

eTicket Germany—An Interoperable Electronic Fare Management Standard for Public Transport

Berthold Radermacher and Elke Fischer

Germany's local public transport system (ÖPNV) makes a significant contribution to mobility in Germany where passengers use ÖPNV more than 10 billion times a year to travel in and around Germany's numerous conurbations.

The high acceptance of public transport is largely due to its clear design, extensive network and simple, interoperable and intermodal one-ticket system in a region. During the 1950s and 60s, the labour-intensive gates used to access the public transport system were removed to improve efficiency. In the 1970s, transport systems were increasingly linked and integrated by the formation of public transport authorities. The implementation of interoperable single tickets, which could be used with all modes of transport and all operators within a transport authority, simplified local public transport usage, resulting in an increase in passenger numbers. Public transport authorities were subsequently established in most areas of Germany.

At the same time, new tariff systems were brought in to provide customers with a fair pricing structure. However, these systems were complex and amounted to a further barrier to mobility for passengers who use public transport only occasionally in one specific area. Past technologies did not enable ticketing terminals to optimally support customer ticket selection processes. Today, most journeys are made using season passes, however, only 15% of the population has a pass. A far greater (40%) part of the population uses public transport occasionally and accounts for about 25% of journeys. This means that occasional users experience the huge majority of sales transactions. For these occasional users, the confusion concerning tariffs and ticketing sales is particularly difficult.

In the 1990s, many transport operators started to make ticket purchase a more efficient and pleasant experience. In particular, they made use of emerging smart-card technology and also investigated other new media, such as mobile phones, as a platform for purchasing and presenting tickets. In the late 1990s, the *GeldKarte* (chip-based electronic purse) was tested in the market for the first time, and the PayCard (based on the Deutsche Telekom telephone card) was put to the test.

The Association of German Transport Undertakings (VDV) developed a standard for integrated data structures for

storing electronic tickets on pre-paid cards implemented as the 'additional e-ticket application' for the *GeldKarte*. Based on this, Bremen began issuing e-tickets on the *GeldKarte* with instant payment from the electronic purse. This was soon followed by initial pilot schemes and successful active systems with automated fare management which recorded passengers boarding and alighting in Marburg, Oldenburg and Konstanz; large pilot trials were held in Berlin (ticket), Cologne-Bonn (i-ti), the Rhine-Main area (Viatic) and Dresden (intermobilPASS/ALLFA Ticket). Around the same time that active systems, such as Octopus in Hong Kong, were being launched throughout the world, the Rhine-Ruhr (VRR), Rhine-Sieg (VRS), and Lower Rhine Transport Association (VGN) transport authorities started introducing the e-ticket over a wide area.

The VDV and German transport operators recognized a historic opportunity to make public transport more user-friendly by introducing a Germany-wide standardized electronic fare management system, enabling them to overcome existing pricing and sales confusion perceived by passengers as a barrier to local mobility, and improve efficiency by reducing costs and increasing profits.

The fare management system was comprised of three variants:

- Cashless electronic payment
- Electronic ticket combined with electronic ticket control
- Automated fare calculation (using check-in/check-out system and automatic ticket recognition)

The interoperability goals were defined as follows:

- Customers access all IFM systems (local public transport and passenger rail transport) interoperably using one medium. For this, an integrated customer interface and the acceptance of integrated payment methods had to be specified.
- Integration of all IFM variants, application to different media and interoperability between all system types and with all acceptance methods

In addition, the IFM systems were required to:

- Be independent of pricing systems. In other words, the authority of transport operators to set fares was to be unaffected.

- Be compatible regardless of different implementations, enabling different variants to be implemented gradually and to coexist with each other.
- Have a security level reflecting the potentially high monetary values and cooperation between several autonomous business partners.

The VDV together with its transport operators, the relevant industry and the Federal Ministry of Research and Technology (BMFT), which was responsible at the time, initially launched the VDV Core Application research project with a budget of about €5.6 million.

To justify the high start-up costs, the industry demanded a high level of commitment to standardization. In a 'declaration of intent to develop and implement an interoperable VDV Core Application standard', VDV decided on 24 April 2001 that: 'The Association of German Transport Undertakings and the signing members ... will ... promote the development of a nation-wide, interoperable standard (public transport core application) for a three-tier electronic fare management system. The association strongly advises all its members to adopt this standard. ... The signing companies and transport authorities undertake to use the VDV Core Application as the basis for all tenders for equipment and plant for electronic fare management, regardless of the tier being implemented.'

In a convincing response, this declaration was signed by all the main transport authorities, Deutsche Bahn AG (DB

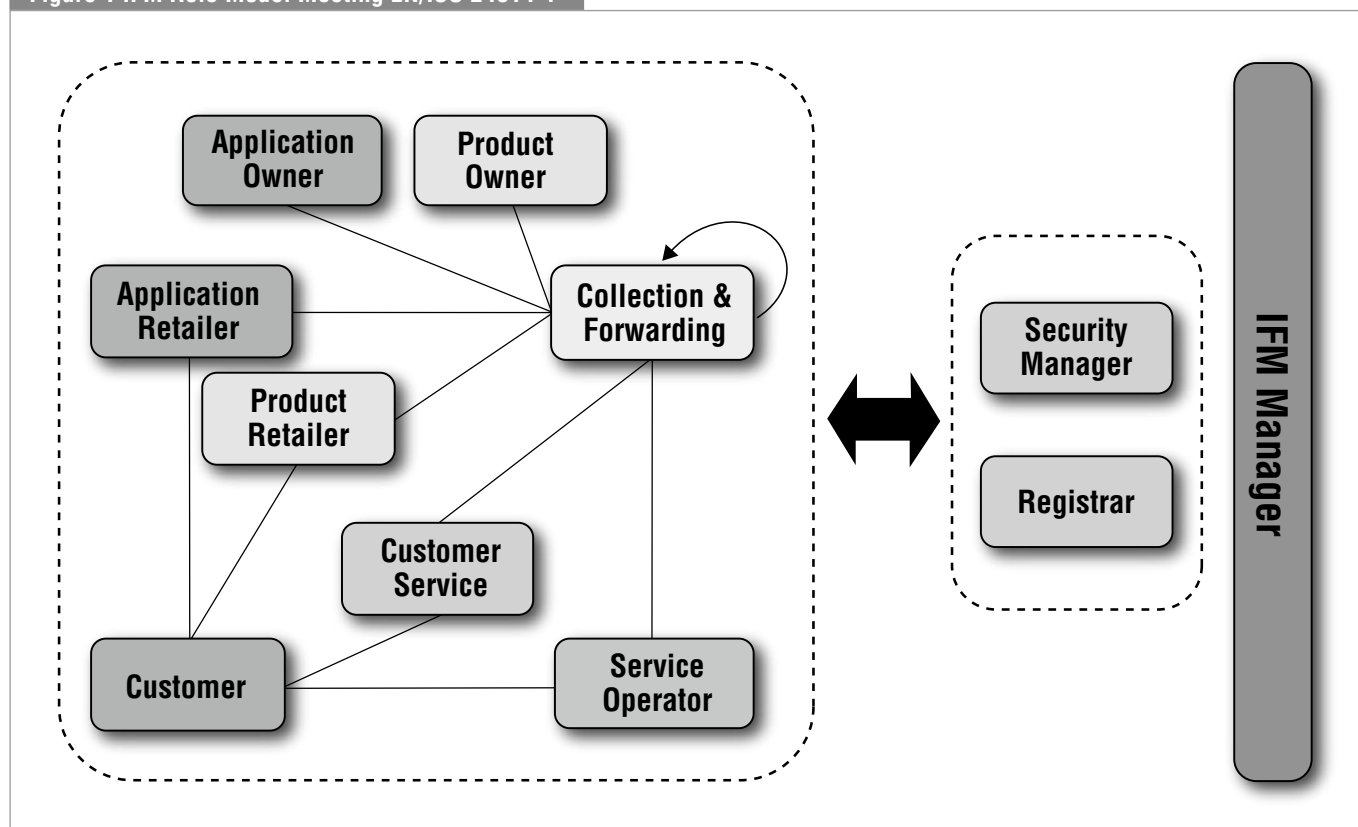
AG), and around 80 other transport operators in the VDV both in Germany and throughout Europe. With this level of support, contracts were signed with industry partners (card. etc, CUBIC, Deutsche Bank, ERG, Fraunhofer-Gesellschaft, infineon, Philips, Siemens, and T-Systems) and the BMFT in early 2002. The project was completed successfully in July 2005.

VDV Core Application Role Model

The VDV Core Application is an open system in which transport operators can work flexibly and independently. Its organizational core is a logical role model that defines the actors and their functional responsibility and their interaction. These definitions are also defining the technical system functions for an operational IFM. Clearly defined functions and business processes are allocated to each role. Existing organizational models and technical systems are now being developed with enhanced security on the basis of a role model that enables data transfer to transcend the limits of the system, thus making sensitive customer data available only to the company that has entered into an agreement with the customer.

The configurations and features of the technical systems and the tariff and service systems remain in the hands of the local public transport operators and authorities. The

Figure 1 IFM Role Model Meeting EN/ISO 24014-1



centralized security management system facilitates shared access to customer media and enables all parties to work together with confidence.

The logical role model of the VDV Core Application is closely interlinked with the architecture of the international standard for an interoperable fare management system (EN/ISO 24014-1), which was also significantly influenced by the development of the VDV Core Application. Figure 1 shows the functional roles specified in the VDV Core Application.

To implement the VDV core application, VDV-Kernapplikation GmbH & Co KG was set up in 2004 to adopt the key functions stipulated in the role model—IFM manager, registrar, security manager and application owner. This includes developing a set of rules comprising the organizational and contractual framework and detailed specifications and designing a registration and security system to include the maintenance and further development of both the security system and the set of rules. In addition, this new company will assist transport operators and transport authorities in introducing the VDV Core Application.

The necessary key organizational and technical procedures were in place just in time for the launch of the first 3 million cards in the Rhine–Ruhr and Rhine–Sieg public transport authorities at the start of 2007.

Smart cards and mobile phones as core ticketing solution

The VDV Core Application, which as a data and interface standard forms the basis for implementing the interoperable electronic fare management system in Germany, will be introduced initially on smart cards. However, it has been designed to be used as a stand-alone application on different electronic media, such as mobile phones. To facilitate this, the electronic media must fulfill the security and interface requirements (e.g. ISO/IEC 14443 a/b, NFC) of the VDV Core Application. Ticket purchasing via GSM interface has already been embedded in the VDV Core Application to enable quick and easy launch of mobile phone ticketing.

Integrated customer interface for eTicket Germany

An integrated customer interface is a key aspect of German-wide IFM.

The standardization of customer interfaces in IFM systems should increase acceptance and bring real benefits to customers. An integrated customer interface offers customers the reassurance that familiar actions will produce the correct ticket wherever they go. With this in mind, integrated procedures and images have been defined for all components with a customer interface. This specifically includes recurrent signs, logos, pictograms, information services, and operator actions to make the system as user-friendly as possible.

The logos and pictograms shown opposite were designed

to aid identification and recognition of eTicket Germany.

VDV Core Application Security System— Background and Objectives

The security system provides operators and customers with a shared, open and trusted platform for interoperability for all aspects of the logic role model, and is therefore designed to relate directly to their function within the system.

The security management system safeguards the autonomy and security of individual organizations (transport operators, public transport authorities, system operators, manufacturers), who have differing interests in one or even several different electronic fare management systems. To this end, it must systematically protect all production and business processes associated with IFM ranging from deliberate attack to unintended events.

The safety management system for eTicket Germany with VDV Core Application comprises the following three pillars (Figure 3), together with associated procedures and monitoring:

- Public key infrastructure (PKI)
- Key management (KM)
- Provision of secure application modules (SAM)

Current Status and Future Developments

In principle, every core application-compliant IFM project can be built on the experiences of earlier projects. Proven processes can just be adopted and improved continuously. In the long term, this will significantly simplify matters and result in a corresponding reduction in project risks and costs for new participants. This is a key advantage of eTicket Germany with VDV Core Application compared to proprietary solutions, which ultimately create isolated solutions in a closely linked German public transport network.

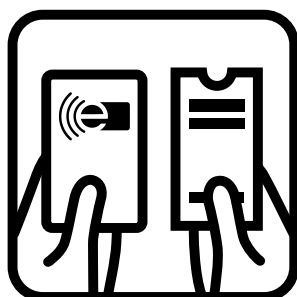
The VRS, VRR and VGN public transport authorities in North Rhine–Westphalia were the first to implement the VDV Core Application on a large scale. In 2006, the 3 million smart cards already in circulation were replaced by new media which are compliant with the VDV Core Application standard, and the control terminals were fitted with the relevant core application interface. Cards were issued to customers with annual subscriptions. At the same time, it was decided to implement an electronic control system on all buses belonging to transport companies operating in the transport authorities.

Since the switch from individual paper tickets to electronic tickets is associated with high capital equipment costs, in future, transport operators will rely on using mobile phone networks and the Internet to provide cost-effective, mobile, point-of-sale terminals. This can easily be achieved via the

Figure 2 Logos and Pictograms of eTicket Germany



Logo of eTicket Germany with VDV Core Application



Pictogram for electronic payment (e-payment) system variant



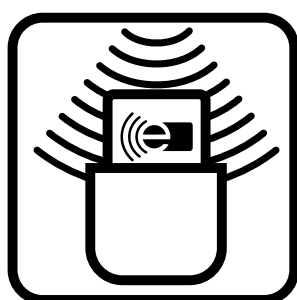
Pictogram for electronic ticket (eTicket) system variant



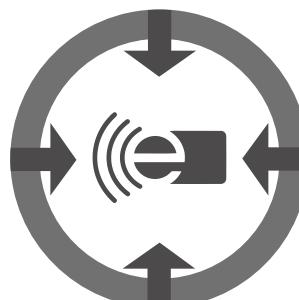
Pictogram for e-ticket with electronic access control (e-control) system variant



Pictogram for active check-in/check-out system variant

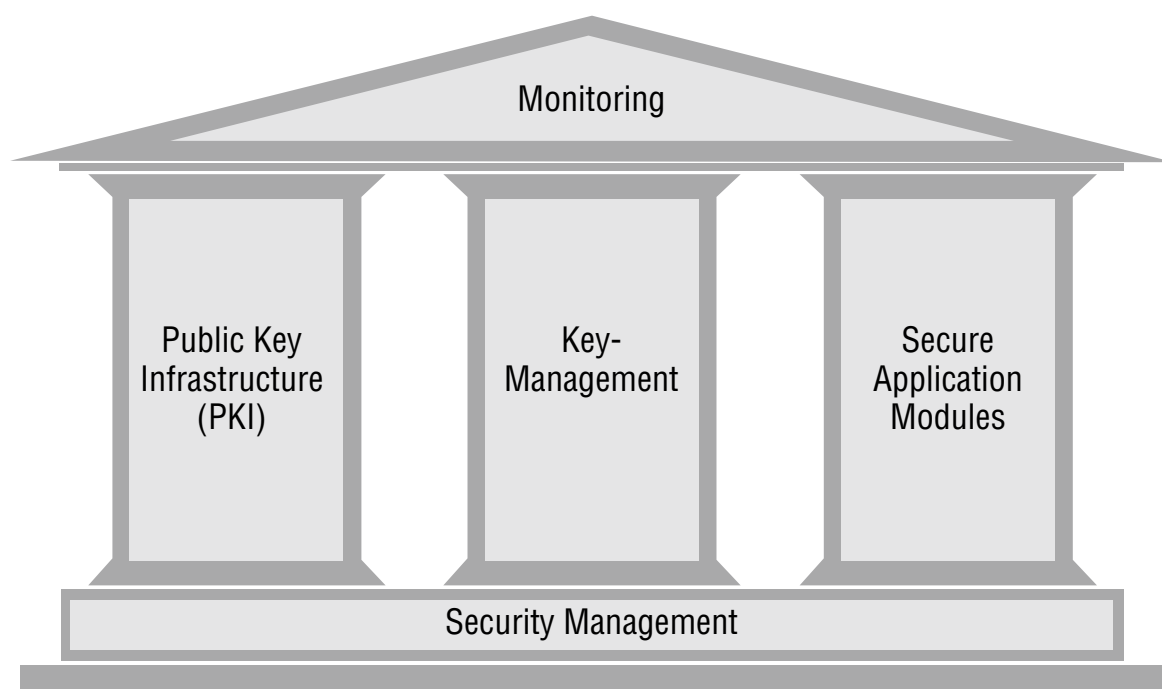


Pictogram for automatic ticket calculation (zone calculation) system variant



Symbol for monitoring area for media with VDV Core Application

Figure 3 Pillars of Security Management for VDV Core Application





CICO in Schwäbisch Hall

VDV Core Application, because it already specifies this option.

As early as 2005, immediately before completing work on the specifications, the first subscription smart cards with VDV Core Application were issued with the formation of a public transport authority in Saarland. At that time, all the central interoperability functions were not yet in place, so these cards are now being replaced by the latest versions.

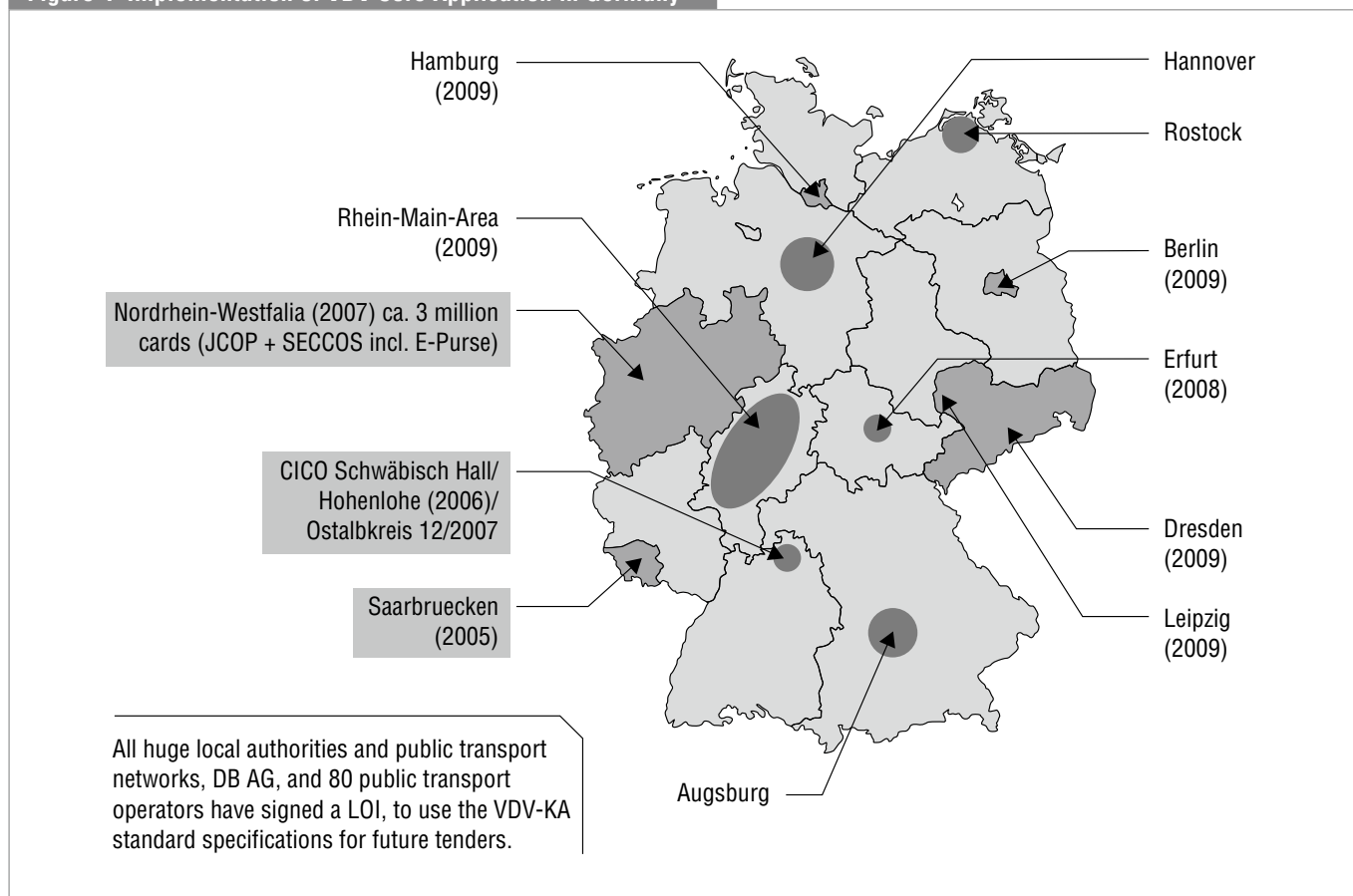
Since 2006, core application smart cards (known as KOLIBRICARD) have been issued to occasional users in the Schwäbisch Hall district, who appreciate the automated fare collection. Customers buy a smart card from the Kreisverkehr Schwäbisch Hall public transport authority, giving them an entitlement to use the system. They check-in and check-out at the CICO terminals at the beginning and end of their journey; the fare is calculated on the basis of usage information recorded in the control centre and deducted from the prepaid credit on their card. When the credit balance on the card reaches a defined minimum level, it is topped up automatically from the customer's bank account. Since 2007, occasional users in the neighbouring Hohenlohe public transport authority have also been issued with core application smart cards that can be used interoperably in

Schwäbisch Hall. All services used by customers in both authorities are priced in the control centres and charged to the customer by the transport authorities. Services are credited to the two networks on the basis of usage data recorded during the check-in/check-out transactions. The relevant customer contract partner (retailer) can verify from the level of entitlement on the user medium that this data has been generated authentically, thereby guaranteeing payment security.

In April 2008, the district of Ostalbkreis became the third public transport authority in the Stuttgart area to use the VDV Core Application with the introduction of the OstalbMobil fares cooperative. In future, OstalbMobil customers will be able to use their cards interoperably in vehicles belonging to the Kreisverkehr Schwäbisch Hall and the Hohenlohe public transport authorities. Similarly, their customers can use their smart cards in Ostalbkreis and will be invoiced for their travel by the retailer from whom they purchased the smart card. The set of rules will be used extensively for the first time in these three public transport authorities. The experience will be incorporated into existing core application contracts to benefit subsequent users.

Several transport operators and public transport

Figure 4 Implementation of VDV Core Application in Germany



authorities are introducing mobile-phone-based ticketing in a joint pilot study. The scheme offers a convenient mobile phone ticket suitable for all tariffs that includes timetabling information. Since secure NFC-based mobile phone devices are not currently available in sufficient numbers, the system is not yet based on the VDV Core Application and corresponding security system. However, further development of mobile phone ticketing is already clearly defined and there are plans to adopt the VDV Core Application standard in future. To achieve this, the VDV Core Application must be stored securely in the mobile phone. The current plan is to use a universal SIM card (USIM). This is linked to the ISO/IEC 14443 standardized near field interface (NFC) in mobile phones. Preliminary laboratory tests with a core application-compliant interface have already been conducted. As well as using mobile phones as a substitute for smart cards, many transport operators are also considering using mobile phones as active terminals at the NFC interface.

For example, in their Touch & Travel pilot scheme, DB AG is looking at whether costly active check-in terminals can be replaced by inexpensive passive RFID tags identifying the location for check-in transactions with the VDV Core Application. Location-based services of the



Touch point in Berlin

telecommunication provider will also be used to determine public transport usage. The Touch & Travel pilot will evaluate the technical solution and results from economic and organizational perspectives.

In the Rhine–Main public transport authority (RMV), RFID tags already support the customer; the passenger's mobile phone uses RFID tag information as the journey's starting point for purchasing the ticket, then the passenger selects the travel destination and purchases the appropriate ticket using the mobile phone.

To successfully install the VDV Core Application in the mobile phone, the chip card application must be downloaded to the secure storage (USIM) of the mobile phone according to a uniform standard. Amendments to the core application specification are currently being developed and these will further specify the RFID tags to be deployed to enable interoperability.

Multi-client enabled core application back-office systems are being developed in other projects that will allow smaller transport operators affordable access to the VDV Core Application by offering back-office services via a third party.

In parallel with this, VDV-Kernapplikation GmbH & Co. KG is continuing to collaborate with its European partners in the UK, France and the Netherlands to develop e-ticketing standards. In a joint EU project, options for migrating national systems are being investigated to enable customers to travel using an interoperable electronic medium throughout Europe. This represents the first step towards simple, seamless travel in greater Europe. Further steps to achieve these objectives are being stipulated and funded by the EU. ■

Further Reading:

Rechtliche und technische Rahmenbedingungen für ein interoperables Fahrgeldmanagement in Deutschland auf der Grundlage der VDV-Kernapplikation, VDV-Kernapplikations GmbH & Co. KG, based on abstract by R. A. Christian Walz and Dr Oliver Glück, GSK Gassner Stockmann & Kollegen, Munich, Cologne/Munich, August 2007

Die VDV-Kernapplikation, Dr.-Ing. Dipl.-Kfm. Till Ackermann, Cologne, *DER NAHVERKEHR*, April 2007

Das Sicherheitssystem der VDV core application–Hintergrund und Ziele, Dr. rer. nat. Joseph Lutgen, Cologne, *DER NAHVERKEHR*, May 2007

Einfach grenzenlos und grenzenlos einfach: die einheitliche Kundenschnittstelle der VDV-Kernapplikation, Dipl.-Ing. Elke Fischer, Berlin, *DER NAHVERKEHR*, June 2007

Die VDV-Kernapplikation: auf dem Weg in die praktische Umsetzung, Dipl.-Kfm. techn. Christophe Fondrier, Cologne, *DER NAHVERKEHR*, August 2007



Berthold Radermacher

Mr Berthold Radermacher has been head of the Section Standardisation, Research Coordination and Industry Contacts within VDV since 1999. He is also the convenor of the joint standardisation subgroup CEN TC 278 WG3 SG5 "Interoperable Fare Management Systems" and ISO TC 204 WG8. Prior to his current position, he worked as group leader and deputy development leader for an automotive component supplier and railway component supplier in the field of system and component design. He graduated from the University of Wuppertal with a masters degree as an electro-technical engineer specializing in automation.



Elke Fischer

Dr Elke Fischer is director of application management and certification at VDV-Kernapplikation GmbH & Co. KG. Previously, she worked as project manager at Transport East West Expert Team GmbH with responsibility for control and information technology and electronic fare management. She graduated from the Humboldt University of Berlin with a degree in electronics technology specializing in communication engineering. She then worked in software development in R&D projects for Deutsche Reichsbahn, and also as project manager for various consultancies in public transport.