CSR Locomotive Report
KISS EMU „Radiography“
Class ALP-45DP Locomotive
InnoTrans Megareport, Part 2
In The Birthplace Of The Gravitas
ALP-45DP01 was officially unveiled at InnoTrans 2010.

Photo: Bohuslav Kotál
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 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 in locomotive or multiple unit guise, and hence the decision by both NJT and AMT to opt for electro-diesels, namely Bombardier’s ALP-45DP (Dual Power) locomotive.

The design of the ALP-45DP is based on NJT’s Classes ALP-46 and ALP-46A (see R 1/10, pp. 40 – 43), ALP standing for American Locomotive, Passenger. The “4” refers to the fact that it has four electric engines, while the “5” denotes the power rating, which is about 5,000 kW. The ALP-45DP is a single-cab machine, and can be used in conjunction with a driven trailer on rakes of double or single deck push-pull stock. The cab layout is similar to that of the ALP-46, while the FLEXX Power 250 bogies have been adapted for AMT’s duty, with a five-axle load and can be used at speeds up to 200 km/h.

The electric power system incorporates Bombardier’s MTTRAC traction and control technology, together with the same type of IGBT traction converters as those installed in members of the European TRAXX family. Diesel power is provided by two high speed diesel engines fulfilling both the current Tier 2 and the future Tier 3 US exhaust emissions requirements and offering lively acceleration, such as is necessary for passenger service operation. Horsepower density is achieved using a novel power management system, which can also be installed in European TRAXXes should clients require this.

NJT is the third largest public transport operator in the USA, while AMT is the second largest operator of suburban rail services in Canada, and the sixth largest in terms of patronage on the continent. It also plans and integrates all forms of public transport in Greater Montreal.

**ALP-45DP Operation**

Metro North, Long Island Rail Road (LIRR) and Amtrak have been using electro-diesels, such as Classes DM30AC and P32-ACDM, for many years on suburban services out of New York, though these locomotives operate off 650 V DC third rail. The reason for this is the prohibition on the use of diesel power in the tunnels which access the principal stations in the centre of New York. The ALP-45DP is, however, the first American main line electro-diesel to combine diesel power with an overhead wire-powered propulsion system, a more complex arrangement. NJT’s 26 ALP-45DPs will be deployed on the Ravine Valley and North Jersey Coast lines, with the change from diesel to electric power taking place at the junction with the Northeast Corridor line, which links Washington with New York.

AMT has plans to increase capacity on the Deux-Montagnes, Blainville-Saint-Jerome (non-electrified) Vaudreuil-Hudson Lines, with doubling of 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, operated off overhead wire-powered propulsion.

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 bodyshell, 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 gravity as low as possible to minimise centrifugal forces on curves. To keep the unsprung mass as low as possible, the traction motors with gearboxes are suspended from the bogies.

**NJT’s second ALP-45DP, 4501, at Kassel works on 7 October 2010.**

### Principal Technical Data

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Ambient Temperatures - NJT Locomotives</td>
<td>-40 to +60 °C</td>
</tr>
<tr>
<td>Ambient Temperatures - AMT Locomotives</td>
<td>-40 to +50 °C</td>
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<tr>
<td>Track Gauge</td>
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<tr>
<td>Axle Arrangement - NJT Locomotives</td>
<td>Bo’Bo’</td>
</tr>
<tr>
<td>Axle Arrangement - AMT Locomotives</td>
<td>Bo’Bo’</td>
</tr>
<tr>
<td>Operating Voltages - NJT Locomotives</td>
<td>25 kV, 60 Hz</td>
</tr>
<tr>
<td>Operating Voltages - AMT Locomotives</td>
<td>25 kV, 60 Hz</td>
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<tr>
<td>Max. Operating Speed - NJT Electric</td>
<td>129 km/h</td>
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<tr>
<td>Max. Operating Speed - AMT Diesel</td>
<td>161 km/h</td>
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<td>Continuous Tractive Power - Electric</td>
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<tr>
<td>Continuous Tractive Power - Diesel</td>
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<td>Starting Tractive Effort - EDB Power At Wheel Rim</td>
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<td>EDB Power At Wheel Rim - During Recuperation</td>
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<tr>
<td>EDB Power At Wheel Rim - During Resistor Braking</td>
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<td>Max. Effort Of EDB</td>
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<td>Minimum Service Brake Deceleration</td>
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<td>Minimum Emergency Brake Decelerization</td>
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<td>Length Over Couplers</td>
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<td>Distance Between Bogie Centres</td>
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<td>Bogie Wheelbase</td>
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<td>Maximum Height Over Rail Top</td>
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<tr>
<td>Minimum Curve Radius Negotiable</td>
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<tr>
<td>Weight In Working Order</td>
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<tr>
<td>Maximum Axle Load</td>
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<tr>
<td>Fuel Tank (Usable Capacity) - NJT Locomotives</td>
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</tr>
<tr>
<td>Fuel Tank (Usable Capacity) - AMT Locomotives</td>
<td>6,813 l</td>
</tr>
</tbody>
</table>

The 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 locomotive tophat) 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 required. 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 unsprung 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 bodyshell, 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 gravity as low as possible to minimise centrifugal forces on curves. To keep the unsprung mass as low as possible, the traction motors with gearboxes are suspended from the bogies.

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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 electric
and auxiliary power, this results in a maximum power of 4,400 kW.

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 double-deck 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 helicoidal 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 Bohumin, 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 angled 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 10 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-diesels 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.
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 tall 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.

The traction converter changes the 1,360 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 1,360 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 (when temperatures can fall as low as -40°C).

There are two diesel gensets, which are situated on either side of the high voltage equipment, delivering a continuous power rating of about 2,600 kW at wheel rim, this value without any HEP load and dependent also on any internal auxiliary loads. Each 1,600 kW traction alternator feeds one part of the central traction converter, enabling the same electric systems to be used when the locomotive is running in diesel or in electric mode. Underneath each engine are situated the fuel tanks, fore and aft of the traction transformer, and close to the inner ends of the bogies. To save weight, the two tanks form an integral part of the bodyshell structure.

The diesels are four-stroke, water-cooled, supercharged Caterpillar 3512C HD models rated at 1,567 kW at a nominal speed of 1,800 rpm, and equipped with direct fuel injection and intercooling. Engine performance is governed by an electronic control module. This also transmits engine status data to the main control and diagnostics system. The fuel cooled engine control module of which the control circuit is housed in a metal box on the front part of the engine, and can easily be accessed from the passageway through the machinery space. The engine is mounted on the underframe using flexible rubber-bonded blocks. Charge air is sucked in through a filter on the roof. The exhaust passes through silencers with integrated Diesel Oxidation Catalysts close to the inner ends of the bogies, sucked in via a roof-mounted exhaust outlets.

The MITRAC TG 3800A traction alternators are produced by Bombardier’s Hennigsdorf works. They have an output of approx. 1,700 kVA at 1,800 rpm. Switching from electric to diesel traction and vice-versa (the so-called mode change) can take place either when the train is moving or stopped, and is fully automatic. The train speed limitations for on the move switching are to be defined by the operator. The only constraint when switching from electric to diesel is that the driver must allow sufficient time before the train reaches the end of the electrified section of track. Trackside indicators on routes operated using ALP-45DPs will inform drivers where to start the mode change.

Most of the remaining equipment (the compressed air rack, the 1,300 kW brake resistor, the low voltage cabinet and the battery housing) is situated in the rear section of the machinery space. There is only one pantograph, of an identical type to that fitted on the ALP46s, produced by Trans Tech (part of Stemmann Technik), which is located at the rear end of the roof, and the remainder of the roof space houses silencers and the hydrostatically powered air and water circuit switches for the diesels, converter and transformer.

Each wheelset is powered individually by a Mitrac DR 3700 F traction motor, rated at 1,300 kW. The three-phase asynchronous traction motors, manufactured at Bombardier’s Hennigsdorf works, are fully-suspended within the bogie and linked by a hollow shaft traction drive to the axles. Gears without any HEP load and dependent also on any internal auxiliary loads. Each 1,600 kW traction alternator feeds one part of the central traction converter, enabling the same electric systems to be used when the locomotive is running in diesel or in electric mode. Underneath each engine are situated the fuel tanks, fore and aft of the traction transformer, and close to the inner ends of the bogies. To save weight, the two tanks form an integral part of the bodyshell structure.

The high voltage and auxiliary power rack contains the switching and protective devices for the 480 V level. The auxiliary power converters for generating the 480 V 60 Hz supply is integrated in the main converter. The battery charger for the 74 V battery is located in the low voltage cubicle in the rear compartment. The main transformer is cooled by a biodegradable fire-safe ester oil, the converter by water with glycol anti-freeze. Mahle Behr Industry supplied one electric cooling unit (for transformer oil and converter coolant) and two diesel cooling units for the roof. Each traction motor is cooled by its own individual blower. The motors of the traction transformers, the motors driving the water circuits of the traction converters, and the motors driving the cooling fans of the traction motors each have independent power supplies whose voltage varies between 0 and 480 V, with a frequency ranging from 0 to 60 Hz. The machinery spaces are ventilated by filtered air which is sucked in from a by-pass on each traction motor blower.

The door at the rear of the locomotive enables train crews to move between the latter and the rest of the train.
Fit for locomotives...

- specially engineered by Zeppelin Power Systems:
  - Caterpillar Locomotive Engine 3506C
  - Output from 920 to 2240 kW
  - Meeting EU Stage IIIA Emissions Regulations
  - EU Stage IIIIB Emissions compliance in preparation
locomotives only an alertor 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 rpm, and both acceleration and braking are actively controlled to minimise the risk of wheel-slip and wheel-slide. Four sanders 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 combined protection system is produced by FOGTEC 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 machinery room do initiate a warning message to the driver. As on the ALP-46s, there is a WC cubicle for the driver, situated near the inner end of the locomotive, in the corridor between the machines.

The traction converter is a separately built component and is not part of the traction system. It is powered from the traction alternator, which in this mode is used as a starting converter for the traction transformer.

On 22 September at InnoTrans 2010 the first ALP-45DP locomotive was formally handed over by Peter Amman, Sales Director Bombardier (right) to Steven H. Santoro, the Assistant Executive Director of NJT (in the middle) and Nancy Frechette, Vice President Operations AMT (left).

Performance Characteristics

Since the ALP-45DP is heavier and larger than the ALP-46 and ALP-46As, both of which have a tractive power of 5,300 kW at wheel rim, its performance is somewhat less than that.

When operating in electric mode the power available for haulage purposes is not diminished when train heating, lighting, air conditioning and other auxiliary functions are added. There is no limitation for this, since the current taken can be drawn from the system. Even small standing losses are covered by the residual capacity of the current source supplying the traction transformer.

Two sliding doors to the cab and two side doors in each end for maintenance access are available. A large clear floor space in the rear end of the locomotive enabling train crews to access the rest of the train.

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 similar power rating delivered by a single large slow speed prime mover. As a result, though depending on the required operating range of the locomotive, smaller fuel tanks may be fitted. Having two engines is better than having one, as well. Should one of the diesels fail, the other can still be used to enable the train to continue to the next station (or until it reaches an electrified line) under reduced traction power. Reduction of power supply for the passenger stock 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 asynchronous alternator for the diesel gensets the weight and size of the latter have been reduced. A stabilized locomotive's track load has also been reduced. The pressure in the airbox may also be reduced. The pressure in the airbox may also be reduced.

The ALP-45DP is designed for high-speed Scottish, English and French services, with a top speed of 250 km/h and a wheel load of 19.8 tons.

On arriving at InnoTrans 2010, the first of the new ALP-45DP locomotives was formally handed over to NJT by Peter Amman, Sales Director Bombardier (right), to Steven H. Santoro, Assistant Executive Director of NJT (in the middle) and Nancy Frechette, Vice President Operations AMT (left).
CONTROL SYSTEMS AND ELECTRONICS FOR ROLLING STOCK

UniControls s. a. is a leading Czech supplier of control systems for transport and industry. Among the most important references in the field of transportation are design and deliveries of control system for refurbished metro trains in Prague, control system and passenger information system for suburban ENBs 471 CITY/Express and passenger information system for DMUs RegioRave. UniControls co-operate with leading world companies, e.g. Alstom Transport, for which UniControls designed and supplies communication node UIC Gateway. The Gateway is installed in high-speed trains Pendolino and Lancersas and trains of Susein. Spanish company CAF ordered Gateway in 5U version for projects in Spain and Mexico. UniControls together with Japanese partner Toyo Denki Saiko K. K. won tender for supply of Train Control and Monitoring System and power part for 776-carriage sets for metro in Chinese Chengdu.

Industrial and transport control systems

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