SIEMENS

# Press Presse Press Presse

## Industry Sector
## Mobility Division

Erlangen, June 29, 2010

**Background information**

**The Vectron – Siemens' new generation of locomotives for rail transportation in Europe**

The liberalization of rail transportation in Europe, which started in the 1990s, has changed the rail market. The flow of goods is moving more quickly over ever greater distances, while the logistics are becoming more and more complex. Consequently, during the development of its completely new Vectron series of locomotives, Siemens Mobility had to meet a number of high demands due to altered statutory requirements and new standards and directives.

The Vectron has a new design tailored to meet current and future market needs. It combines the experience of service-proven solutions from the Eurosprinter and Eurorunner series of Siemens locomotive with innovations systematically oriented toward customer benefit, exceptional flexibility and cost-effectiveness.

The Vectron is the impressive successor to the proven Eurosprinter. Building on the basis of the experience gained from the Siemens ES64F4 and ES64U4 multi-system locomotives, this new unit expands the portfolio to include new applications in the medium performance class, such as strictly alternating-current and direct-current locomotives. However, the Eurosprinter will still remain in the range for fleet customers for some time to come.

The Vectron benefits from the operating and project expertise gained in connection with over 1,600 Eurosprinters and Eurorunners. Market demands and customer feedback and interviews have also been channeled into the development, as have the new normative requirements and sensitivity analyses of technical parameters.



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Apart from basic technical data that are unsurpassed in the competitive market, the main aim in the development of the Vectron was to optimize the total cost of ownership. That meant ensuring a exceptional investment protection, offering a wide range of design, retrofitting and conversion options, and eliminating expensive customized specifications and special solutions from the basic versions.

**Requirements placed on the Vectron**

The privatization of European rail transportation and the rising flow of goods over longer distances have, above all, radically changed the freight traffic market. Alongside the traditional state railway authorities there are now a large number of private rail transport companies and leasing companies that want to buy small numbers of locomotives at economical prices.

The international traffic axes in Europe have changed radically over the last ten to fifteen years. The diagram below *(Fig. 1)* clearly shows where the most important European passenger and freight traffic flows are expected to be heading in ten years' time.


Fig. 1: Passenger and freight traffic flows in 2020

The diagram shows heavy cross-border traffic in Central Europe and in the Southeast Corridor. Routes with predominantly international traffic are:

- Hinterland traffic from the ARA ports (Amsterdam, Rotterdam, Antwerp), and traffic through the Benelux countries
- Transalpine traffic
- West-east traffic through the Baltic states (port hinterland traffic to Russia)



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- North-south traffic through Poland
- West-east traffic along the corridor through Czech Republic, Slovakia, Hungary and to points further east.

The analysis of "consignments per year" clearly shows the predominant flows of goods.

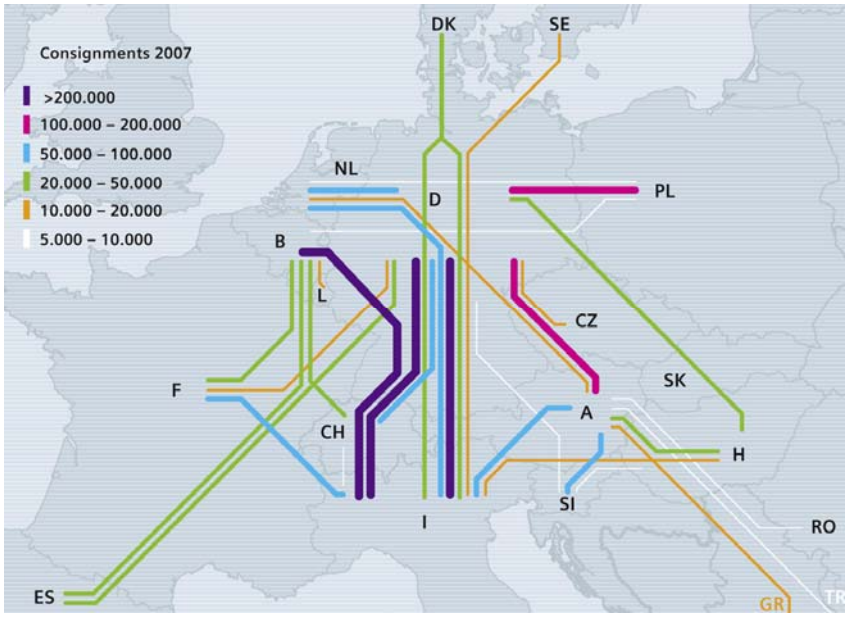


Fig. 2: Example: Combined international traffic 2007 (consignments)

At the top are the routes Germany – Italy with approx. 600,000 consignments and Belgium – Italy with approx. 200,000 consignments.

The following routes lie in the five to six-digit range:

- Austria – Germany (approx. 130,000 consignments)
- Germany – Poland (approx. 110,000 consignments)
- Austria – Italy (approx. 90,000 consignments)

The combined traffic through the Southeast European Corridor will continue to increase in future.

Modern, future-oriented locomotives have to be able to serve these main routes and future growth regions, which means they have to be interoperable and pre-equipped to operate there. This calls not only for multi-system versions with cross-border capability but also for an intelligent train protection concept that ensures a high degree of flexibility for the retrofitting of additional country-specific systems.



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However, this rising volume of international traffic is also mirrored by the increasing significance of domestic rail transports – not least because of greater environmental awareness, but also as a result of the intelligent logistics concepts of the new service providers. However, the railway can only take advantage of its ecological advantages in competition with road haulage if it can also offer economic advantages. Therefore, locomotives should not carry any unnecessary expensive systems, but be optimally designed for their transport tasks and customers.

The Vectron offers nationally operating carriers economical single-system versions which can be converted to interoperable multi-system versions with appropriate country packages.

Over a decade of experience in the testing of rail systems went into the testing of the Vectron. The Siemens Test and Validation Center in Wegberg-Wildenrath near Düsseldorf offers the best conditions for the multitude of measuring and acceptance runs that are necessary in the course of the development and certification of a new locomotive. These tests are based on precisely defined conditions, such as specific track geometries and environmental conditions, and they also have to be reproducible. This is rarely possible in everyday railway operations or, if so, then only at great expense. In addition to the measurements, an independent authority must be able to assess the results with reference to standards and statutory requirements.

**The product concept**

The product concept of the Vectron covers single and multi-system locomotives for the European alternating-current (AC) and direct-current (DC) networks for high-speed passenger traffic and interoperable cross-border freight traffic. Vectron is a product with a wide range of options that meet customer needs with proven solutions. Siemens offers a number of Vectron versions for a range of traction tasks. These locomotives can be delivered from the factory quickly and cost-effectively. A diesel-electric version is planned for the medium term.

The Vectron not only covers the high performance range up to 6,400 kW, well-known from the Eurosprinters, but also provides solutions in the medium performance class up to 5,200 kW for regional passenger traffic and lighter freight trains.

There are four basic versions of the Vectron available with standardized interfaces:

- High-power AC locomotive
- Medium-power AC locomotive



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- Medium-power DC locomotive
- High-power MS locomotive

Ex works, the Vectron is built for a maximum speed of either 160 or 200 km/h. With a preliminary equipment package, a Vectron can be upgraded from a 160 km/h version to a 200 km/h high-speed version without any major modifications.

Table 1 lists the main technical data and features of the Vectron and the maximum tractive and braking efforts for the high-performance versions.

| **Table 1: Main technical data and features of the Vectron** | |
|---|---|
| Voltage systems | 15 kV AC, 16.7 Hz<br>25 kV AC, 50 Hz<br>3 kV DC<br>1.5 kV DC |
| Maximum power at the wheel rim for high-power versions | 6,400 kW (motoring and regenerative braking) |
| Maximum power at the wheel rim for medium-power versions | 5,200 kW (motoring and regenerative braking) |
| Maximum speed (high-speed version) | 200 km/h |
| Starting tractive effort | 300 kN |
| Electric braking effort | 150 kN (optionally up to max. 240 kN) |
| Wheel arrangement | Bo'Bo' |
| Track gauge | 1,435 mm |
| Ambient temperature | -30°C to +40°C |
| Maximum altitude | 1,400 m above mean sea level |
| Vehicle length (length over buffers) | 18,980 mm |
| Vehicle loading gauge | UIC 505-1:2006-05<br>sections 5.1, 5.2 and 5.4 |
| Total weight | 80 - 90 metric tons (depending on version and equipment) |
| Drive wheel diameter | 1,250 mm new / 1,170 mm worn |

Table 1: Main technical data and features of the Vectron

**Locomotive body structure**

The body of the Vectron is designed as a self-supporting structure to meet the high mechanical strength requirements. It has three main subassemblies: the underframe, the driver's cabs



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including cab rear walls, and the side walls of the machine compartment. The roof comprises three detachable segments, which also carry the roof-mounted equipment. The front part of the driver's cab is a replaceable steel front end. It is attached to the locomotive body by means of steel locking bolts.

The structure and shape of the steel front end has already proven itself in the previous generation of Eurosprinters and Eurorunners. It stands for the modern, future-oriented and timeless Siemens front end design. Therefore, for the Vectron, it was not changed for the sake of achieving a short-term marketing effect. The advantages for the customer: All recent types of Siemens locomotive have a uniform, replaceable energy-absorbing section that enables a quick return to service after an accident.

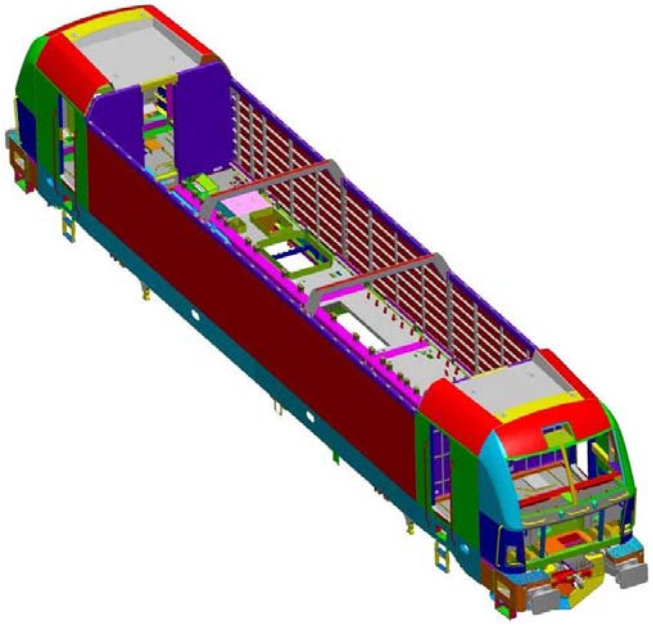

Fig. 3: Locomotive body structure with front end

The locomotive body is designed so that it can withstand the stresses from load cases according to DIN EN 12663:2000 category P.1 and prDIN EN 12663-1:2007 category L and UIC 651:2002. That means a maximum static tensile force of 1,500 kN and a maximum static compressive force of 2,000 kN. That is more than is demanded from conventional locomotives and also qualifies the locomotive for future transport tasks.

The underframe consists of two side sills, a center sill, two center pivot cross members, two transverse transformer cross members, and the two end sills. The design also facilitates mounting of the locomotive on broad-gauge bogies for a track gauge of up to 1,676 mm.



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The two driver's cabs with integrated cab rear walls each consists of the cab side walls, the roof and the front-end flange. The side wall of the cab is reinforced to ensure survival space for the driver in crash scenarios according to TSI HS RST:2008 and EN 15227:2008. The stable cab roof also contributes to driver safety.

A special feature of the Vectron vehicle concept is that the front end, which is a defined deformation zone, has a detachable connection to the car body. That ensures unrivaled ease of repair because there is no longer any need to remove large sections with the aid of cutting grinders, cutting torches or welding gear.

The safety concept has been well thought out and ensures quick repair and return to availability after an accident. The crash energy is absorbed by absorption structures at the ends of the locomotive. These work on a multi-stage concept, and consist of reversible elements in the buffers, behind which are the crash elements, the front end and a vehicle end structure which deforms in a controlled manner in the event of a collision.

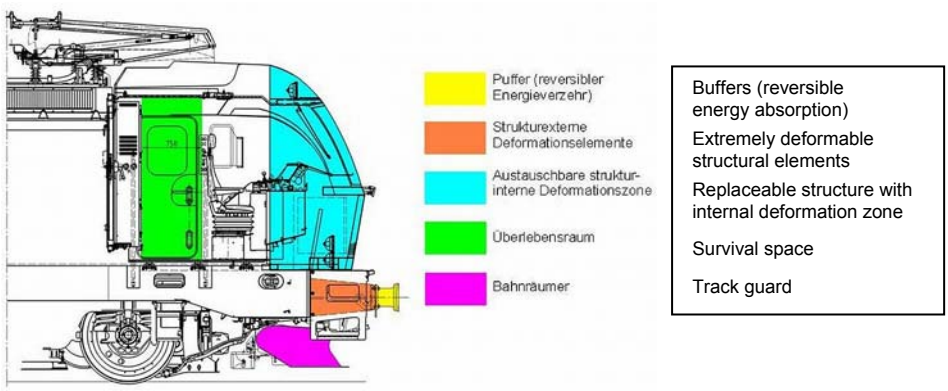


Fig. 4: Diagram of the principles of the Vectron crash concept

The reversible elements in the buffers absorb light shunting collisions without irreversible damage being caused to the vehicle. The crash elements behind deform by means of controlled folding if a triggering force is exceeded. The front end protects the driver by a crumple zone in front of the driver's desk, deforming selectively without breaking up the protective structure of horizontal and vertical members combined with an impact wall.
The locomotive fulfills all requirements for survival space for the driver, the maximum deceleration limit values in the locomotive body, and the requirements to limit overriding in the crash scenarios according to TSI HS RST:2008 and EN 15227:2008.



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Fig. 5: Vectron car body

**Machine compartment layout**

The machine compartment layout is a widely debated issue, to which a systematic analysis was able to provide only one convincing answer. All design decisions were put on the test stand during the development of the Vectron. The decisive criteria were customer orientation, economical use of space, ease of maintenance, clarity, safety, flexibility and convertibility. The proven central aisle concept of the Eurosprinter family was therefore retained. The side aisle and the Y/Z aisle were deliberately rejected.

This machine compartment layout with a central aisle provides a straight, panic-proof escape route without dead ends that can save the driver's life in an emergency situation. The use of space is optimal without transverse aisles. The wide aisle also ensures ease of maintenance, which saves time and money.

The driver's cabs at each end of the machine compartment are separated by a steel back wall. The entrance is through centrally located doors. The back wall provides 15-minute fire resistance in the event of a full-scale fire – an important safety aspect if the driver is injured.



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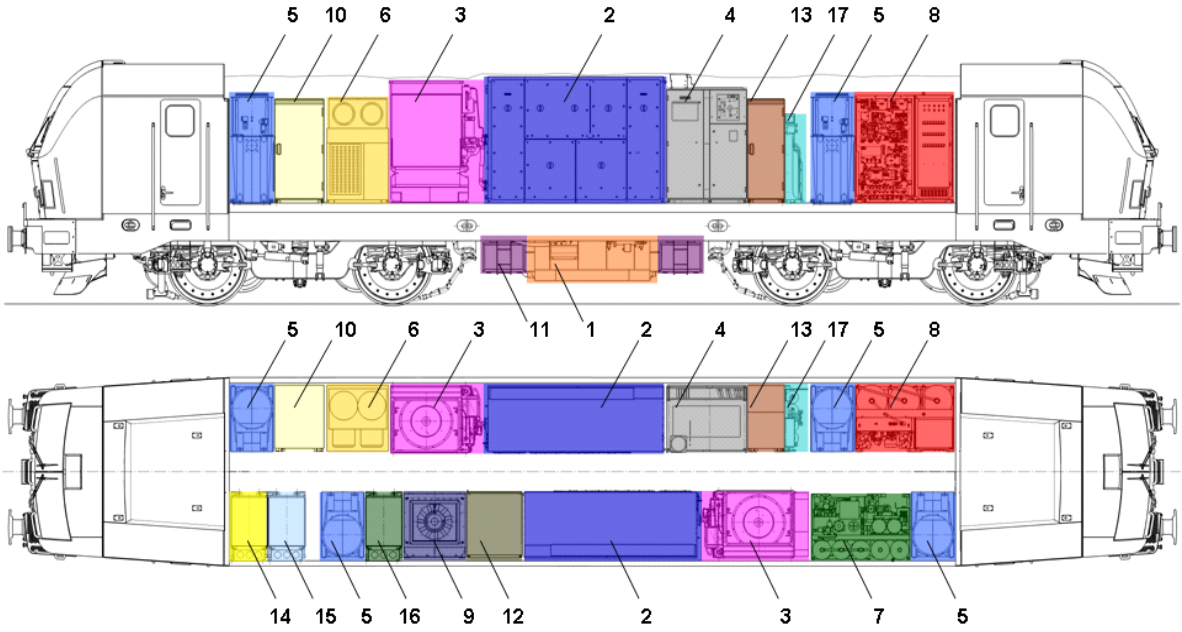


| | | | |
|---|---|---|---|
| 1 | Main transformer | 10 | Low-voltage eq. cabinet |
| 2 | Traction converter | 11 | Battery compartment |
| 3 | Oil and water coolers | 12 | AC high-voltage eq. cabinet |
| 4 | DC high-voltage equipment cabinet | 13 | Auxiliary equipment cabinet |
| 5 | Traction motor blower | 14 | Train protection cabinet 1 |
| 6 | Auxiliary transformer rack | 15 | Train protection cabinet 2 |
| 7 | Compressed-air equipment rack | 16 | Train protection cabinet 3 |
| 8 | Compressed-air processing rack (incl. brake control) | 17 | Fire-extinguishing system |
| 9 | Dynamic braking resistor | | |

Fig. 6: Machine compartment layout taking the example of the multi-system locomotive

The cable and pipe duct is located under the central aisle and carries the control wiring and compressed-air pipes. This duct is covered by removable, non-slip segments so that the lines can be easily accessed without removing racks. That also simplifies retrofitting work if additional train protection systems are required.

The racks and cabinets are arranged on both sides of the straight central aisle in the machine compartment. They contain the traction, brake, train protection, vehicle control and auxiliary



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equipment. The attachment points are already provided in all Vectron versions, which also makes retrofitting easier.

Siemens specifies that racks with the same function must be installed in the same positions across the entire range. The principle of "no wandering installation positions for identical functions" is strictly enforced. This unequivocal placement eliminates uncertainties for drivers and maintenance workers.

In the search for space-saving units, the Siemens engineers have been able to shorten the traction converter even further in comparison to the unit in the current high-speed, multi-system ES64U4 locomotives. The space subsequently gained from this has been used to separate the AC and DC equipment. The main AC current components previously located on the roof (main circuit-breaker and line-voltage transformer) are now located with the AC train bus in the AC high-voltage rack in the machine compartment. In the event of damage to the overhead contact line, this will ensure a further reduction of consequential damage on the roof and, in turn, of repair costs and downtime.

The roof has space for four pantographs. The modular roof layout enables even easier retrofitting and conversion than is the case with the Eurosprinter.

The compressed-air equipment rack contains all the devices for generating and processing the compressed air: compressor, air-drier and auxiliary components. The rack is suitable for both the standard screw-type compressor and the optional, oil-free piston compressor with a delivery rate of 2,400 l/min. The air compressor has been retained in the machine compartment for the purpose of protecting it against external influences and reducing noise emission.

**Bogie concept**

The Vectron bogie is used in all versions. The design is based on tried-and-tested components, and reflects the state of the art. The bogie can be adapted to customer specifications for maximum speeds from 160 to 200 km/h. As well as standard gauge bogies (1,435 mm), broad-gauge bogies for up to 1,676 mm can also be used.

Various methods of transmitting tractive effort were re-examined during the development phase, but the center pivot concept was purposely retained. Its very good rolling resistance characteristics



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and excellent utilization of the adhesion coefficient had already proved to be convincing in the Eurosprinter series.
The bogie has the following outstanding features:

- Robust, fully welded bogie frame
- Axle guidance via triangular rod
- Transmission of the tractive effort by means of center pivot
- Secondary suspension (Flexicoil springs) with low rotational stiffness
- Semi-suspended pinion hollow shaft drive
- Wheel discs with a diameter of 1250 mm (new) and a width of 140 mm, with disc brakes
- Prepared for the mounting of antenna packages for the various European countries and corridors

The semi-suspended pinion hollow shaft drive that proved so reliable in the Eurorunner has been developed further for the required speed range. Compared with the nose-suspended drive used in freight locomotives, the pinion hollow shaft drive is distinguished by substantially lower unsprung massed, which reduces track wear.

On the Vectron bogie, the traction motor is connected flexibly to the bogie frame. The gear unit is mounted on the wheelset shaft and supports itself on the motor by means of a torque reaction brace. The torque is transmitted from the traction motor to the gear unit by a maintenance-free multiple-disc steel coupling, which also compensates for relative motions and so decouples the motor from the axle-mounted gear unit. The two components are connected near the coupling by a tilt arm in order to reduce the relative motion between motor and axle-mounted gear. The traction motor is suspended flexibly from a traction motor bearer and a rubber tilt arm in the bogie frame.

The pinion hollow shaft drive covers the speed range up to 200 km/h. One bogie can be used for both passenger and freight traffic, so there is no need to change bogies. The customer benefits here from both unique quality and future viability. If required, the Vectron can also be equipped with a fully suspended hollow-shaft drive system with the same interfaces.

Another special feature is the option of using brake equipment with the same interfaces from two suppliers. This two-supplier strategy reduces the risk of obsolescence and offers greater flexibility to fleet operators.

The service brakes are compact brake calipers with brake discs mounted on each wheel. They are known for their minimal noise development. The wheel discs and bogie frames are designed so



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that brake discs and compact brake calipers from two suppliers can be used. The holding brake consists of one spring –loaded brake on each brake control unit per axle.

The energy generated during braking is also fed back into the power supply system or used to supply the auxiliaries and the train.

The bogies can be originally equipped or retrofitted with active rotational dampers (ADD). The ADD fulfills the function of a conventional rotational damper while also being an actuator. This generates a tensile or compressive force proportional to the rotation angle of the bogie. The force couple arising between the locomotive body and bogie increases the rotating motion of the leading bogie and reduces that of the trailing bogie. This reduces the guiding forces in curves and increases wheel service life because tread and wheel flange wear is lower.

**Train protection equipment**

In the first stage, the Vectron has been designed to operate with the following train protection systems:

- ETCS Level 1 or 2 with Euroloop
- PZB90 / LZB80 (CIR-ELKE I)
- ZUB262ct / INTEGRA
- SCMT
- ATB-EG
- TBL 1+ and Memor
- KVB
- RPS
- SHP
- Mirel (incl. LS and EVM)

Additional train protection systems are currently in preparation and will be able to be integrated. There are three rack positions in the machine compartment for the train protection cabinets. These cabinets contain the stated systems and have a modular structure, so that conversion or retrofitting is very simple. Each system has a fixed, defined rack position. The underfloor area and the bogie have been prepared for the mounting of antennas and speed encoders.



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**Driver’s desk**

The ergonomics of the driver’s desk are based on the experience gained from many Eurosprinters and meet the requirements of a modern workstation. All the elements are readily accessible, non-glaring and easy to recognize. The field of vision complies with UIC 651. Despite the increasing integration of the controls and displays in the standard, existing display concept, the controls and displays of the national train protection systems must be permanently connected to it. Here again, the concept of fixed, predefined installation locations has been pursued consistently. Two versions of the driver's desk – a high and a low version – have been designed *(Fig. 7)*.

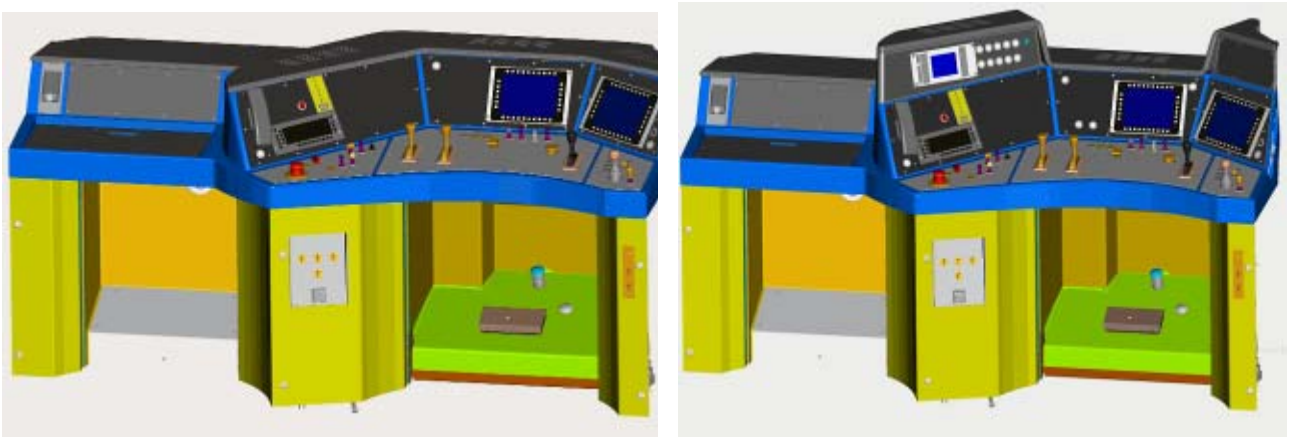

Fig. 7: High and low version driver’s desks

The main advantage is that subsequent retrofitting of additional train protection systems does not require any makeshift structures. The low version of the driver’s desk is simply replaced by the high version of the blind on the driver's desk. The high version is an integral part of the new driver's desk design.

**Multiple traction and push-pull operation**

All Vectron locomotives can be operated in multiple traction mode, no matter which line voltage. Even mixed multiple-traction formations, such as AC and multi-system locomotives, are possible.

The ZDS and ZMS system enables Vectron to operate in multiple traction with the Classes 152, 182, 189/ES64F4, ES64U2 MRCE and ER20. Locomotive Classes 182, ÖBB Rh 1016/1116,



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ES64U2, MAV 1047, GySev 1047, ÖBB Rh 1216, ES64U4, ÖBB Rh 2016 and ER20 can run optionally in multiple via the wired train bus (WTB). All modern Siemens locomotives therefore have multiple traction capability. Multiple running is also possible with locomotives from other manufacturers which have ZDS / ZMS system like the Class 185.

In push-pull operation, the Vectron uses the ZWS push-pull control system, but WTB is also possible with the Austrian remote control concept. The TB0, SAT and TAV dispatching processes are available.

**The Railcover service concept**

With the Vectron, Siemens developed the new Railcover service concept. A locomotive should be easy for the locomotive personnel to operate. But Vectron's design also placed great importance on making work easier for the maintenance personnel, enabling them to offer a better service and thereby reduce maintenance costs. The main goal was to increase the availability of the vehicles and to raise the cost effectiveness to a new level for the operating company.

Serviceability: Maximum availability of vehicles in operation was a crucial specification in the development of the new locomotive concept. The new design provides easier access to important vehicle components, thus making maintenance easier.

During development and selection of the components, great value was also placed on reducing maintenance costs. The replaceable front end and the optional fitting of active rotational dampers (ADD) make a big contribution to serviceability. The components deformed in a crash can be replaced quickly, thus reducing downtimes and restores the vehicles more quickly to productive use. ADD reduces wear rates, which reduces the maintenance costs for locomotive and track, and so saves money.

Remote data transmission: Vectron locomotives can transmit fault data by mobile radio to help the field service rectify malfunctions quickly on site. The fastest possible data transmission in the mobile telecommunication standards GSM, GPRS and UMTS are used. A great number of locomotive data and operating parameters can be called in real-time to determine the causes of malfunctions. This means that the experts in the Siemens Rail Support Center directly receive the information required to take action to rectify faults quickly. Precise localization of the locomotive at the time of the malfunctions by the integrated GPS not only determines the location but in many



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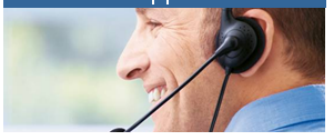
cases also enables conclusions to be drawn about faults in the infrastructure.

Condition-based maintenance: Why replace a component if it is still serviceable? As far as possible, technically feasible and capable of being homologated, the prerequisites for condition-based maintenance have been created for the Vectron. The maintenance schedules can be systematically amended to match the condition of the vehicle and individual components. The regular collection of operational data via remote data transmission and its evaluation by specially developed software modules enables the condition of important components to be established and tracked online. That simplifies the optimal scheduling of the maintenance work.

Service module: Railcover offers tailor-made modules for support, maintenance and spare part supply, which can be combined to match the customer's specific needs.

| Support | Maintenance | Spare Parts |
|---|---|---|
|  |  |  |
| **Rail Support Center** | **Maintenance management** | **New parts** |
| **Mobile service technicians** | **Corrective maintenance** | **Replacement parts** |
| **Workshops** | **Preventive maintenance** | **Periodic maintenance packages** |

The Siemens Rail Support Center can be contacted round the clock in emergencies. In the event of malfunctions, the locomotive personnel can speak directly to the Siemens experts. Depending on the type and extent of the malfunction, the driver can rectify minor problems him or herself with telephone support, or a service technician can bring the spare part to the location and install it. More serious malfunctions are rectified in the nearest partner workshop. Even difficult malfunctions can be rectified quickly by remote diagnostics and calling in development engineers if required.

By preventive or corrective maintenance, Railcover ensures the maximum availability of the Vectron – throughout Europe. The Siemens-own service center network and authorized workshops offer depot infrastructures which are suitable for the diverse types of scheduled work. Certification of the workshops by Siemens Mobility ensures that maintenance activities are always performed



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correctly according to specifications.

The spare part supply focuses on reducing downtimes. Siemens offers new parts, exchangeable parts and maintenance schedule packages. Spare parts are available at short notice from the Siemens warehouse, so they can arrive at the location of the locomotive within a short time.

Siemens's experience of 1,000 contract years in worldwide maintenance projects went into the development of the modular service concept. Railcover expands the service offer for locomotive operators; it is customer-oriented, modular and flexible. Almost every conceivable and practical degree of maintenance support can be provided.

From the accident and breakdown cover – for quick help in the event of a fault – to full service for the entire fleet of vehicles, Siemens has a tailor-made service offer that guarantees maximum availability of the Vectron.

The **Siemens Industry Sector** (Erlangen, Germany) is the world's leading supplier of production, transportation, building and lighting technologies. With integrated automation technologies as well as comprehensive industry-specific solutions, Siemens increases the productivity, efficiency and flexibility of its customers in the fields of industry and infrastructure. The Sector consists of six Divisions: Building Technologies, Drive Technologies, Industry Automation, Industry Solutions, Mobility and Osram. With around 207,000 employees worldwide Siemens Industry posted sales of about EUR35 billion in fiscal year 2009.. http://www.siemens.com/industry

The **Siemens Mobility Division** (Erlangen) is the internationally leading provider of transportation and logistics solutions. With “Complete mobility”, the Division is focused on networking the various modes of transportation in order to ensure the efficient and environmentally compatible transport of people and goods. “Complete mobility” targets the goal of sustainability and combines the company’s competence in operations control systems for railways and traffic control systems for roadways together with solutions for airport and postal logistics, railway electrification, rolling stock for mass transit, regional and mainline services, as well as turnkey systems and forward-looking service concepts. With around 25,000 employees worldwide Siemens Mobility posted sales of EUR6.4 billion in fiscal year 2009 (ended September 30). www.siemens.com/mobility



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