massive construction, on account of the greater weight of the electro-diesel version of the ALP.
1350, the third ALP-45DP electro-diesel to be built, and the first of the batch ordered by AMT, at Kassel on 7 October 2010. At 7 kW the Liebherr air conditioning units are very powerful indeed, and like on the TRAXX and ALP-46(A) locomotives they are situated in the cab ends under the driving consoles.

The traction converter changes the 1,380 V (approximate value) single-phase voltage from the main transformer into a three-phase, pulse-modulated voltage of around 2,100 V 50 Hz for the traction motors. The DC intercircuit functions on 2,800 V. From the DC link the four traction inverters supply each traction motor individually. The rectifiers are water-cooled, incorporating IGBT elements with a closing voltage of 4,500 V. The inverters, of compact design, also have a 3 x 480 V, 60 Hz output for the train power supply (known in the USA as HEP, or Head End Power).

The traction transformer is suspended beneath the underframe of the locomotive, at the centre-point, immediately underneath the high-voltage devices, thus ensuring short high voltage line connections. Despite the space and weight constraints, the transformer can operate off three voltage systems (12 kV 25 Hz, 12.5 kV 60 Hz and 25 kV 60 Hz), giving an output up to 6,000 kVA. The main transformer has four secondary windings, that can be switched to provide a constant voltage of 1,380 V independently of the catenary supply to supply both traction converters. The main transformer also incorporates:

- a large 1,100 kVA three-phase transformer which provide the 3 x 480 V 60 Hz power for the train’s electrical requirements (HEP).
- one 140 kVA variable frequency auxiliary transformer (supplied by a converter making a U/F ramp), which feeds the motors powering the fans, the transformer oil pump and the compressor at 480 V.
- two second harmonic reactors that can be switched to operate using either 50 Hz or 120 Hz.

The transformer withstands the intense thermal shock caused by instantaneous acceleration, since locomotives in North America are commonly required to go from zero to full throttle at once even under Canadian winter conditions.

The driving consoles of the ALP-45DP are, as far as is possible, identical to those installed on the ALP-46(A) electrics, though of course with certain adaptations on account of the fact that diesel power is also involved.

On the right-hand panel is the brake control, the red lever activating the train brake and the black one the locomotive brake. The left-hand panel includes the direction of travel switch and the tractive/EDB force controller. The red switch on the far left is the alerter acknowledge button, and the tail lever (only fitted on the NJT version) in front of it operates the horn. The adjacent panel on the far left includes the lighting switches. The central horizontal panel incorporates controls for the pantograph, Sanders and front/rear lights, and a switch for Voltage Changeovers/Phase Breaks (neutral sections). The sloping central panel houses the ACSES display and switches. The operation data and diagnostics screen is on the left, while on the far left is the train radio panel. On the right are the two main manometers together with the three gauges showing the tractive and braking effort and the overhead wire voltage. Rear view mirrors are fitted on the cab sides.

Because the mode change is fully automatic, there are no dedicated switches for activating the diesel engines on the driver’s desk. Switching from electric to diesel traction is initiated via the Fault Reset button on the left-hand panel (the orange one). The change-over sequence from electric to diesel mode runs automatically as follows: converter one switched off, diesel engine one started via alternator 1, converter two switched off, diesel engine two started via alternator 2, pantograph lowered. For the diesel to electric traction change-over the Pantograph-Up button on the central horizontal panel is used.

FOGTEC supplies the fire protection system for the BOMBARDIER ALP-45DP platform.

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Two CAT 3512C HD engines at Kassel works for NJT’s second ALP-45DP, on 7 October 2010. The engines, weighing 7,100 kg each, are built at Caterpillar’s works in Lafayette, Indiana.

The compressed air is generated in by a Knorr SL-40 screw compressor, which is capable of producing around 3,400 litres per minute of air pressurised at 10 bar. Outside air is sucked in via a highly effective dry air cleaner, and the compressed air is stored in two 450-litre chambers. These are situated underneath the mainframe adjacent to and between the bogies, and they are fitted with safety valves to prevent damage to the pneumatic system should the pressure rise above 10.5 bar. A pressure sensor is also incorporated in the system, and this switches the compressor on should the air pressure fall below 6.5 bar. Should the pressure fall below 5.0 bar the brakes are applied automatically, and only when it has risen again to above 6.0 bar can the locomotive be made operational again.

Bombardier’s MITRAC control system governs and monitors the running of the locomotive’s systems. Commands from the driver or signals from the automatic train control and safety systems are converted into data telegrams by control processors before being distributed to the addressed functions via data buses. The diagnostic system analyses the data and suggests corrective action the driver might take. The control system computers and processors also supervise and self-test their own operation and report any defects. Operation in multiple is possible - two locomotives being the maximum, and this is also feasible when the locomotives are operating in push-pull mode. It is also possible for ALP-45DPs to run in multiple with ALP-46(A) and other existing NJT (and AMT) vehicles. The NJT locomotives are equipped with ACSES ATP and alerter (the driver vigilance device), while on the AMT

The door at the rear of the locomotive enables train crews to move between the latter and the rest of the train.
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Internet: www.zappella.de
locomotives only an alterer is installed, since the AMT network does not have an ATC (Automatic Train Control) system.

The anti-slip/slide protection system is an integrated function of the propulsion drive system. A sensor on the axle-box measures wheel rpms, and both acceleration and braking are actively controlled to minimise the risk of wheel-slip and wheel-slide. Four sander are fitted, two on each leading axle, and each set is activated according to direction of travel, either manually from the console or automatically, should slipping or sliding occur. No flange lubricator system is installed.

The fire protection system is produced by FGTEC Rail Systems. It is a high pressure water mist system, with linear heat detectors in the machinery room to monitor the two diesel engines. Additional smoke detectors in the machine room do initiate a warning mes-

sage to the driver. As on the ALP-44s, there is a WC cubicle for the driver, situated near the inner end of the locomotive, and a shower facilities. When operating in electric mode the power available for haulage purposes is not diminished when train heating, lighting, air conditioning and other auxiliary func-
tions are used, as auxiliary power is supplied. However, when in diesel mode, there is a certain amount of the available power that has to be abstracted for these facilities - around 600 kW with a rake of eight double deck carriage - still leaving some 2,040 kW available at wheel rim for haulage. In both diesel and electric modes the starting effort is identical, 316 kN.

The ALP-45DP is designed both for suburban-type services, with station stops every 5 km or so, and for limited-stop middle distance operations, on which smart acceleration and high maximum speeds are essential. The high speed diesels, running between 600 and 1,800rpm, ensure that acceleration with a rake of between five and eight double deck carriages is only a fraction of the trailing load, and not a function of the reaction time of the diesels. Medium speed diesels require over 30 seconds to reach their design performance. So, compared with locomotives fitted with the latter type of prime mover, the ALP-45DP will be capable of cutting inter-station journeys.

As a result of TRAXX gross over 1301 and has an adhesion weight around 25%, while the European TRAXXes, by way of comparison, have an adhesion weight of around 36% on account of their lower weight. Because of this value for the ALP-45DP is accounted for by the greater locomotive weight coupled with an identical (to the TRAXX) traction force. When a lower adhesion factor is required, better acceleration is achieved under conditions of low adhesion (such as during the autumnal leaf-fall), thus ensuring that train schedules are not disrupted.

The four types of American and Canadian diesels gained an unwanted notoriety in urban areas for their high noise and noxious exhaust emission levels, especially when they were left with their engines idling at night, in order to heat coaching stock. The ALP-

45DP can be stabilised in electric layover mode on electrified sidings, using either the catenary power supply or a plugged-in shore supply with its diesel switched off. A shore supply of electro-

ricity for train heating and air condi-
tioning can also be used on non-electrified sidings, this being more environmentally friendly than using idling diesel engines. Moreover, on non-elec-

trified stabilising tracks where there is no shore supply’ the on-board power system when stock is standing between duties can comfortably be met using just one of the two engines. And in addition to this, when power require-
ments are low during a journey over a non-electrified line, one of the diesels can simply be switched off, to reduce noise levels, exhaust emissions, and fuel consumption.

Fuel consumption is an important consideration, and that of the ALP-45DP is, naturally, lower than that of an older American or Canadian diesel of a simi-

lar power rating delivered by a single large slow speed prime mover. As a result, though depending on the re-

quired operating range of the locomo-
tive, smaller fuel tanks may be fitted. Having two engines is better than having one, as well. Should one of the diesels be unable to pull the train to continue to the next station (or until it reaches an electrified line) under reduced traction power. Reduc-

tion of power supply for the passenger is not allowed, thus the reduction will follow on the traction power only.

The diesel exhausts conform to the new Tier 3 requirements of the U.S. Environmental Protection Agency (EPA). Through use of a self-ventilated asynchro-

nous alternator for the diesel gensets the weight and size of the latter have been reduced. A stabilized locomo-
tive’s diesel gensets can also be started up using the energy from the intermediate DC circuit of the traction converter for the traction alternator, which in this mode is used as a starting gear. This eliminates unnecessary drain on the batteries. It also implies that the latter need not be quite so large in terms of capacity as would otherwise be the case.

The principal technical differences between the NJT and AMT ALP-45DPs are:

- the AMT locomotives have a snow-

plough of a slightly different design (on account of track clearances),

- the AMT locomotives are not equipped to be fuelled automatically, whereas the fuel tanks on the NJT machines are designed so that they can be filled using automatic pistols,

- the AMT locomotives have fuel tanks with a greater usable capacity. Under NJT rulings regarding safety in tunnels, each fuel tank compartment has a ca-

pacity of just 400 gallons (1,514 litres), ie. of 4 x 400 gallons in total,

- the AMT locomotives have two horns with high notes and two with low notes, whereas those of NJT have only one set of horns,

- the AMT locomotives have an addi-

tional compressor and side mirror heating,

- the AMT locomotives have different sets of on-board tools, such as signal flags and indicators, spanners and cables,

- the AMT locomotives have no ATC

system, but are equipped with a sepa-

rate speed indicator,

- the AMT locomotives have different

Train Line Cabling (HEP supply and control circuits) and functions,

- the AMT locomotives have different software functions and screens for use when running in multiple on account of other types of rolling stock,

- the AMT locomotives have labelling

either in French or in both French and English.

Construction And Deliveries

The bodyshelves of the ALP-45DPs are built at Bombardier’s Wroclaw

works, while the bogies come from Siegen, and assembly and fitting out are undertaken by the rolling stock design and build company. The company is keen to get the locomotives into service as soon as possible, so everything was done to ensure that construction could be brought to the shortest time feasible. Experience with the ear-

lier ALPs and with the TRAXX family was of course invaluable. Both NJT and AMT have their own competing bus-

nies, each with five sub-groups, and up to November 2010 there had been around 120 official meetings to discuss design and progress work on the loco-
motives. It is planned that the remainder of the whole batch of 46 locomotives during 2011.

The NJT locomotives will be num-

bered 4501 to 4525. NJT’s 4501 was photographed at the end of October 2010. It was subjected to static testing within the Kassel complex, since dyna-
mic testing on the German network or on the European test circuits are not yet feasible, because of both the locomotive’s greater loading gauge and its different operating voltages. 4501 is to be dispatched to the USA in January 2011. AMT’s number 4501, at the TCTi centre in Pueblo, Colorado, and the locomotive will be handed over to NJT in August 2011. However 4500, the first member of the batch, which went on InnoTrans 2010 exhibit, is to remain in Germany until February 2011. In July 2010 NJT’s board decided to order another ten ALP 45DPs as part of the option clause, however, the con-

tract was signed in August 2011.

The AMT locomotives will be num-

bered 1350 to 1369. The first was completed in November 2010 and will be dispatched to Canada in early 2011. AMT’s second locomotive, 1351, is scheduled to pass the proof run on the Rail Tec Arsenal climatic tunnel in Wien. This is a vital stage in the testing procedure, on account of the severe winter conditions in and around Montreal. One of these two machines, together with a complete traction chain, has also been subjected to tests at Bombardier’s PowerLab centre in Zurich-Gerikon.

Bombardier was among the Euro-

pean pioneers in developing the latest generation of electro-diesel trains - namely the AGC BiBi multiple units for SNCF. But the ALP-45DP represents a further step not yet been signa-

ted off. Using the DC inter-

circuit of the traction converter as an interface, it would be a simple matter in the future to incorporate various other energy sources such as capacitors, supercapacitors and fuel cells. It would also be feasible to do this while keeping the locomotive’s axle-load within the 22.5 t limit of most European networks.

Jaromír Pernička

using Bombardier Transportation

sources

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