

**Design and development of  
IC+ InterCity rail carriages  
for international transport,  
suitable for operation in  
international services at  
speeds of up to 200 km/h**

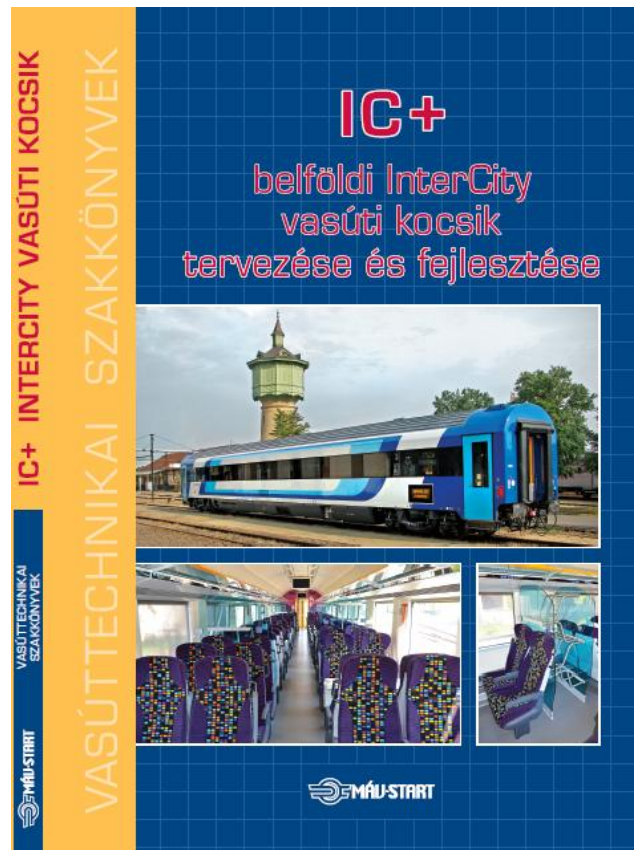
As a consequence of MÁV Group's failure to develop its fleet of rail carriages over the recent decades the existing passenger rolling stock is growing more and more obsolete. Consequently, not only is the maintenance of the vehicles excessively costly, but in many cases the standards of customer convenience and the services provided for customers fall way short of today's requirements owing to the technologies and facilities built into the existing carriages some 25-35 years ago.

This is why it has become necessary to create a new vehicle that will cater for transport requirements of decades to come and whose services and convenience attracts customers so they can be manufactured and later maintained economically. These are the very aims to be accomplished by the current design of the IC+ carriages.

The new IC+ carriages have been developed primarily for domestic InterCity, as well as international EuroCity services where their up to 200 km/h maximum permitted speed capability can be utilised in Austria and Germany. In the wake of the necessary tests and measurements they are provided with a certificate, after which the National Transport Authority makes out their type approval and the licence for putting the carriages into service in scheduled transport.

The prototype of the IC+ carriage has been developed solely by Hungarian engineers. The relevant statutory regulations, laws, decrees rules and the relevant technical specifications for interoperability (TSI), UIC decisions and the DIN, ISO, IEC, EN, MSZ, MÁV SZ standards were all taken into account in the course of the design and manufacturing process. Particular attention was paid in the course of the design process to the economic effectiveness of maintenance, ease of operation and good access.

The designs of the (Bpmz series) IC+ passenger carriage were drawn up with the help of computer programmes. The diagrammatic drawing and the less complicated parts were produced using the AutoCAD (2D) program, the majority of the engineering designs were drawn with the INVENTOR (3D) program, integrated with the Vault (PLM) data processing program. The electrical designs were produced with the EPLAN electrical designer program. Strength calculations were carried out with the help of the NASTRAN finite element program and the MSC SimXpert pre- and post-processing system while the brake engineering calculations were performed with the MathCad program.



The total cost of the project is HUF 1.4 billion of which the EU's contribution is HUF 462 million. This amount includes our own design costs, the contract manufacturing of the two prototypes, the necessary manufacturing assets, tools and infrastructure developments whereby our Company got prepared for serial manufacturing.

The newly manufactured, air-conditioned IC+ carriages designed in accordance with the UIC 505-1 loading gauge norm, for speeds up to 200 km/h, make it possible to develop an IC and EC standard carriage family for use in Hungary and in international services, comprising the following types of vehicles:

- *second-class* saloon carriage,
- *first class* compartment or saloon carriage, with a separated buffet section in one half of the vehicle,
- *multipurpose* carriage, with second class compartment/saloon design, for people with limited mobility, for carrying bicycles and with separated children-friendly carriage sections.

There are four seats per row – in a combined arrangement – in the passenger compartment of the passenger section of the two second class compartment carriage prototypes. There are four attractive luggage racks of stainless steel tubes in the passenger compartment. Seven of the ten side windows on both sides are of a fixed design, while the top third of three windows on both sides can be tilted. The upper third of the narrower toilet windows are can also be tilted down.

Passengers can board the carriages through two swinging-sliding doors in accordance with the UIC 560 standard on both sides of the vehicle, while passage to the next carriage is through the electrically operated two-wing sliding doors installed in the rear and front walls.

The hand brake cabinet and the electrical switch cabinet is installed in the No. 1 (front) enclosed platform, Two facing – closed system – toilet rooms are to be found in the No. 2 (end) closed platform of the carriages, where no hand brakes are installed. The two units' shared wastewater container is underneath the chassis. Passengers can move from the closed platforms into the passenger section through automated doors of a 650 mm clearance.

The carriages are non-smoker units, designed for the T1 climate zone according to the EN 50125-1 standard, for operation between -25 °C and +40 °C outdoor temperature extremes, but they are not damaged and remain perfectly operable even at temperatures as low as -30 °C.

From the aspect of strength the carriage body is up to the requirements of the EN 12663 standard, as is proven by the testing methods set out in the same standard. Conformity to the strength requirements was proven by finite element analysis (FEA) and type measurements carried out with the help of a fatigue testing machine.

The carriages are built on top of Siemens made SF 400 MAV type air-spring bogies, with one of the bogies equipped with hand brake.

In the enclosed platform of the No. 2 end of the carriage (where the toilets are to be found) there is a metal selective waste collecting bin with cover, for the separated collection of four types of waste (paper, glass, metal cans, plastic). In each enclosed end-platform there is a TFT monitor to display the same information as those displayed on the direction and service number board.

There is a handhold fixed on the corridor side of the seats, with the seat numbers on top of each in Braille writing.

The carriage's Liebherr-made single channel compact air conditioning equipment uses R134a coolant, blowing the amount of air prescribed by the UIC 553 norm inside the carriage.

A public address system meeting the UIC 568 requirements along with a GPS-controlled passenger information system has been installed in the carriage, together with the necessary GPS and GSM antennas. The data required for the operation of the equipment can be uploaded through an USB port.

Four LCD screens hang vertically underneath the ceiling of each carriage, displaying the name of the station concerned, communicating information during the journey, including the name of the next station, the date and time, temperature, map, the vehicle's actual position, as well as the names of the stations and stops to come.

The functions of the vehicles' remote diagnostics operating via GSM:

- querying, without deleting, of errors stored in the central diagnostics system,
- querying current errors stored in the central diagnostics system,
- database upload option for the GPS-based passenger information system (this function will only be available after a software upgrade).

The carriage's central fire alarm system monitors the inside of the switch cabinet, the passenger section, the toilets, the front and end platforms and the corridor. The two LED direction and service number boards – 64x144 pixels each – are to be found on both side walls of the carriage, under a glass plate, near the boarding door.

A closed circuit surveillance system is installed in the carriage front and end platforms and the passenger section. Electronic boards indicating whether the seat is free or taken, are attached to the front side of the luggage holder. The operation of the front side doors in the front and end walls of the coupled carriages is synchronised, i.e. opening the door at the end of one carriage controls the opening of the attached end of the next carriage as well.

The power supply installation supplies the fans of the air conditioning equipment of the IC+ carriages, their air compressors, radiators, the 230 V cleaning machine and the computer sockets, along with the battery recharger. Its key components are a JN3014-11/400/24 transformer, a PS3-12 NF grounding and circuit braking cabinet and a ZJ2 diagnostics display.

As in the case of all railway passenger carriages built for long distance service, one 230 V socket is installed next to each seat for recharging laptops and mobile phones.

In accordance with the relevant regulations, there are three emergency call devices in each carriage, enabling passengers to talk to the train personnel if necessary. The passengers travelling in the carriage can get connected to the world wide net through free WiFi service.

The diagnostics, covering all of the main electrical control unit, enables online remote monitoring of the carriages. The designers can – even from their own office – monitor the carriage's technical status continuously, receiving information on the functioning of the components and any defect or malfunction. Failures can also be queried with portable computers on board the train.

The vehicle outside colour scheme:

base colour:	RAL 9002	greyish-white
roof:	RAL 7031	bluish-grey
front, side wall:	RAL 5010	gentian blue
door, side wall:	NCS S1050-B20G	lagoon blue
between windows:	RAL 5004	blackish blue
chassis, bogie:	RAL 7015	slate blue
doors between carriages:	RAL 1028	melon-yellow

The carriage's noise levels: while stationary: 54 dB(A), at a speed of 80 km/h: 57 dB(A), pass-by noise: 78 dB(A), at a speed of 160 km/h: 62 dB(A), pass-by noise: 84 dB(A). The TSI noise levels are not exceeded by the carriage.

The manufacturing of the two prototypes of the IC+ carriage, commissioned by MÁV-GÉPÉSZET Zrt., was started on 15 July 2012 at the rolling stock repair site called Szolnoki Vasútjármű Javítási Telephely. The main repair plant, with its 158-year history, is one of Hungary's most important rolling stock repair and manufacturing plants. The final phase of the manufacture of the carriages is carried out by the relevant organisational units of MÁV-START Zrt.

The materials and components as well as various pieces of equipment required for the construction of the two prototypes were manufactured and delivered by more than a hundred domestic and foreign companies.

TÜV Rheinland undertook to assess the conformity of the vehicles from the aspect of the following technical specifications for interoperability (TSI):

- Technical Specification for Interoperability relating to rolling stock operating on the trans-European high-speed rail system (TSI HS) (as prescribed in Directive (EC) 2008/232);
- Technical Specification for Interoperability relating to locomotives and passenger rolling stock operating on the trans-European conventional rail system (TSI LOC&PAS) (as prescribed in Directive (EU) 2011/291);
- Technical Specifications for Interoperability relating to "persons of limited mobility" in the trans-European conventional and high speed rail system (TSI PRM) (as prescribed in Directive (EC) 2008/164);
- Technical Specifications for Interoperability relating to "safety in railway tunnels" in the trans-European conventional and high speed rail system (TSI SRT) (as prescribed in Directive (EC) 2008/163);
- Technical Specifications for Interoperability relating to "the noise subsystem" in the trans-European conventional rail system (TSI NOI) (as prescribed in Directive (EU) 2011/229).

Each relevant step of the manufacturing process – with particular focus on the conformity of the welded vehicle structure – was regularly checked by TÜV Rheinland at the site of manufacturing. Proposals and comments made in the course of the inspections can be utilised in the serial manufacturing of the carriages.

Our employees participating in the design, manufacture, assembly, putting into service and testing of the prototype vehicles delivered an outstanding performance to revive the domestic railway vehicle manufacturing sector.

Decision on the serial manufacturing of the IC+ carriages may be adopted following the completion of the testing procedures and the evaluation of the results. We sincerely hope that the carriages that are soon to be put into service, will provide passengers with a convenient and comfortable travelling experience.