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ERTMS – The Aims, Myths and Reality
A Railway Engineers Forum Analysis of the British Position

Introduction

The European Rail Traffic Management System (ERTMS) is being installed at an ever increasing pace across Europe. Many railways now have systems in operation on selected lines and more will follow. After many years of development, the technology has matured sufficiently so that the ultimate goal of a fully interoperable train control, communication and protection system throughout Europe can be foreseen with confidence.

Challenges remain before fully interoperable ERTMS operation can be guaranteed and not all of these are properly recognised. This statement from the Railway Engineers Forum sets out to identify these challenges both for those common to Europe and some which are peculiar to the UK. The Railway Engineers Forum (REF) is a multi-disciplinary liaison body comprising the rail interest groupings within the Professional Engineering Institutions. These are the Institution of Civil Engineers (ICE), the Institution of Engineering and Technology (IET), the Institution of Mechanical Engineers (IMechE), the Institution of Railway Operators (IRO), the Institution of Railway Signal Engineers (IRSE), the Railway Civil Engineers Association (RCEA) and the Permanent Way Institution (PWI). The REF provides informed engineering comment on railway issues both in response to government and transport industry proposals and to matters of more general concern

What is ERTMS?

A brief reminder is necessary as to what ERTMS is all about. It contains three basic elements:

1. ETCS (European Train Control System) – the 'signalling' element of the system and includes the control of movement authorities, automatic train protection and the interface to the interlockings
2. GSM-R (Global System for Mobiles – Railways) – the 'communication' element containing both a voice communication network between control rooms and trains, and a bearer path for the ETCS data
3. ETML (European Traffic Management Layer) – the operations management level intended to optimise train movements by the intelligent interpretation of timetable and train running data

Good progress has been made with ETCS and GSM-R but little work has been done on ETML. ERTMS tends to be the generic term used regardless of the actual element in question.

ERTMS also comes in 3 application 'levels'.

- Level 1 – little more than a harmonised ATP system overlaid on existing conventional signalling systems but built to EU standards as specified by the Control Command Signalling TSIs. Requires only a limited part of the ETCS element. It also permits non ETCS fitted trains to continue to run.
- Level 2 – a full train control and communication system using both ETCS and GSM-R. Retains existing train detection systems for positional information and can, where necessary, be overlaid on existing colour light signals. Uses radio for the delivery of movement instructions. Unless overlaid on conventional signalling, non ETCS trains cannot run

- Level 3 – a fully radio dependent version of Level 2 where most trackside signalling infrastructure can be removed and the functionality moved to either Radio Block Centres (RBCs) or the on board train equipment. Can also facilitate moving block signalling. Non fitted ETCS trains cannot run.

Levels 1 and 2 are commercially available and a variant of Level 3 is under development for regional use. Much work remains to be done before Level 3 is a reality for mixed traffic, densely used, main lines.

Beyond the three basic levels, other measures to improve train operating performance can be achieved without impacting on compatibility or functionality of the system. In Level 1, these measures provide in-fill data between signals to improve performance and in Level 2, optimising block lengths on the approach to junctions or stations can be obtained.

System Roll Out to date

Many ETCS Level 1 systems are in service at speeds up to 300kph. A number of Level 2 systems are now operational at similar speeds and more are being installed. A list of lines and levels is shown in the Appendix. In the UK, only the Cambrian line early deployment scheme is authorised but proposals exist to equip the GWML and ECML with Level 2 systems in due course. All lines covered by the EU Interoperability Directives will be equipped as and when they are upgraded or renewed, and the DfT has recently produced its plan for ERTMS deployment.

ERTMS as a Universal Train Control Reality

The vision of a pan European operation is within sight. So what are the remaining problems and are they significant.

- **Software development and backward compatibility**. The current software is in accordance with SRS 2.3.0. Railways who committed to earlier ERTMS versions are finding it expensive to upgrade their systems to the 2.3.0 version. Dutch Railways estimate it is costing €30M to convert their ERTMS project from v2.2.2. to v2.3.0. The cost of revalidating the safety case evidence has been significant and from this experience, it seems essential that there is a need to harmonise such evidence to ensure that ETRMS can be introduced elsewhere as efficiently as possible. The objective of interoperability is for trains to go anywhere without the need for country specific additions or a special safety case for each infrastructure. The logistics of updating the control centres and the train fleets in a short period of time will need to be carefully managed.

  Version 2.3.0 is an interim solution to improve compatibility of the existing schemes but without the full functionality of version 3.0.0, which is under development by the European Rail Agency. Some railways are stating however that they cannot achieve the required levels of capacity and performance before v3.0.0 is in place. The migration to this version will be more arduous as the number of control centres and equipped trains will have increased by then. However, this challenge will be managed by the concepts contained in the ERA System Version Management document. It will be logistically impossible to carry out a changeover within a 24 hour period, so new software must therefore be backward compatible with the old. The computer industry is well used to these challenges (e.g. Windows XP and Windows 98) but what does not exist in such scenarios is the control of safety related systems both on train and in infrastructure. The train control industry will therefore have to plan for ERTMS upgrades in a controlled and safe manner, such that train operations are not disrupted. The European Rail Agency (the System Authority for ETCS), in conjunction with suppliers, operators and

infrastructure managers, is developing the process for the management of forward and backward compatibility control including software version management.

- **Interoperability between Suppliers.** There is considerable evidence that in the past, signalling suppliers have worked closely with railway authorities to design systems tailored to national requirements and this has sometimes resulted in a single source of supply. To achieve interoperability, this is not possible, but the culture remains. This situation is of course not unique to railways and will always happen unless and until there is a standard agreed specification that cannot be interpreted differently by different entities.

  ERTMS development must cut across these historic problems. The interoperability requirement is for on board equipment supplied by any manufacturer to be capable of working with lineside systems supplied by any other manufacturer. This will be achieved by having the systems built up with interoperable components, each of which will be made to standard interface and performance specifications, akin to USB 'plug and play' in the everyday home computer. It sounds simple in theory, but the practical realisation is proving to be a real challenge. The requirements are:

  - all equipment to be at a compatible software level
  - all equipment to interface into line plant, on air radio standards, power supplies and other ERTMS elements with compatible components
  - a reduction (to zero) in the number of 'national' requirements in each member state
  - equipment not programmed with 'national facilities' must still be capable of working to the international ERTMS standards after crossing an international border
  - a robust test regime and facility must be in place to prove that a piece of ERTMS equipment has the required functionality to achieve interoperability
  - reduced diversity of interpretation of the specifications
  - a reduction (to zero) in the diversity of operational rules

  The 'Unisig' groups of suppliers know what has to be done and equipment is now being delivered that meets the interoperability requirements. Because 'Interchangeability' was not specified within the interoperability specification at the sub system or component levels, parts from different manufacturers cannot be interchanged,. However, train operators, both in the Britain and mainland Europe have an objective to make interchangeability possible at these interoperability constituent levels. Much work needs to be done before this objective can be realised.

- **Interoperability and Supplier Independence, Infrastructure and Rolling Stock**

  Traditionally, a signalling project is predominantly infrastructure based and is supplied by a single main signalling contractor. With ERTMS, the safety responsibility for train and infrastructure is separated and train operators (including the new open access operators) may want to run over several 'infrastructures'. Thus the on board train equipment will be procured separately by the train builders or owners. The train operators and maintainers are responsible in law for the performance and safety of the entire train technology. Train control and radio equipment are therefore no different to the pantograph, electric motor, diesel engine or wheels. This reinforces the need for guaranteed interoperability as it will be almost certain that the ERTMS infrastructure and train borne equipment will be from different suppliers. The process for proving interoperability between infrastructure and train equipment will have to be robust enough to ensure compatibility before the train enters the ERTMS section. Whilst this is no easy task, important lessons have been learned and it has proved to be achievable in both Spain and Switzerland where train borne equipment from different suppliers work in daily service with several suppliers' infrastructure.

- **The ERTMS 'Key' Verification System**

  There are a number of 'open points' in the current interoperability specifications, nearly all of which relate to the original specifications envisaging a 'system boundary' around each country, managed by one entity. One such point is 'key management'.

  Users of mobile phones are well acquainted with the SIM card system. This contains the identity of the phone, the service provider, the tariff arrangement and the services that can be accessed. Before a phone is used it must be 'registered' with the MSC (Mobile Control) in the country/area concerned. Each mobile phone also has a hardware identity number that is transmitted to the service provider every time the mobile is switched on. Rogue or stolen mobiles with an invalid SIM card can thus be traced and will be barred from use. Something akin to this is required for GSM-R and ETCS fitted trains and the 'Key' system has been invented. The basic requirements are:-

  - To identify the train type and its characteristics: loading gauge, braking performance, permitted speed, etc
  - that the train is fitted with ETCS and GSM-R
  - that these are compatible with the approaching infrastructure
  - that the train description and radio number are valid
  - the software/firmware of the equipment is compatible
  - that movement instructions sent by the interlocking can be correctly and safely interpreted by the train
  - the train routing details are recognised

  The GSM-R radios installed in train cabs and used for voice communication purposes, will have a numbering system derived from the public GSM networks. This will embrace an international number as defined in European specifications. Also included is a facility to establish the important correlation between train running number (description) and train stock number. GSM-R radios will be able to roam on to public networks if the necessary agreements are in place.

  When GSM-R is used as a bearer for ETCS, an additional radio is provided and contains a SIM card as before. This radio controls the communication to and from the ETCS equipment but not the security of the movement authority information. The radio links into the EVC train borne equipment including the Euroradio unit. The train description for the journey together with train type and characteristics have to be identified to this unit so that secure messages can be transmitted to and from the Radio Block Centre as part of the line control and interlocking system.

  To prevent movement authorities being sent to the wrong train, ETCS needs an equivalent process to GSM-R but implemented in a safety critical manner. To do this, cryptographic 'Keys' have been devised. These achieve;
  - a mechanism to safely load information to each EVC and to update it periodically
  - a mechanism to safely load information to each RBC that will control a train during its journey

  This requires a process to store and maintain all current EVC 'Keys' in each RBC in a country and to send authorised 'Keys' to RBCs in other countries on demand for when a train crosses a border. Currently international protocols to achieve this are not in place and are not yet in the ETCS specifications. This is a significant omission. ERTMS schemes to date have required suppliers develop pragmatic solutions that meet immediate needs and functionality. No one supplier can however unilaterally develop an interoperable solution. To do this requires a solution that:

- defines and incorporates procedures to register newly fitted rolling stock on its home network (similar to SIM registration)
- produces a register of 'Key Servers' on each network that can be linked into other networks
- allows 'Keys' to be independent of driver or signaller intervention except on rare occasions when trains arrive at a border and have the EVC Key rejected

Up until recently, all ERTMS Level 2 applications have involved dedicated lines and/or captive fleets, where 'key' control was self contained. With the opening of international corridors, the first of which is the Betuweroute in Holland, the prospect of international trains arriving with SIM cards and 'keys' from many infrastructure managers has highlighted the urgent need for a European solution to be contained within version 3.0.0.

- **Braking Curves**

  Another 'open point' is the question of braking curves. Although a common algorithm is used by the on board system to calculate the allowable speed profile, different countries have different methods of calculating the input parameters, in particular the values and distribution of safety margins. Again, a single European solution is required and will be contained within v 3.0.0.

The British Realisation of ERTMS

The challenges listed so far are international and will require international solutions. With the first scheme now underway in Britain together with proposals for ongoing main line roll out, further national challenges are emerging.

- **Cost of Fitting Rolling Stock** – Fitting rolling stock with new equipment is always expensive. ERTMS is no exception and it is an international challenge to get costs down. In Britain it is a particular problem as (i) the rolling stock is generally all quite new, and, (ii) many of the cabs are much smaller that continental equivalents.

  An international study in 2006 showed train costs in Europe to be:

  - Train Equipment cost per cab £50k
  - Fitting cost per cab for new train £35k
  - Retro fitting existing train per cab up to £200k

  These numbers may be higher in Britain. Indirect costs, such as the charges for leasing alternative trains, are also significant if the train has to be specially taken out of service for fitting.

  The policy advocated by the REF is therefore:

  - all new build trains to be fitted with ETCS and GSM-R in the factory
  - provision for ETCS and GSM-R in existing trains to be done during rolling stock major overhauls, preferably with equipment being fitted as well. An alternative to this would be breaking the task down into several small stages that can be done during normal maintenance
  - rolling stock manufacturers/maintainers/operators to be given the freedom to choose the most suitable train equipment. The balance between space envelopes in different train types and the need for a common driver interface in a train company fleet will need to be struck. Commonality of maintenance regimes will also need to be considered.

- **Cost of Fitting Lineside Equipment** – The cost benefit analysis conducted by the National ERTMS Project team in 2006 concluded that ERTMS was significantly cheaper than conventional signalling and that therefore ERTMS would be the system of choice for the future. Additional benefits, such as improved capacity, would be a bonus. The costs will vary depending upon whether systems such as interlockings can be economically life extended to work with ETCS. Some such equipment will inevitably be near the end of its working life, whence renewal will be required. Other equipment will not be ETCS compatible and replacement will also have to happen. Implementation must be planned in sensible stages according to the needs of the route and the desired migration. It may also be possible to pre-fit ETCS equipment in parallel with conventional signalling, for commissioning at a later date.

- **The Cambrian Early Deployment Scheme** – the decision by Network Rail and the ERTMS project team to have an ERTMS trial is welcome. Choosing the Cambrian has the added benefit of providing a modern day replacement for the RETB system now 25 years old. The trial will provide useful data on

  - how British operating rules will adapt to cab signalling and ERTMS
  - which operating rules will need to be changed / developed
  - the precise radio coverage required for assured ETCS operation
  - the suitability of industry designed man machine interfaces both in the control centre and in the cab
  - the ease or otherwise of retrofitting rolling stock
  - the challenge of managing the process under each Duty Holder's approved Safety Management System

  Many of these factors will already have been resolved in continental Europe and it is up to the UK bodies (DfT Rail, ORR, Network Rail, TOC's etc) to take advantage of what has gone before by using the processes within the Interoperability Directives. Cross acceptance of proven equipment should also feature.

  What the Cambrian trial will not do is test the operating capacity of ERTMS. It is a sparsely trafficked line where capacity issues do not dominate beyond the management of a single line. Further test routes will be needed in this respect.

- **Is ERTMS being applied to the Right Routes?**

  The roll out plan for the UK hints at routes that might be equipped prior to the GWML and ECML. These were initially listed as: Peterborough-Ely–Norwich, Oxford–Evesham and replacing the other RETB lines. Other options are now being considered in line with emerging projects, e.g. Crossrail. Is this making the most of the opportunities? These lines are isolated geographic areas but where the train service pattern sees trains emanating from distant places e.g. Norwich-Liverpool. Rolling stock fitment will either mean large numbers of trains having to be equipped, or a captive fleet created with the consequence of operational restrictions.

  There is a case for the North Wales area being part of the plan; Chester–Holyhead and Wolverhampton–Chester are lines that still have traditional absolute block signalling. If equipped with ERTMS, they would be adjacent to the Cambrian trial and should yield economies of scale for rolling stock usage, spares, staff expertise, etc.

  Other secondary routes in remote places with life expired signalling may be attractive financially and would facilitate the fitting of trains in a gradual progression that allows steady introduction into service and usage familiarity.

Main line deployment will never be easy and the DfT rightly suggest 'shadow' schemes in advance of the full project. Oxford–Evesham partly fills this function for GWML, and Cornwall might be another contender. However, the main line roll out will involve some difficult decisions and options

- the overlay of ERTMS in parallel with existing signalling
- the fitting of large fleets of rolling stock at an early stage to enable through services to continue as now
- the creation of small captive fleets which are never easy to manage
- the temporary truncation of passenger services at the boundary points – Worcester, Oxford and Plymouth in the above examples

The railway's customers, many of whom would be forced to change trains, would not welcome the latter. It may also prevent the provision of services as specified under the franchise agreements. There will also be implications for crew training, rolling stock availability, station capacities and depot facilities.

It is noted that in SBB (Switzerland), a Level 1 system with limited supervision is being advocated to replace obsolete train protection systems (equivalent to British AWS and TPWS) on regional lines, where Level 2 fitment is difficult to justify because international traffic or high speed running does not occur. Such a system will involve full lineside fitment but only partial fitment on the trains and will allow rolling stock migration to be done at reduced cost, complexity and downtime. There would be little benefit in deploying such a system in Britain as the relatively modern TPWS achieves similar functionality, A limited level 1 system might be of use as a migration step should full deployment of ETCS be delayed and TPWS becomes obsolete in the meantime. However, moving direct to Level 2 cab signalling as renewals are required would seem to be the optimum approach.

The REF is concerned that these factors, whether they be operational, commercial or engineering, are not being fully understood. While some disruption to service provision may be inevitable in the short term, it will be necessary to assure the TOCs and their customers, that the effects of this will be kept to a minimum, and that significant long term benefits will be realised.

- **Cost Benefit Analysis**

The commonly held perception is that ERTMS (principally the ETCS and GSM-R elements) has a high first cost with an expensive on board installation element, but that in the longer term, the 'whole life' costs will be cheaper when compared to a current proprietary signalling system. The further assertion is made that with the advent of Level 3 technology, significant savings over conventional signalling systems are possible. How true is this perception? As always in these situations, finding a precise answer is not possible. So many factors will impact on the true cost. Key questions are:

- Would GSM-R radio be installed anyway to replace obsolete analogue systems
- If 'yes', are there incremental costs for additional coverage and capacity
- On the routes to be chosen, will the train fleet be completely fitted with ETCS and GSM-R
- If 'yes', can the traditional signalling be dispensed with
- If 'no', what work is necessary to make the two technologies work in harmony
- Does the train fleet have to be retro-fitted with ETCS and GSM-R
- If 'yes, can this be made to coincide with the trains' major overhaul schedules, or at least to break the work down into small stages achievable at normal maintenance intervals. Can more cost effective methods be found for fitting equipment to trains
- Are there Safety Case and other approval implications? Can the approval processes mandated in the Interoperability Directives and within UK Regulation be made to

work as intended so as to remove most of the safety bureaucracy that has beleaguered the introduction of new systems in the past
- What redundancy and degradation precautions have to be in place to meet operational availability targets, and what form will these take

There is also the delicate issue of how the management of both business and safety risk associated with signalling systems (currently solely with Network Rail) will evolve in the future. Network Rail will potentially lose much of its lineside infrastructure but the Train Operators pick up the cost and risk of more complex on train equipment. A formula to facilitate this change needs to be devised.

- **Ownership of ERTMS**

With infrastructure being split from train operations and ERTMS equipment being divided between the two, who will have overall responsibility for system management, control and performance? In Britain, whilst Network Rail is the dominant infrastructure owner, there are others, e.g. CTRL. Equally there are many Train Operators some of whom (EWS and Eurostar) will operate over different infrastructures. No one entity will have overall responsibility for ERTMS system management, control and performance. Each of the infrastructure owners and train companies will be responsible for their part of the system and to comply with European and national specifications that define the responsibilities at the interfaces. They all must co-operate under the watchful eye of HMRI and the other safety authorities to make the shared system work as a whole.

Since 2006, the European Rail Agency has been given the role of ERTMS System Authority. With the RSSB established in the role of controlling the mechanism for co-operation between Network Rail and the Train Companies, some experience of managing the contractual interfaces in a shared system has been gained. However, Britain might be well advised to seek out best practice from those vertically separated railways that already operate a full ATC/ATP system as to how the contractual divide is effectively managed. In the UK, the Network Code regime will need to be adapted to deal with ERTMS operation and performance. Track Access charges and penalties will need to be adjusted to reflect the performance risk that is being moved from the Infrastructure Manager to the Train Company and the reduction in cost that removal of fixed signals will bring.

The Next Few Years

There is little doubt that ERTMS will become the natural choice for future train control and communications system in many other parts of the world as well as Europe. The manufacturers are geared up to producing the equipment and there may be little alternative choice if a cab signalling system with full ATP is required. The successful resolution of the various issues described in this statement is important but the critical factor will be to ensure ERTMS is both affordable and that it provides real benefit to the train operators and their customers.

There will be continuing pressures to reduce deployment costs. Migration options that do not demand early investment in equipment that then lies dormant, will be sought. There will be increasing demand for cheaper forms of ERTMS for secondary lines and the Swiss and Swedes will lead the way on these. Equipment costs will be subject to competitive tendering and this should ensure that prices reflect the true cost of production plus the usual recovery of overheads and profit. More uncertain is the cost of gaining safety approval, which can be prohibitive if excessive zealousness is applied or if the principles of shared system management as detailed in the interoperability directives are ignored or overlaid. The cost of both equipment and approvals will become too onerous if national variations to the standard

products continue to be specified. The objective must be to eliminate such variations by closing the 'open points' in the European specifications and clarifying the interpretations. The process of using interoperability to facilitate cross acceptance of the products must become the norm and demands by any of the UK participants for changes to the standard product, thus requiring re-engineering and re-validation, must be comprehensively justified and rigorously challenged.

The rail interests of the professional institutions will do all in their power to promote the appropriate roll out of ERTMS. Infrastructure companies and train operators are encouraged to use the expertise available to further their own aspirations. In Britain, ERTMS represents a big culture change for a railway that currently has very little ATP. The migration of some train control functionality from infrastructure to trains will require a change of approach by both signalling and rolling stock engineers, also by the operators. The REF will be pleased to help in facilitating this culture change by encouraging better inter-action between the relevant Institutions in the provision of information, seminars, conferences, etc. In short, the REF is willing to be the catalyst in the UK for this to happen.

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Appendix – Lines Equipped with ERTMS as at end June 2007

Glossary of Acronyms

ATC	Automatic Train Control
ATP	Automatic Train Protection
DfT	Department for Transport
CTRL	Channel Tunnel Rail Link
ECML	East Coast Main Line
ERA	European Rail Agency
EVC	European Vital Computer
GWML	Great Western Main Line
ORR	Office of Rail Regulation
RBC	Radio Block Centre
RETB	Radio Electronic Token Block
SRS	System Requirement Specification
TOC	Train Operating Company

What is actually with (ERTMS)/ETCS in operation (mid-2007 = at the time of publication)?

in red = to be checked/confirmed; in orange: still not in service; in green = presently already in service

ETCS Level	Country	ETCS kms in service	from when?	kms % (of total network)	ETCS vehicles in service	from when?	vehicles % (from total fleet)	kinds of trains with ETCS	max speed (km/h)	wayside signals	Trains per day (2 dir. included)	special operation conditions	others; comments
Level 1	Austria	67	tbd	<3%	13	tbd	<2%	loco-hauled	160	X	tbd	no	should have been in service Q4-06; EBA qualification expected
	Hungary	170	Q3-06	~5%	17	Q3-06	<2%	loco-hauled	160	X	<20	no	
	Luxembourg	50	Q1-06	~20%	12	Q1-06	7%	EMUs and loco-hauled	160	X	~50	no	
	Korea	1st part of 700km	Q4-06	30%	100 (out of 413)	Q1-06	~50%	diesel (DMUs)	200	X	?	STMs for exisiting ATC and Japanese "mushrooms"	not really/fully ERTMS? is a safety case available?
	Spain (Zaragoza-Hu)	80	Q2-06	~2%	10	Q2-06	<2%	EMUS	160	X	6		
	Spain (Madrid-Le)	460	Q2-06	5%	16 vehicles (32 ends)	Q2-06 (Q4-06)	<3%	High-speed trains	250 (300)	X	30	Level 1 only until end 2007 when Level 2 will be operational	
	Spain (Lerida-Tarr)	120	Q4-06	3%	32	Q4-06		High-speed trains	300		10	Level 1 only until end 2007 when Level 2 will be operational	
	Spain (Cordoba-Málaga. 1st-Section)	90	end 07?	2%	?	end 07?		High-speed trains	250 (300)		?	Level 1 first	
	Taiwan	1100	Q2-05	first 10% (in Q2-05?)	500 (of 756+52)	Q3-05	first 33% (in Q2-05?)	DMUs, EMUs and loco-hauled including	130	Yes: 3100	to be precised	Tropical; Earthquake zone; Landslides.	33% local content is a mandatory contractual requirement. Total of 22 classes of vehicles. 14 types currently type approved
Level 2	Belgium	65	Q4-07	~2%	?	Q4-07	?	High-speed trains	300	NO	?	high-speed only	
	France	300	Q3-08	<2%	48 cabs	Q3-08	<1%	High-speed trains	320	NO	50	high-speed only	
	Germany	150	Q4-05	<1%	5	Q4-05	<<1%	loco-hauled	200	X	to be precised	200 km/h only for ETCS-equipped trains	
	Holland Betuwe Route	160	Q2-07	~2%	>50	Q2-07	to be precised	freigth trains (loco-hauled)	160	very few	?	high-speed only	
	Italy (Ro-Na)	216	Q4-05	~3%	27	Q4-05	2%	High-speed trains	300	NO	30	high-speed only	
	Italy (To-No)	75	Q1-06	~1%	(same as above)	Q1-06	(same as above)	High-speed trains	300	NO	10	high-speed only	
	Spain (Madrid-Le)	460	Q2-06	5%	16 vehicles (32 ends)	Q2-06 (Q4-06)	<3%	High-speed trains	250 (300)	X	30		
	Spain (Lerida-Tarr)	120	Q4-06	3%	32	Q4-06		High-speed trains	300	X	10		
	Switzerland (Mattstetten-Rothrist new line)	55	Q3-06	~2%	474 vehicles (518 ends)	Q3-06	30%	EMUs and loco-hauled	200	very few	270		
	Switzerland (Lötschberg basis	40	Q3-07	~2%	same vehicles as for "Matt-Ro"	Q3-07	30%	EMUs and loco-hauled	200	very few	80	up to 200 km/h only for ERTMS-equipped	