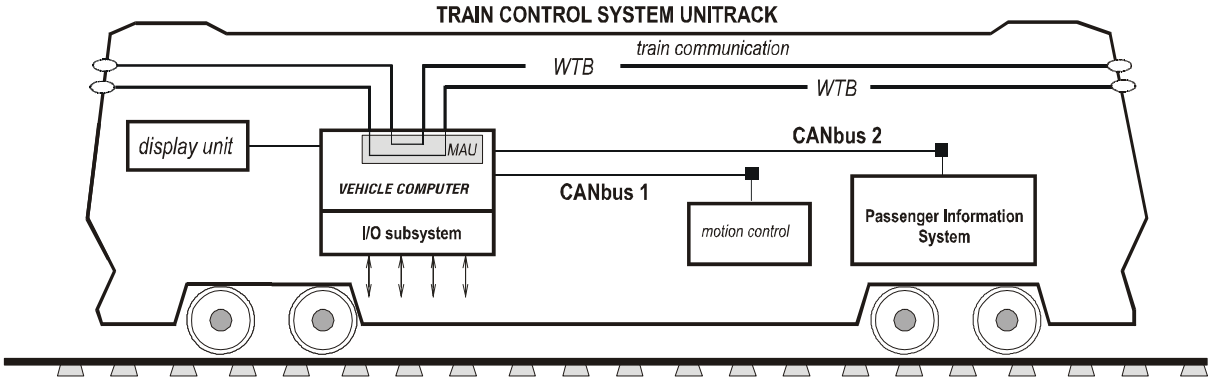
Reconstructed Vehicles of Prague Metro

In the Czech Republic, operation of the Prague Metro began on the first line C on 9th May 1974. The Metro has been gradually extended, and today it has in all three lines - A, B and C. For its operation, gradually approx. 600 coaches 81-717.1 and 81-714.1 manufactured by Metrovagonmach – Mytishtchi were put into service in **1975 to 1990**. At the present approx. 450 of them have been operated. Due to uneconomic rheostatic power control, big weight and growing maintenance, the need of reconstruction and modernization of the metro vehicle fleet has arisen.

The modernization includes reconstruction of bogies, electrical part, driver's stand, including the front of the driving vehicles and pneumatic equipment, reconstruction of interior and installation of the train control and information system.

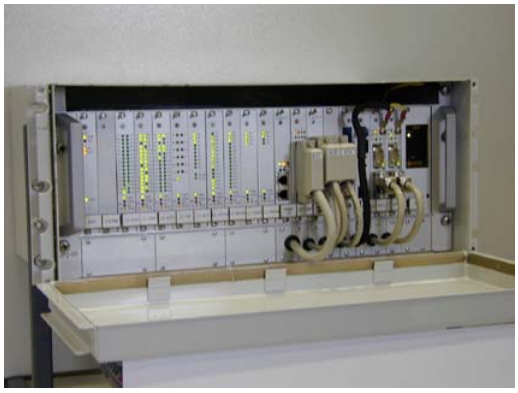
In 1998 Czech company Škoda Dopravní Technika started the reconstruction of original vehicles of type designation 8171M. The goal of the reconstruction was to substitute those mechanical components, which had caused failures or directly endangered safety of traffic, while keeping the other components which, thanks to their robust design, were capable of further operation for the whole life of the reconstructed vehicle. Energy savings were reached by utilization of low-loss pulse control of traction motors with better control properties of the drive, while observing DC traction motors. The weight of the vehicles was reduced by suitable arrangement of electric equipment on the train. Modernization of interior and exterior in accordance with European standard provided required comfort for passengers. The vehicles were equipped with modern passenger information system, and, above all, with modern superior control and diagnostic system utilizing communication facilities according to the new European standard TCN – Train Communication Network. To improve safety of traffic, the vehicles were equipped with a fire alarm system which was connected to the master computer. Roomy driver's cab was equipped with a new console with integral graphic screen and touch panel, which provides necessary information both on timetable and states of individual units of the train. Up to now 95 vehicles were reconstructed.

These reconstructed vehicles have been equipped with modern communication and control systems, which were developed and manufactured by UniControls to fully meet European standards. Data communication in the train is a backbone of the whole control, information and diagnostic system. The communication system is based on IEC 61375-1 standard TCN – Train Communication Network. The standard defines two communication buses, in particular WTB and MVB
WTB (Wire Train Bus) – communication between individual vehicles of the train
MVB (Multifunctional Vehicle Bus) – communication inside the vehicle itself
In implementation of the control system MVB was replaced by CAN communication, because not all train component suppliers had been able to change to MVB communication.
Communication node WTB and its software provides functions which are specific for trains. By contrast to control systems for industrial production, this system requires, for example, dynamic configuration: train composition, extension or reduction, vehicle orientation to front vehicle, 100% redundant deterministic communication, frequent change of main control stand of the driver.



Electronic equipment of the reconstructed metro vehicles includes communication system, control system, diagnostic system, display unit for the driver, fire system, and audiovisual passenger information system. In each vehicle there is a vehicle computer **VP2Mt1** with communication unit WTB2000, which performs communication and control functions, and is equipped with local I/O modules. This computer is a specific configuration of the modular control and communication system UNITRACK, which is designed for mobile transport means.

Vehicle computer executes all control algorithms of the train. The algorithms are programmed by means of the development programming aid ISaGRAF according to IEC 61131-3. The vehicle computer in the front vehicle is the source of data for passengers. Operating and diagnostic data of all vehicles of the train are displayed on the driver's graphic display. Detailed historical diagnostic data are displayed in the service mode on common screen of the driver. Furthermore, these can be copied into a laptop.



The set of control computer with communication unit WTB 2000 and local I/O modules of CZ-CAN series.

Control computer communicates with the safety system PA135 of French company MATRA, from which data of motion parameters are transferred into the containers of the train drives.
Modern design of the driver's stand increases the safety of operation and simplifies train control.

New Vehicles for Kiev's Metro

The results achieved in modernization of vehicles of Russian production in Prague were the reason that the company Vagonmash (Petersburg) and Kijevski Metropoliten in deciding on electric equipment of new vehicles selected cooperation with Czech firms. Based on this cooperation Czech company Škoda Dopravní Technika developed and delivers electric equipment. The vehicles of the Kiev Metro differ from Prague ones mainly in the use of asynchronous motors instead of DC ones. Vagonmash up to now manufactured one five-vehicle train.
Control, diagnostic and communication system of the metro train, driver's information system and other electronic equipment has been delivered by UniControls. Modern modular control unit of traction drives TR-1 of the same company is used for control of drives. This control unit is generally designed for control of power switches of various types such as IGBT, IGCT or thyristors. In the mentioned case it controls power converter with IGBT elements. The controlled power elements of the drives are connected by means of optical fiber cables, to depress the impact of heavy electromagnetic interference as much as possible. Hardware protections of the switches are integrated in the control unit. TR-1 communication with superior control level - vehicle computer - is implemented via CAN bus (protocol CANopen). TR – 1 conception enables to use communication MVB instead of CAN. Basic parameters of the control unit meet EN 50155.

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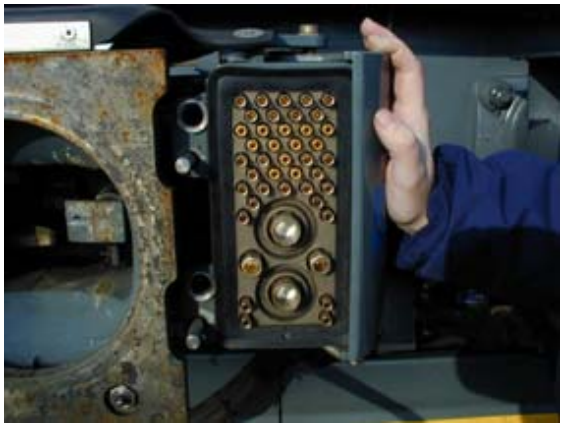
Suburban Train Unit EMJ471.

EMJ 471 train units are manufactured by ČKD Vagonka for the Czech Railways. Up to now 12 three-coach units were manufactured. The train unit is, from both design and electronic equipment point of view, an advanced product which meets current most stringent requirements for rail vehicles. The train units can be operated separately or connected to form up to twelve-coach train.

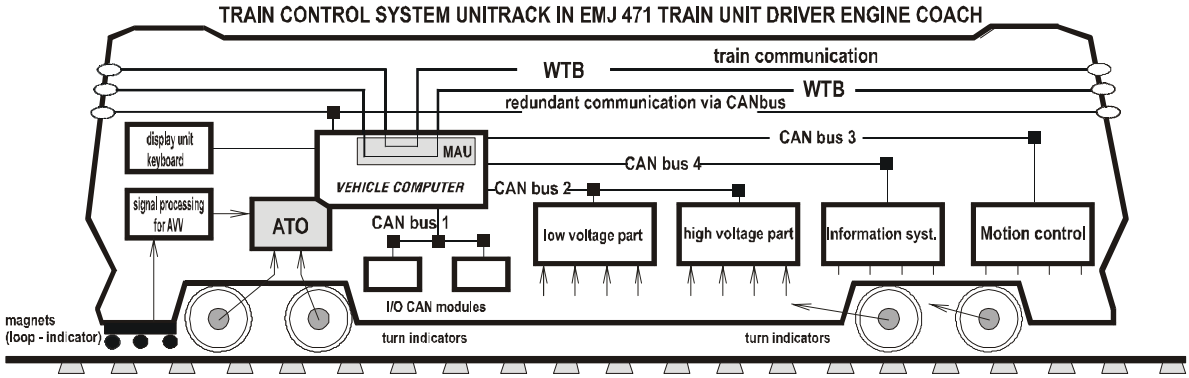
EMJ 471 is a suburban double-decker for the lines with voltage 3 kV DC. Design speed of the train unit is 160km/h. The train unit is designed for climatic conditions –30°C .. +40°C. It consists of three coaches, each of which is intended for passengers, but has different equipment.
Motor coach 471, which is equipped with 4 asynchronous motors, two power converters of total output 2MW, collector, and the driver's stand.
Control coach 971 is equipped with the driver's stand.
Intermediate coach 071 has no special equipment.

Standard train unit consists of three coaches (471 + 071 + 971).
The coaches of the train unit are equipped with automatic coupling, which enables (without the operator's intervention) not only mechanical connection of the units, but also communication interconnection of the unit or coupled units.



Automatic coupling

The train unit electronic equipment from UniControls is similar to the system delivered for reconstructed vehicles of Prague Metro. In each vehicle there is a control and communication computer with inter-vehicle communication WTB and vehicle communication CAN. However I/O modules are not located in the cassette of the control computer; instead, distributed modules of CAN-O series connected via redundant CAN bus and installed close to the technological nodes of the vehicle are used. There are 30 of these modules in the three-coach unit.



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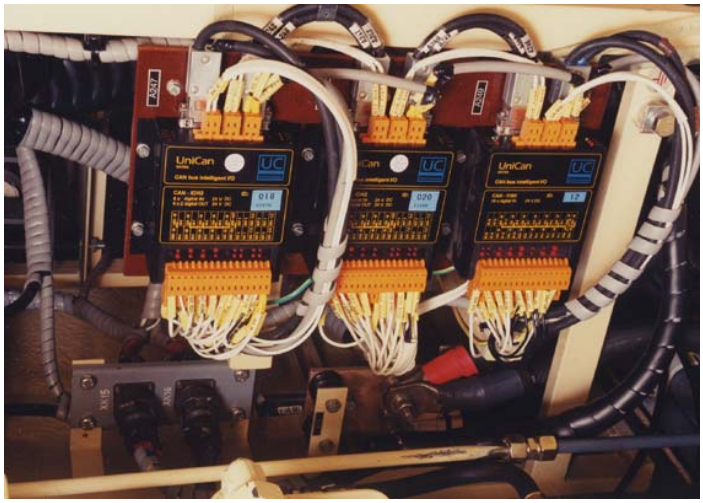
The system performs control, communication, diagnostic and filing functions. The system includes a database of timetables and relevant software, which enables to monitor relevant observance of or deviations from the train traffic diagram. The driver's stand is equipped with a keyboard and graphic display unit with touch screen, which displays all data including that of the speed controller and ATO – Automatic Train Management.



Distributed modules CAN-O

Control computer contains speed controller subsystems, ATO and is equipped with a communication channel for GSM/GPS module, which will mainly serve for transfer of data into the service center and at the same time for localization of current position of the train (System Telerail).
The implementation of this suburban train unit showed all advantages of TCN communication, which individual program modules provide automatic inauguration of the train unit, its extending or shortening. The control program itself works with the data which are provided and distributed by the communication system.

The most complex operation which must be dynamically solved by the communication system is "inauguration" – marshalling of trains. In course of inauguration individual vehicles are gradually detected and included into the train.
The result of the inauguration process are the following data: vehicle orientation to front vehicle (right/left side, forward/back); order and identification of the vehicles in the train; vehicle equipment; parameters of individual vehicles. All the data are finally sent to all vehicles of the train. Inauguration time is limited by 1 s for 32 vehicles (coaches). In course of inauguration the process of detection of the train extension or reduction takes place continuously. In practice this means that both end vehicles are checked for connection of another vehicle. If it is connected, the train is extended automatically. Furthermore, availability of end vehicle is tested. If it is not available, the train is reduced immediately. After the inauguration the system is in the operating mode. In this phase operating data are transferred between the control computer in the front coach and individual devices in the train vehicles. Typical representatives of the vehicle equipment are elements of control of main and auxiliary drives, brakes, recording speedometer, power units, doors, lighting, water system, air conditioning system, information system for the driver and engineman, passenger information systems.
The use of the modular control and communication system UNITRACK equipped with TCN communication makes it possible to implement an advanced conception of control and acquisition of data of rail vehicles (Management and Diagnostic System). The system provides complete train control, almost without attendance, and safety operation of the train. Continuous and timely diagnostics and alarm system increase the safety of traffic and reduce maintenance costs. System modularity and openness enables its utilization in the whole range of production of rail vehicles for passenger traffic. The system can be used from the simplest configurations as a diagnostic system for separate or coupled locomotives, as tram control system, up to the most complex applications for express train units.

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