Huawei GSM-R Accelerates Your Success

HUAWEI TECHNOLOGIES CO., LTD.

HUAWEI

GSM-R Overview

GSM-R (GSM for Railway) is a GSM-based rail communication system.

In 1993, in order to unify the rail communication technology for improving transportation efficiency, UIC (International Union of Railway) and various European railway companies decided to select GSM as the technological basis for their next generation mobile communication systems following a two-year feasibility study. The EIRENE (European Integrated Railway Radio Enhanced Network) specification has been finally frozen in 2000.

Compared with GSM, GSM-R possesses excellent extension capability, and introduces additonal ASCI (Advanced speech call item) services, including VGCS (Voice group call service), VBS (Voice broadcast service), eMLPP (Enhance multi-level priority preemption), as well as other railway features, including functional addressing, presentation of functional numbers, location dependent addressing, access matrix. Many railway applications can be realized on the GSM-R platform, including communication between dispatcher, driver, station controller, and maintenance staff, and communication between train and ground, as well as passenger service, shunting function. The relationship between railway application and GSM-R is shown in the Figure 1.

As an advanced radio solution, GSM-R acts as a bearer for ETCS (European Train Control System). The combination of GSM-R and ETCS solve the train safety problems at high speed, shorten the train interval, and improve the railway transport efficiency greatly.

GSM-R has following advantages:

- Open standard makes companies to enter this area easier and ensures the maturity and integrity of industry chain.
- Efforts from GSM-R IG (Industry Group) members bring stable products and success references, and make GSM-R much easier for you.
- Getting the low expenditure advantage from GSM industry, GSM-R is the most cost-effective rail communication technology, and develops continuously with the development of GSM technology.

The great success of GSM-R in Europe is attracting more and more countries to adopt GSM-R as rail communication technology. The statistics data shows that there are more than 30 countries has selected GSM-R solution according to the final specification. More and more GSM-R networks are deployed in Europe , Asia , North Africa, etc.

However, it is widely believed that railway control system will highly depend on radio communication system in the future. Meanwhile, the number of train and train speed keep increasing. How to enhance railway safety and promote frequency resource efficiency will be the top 2 critical challenges. Based on excellent interoperability, Huawei GSM-R solution focuses on improving system reliability and high speed performance. And it doubles the network coverage and provides unique fast handover algorithm. Huawei is the first one having finished GSM-R testing and verfication at a high speed of 430 km/h.

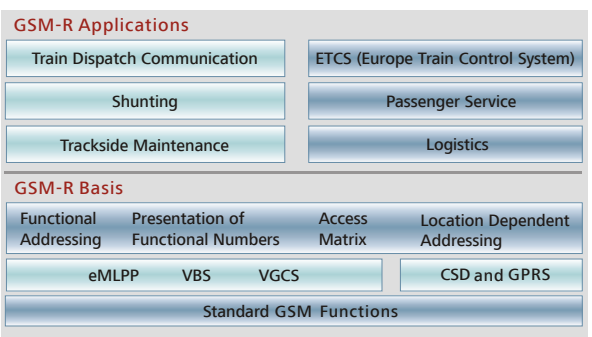

Figure 1: GSM-R Application Layers

Step into Huawei GSM-R

Since 1998 when Huawei began the GSM-R technology research and product development, Huawei has been one of the most important GSM-R suppliers in rail communication market. To improve the network performance, we are endeavoring to provide stat-of-the-art GSM-R network products and solution based on the latest mature GSM technologies including softswtich and All-IP BSC. Furthermore, we also can provides a series of optical network and data-communication network products, which have been widely applied in over 100 countries.

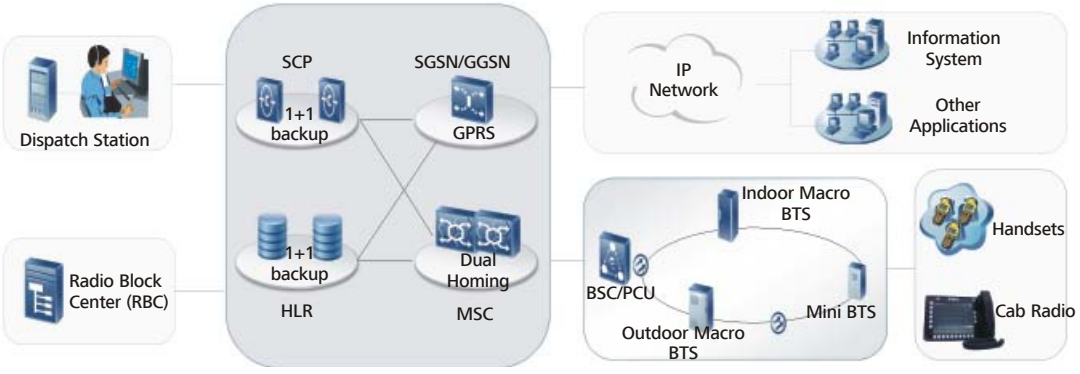

Figure 2: GSM-R Network Infrastructure

Features of Huawei GSM-R Solution

≫ Standard

The GSM-R is a part of 3GPP of rail communication specifications, and its products are designed to meet all function and service requirments defined by EIRENE. Meanwhile, Huawei is participating in the GSM-R standard work actively, and shares the research result with all the companies regarding this field.

≫ Reliable

Rail communication is important in the safety of rail transportation. In order to that, Huawei GSM-R solution improves reliability from two levels: equipment level and network level.

On the equipment level, 1+1 hot backup mode is applied to key hardware components, and software fault tolerance technologies is applied, such as failure isolation, flow control, task monitor, memory protection, and data verification.

On the network level, core network elements support node-backup in different cities, so that the impact of natural disaster on the rail communication will be reduced maximumly.

≫ Excellent Interoperability

All GSM-R products are open to have interoperability tests, and we have completed the IOT with SAGEM, KAPSCH, Siemens, ALSTOM etc. The IOT results show that our GSM-R network can work well with all the equipments of these vendors.

» Flexible

We can provide a series of base stations products and coverage solutions to meet different requirements of network constructions under various environments.

The complexity of railway environments and the construction of infrastructure make it difficult and expensive to find a tower, equipment room, etc. Huawei outdoor base station products can reduce the construction difficulty and investment, shorten the construction period.

Depending on Huawei base station product family, broader and more flexible coverage solution can be realized. For example, the cooperation of iSite mini-BTS and leakage cable can make effective coverage at special landform, such as mountainous area, tunnel, and ravine, etc. We also have abundant experience in network planning, and can provide flexible coverage solution for various landforms.

» Advanced Technologies

In order to increase the transport efficiency and shorten the travel time between cities, the train speed is contineously being enhanced and gets higher and higher. GSM-R network must consider the influence caused by high speed application, such as Doppler effect, and frequent cell change. AFC (Automatic Frequency Correction), fast handover, NACC (Network Assisted Cell Change) technology are used to improve the high speed performance.

It is well known that the investment of base stations and related infrastructure is the biggest portion of the total cost of GSM-R network. We apply multi-carrier enhanced interference calling and diversity technology to enhance the coverage performance, typically 20% improvement of coverage radius on the flat landform. The network cost will be reduced effectively by less number of base stations required.

In consideration of the complexity of electromagnetic environment around railway, ICC(Interference Counteract Combining) technology is adopted to improve the anti-interference capability.

Professional Solutions Match Railway Applications

Compared with public GSM communication network, the performance requirement of GSM-R is higher. For example, in order to guarantee the security of train running, the GSM-R network needs high reliability to ensure the signaling never interruption at the train's speed over 220 km/h .

Normally most parts of a railway are located in the mountain area or somewhere far from the city, where there is no equipment room, high or low temperature, and arduous landform, etc. So the landform of coverage range of GSM-R is so complex that it is very difficult to build the wireless network along the railway.

Focusing on the your challenges and requirements, Huawei dedicates to providing professional solution for railway special application requirements. For example high and reliability solution, high speed solution, fast network deployment solution, and special environment coverage solution.

High Reliability Solution

» Double Network Coverage Solution

GSM-R network can be affected by the natural conditions greatly as running in the challenging physical environments, Huawei applies Radio Access Network Redundant Backup Solution to guarantee the reliability and continuity of train dispatching communications.

There are two types of double network coverage, one is Co-site Coverage, and the other one is Overlap Coverage.

• Co-site Coverage

Co-site Coverage which means that two wireless networks coexist with the same site place and the same coverage range.

- Profits

Less BTS sites, same coverage for two levels simplify network plan, low cost.

- Application Scenarios

These places where are difficult to build new site, such as mountain area.

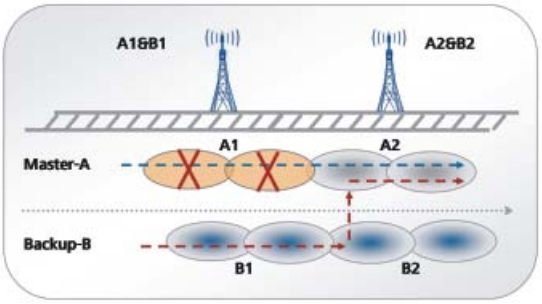

Figure 3: Co-site Coverage

• Overlap Coverage

Overlap Coverage which means that two radio networks use different site place to implement the interleaved coverage.

- Profits

More reliability and safety, the service will not be interrupted in case of single site or infrastructure (cabinet or iron tower) damage.

- Application Scenarios

The railway line needs high reliability and is easy to built new site, such as plain area.

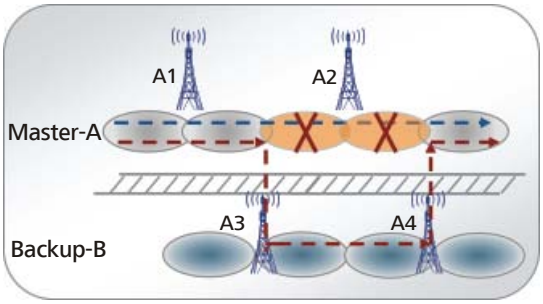

Figure 4: Overlap Coverage

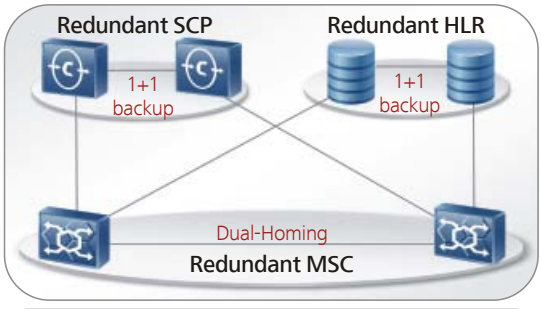

Figure 5: Redundancy and Backup Core Network

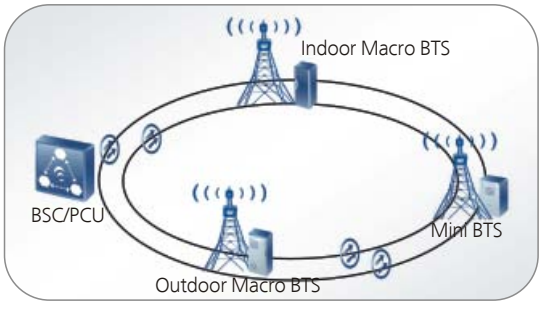

Figure 6: BSS Ring Solution

» Redundancy and Backup Core Network Solution

The GSM-R core network uses network-level reliability mechanisms such as dual-homing, Mini-Flex, HLR and SCP redundancy solutions to considerably enhance the reliability and availability of the telecommunication network.

- The dual-homing solution was initially put forward by Huawei, is used to guarantee network security and enhance MSC Server security. It offers two working modes: 1+1 active / standby and 1+1 mutual-aid.
- The Mini-Flex technology provides a concept of "pool" which contains several BSCs and CN network elements. Each BSC can be connected with several CN network elements (MSC / MSC Server + MGW / SGSN). If one CN node is faulty in the pool, the BSC re-allocates the faulty node's subscribers to another working node through a specific algorithm.
- To ensure the stability and reliability of operators' network, Huawei comes up with a complete set of HLR redundancy solutions, including 1+1 load share redundancy, 1+1 mated redundancy, N+1 mated redundancy, and N+1 compatibility redundancy.
- Huawei's IN provides three levels of disaster recovery, such as local data backup, remote data backup, and remote application switchover.

» BSS Ring Solution

- Support ring network composed of optical fiber or E1.
- In case of certain transmission line interruption, the BTSs can switch to the reverse ring automatically after the breakpoint.
- No service interruption during the these two ring networks switches, which fully safeguard the railway running.

Enhanced High Speed Solution

» AFC (Automatic Frequency Correction)

High speed movement cause radio signal frequency excursion by Doppler Effect. If the system doesn't adopt any method to prevent this influence, rail communications will be interrupted when speed is over 220 km/h.

In current railway industry, the speed of express line has reached 300 km/h or 350 km/h. Thus the traditional mobile communication system can't meet the railway requirements.

Huawei GSM-R applies the AFC technology to correct the Doppler frequency shift in high speed. Demodulation threshold of Doppler frequency shift can achieve 1000 Hz, corresponding to mobile station's speed against BTS can reach 500 km/h.

At the same time, by innovatively applying AFC in GPRS, Huawei GSM-R can support GPRS service in high speed situation.

This technology has been fully verified on Shanghai maglev with its peak speed at 430 km/h.

» Fast Handover Algorithms

When a mobile station passes from one site to another, it will implement the handover operation and change the radio resource connection from one BTS to another. So it will take some time to complete these actions.

In express high railway, the train quickly passes site one-by-one. The traditional mobile telecommunication system would not complete the handover process if only using the traditional handover algorithms, because the train has no enough time to change the radio connection to the new BTS when passing the previous site.

The fast handover algorithms are designed to meet the railway requirements, which ensure timely and reliable handover in high speed.

- Develop frequency shift handover algorithm, which based on moving direction against BTS derived from frequency shift to avoid wrong handover.
- Develop fast PBGT (Power Budget) handover algorithm to ensure the handover to better cell within a short time.

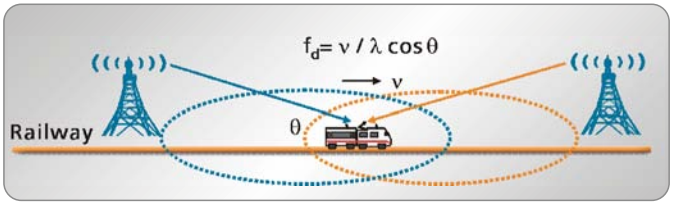

Figure 7: Fast Handover

» Fast Cell Re-selection in Group Call Receive Mode

The current cell re-selection interrupt time of 2 seconds is fairly long according to 3GPP protocol. It can not meet the requirement of high speed railway application.

Huawei optimized this solution after analysis and practical test.

- With the optimized solution, the cell re-selection interrupt time less than 250 ms.

Fast Network Deployment Solution

We provide BTS product family to meet GSM-R network construction requirements in different railway environment.

In railway stations or some places need large network capacity, it can be used indoor or outdoor Marco BTS to deploy the network.

Normally the large part of a railway is located on the mountain area or somewhere far from the city, where there is no equipment room, too high or too low temperature, heavy dust, and arduous landform etc. It is very difficult to build the wireless network along the railway with traditional indoor or outdoor BTS.

Fortunately, Huawei's mini-BTS product must be an ideal solution to solve these problems. It can be installed at anywhere and in any condition to deploy the network.

Huawei iSite mini-BTS is introduced to overcome these difficulties and consequently to fast deploy a GSM-R network along the railway.

With innovative development, Huawei iSite mini-BTS's features are as follows:

- IP 55 high protection grade.
- All-weather Design, no need air-conditioner, room and tower.
- All-in-one design, embedded SDH interface, power adapter.

Railway station

Along the railway

Special Environment Coverage Solution

The coverage of special environments such as tunnel and ravine is the key point of GSM-R networking, Huawei provides railway tunnel coverage solution based on features of radio signal transmission and equipment installation conditions for railway tunnels.

- Effective coverage for short tunnel, medium length tunnel and long distance tunnel
- Supporting various distributed system: antennae distributed system of the coaxial cable, distributed antenna system of the optical fiber and leakage cable.

Taking the tunnel coverage as an example, we provide you three solutions:

- Coverage by antenna for the tunnel with the length less than 400 meters.
- Splitter and leakage cable for the tunnel that is less than 1,000 meters.
- Optical repeater and leakage cable for the tunnel exceed 1,000 meters.

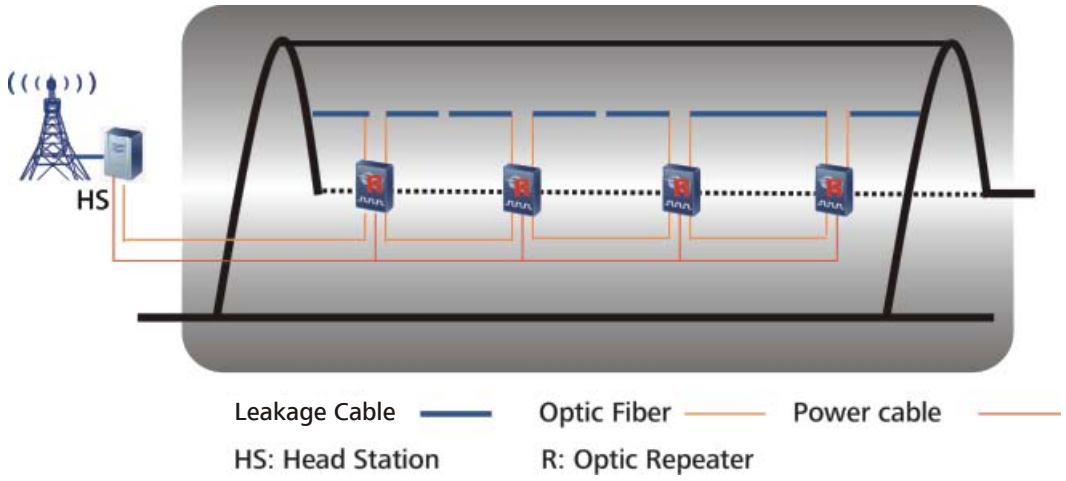

Figure 8: Tunnel Coverage Solution

GSM-R Testing and Verifying at a High Speed of 430 km/h

The maglev in Shanghai China is the first commercial maglev line in the world, with its total length of 36 km and max speed of 430 km/h.

In order to verify the technologies for high speed solution and the system performance, we built the GSM-R testing network along the railway of Shanghai maglev in 2005, and finished the test early in 2006. The test results on the Shanghai maglev of 430 km/h shows that Huawei GSM-R system can fully meet the mobile communication requirements in high speed movement.

» Technologies Developed for High Speed:

- Enhanced built-in AFC technology.
- Fast handover algorithms.
- NACC, packet SI status.

» Test Results:

- Excellent voice quality.
- Handover success rate > 99.8%.
- Radio connection loss rate < 0.3%.
- QoS of CSD satisfy EIRENE standard.
- Cell reselection interrupt period in group receive mode < 250 ms.
- GPRS cell reselection interrupt period < 1 second, Average transfer rate > 30 kbps.

The First Commercial GSM-R Application over GPRS in the World

» Project Information

The first commercial GSM-R railway of China is Daqin line,of which GSM-R network is deployed by Huawei.

Daqin railway is the most important coal transport line in China, from Datong city of Shanxi Province to Qinhuangdao city of Hebei Province with its total length of 670 km.

Huawei won the contract in December 2003. It took less than one year to complete the whole construction.The GSM-R services were commercially launched in Daqin railway in June 2005. The transport capacity is improved by 40% after launching GSM-R, it increased up to 250 million tons in 2006.

The project environment of Daqin line is extremely complicated. Firstly, as far as the landform is concerned, there are 60% mountainous regions, 40% plains and hills, and near 60 tunnels (The total length is 48 km, The longest one is 8.4 km). At the same time, there is heavy coal dusty along the railway, and there is a wide temperature from -30 ˚C to +40 ˚C.

The network capacity is 5,000 subscribers, 1,000 GPRS subscribers, 2 BSC, 106+101 BTS and 252+189 Transceivers (double radio network coverage).

» The Network Structure of Daqin Railway's ICS

The network structure of Daqin railway's ICS (integrated communication system) is shown in Figure 9.

The ICS of Daqin railway involves the following components:

- GSM-R network.

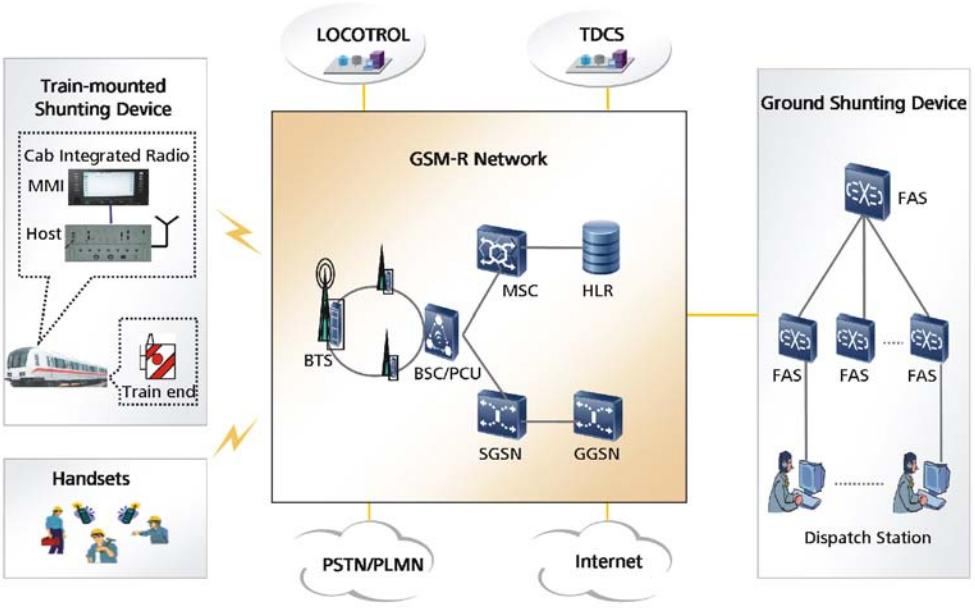

Figure 9: GSM-R Solution for Daqin Railway

- Ground shunting device: it includes the fix access system (FAS) network and dispatch station.
- LOCOTROL: Locomotive Control System of GE Company.
- TDCS: Train operation Dispatching Command System.
- Train-mounted radio device: it includes cab integrated radio and train end equipment.
- Handset: it includes the OPH and GPH handset.

» The Features of Daqin Railway's GSM-R System

MoR (Ministry of Railway) of China signed MoU (Memo of understand) with UIC in October 2004. The MoU had declared that China Railway would adopt EIRENE specification as the base of GSM-R system. The Daqin railway's GSM-R system deployed by Huawei fully comply with the EIRENE specification, which closely meet the MoU's requests.

In this project, we are in charge of providing end-to-end solutions, not only the GSM-R network, but also including integration of the cab radio, dispatcher system, and the FAS (Fix Access System) .

In Daqin railway, besides using the high security CSD service to transmit the shunting engine signal and monitor information, the another innovation is the railway dispatching command transmitted by GPRS. It is the first time that realizing transmit railway dispatching command, train pull-in forecast information, train number, train stop information, and train end information by GPRS in the world. It greatly improved the data transmit capacity by GSM-R network for railway.

Introduction to Huawei GSM-R Products

As a world leading telecom system equipment provider, Huawei provides you GSM-R solution based on fully verified products and advanced platforms. Also we are able to provide you end-to-end products including series optical network and data communication network products.

» Future Oriented MSC

Availability: >=99.999%

MTBF: >10 years

Softswitch architecture

High integration, 150,000 subs with 0.48 m2 footprint.

Modular design, smooth expansion

Trunk Interface type: IP/ATM/TDM

» BTS Product Family

Various capacities: 2/6/12 Transceivers per cabinet

Various output power for different coverage: 20 / 40 / 60 Watts

High receiving sensibility: -112dBm

Support tree-, chain-, star-, and ring networking

Flexible transmission modes: E1/T1, SDH, Microwave,Satellite

Low transmission requirements, Abis 15:1

» Series Optical Transmission Products

Optix Metro 100	1 STM-1
Optix Metro 500	6 * 6 VC4
Optix Metro 3000	128 * 128 VC4
Optix Metro 1000	26 * 26 VC4

One of the leading suppliers in the global optical market, Huawei optical solution offers a full set of NMS and four series products: DWDM, MSTP solution, intelligent optical transmission and SONET solution.

» Series Data Communication Products

Quidway NE05/08/16	Edge Router
Quidway NE20	Multi-service Switching Routers
Quidway NE40	Universal Switching Routers
Quidway NE80	Gigabit Core Router

Huawei is a leading end-to-end IP network and service solution provider ,and providing many kinds of data communication products including low and middle range routers, core routers, Multi-service Control Gateways (MSCGs), LAN Switches and network management systems.

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Version No.: M3-030030-20070205-C-1.0

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