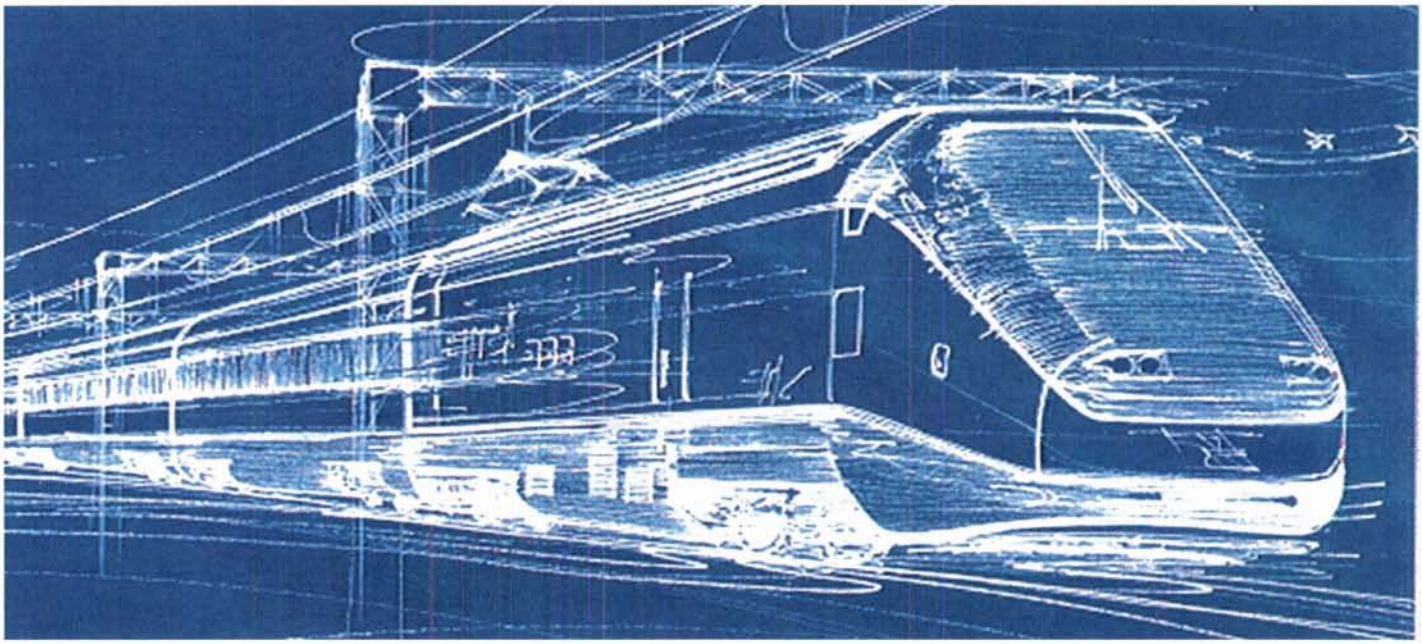

ERTMS Implementation Plan

Revision: 4
Date: 2009-06-15

Jernbaneverket

REVISION HISTORY

Rev.	Changes/Comments	Date
3	Document written in English, based on *Implementeringsplan for ERTMS*, rev. 4, date 2009-06-15, written in Norwegian.	2009-06-15

CONTENTS

1 Summary

Due to the high average age of its railway signalling systems, Jernbaneverket will in the near future face considerable challenges related to the renewal of these systems. The European requirements for interoperability and the introduction of the European standardised systems ERTMS/ETCS coincide timewise with Jernbaneverket's renewal needs.

This document is Jernbaneverket's ERTMS implementation plan for the Norwegian railway network. The plan is based on evaluations carried out in the development of Jernbaneverket's signalling strategy. The document describes the implementation order for the different lines in this network in the transition from conventional to ERTMS signalling solutions.

Jernbaneverket's choice of technological platform for future signalling and speed supervision is named "ERTMS Level 2 – system". It presupposes a "rolling stock strategy", i.e. ERTMS on-board equipments is installed in the relevant rolling stock before ERTMS infrastructure is placed into operation on a railway line. Furthermore, all ERTMS infrastructure associated with the defined railway line should be completely built before the line is placed in ERTMS operation. It is worth mentioning that this approach was used successfully when introducing the previous generation interlocking/signalling systems and speed supervision system, represented by NSI-63 and ATC (Ebicab 700) respectively.

The railway train companies will face considerable challenges in the migration period since the migration order for onboard equipment will to a large extent be determined by Jernbaneverket's implementation plan for infrastructure. Accordingly, it is essential that the plan is coordinated and agreed with the railway train companies and Statens jernbanetilsyn (the Norwegian Railway Inspectorate).

The onboard equipment will, like for the previous generation system called ATC, need to be considered part of Jernbaneverket's overall railway signalling system. It is essential that the distribution of responsibilities for safety and functionality, between the supplier, railway train companies, Jernbaneverket and Statens jernbanetilsyn, is agreed on in advance of migration and implementation.

The implementation plan recommends an implementation order by railway line for ERTMS infrastructure based on a balanced set of chosen input criteria.

The first railway line to be equipped with ERTMS infrastructure and placed into service in Norway shall be the pilot line. After an overall evaluation of potential railway lines in Norway that met the criteria, Østfoldbanen østre linje was selected to be the pilot line.

The pilot line will be put into operation in 2014. After a period of at least one year, but not more than three years, ERTMS should be put into operation on the first line given first priority in the implementation plan. A longer period than this might cause the loss of achieved competence.

On the infrastructure side, the costs for the implementation of ERTMS Level 2 – system are estimated to 13,4 billion NOK. The costs for the railway train companies and for Jernbaneverket in connecting with installation of ERTMS on-board equipment in s work machines are additional.

2 Introduction

2.1 Background

Jernbaneverket has previously produced a signalling strategy that recommends implementation of ERTMS Level 2 as a replacement of the current ATC-system, co-ordinated with the replacement of current interlocking systems with standardised systems.

Due to the high average age of its signalling systems, Jernbaneverket will in the near future face considerable challenges related to the renewal of these systems. The European requirements to interoperability coincide with Jernbaneverket's renewal needs.

Samtrafikkforskriften (Norwegian regulation for interoperability) and decision 2006/679/EC, regulation 26. October 2007 nr. 1194[1] (TSI-CCS), give clear restrictions on future choice of signalling systems. August 2005, JL (Jernbaneverket's management group) chose ERTMS Level 2 – system as the future technological platform for Jernbaneverket's signalling systems (JL-item 173/05). An outline of a draft ERTMS implementation plan was August 2005 sent to Statens jernbanetilsyn. 31. October 2007, JL agreed to a revised outline of the implementation plan (JL-item 230/06), and that it could be sent for hearing to the railway train companies. The deadline for comments was set to 15. January 2007.

In the current development of the European railway, EU legislation has so far not given any option for alternative technologies other that ERTMS/ETCS-compatible systems in the TEN (Trans European Network) for railway.

In the change directive 2004/50/EF to the directives 96/48/EF and 2001/16/EF it is assumed that TEN for railway eventually will encompass the whole national railway network in the EU/EEA-countries.

An outline of a draft ERTMS implementation plan was August 2005 sent to Statens jernbanetilsyn. Subsequently, Jernbaneverket has been working mainly with the following activities of importance to the further development of the implementation plan:

- Hearing on the signalling strategy at the railway train companies and personnel organisations
- Decision that the northern part of Nordlandsbanen will not be developed as a pilot line for ERTMS (JL-item 265/05)
- Establishment of a cooperative agreement with Banverket on a Nordic cooperation on the adaptation of ERTMS/ETCS onboard equipment
- Longevity analysis of ATC
- Economic uncertainty analysis
- Requirements specification of ERTMS Level 2 – system
- Capacity analysis
- Uncertainty analysis of ERTMS implementation plan

[1] Vedtak 2006/679/EF, forskrift 26. oktober 2007 nr. 1194 om gjennomføring av den tekniske spesifikasjonen for samtrafikkevnen for delsystemet "styring, kontroll og signal" i det transeuropeiske jernbanesystemet for konvensjonelle tog (TSI – styring, kontroll og signal)

2.2 Purpose

This document describes the realization of the migration strategy for ERTMS level 2 – system, and thereby recommends an order and time period for the implementation of the system.

Figure 1 shows the document structure for the signalling strategy and its relationship to the migration strategy and the implementation plan.

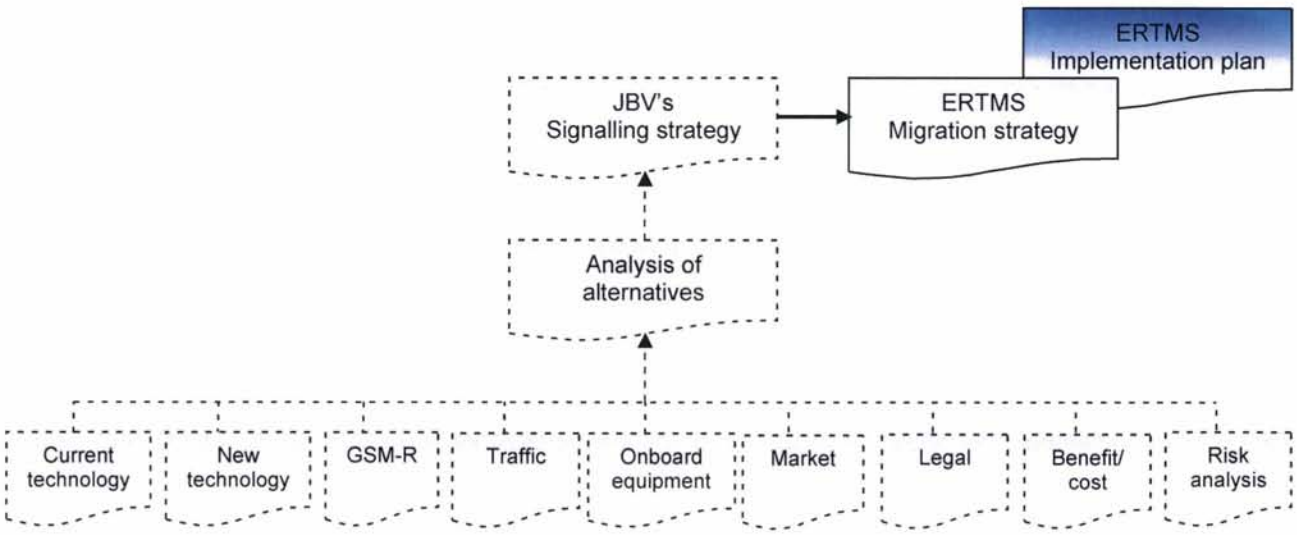

Figure 1 Document structure

3 Future situation with ERTMS/ETCS in Europe

3.1 European development

The basic principle underlying CR-TSI CCS is that the different countries employ a proactive implementation strategy that prevents the ERTMS implementation from being jeopardised by aging problems related to existing systems. It is however acknowledged that migration of signalling systems is complex. Apparently, the intention to co-ordinate the implementation for consecutive lines might conflict investments and priorities in the different countries. Of this reason, a certain number of projects (corridors) have been defined in order to co-ordinate the ERTMS implementation at an acceptable cost (EU funding => not EEA relevant). The objective of such an implementation strategy is threefold:

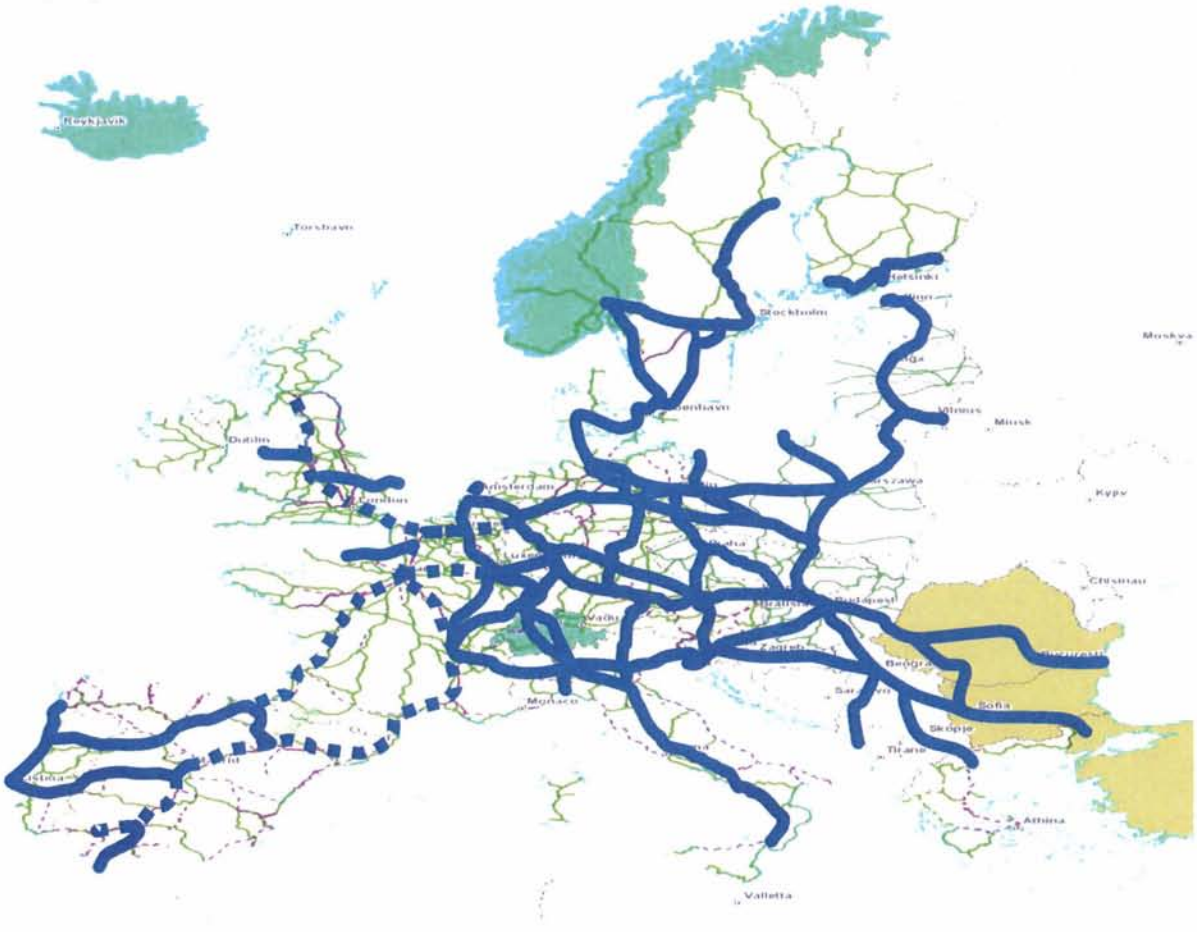

Figure 2 EU's prioritized ERTMS/ETCS corridors in Europe

- Establish a coherent interoperable railway network (ETCS-net, see Figure 2) in order to achieve an early improvement of the competitiveness of rail transport.
- Focus on a multilateral co-ordination that facilitates a well focused funding of a fast implementation (10 – 12 years) of ERTMS on European major lines.
- Satisfy the conditions for a so-called critical mass so that ERTMS becomes the natural choice both for new investments and for upgrades of signalling systems on the conventional railway network.

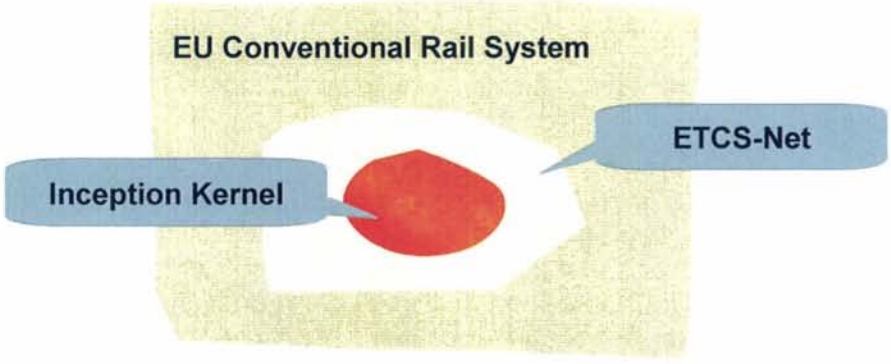

Figure 3 The principle of an ETCS-net with an inception kernel.

To reach the objective of a fast implementation on the ETCS-net, a subset of EU projects (6 highly prioritized corridors) have been defined where implementation of ERTMS is mandatory (defined as an inception kernel, see Figure 3). The inception kernel is established in order to have a stepping stone to full implementation of the ETCS-net, as defined above (Figure 4 shows the inception kernel with the 6 highly prioritized corridors).

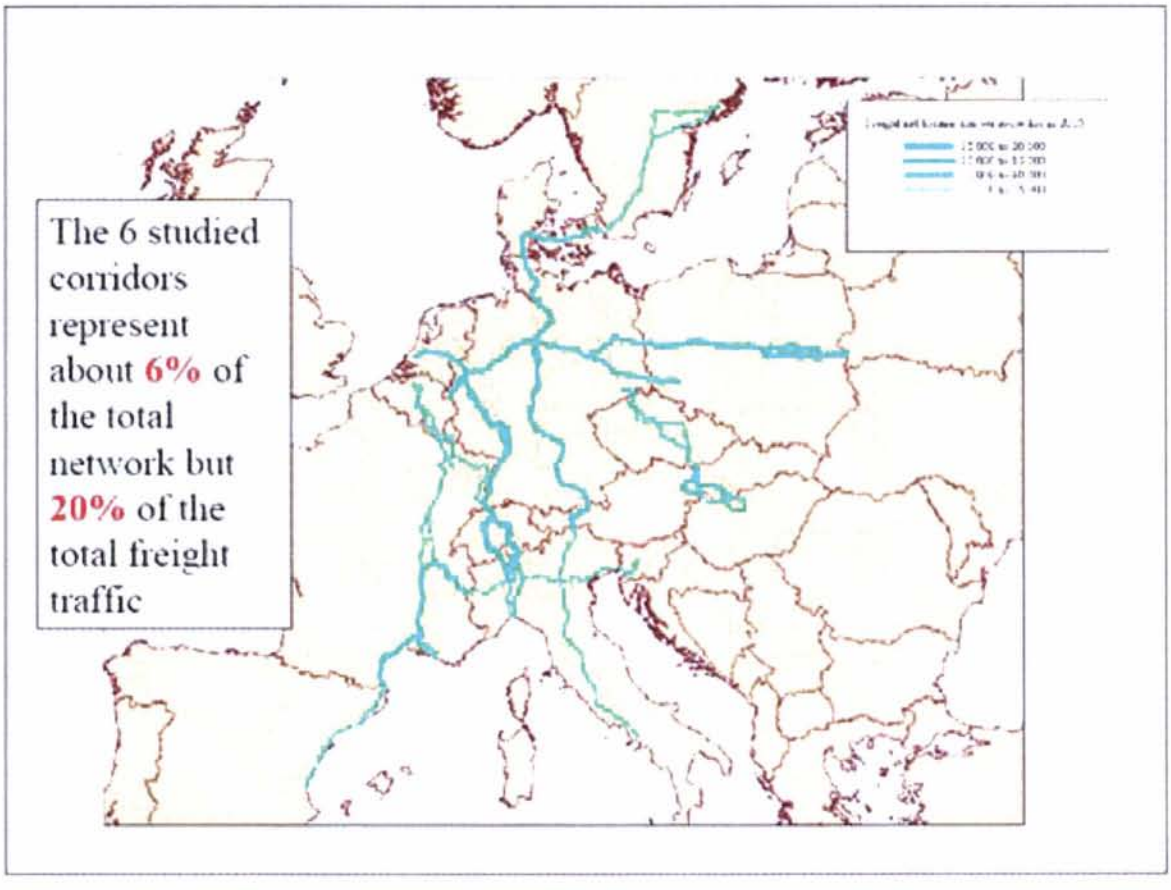

Figure 4 ERTMS/ETCS corridors – the inception kernel

The EU/EEA-countries are requested to produce ERTMS implementation plans at a national level. Within 2007, these plans are to be collected in an EU Master Plan for ERTMS implementation. In the longer term, this plan will constitute an annex to CT-TSI CCS and thereby become mandatory. The EU/EEA-countries will also be invited to adapt their national implementation plans to the EU Master Plan. The overall process is illustrated in figure 5.

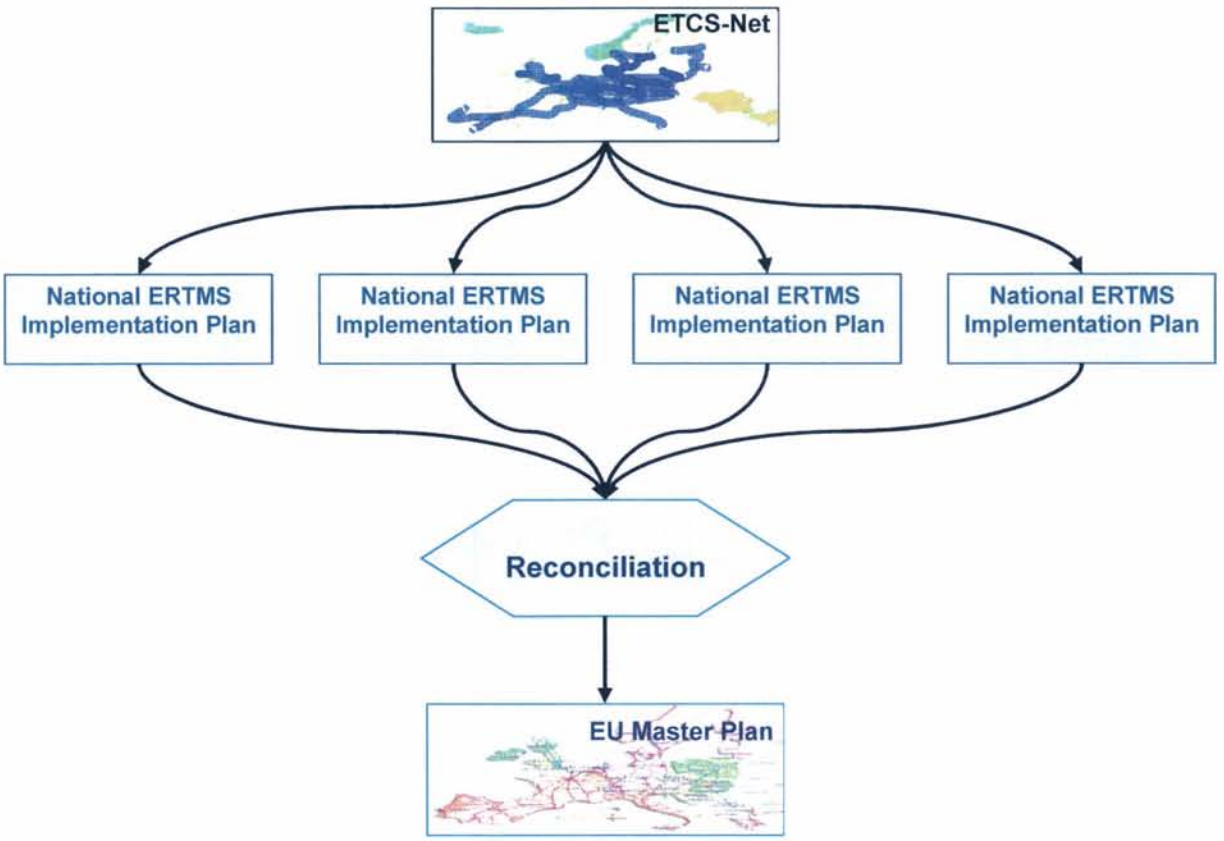

Figure 5 EU Master Plan for ERTMS implementation

3.2 Technical principle for ERTMS Level 2 – system

In this system (see
Figure **6**), the movement authorities and information about speed limits are transmitted directly to the trains through the GSM-R net. This means that the need for line side signals disappears, including the associated cabling and balises. ERTMS will also facilitate activation by the trains of other systems, such as level crossings. The movement authorities can be supervised together with the status of the level crossings to check that the road traffic is properly secured. This mechanism should give considerably cheaper solutions for securing level crossings, since the level crossings can be constructed without the usual cabling and train detection systems.

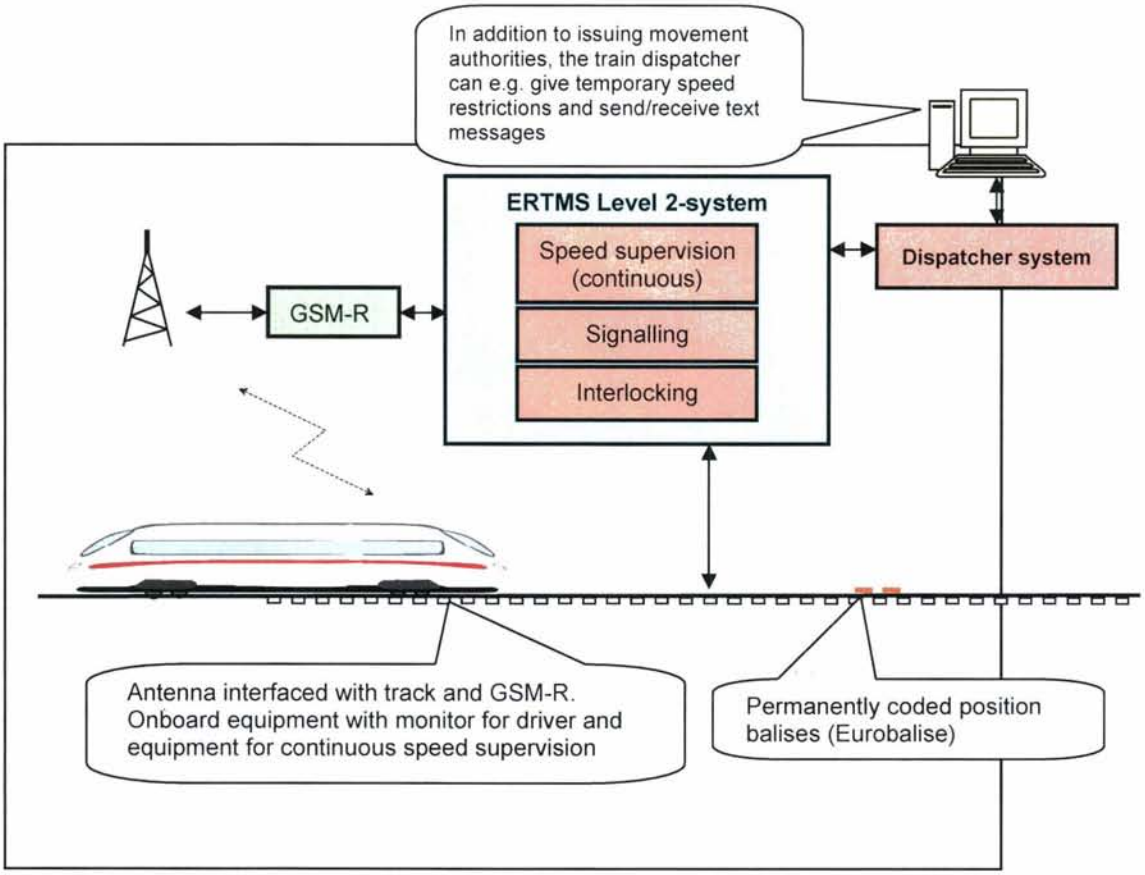

Figure 6 Technical principle

4 Overall migration strategy

This is a summary of Jernbaneverket's ERTMS migration strategy [3] which, concerning the signalling systems, describes the migration from the current situation to ERTMS level 2 – system. The migration strategy will in the near future be updated to fit the chosen implementation alternatives.

4.1 Rolling stock strategy

In the pre-study [1], the so-called rolling stock strategy was considered the most suitable migration strategy for Jernbaneverket. In principle, this implies that before a line is put into operation with ERTMS level 2 – system, the rolling stock planned to traffic the line need to have ERTMS installed on board. The reason for this is that when a line is put into operation with ERTMS, the ATC installations can be removed. For Jernbaneverket this is an important principle, since ATC will need to be renewed or replaced during a period lasting from 2015 to around 2030. ERTMS-equipped rolling stock which in the migration period also will traffic lines equipped with ATC, will in addition need to be equipped with an STM (Specific Transmission Module).

Jernbaneverket's rolling stock strategy was in reality decided with the establishment of the co-operative agreement with Banverket on the development of STM.

STM is a temporary solution, and does not extend the longevity of the current ATC system. STM will be phased out together with ATC.

Even if Sweden plans a massive replacement of ATC, it is not probable that Jernbaneverket can buy the Swedish ATC equipment and use this as a stock of spare equipment. In contrast to relays, ATC consists of discrete electronic components with poor storage capabilities. This means that the electronics experience aging on stock, even if they are not being used. An additional problem is the fact that the discrete components are removed from the market. It is not necessarily the case that these components can be replaced one-to-one by components that are offered on the market. A possible start-up of own production of this equipment would require a redesign of larger parts of the ATC-system.

The rolling stock strategy constrains the way the railway train companies will have to act in relation to the implementation of ERTMS on the Norwegian railway network. During 2008, a survey has been made regarding the consequences for rolling stock. The owners of the rolling stock have not reacted negatively to the strategy. It has however been pointed out that the necessary investments represent a challenge to the railway train companies, financially as well as logistically. Furthermore, it has been considered unsuitable to prolong the implementation period when it is first started, since this will require a duplicate set of rules for train regulation. This would be demanding e.g. in terms of training in, and maintenance of, safety related knowledge.

4.2 Line wise replacement of systems

The implementation of ERTMS level 2 – system demands the adoption of new operational rules, since optical trackside signals are being removed. Of this reason, and with respect to important safety and efficiency considerations, the implementation should be accomplished line by line.

Several regulations need to be revised in order to cover lines equipped with ERTMS, including the following (in Norwegian):

- Forskrift 4. desember 2001 nr. 1336 om signaler og skilt på statens jernbanenett og tilknyttede private spor (signalforskriften)

- Forskrift 4. desember 2001 nr. 1335 om trafikkstyring og togfremføring på statens jernbanenett og tilknyttede private spor (togframføringsforskriften)
- Forskrift 7. februar 2005 nr. 113 om krav til kompetanse og autorisasjon for førere av trekkraftkjøretøy på det nasjonale jernbanenettet.

When the implementation on a complete line has been finished, it will be possible to replace single systems belonging to the line. A line wise replacement of systems will possibly comprise interlockings for the individual stations, block posts, sidings, level crossing systems and avalanche warning systems. It is considered practical to let the lines be limited by border stations currently operated locally.

4.3 Migration speed

Concerning the needs of operational traffic regulation, the migration to ERTMS should be accomplished in a short time. Also the age profile of existing systems suggests the need for a rapid migration. These concerns will however have to be balanced against the economical possibilities for the railway train companies and Jernbaneverket.

The pilot line will be put into operation in 2014. The period from the completion of the pilot line to the start-up of normal implementation should last from one to three years. The limitation on three years is made with concern to the competence building made by Jernbaneverket, the railway train companies and the supplier during this period. With too long a period, useful competence will be lost and the next implementation will become less efficient.

5 Implementation of ERTMS Level 2 – system

5.1 Introduction

The implementation plan indicates a prioritisation of the different lines based on ranked selection criteria. At the same time it is acknowledged that upcoming needs might imply the need for changing some of the priorities. Particularly with a long migration period, uncertainties concerning the order of priority will increase as new conditions might influence this order until the end of the implementation period.

5.2 Pilot line

Transition to a new technological platform will have an impact on organisation and regulations both for the railway train companies and for the infrastructure manager. The first line equipped with ERTMS will generate important experience in these areas. Generating experience on technical functionality will however be less important for this kind of standardised European systems.

The following lines have been evaluated as a possible ERTMS pilot line:

- Østfoldbanen østre linje
- Raumabanen
- Vestfoldbanen and Gjøvikbanen have also been discussed initially, but these are not considered as particularly relevant

31. October 2006, Jernbaneverket selected (JL-item 230/06) Østfoldbanen østre linje as a pilot line for ERTMS.

The arguments supporting Østfoldbanen østre linje as a pilot line include:

- The traffic density on the line is low
- The line is electrified, which makes it possible to try out the equipment with respect to EMC (Electromagnetic compatibility), return current and earthing, etc.
- With ERTMS, Østfoldbanen østre linje will become remotely controlled
- The line has possibilities for diversion
- The line is connected to an important cross-border line that constitutes a natural part of the European ERTMS corridors
- The implementation of ERTMS on the line can be co-ordinated with the implementation on the rest of Østfoldbanen, including the new double track Oslo – Ski
- It should be possible to reduce the need for installation of ETCS onboard equipment in rolling stock, thereby minimising the expenditures for the railway train companies in an early phase

Raumabanen has many of the same properties as Østfoldbanen østre linje, but certain criteria suggest that Østfoldbanen yields more experience:

- In order to facilitate the generation of experience, it is sensible to stay geographically close to the system with which experience is to be collected. The majority of the resources that will be involved in the pilot project are located in Oslo. It is also likely that the company chosen as supplier already will be located in the area around Oslo, or will be located in this area. This gives efficiency and the best possibilities for generation of experience.
- Raumabanen is not electrified. It will be suitable to get necessary experiences also with respect to EMC (Electromagnetic compatibility), return current and earthing, etc.

At a European level, a solution called "ERTMS Regional" is being promoted. The solution is claimed to constitute a cost-effective solution suitable for low-traffic lines. It is possible that

Raumabanen is a good candidate for this solution. However, the experiences with this solution are as yet too limited to provide definite answers regarding its positive and negative effects. Currently, it therefore appears sensible to postpone the choice of solution of this type of lines until more knowledge has been established internationally.

5.3 Alternative implementation plans

Figure 7 shows the age profile of the interlockings and ATC on Norwegian lines in 2006. The overview shows average age on each line.

The implementation strategy employs the following selection criteria, ranked in order of expected importance:

1 – Average age of the interlockings/ATC
2 – Traffic across national borders
3 – Large existing development plans
4 – The line should be rebuilt for remote control or includes a number of locally operated stations

These criteria constitute the basis for the prioritisation of the lines shown in Table 1 below.

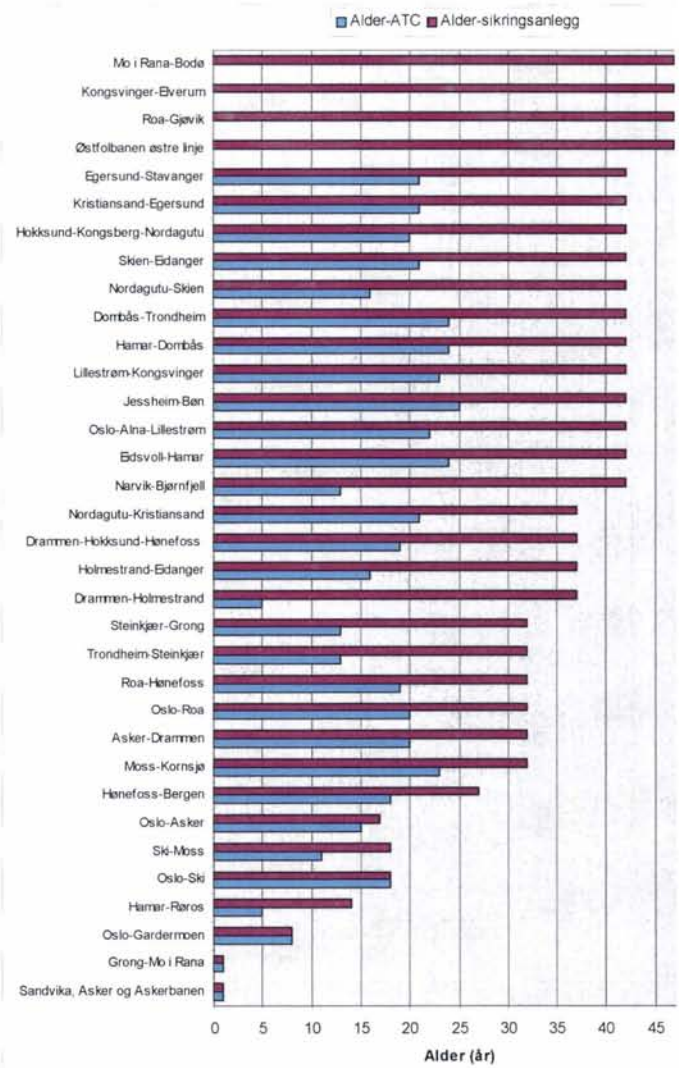

Figure 7 Age profile of ATC and interlocking

Detailed explanation to Table 1
The column "Migration of rolling stock" is not included in the evaluation basis, but gives a rough estimate of the current traffic density (high/medium/low) on the different lines, and is intended as a basis for railway train companies' assessment of the migration of rolling stock.

For the column "priority":
E Pilot line ("E" for experience)

x Interoperable solution will be decided at a later stage. Implementation of interoperability is co-ordinated in time with the associated main line. In principle, this is unproblematic since the line will not be associated to one of the lines with highest priority.

For the column "Cross-border traffic":
Yes Yes (coloured orange) does not mean national border, but indicate that operational needs make it suitable to start from a "border" and implement the line in the direction of Oslo. The reason for this is, as mentioned above, that ERTMS introduces new rules for traffic regulation. From a traffic viewpoint, it is considered more optimal to change operation modus only once instead of frequently shifting between different modes of operation.

For the column "Line number":
(x) The line numbers put in parentheses and written in red are smaller sidings, partly closed lines, or single elements on a main line where the renewal needs have not been determined.

The line numbers are included for completeness. In the overall, these lines are not relevant for implementation of ERTMS level 2 – system.

Line[2]	Line number	Corridor	Average age[3]	Cross-border traffic	Large development plans	FATC planned	Remote control needed	Priority	Migration of rolling stock
(Ski)-(Sarpsborg) Østre linje	580	1	45	Yes			Yes	E	L
(Oslo)-Ski	540,541	1	15	Yes	Yes	Yes		1	H
Ski-Moss	550	1	15	Yes				1	H
Moss-Kornsjø	560,570	1	30	Yes	Yes	Yes	Yes	1	M
(Oslo)-Alna-Lillestrøm	210,211,220,221,510 (20,30,40,240,250)	6	40	Yes				2	H
Lillestrøm-Charlottenberg gr.	300,310	6	40	Yes				2	M
(Drammen)-Larvik-(Nordagutu)	1510,1511,1820,1830 (1550,1560)	3	35		Yes	Yes	Yes	3	M
Asker-Drammen	1420,1421	3	30					4	M
Drammen-Hokksund-Hønefoss	1600,1610	3	35					4	M
Hokksund-Kongsberg-Nordagutu	1650,1660 (1700,1710)	3	40				Yes	4	M
(Nordagutu)-Kristiansand	2000,2120	3	35					4	L
(Kristiansand)-Stavanger	2130,2220	3	40	Yes	Yes	Yes		4	L
(Eidsvoll)-Hamar	700	6	40					5	M
(Hamar)-Dombås	710,720,721	6	40					5	M
Dombås-Trondheim	1100,1110,1111,1120 (1121)	6	40					5	L
Roa-Hønefoss	670	5	30					6	L
Hønefoss-Bergen	1680,2301,2310,2311, 2312,2320,2330,2340 (1630,2313, 2331, 2341,2342,2343, 2344)	5	25	Yes				6	L
Jessheim-Eidsvoll	230	6	40					6	M
(Oslo)-Gardermoen-Eidsvoll	270,280	6	6	Yes				6	H
(Oslo)-Roa	610,611,620	6	30					6	L
Oslo-area (GS system)	10,11,12,13	1	28		Yes		Yes	7	H
(Oslo)-Asker	1400,1401,1410,1411 (1450)	3	15					7	H
(Sandvika)-(Asker) Askerbanen	1414	3	1		Yes	Yes		7	H
(Asker)-Spikkestad	1460	3	1					7	L
Hell – Storlien gr.	1210	6	30	Yes				7	L
Hamar-Elverum-Røros	900,910,920,1000	6	12				Yes	8	L
Røros-Støren	1010,1011	6	45				Yes	8	L
Trondheim-Steinkjer	1200,1300 (1302,1130)	7	30					8	M
Steinkjer-Grong	1310	7	30					8	L
Grong-Mo i Rana	1320,1321,1330	7	1					8	L
Mo i Rana-Bodø	1340,1341,1350	7	0	Yes	Yes	Yes	Yes	8	L
Narvik-Bjørnfjell	2400	8	40	Yes				S[5]	L

[2] Place names in parentheses indicate that the location is not included in the line
[3] Most lines have both older and newer interlockings relative to the indicated average age
[4] CTC on Bergensbanen needs renewal
[5] To be co-ordinated with Sweden

Line[6]	Line number	Corridor	Average age[7]	Cross-border traffic	Large development plans	FATC planned	Remote control needed	Priority	Migration of rolling stock
(Kongsvinger)-(Elverum)	400	2	45				Yes	x	L
Hjuksebø – Notodden	1800	3	?	Yes	No		Yes	x	L
Nelaug - Arendal	2160	3	?	Yes	No		Yes	x	L
Roa-Gjøvik	630,640 (680)	6	45				Yes	x	L
(Dombås) - Åndalsnes	800	6	?	Yes	No		Yes	x	M
Grong - Namsos	1360	7	?	Yes	No		Yes	x	L

Table 1 Implementation basis for prioritation

The assessments above give a prioritisation in terms of corridors, depicted in the map below.

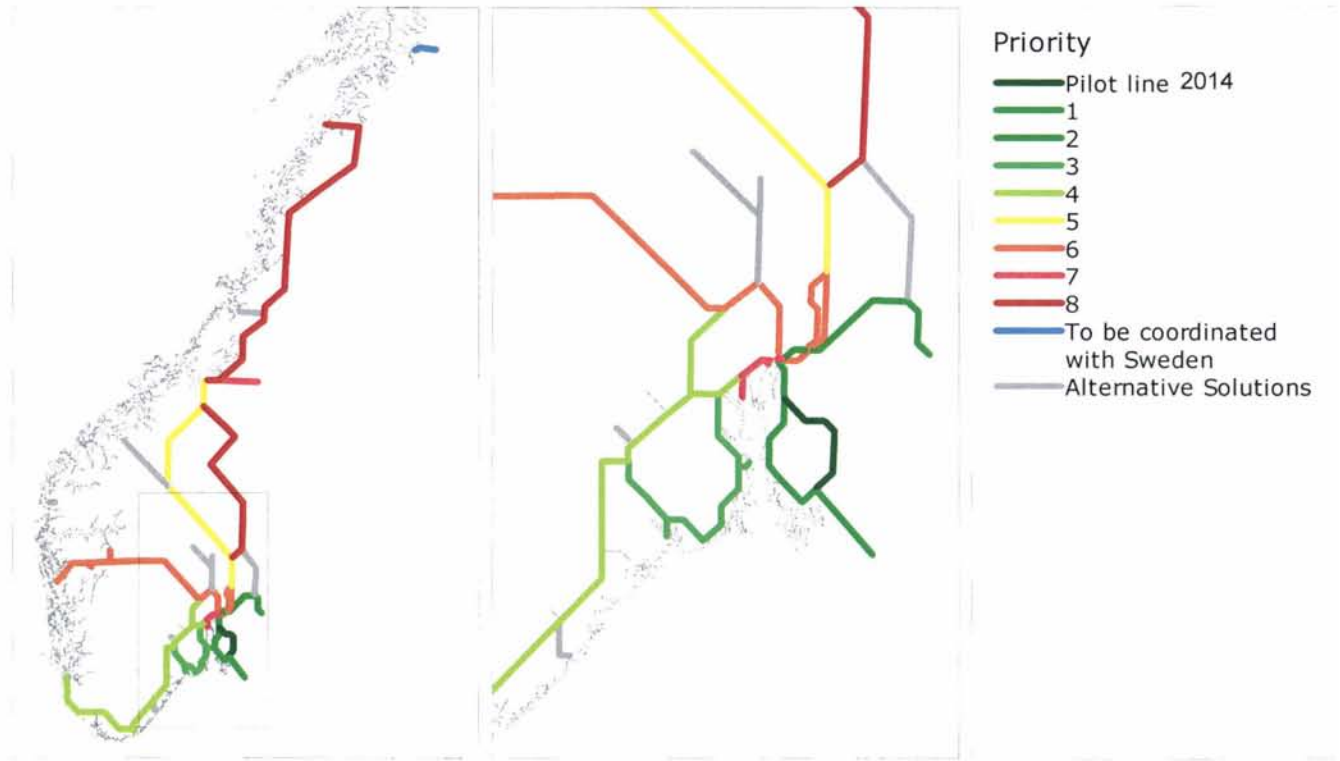

Figure 8 Prioritation of corridors

The pilot line is planned to be put into operation in 2014, followed by pilot operation/testing to 2015. At this point of time, ERTMS will already have been in use for up to 10 years on several lines in Europe. By way of example, Botniabanan in Sweden will have been in ordinary operation since 2010. Technology and functionality will expectedly satisfy the needs and be sufficiently stable for implementation in Norway. Because of the age profile of existing systems, the first line after the pilot line will be put into operation already around 2015.

[6] Place names in parentheses indicate that the location is not included in the line
[7] Most lines have both older and newer interlockings relative to the indicated average age

The indicated years for start of operation are outlined on basis of an implementation period of 15 years. Determination of the implementation order is important both with respect to project planning and for the railway train companies' needs for predictability. Currently, there is not enough evidence to claim that a longer implementation period will be feasible. Considering supply risk, the ATC-system can be compared to the train radio system Scanet.

The map below (Figure 9) shows the line wise development starting with the pilot line in 2014.

The implementation period is relatively long, with a corresponding high probability for changed conditions with respect to market and/or political situation. It is necessary to adapt to external influence and conditions that may have an impact on Jernbaneverket's process regarding the renewal of interlockings related to the implementation of ERTMS. The implementation plan will therefore be regularly reviewed, and if necessary revised, as part of Jernbaneverket's ordinary planning processes. Relevant planning processes in this context include National Transport Plan (NTP), the program of action for Jernbaneverket and annual revision of 10-years maintenance programs.

It is possible that the implementation plan will have to be adjusted to cope with the development of availability and safety of existing signalling systems. Of prime importance in the short term is to be prepared for a possible revision of plan if the availability or safety deteriorates.

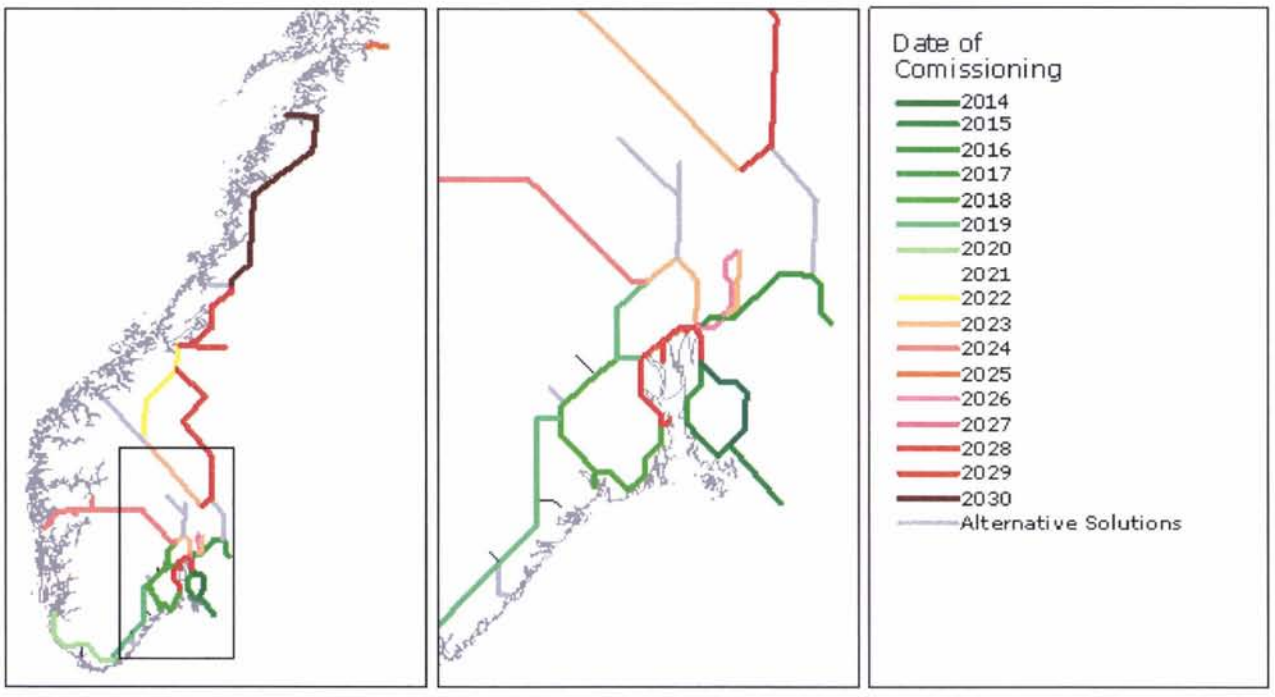

Figure 9 Linewise prioritation

At reading, it might be difficult to distinguish between the colours in the figures above. The year for start-up of operation of the individual lines is therefore given in the table below.

ERTMS implementation plan

Year	Line
2014	Østfoldbanen østre linje
2015	(Moss)-Kornsjø
2016	(Ski)-Moss, Lillestrøm-Charlottenberg gr.
2017	(Oslo)-Alna - Lillestrøm (incl. Alnabru and Loenga)
2018	Hokksund-Kongsberg-Nordagutu, (Tønsberg)-(Nordagutu),
2019	(Nordagutu)-Kristiansand, (Drammen)-Hokksund-Hønefoss
2020	(Kristiansand)-Stavanger
2021	(Eidsvoll)-Hamar
2022	(Dombås)-Trondheim
2023	Jessheim-Eidsvoll, (Hamar)-Dombås, (Oslo)-Roa, Roa-Hønefoss
2024	(Hønefoss)-Bergen
2025	Narvik-Bjørnfjell
2026	(Oslo)-Gardemoen-Eidsvoll
2027	Osloområdet (GS system), (Oslo)-Ski
2028	(Oslo)-Asker, Asker-Drammen, Drammen-Tønsberg, Hell-Storlien gr., (Sandvika)-(Asker) and Askerbanen, (Asker)-Spikkestad
2029	Røros-Støren, (Trondheim)-Grong, Hamar-Elverum-Røros
2030	(Grong)-Mo i Rana, Mo i Rana-Bodø

Table 2 Implementation year and line

5.4 Costs

The estimated infrastructure costs related to the implementation of ERTMS level 2 – system amount to 13,4 billion NOK. The cost estimate is based on prices from 2005/2006. Average periodical budget is estimated to 900 million NOK a year.

Jernbaneverket's estimated costs for the pilot line, Østfoldbanen østre linje, amounts to 150 million NOK. This is higher than what can be expected for the normal implementation on the other lines. The sum includes also costs for introducing ERTMS in the Norwegian railway train network, training, interfacing with existing systems, tests and measurements.

The costs for the railway train companies related to the pilot line and for each phase in the further implementation will emerge in the continuing work. In the hearing it was commented that the costs related to the installation of ERTMS onboard equipment, calculated on the basis of the current price level, would amount to approximately 1 billion NOK for NSB and minimum 130 million NOK for CargoNet.

At a European level, the price level for ERTMS onboard systems have so far been very high. The market price has been between €200.000 and €300.000 (1,6 - 2,4 million NOK), installation included.

Jernbaneverket has the disposal of around 115 work machines that will need to be equipped with ERTMS onboard system. The costs for purchasing and installing ERTMS onboard systems will therefore amount to 276 million NOK, if the highest observed market price in Europe is used. The actual costs are however difficult to predict. While all work machines do not need to be equipped immediately, new work machines will probably have ERTMS as standard equipment.

5.5 ERTMS implementation from the perspective of Jernbaneverket's program 2006-2015

In Jernbaneverket's program 2006-2015, a number of developments are planned where the interlockings will have to be modified or replaced. The ERTMS implementation plan will in many cases interfere with these projects. It is important that the choice of interlockings for these projects is agreed. Jernbaneverket faces the following alternatives:

- Extension of existing interlockings
- Utilization of interlockings from other lines, where ERTMS is being implemented
- Build temporary conventional interlockings
- Delay until implementation of ERTMS

Unfortunately, there is no simple answer to this question. A possible solution is that Jernbaneverket performs benefit/cost analyses for each individual project and uses these as a basis for the evaluation. The question then becomes: What is the benefit/cost-factor of the project and, based on an overall evaluation, should the project invest in a new conventional interlocking and carry out the project immediately, or should the project be postponed until ERTMS implementation because the benefit/cost-factor does not support a temporary, conventional system?

TSI-CCS, chapter 7.2.2.4.4, gives requirements to a pre-fitment strategy. This implies that ETCS-equipment should be pre-fitted in connection to larger developments. For most projects, there will be a considerable time span from this kind of development activities and the implementation of ERTMS. Because of the risk of pre-fitting ETCS equipment that are incompatible with the future ERTMS infrastructure, Jernbaneverket will not carry out pre-fitting.

For projects where it is not desirable or feasible to await implementation of ERTMS, construction of conventional interlockings will be necessary. In such cases, it is tacitly understood that the extra costs involved in later replacement with ERTMS are accepted. It is not considered suitable to keep a conventional system as an island on an ERTMS line. Changing operation modes on such a small part of the line is not found acceptable.

The present chapter summarizes planned developments distributed on the different corridors defined in Jernbaneverket's program 2006-2015 and National Transport Plan. Furthermore, it is described how each individual development is planned implemented within the same period. Tables 3 and 4 show the development planned for each individual corridor. The map in Figure 10 shows the corridor numbers used in the tables.

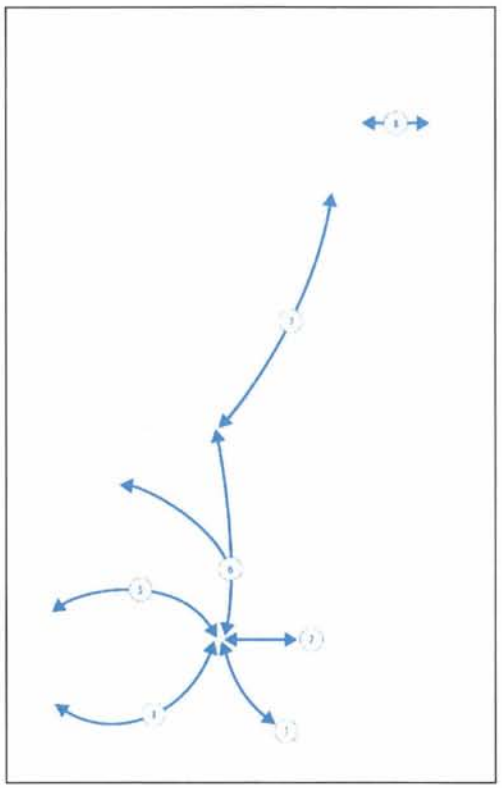

Figure 10 Corridors as shown in Jernbaneverket's program 2006-2009

	Corridor	Program area[8]	Description of scope	Level of renewal	Signalling	Type of signalling	Comment
Alnabru godsterminal	0	N			Modif.	Conventional	
Berg	1	B1	Extended passing track		Modif.		
Halden	1	B1	Yard and new tracks		Modif.	Conventional	
Sarpsborg - Skjeberg **	1	B1	New or extended passing track		New	ERTMS	Change in investment level might involve delayed implementation. This could require implementation of a conventional type interlocking that possibly will have a short longevity.
Grorud	1	C2	Modification of tracks and platform access from passenger subway		Modif.		New plan is needed
Østfoldbanen Østre linje	1	E2			New	ERTMS	Not included in Jernbaneverket's program - Related to Ski station and the rest of Østfoldbanen - Introduction of remote control important - Co-ordination with Sweden is suitable ("the railway connection to Europe") - Part of the EIRENE plan - Connection to Oslo-Ski - Must in the longer term be extended to Alnabru
Kolbotn - Ski, incl. Ski station	1	N			New	ERTMS	Ski station development step 1 is carried out as planned, with a modification of existing interlocking. When Ski station is implemented with ERTMS, most rolling stock will need to be equipped with ERTMS onboard system. Change in investment level might involve delayed implementation. This could require implementation of a conventional type interlocking that possibly will be short-lived.
Oslo S - Kolbotn	1	N			New	ERTMS	Change in investment level might involve delayed implementation. This could require implementation of a conventional type interlocking that possibly will be short-lived.
Haug - Onsøy	1	N			New	ERTMS	Change in investment level might involve delayed implementation. This could require implementation of a conventional type interlocking that possibly will be short-lived.
Sandbukta - Moss - Såstad	1	N			New	ERTMS	Change in investment level might involve delayed implementation. This could require implementation of a conventional type interlocking that possibly will be short-lived.
Solørbanen	2	E2	Kongsvinger - Elverum		New	ERTMS	Not included in Jernbaneverket's program. Need to be seen in a larger context involving

[8] Program areas in the action program of Jernbaneverket:
E2 – safety
N – Investments in new installations
B1 – Improvements in capacity
C2 – Stations and central traffic points

	Corridor	Program area[8]	Description of scope	Level of renewal	Signalling	Type of signalling	Comment
							the potentials for cargo traffic at Rorosbanen (via Kongsvingerbanen/Sweden)
Stavanger	3	B1	New yard	X	New	Conventional	
Sandefjord - Lauve	3	B1	New passing track Jåberg	X	New	Conventional	Implementation of ERTMS will be co-ordinated in time with the line Farriseidet – Porsgrunn. This means that the conventional installations expectedly will have relatively short longevity.
Egersund - Stavanger **	3	B1	Extended passing track Vigrestad		Modif.		Cable installations only
Nærbø	3	C2	Broader platform, shed, tracks	X	Modif.		Passenger stop submitted for approval
Sandefjord 1	3	C2	Passenger subway, platform, parking, signalling, public safety	X	New	ERTMS	Passenger stop submitted for approval
Drammensbanen	3	E2	CTC/ATC Drammensbanen	X	NA		CTC upgrade
Arendalsbanen	3	E2			New	ERTMS	Not included in Jernbaneverket's program
Lysaker station	3	N			New	Conventional	
Lysaker - Sandvika	3	N			New	Conventional	
Sandvika-Asker	3	N			New	Conventional	
Barkåker - Tønsberg	3	N			New	Conventional	Implementation of ERTMS will be co-ordinated in time with the line Farriseidet – Porsgrunn. This means that the conventional installations expectedly will be relatively short-lived.
Holm - Holmestrand	3	N			New	Conventional	Implementation of ERTMS will be co-ordinated in time with the line Farriseidet – Porsgrunn. This means that the conventional installations expectedly will be relatively short-lived.
Holmestrand - Nykirke	3	N			New	Conventional	Implementation of ERTMS will be co-ordinated in time with the line Farriseidet – Porsgrunn. This means that the conventional installations expectedly will be relatively short-lived.
Farriseidet - Porsgrunn	3	N			New	ERTMS	
Ganddal godsterminal	3	N			New	Conventional	
Sandnes - Stavanger	3	N			New	Conventional	
Arna	5	B1	Extended passing track Start-up Ulrikken		Modif.		Cable installations only
Flåmsbana	5	E2	CTC/ATC Myrdal – Flåm		New	Conventional?	New interlockings short-lived? Must be seen in connection to Bergensbanen
Two tracks Bergen st. - Fløen	5	N			New	Conventional	
Eidsvoll - Hamar	6	B1	Extended passing track		Modif.		
Heimdal	6	B1	Extension of track 3		Modif.		

	Corridor	Program area[8]	Description of scope	Level of renewal	Signalling	Type of signalling	Comment
Kløfta	6	B1	Simultaneous train movements into the station, new switches		Modif.		
Lillestrøm	6	B1	Extension of track 13		Modif.		
Fokstua	6	B1	Extended passing track		Modif.		Cable installations only
Brattøra	6	B1	Modernisation of yard	X	Modif.		
Gjøvikbanen	6	E2	CTC/ATC Roa – Gjøvik		New	ERTMS	
Rørosbanen	6	E2	CTC/ATC Støren – Røros		New	ERTMS	Need to be seen in a larger context involving Rørosbanen - Previous radio line block (ERTMS Regional?) - In the short term, three interlockings will be transferred from Nordlandsbanen in order to achieve remote control of the line, if this turns out to be cost-effective
Raumabanen	6	E2			New	ERTMS	Not included in Jernbaneverket's program Implementation to be co-ordinated with Sørlandsbanen
New double track sections Eidsvoll - Hamar	6	N			New	ERTMS	Need to be seen in a larger context involving Dovrebanen
Trondheim - Marienborg	7	B1	Modification of track layout Double track		Modif.	Conventional	
Steinkjer - Grong	7	B1	Two new block posts		New	Conventional	Cancelled – The main plan did not recommend the development
Remote control Grong-Mosjøen	7	N			New	Conventional	
Remote control Mosjøen-Bodø	7	N			New	Conventional	
Straumsnes **	8	B1	Extended passing track	X	Modif.		

Table 3 Jernbaneverket's program 2006-2009 and signalling-technical developments with normal budget

With a low budget, a number of developments will have to be cancelled or postponed. This requires a new prioritisation. This is reflected in the table below, which shows the most important developments in this situation.

	Corridor	Program area[9]	Description of scope	Level of renewal	Signalling	Type of signalling	Comment
Grorud	1	C2	Modification of tracks and platform access from passenger subway		Modif.		New plan is needed
Nærbø	3	C2	Broader platform, weather protection, tracks	X	Modif.		Passenger stop submitted for approval
Sandefjord 1	3	C2	Passenger subway, platform, parking, signalling, public safety	Xs	New	ERTMS	Passenger stop submitted for approval.
Onsøy		B1	2 new block stations**		New	Conventional	
Tangen / Strandlykkja		B1	Extended passing track**		Modif.		Cable installations only
Kvam		B1	Extended passing track**		Modif.		Cable installations only
Kjelsås*		C2	New platform and safe access		NA		
Haugenstua*		C2	New access and platform		NA		Plan under development
Heimdal*		C2	Intermediate platform and access via e.g. passenger subway	X	NA		Plan under development
Nationaltheatret *		C2	Safety	X	NA		Plan approved
Strømmen *		C2	Platforms, completion of Jernbaneverket's part of Oslopakke 2		NA		Main plan developed
Voss 1*		C2	Platform elevation/extension, Intermediate platform/passenger subway	X	NA		E. approved main plan
Drammen 1		C2	Main platform access/bicycles		NA		E. approved main plan
Trondheim 1*		C2	Universal design of access, platforms, etc.	X	NA		Exposition is started
Kongsberg *		C2	Final funding		NA		Already completed developments.
Mo i Rana		C2	Intermediate platform and access via e.g. passenger subway		NA		F. approved main plan
Holmlia		C2	New open platform (freight) – improved traffic regulation benefiting all passengers		NA		Development plan
Bryn		C2	New side platform and new access		NA		Preliminary project
Oppegård		C2	Oslopakke 2, JBV funds platform and stairs		NA		Development plan

[9] Program areas in Jernbaneverket's program: E2 – safety
N – Investments in new installations
B1 – Improvements in capacity
C2 – Stations and central traffic points

	Corridor	Program area[9]	Description of scope	Level of renewal	Signalling	Type of signalling	Comment
Alna		C2	New passenger bridge, improved capacity, potentials for growth		NA		New plan is needed
Stavanger		C2	Platform elevation, lift, bicycles, Covering in concrete, illumination		NA		Plan is needed
Sørumsand		C2	Adaptation to external projects + platform developments	X	NA		Plan is needed
Tverlandet		C2	New station, access to platform		NA		P.Prog 2001
Levanger		C2	Reduce the number of tracks and improve access		NA		Main plan submitted for approval
Hokksund		C2	Elevation and other amendments of platforms		NA		Plan is needed
Langhus		C2	New and safer access to side platform		NA		Development plan
Stokke-Sandefjord (Råstad)		C2	Reopening, new platforms and access, vicinity to airport		NA		Main plan developed
Fetsund		C2	New and safer access to side platform		NA		Plan is needed
Tønsberg		C2	Improved access, improved parking facilities, co-operation with Statens vegvesen	**	NA		
Stjørdal		C2	Establishment of passenger subway, improved facilities for the passengers, bicycles	**	NA		Main plan developed
Vikhammer		C2	New access and parking lot, planting, furniture		NA		f approved main plan
Greverud		C2	New side platform and new access from passenger subway	**	NA		Development plan
Skansen		C2	New side platform facilitating the utilization of double track		NA		Plan is needed
Frogner		C2	New platforms and access	**	NA		New plan is needed
Lørenskog		C2	Platforms and access/improvement of passenger subway, parking lot	**	NA		Plan is needed

Table 4 The action program of Jernbaneverket 2006-2009 and signalling-technical developments with low budget

6 Plan for revision of the ERTMS implementation plan

The ERTMS implementation plan describes a strategy that aims at implementing ERTMS over a period of 15 years.

The average age of current signalling systems is already high. The RAMS performance will expectedly change over time as the systems approach the end of their expected lifetime. Of this reason, careful supervision of the RAMS performance becomes all the more important.

The government report on the National Transport Plan 2010-2019 was presented 13. Mars 2009. This report presents the main aspects of the government's transport policy, and provides a basis for concordant political decisions. The time range is 10 years. NTP is revised every four years.

The ERTMS implementation plan covers two NTP periods and four revision periods. The implementation of ERTMS, including renewal of interlockings, is financed through the investment budget, with a basis in the NTP.

There are a number of uncertainty factors related to the RAMS performance of the existing signalling systems. Also the time range measured in terms of NTP revisions is long. This implies that it will be necessary to revise the ERTMS implementation plan. The frequency of revisions will be co-ordinated with the revision process for the NTP. One of the objectives is to put forward the revised implementation plan early enough to provide direct and concrete input to the revised NTP. The next NTP-period is 2014-23. A revised implementation plan is planned for completion ultimo 2010, thereby making the implementation plan part of the basis for next revision of the NTP for the period 2014-23. Possible modifications of the ERTMS implementation plan include:

1. Implementation speed
2. Implementation order
3. Implementation solution (ERTMS/ETCS)
    a. – based on revised signalling strategy
4. Pre-fitment strategy
5. Amount of implementation (reflecting possible new or modified TSI requirements, related to inception kernel, TEN-T, etc.)
6. Expected cost
7. Jernbaneverket action program 2010-2019

7 References

Ref. nr.	Dokument (in Norwegian)	Rev./ Dato
1	Forstudie for: Strategi for implementering av ERTMS	2004-06-25
2	Signalstrategi	2005-06-13
3	ERTMS Migrasjonsstrategi	2006-06-13
4	Usikkerhetsanalyse av Implementeringsplan for ERTMS	2007-05-21

8 Glossary

ATC	Automatic Train Control. Jernbaneverket's speed supervision system. Enforces compliance with speed restrictions and signal aspects by trains.
Balise	A passive transponder mounted on the track which can communicate with a train passing over it. ETCS and ATC use balises to communicate information to the ETCS/ATC onboard system.
DATC	Partly equipped ATC-line. Supervises mainly the compliance with signal aspects.
EA	End of Movement Authority. Location to which the train is permitted to proceed and where target speed = zero.
ERTMS	European Rail Traffic Management System, a standardised technical system for signalling and traffic control. ERTMS = ETCS + GSM-R
ETCS	European Train Control System. Standardised European train control system. A subset of ERTMS.
ETCS Level 1	A level of ERTMS/ETCS overlaid onto conventional line side signalling. Uses balises to communicate information from line side signals to the ETCS onboard system.
ERTMS Level 2	A level of ERTMS/ETCS that uses radio (GSM-R) to pass movement authorities to the train whilst relying on conventional means to determine train location.
ERTMS Level 3	A level of ERTMS/ETCS that uses radio (GSM-R) to pass movement authorities to the train, but which uses train reported advice of location and integrity to determine if it is safe to issue the movement authority.
ERTMS Level 2/3 – system	Signalling and train control system that includes ERTMS Level 2 or Level 3 with signalling and speed supervision.
FATC	Fully equipped ATC-line. Supervises all speed restrictions in the infrastructure. Is considered a good barrier against human errors made by the train driver, given that the braking system onboard functions properly.
GSM-R	Global System for Mobile communications – Rail. Radio system which in ERTMS passes movement authorities to the trains.
Interlocking	A general term applied to the controlling of the setting and releasing of signals and points to prevent unsafe conditions arising, and equipment which performs this function. As a technical system, the interlocking ensures that the movement authorities are given only if necessary conditions are satisfied. While modern systems are computer-based, older systems implements the interlocking with relays.
LCC	Life Cycle Cost. The sum of the costs sustained or to be sustained for performing and appropriately supporting the activities occurring in the context of the operational parts of the system lifecycle.
LEU	Line side Electronic Unit. A device for communication variable signalling data to switchable balises.
Local operator	Person that manages the traffic locally on a station.
MA	Movement Authority. Permission for a train to run to a specific location within the constraints of the infrastructure.
RBC	Radio Block Centre. A centralised safety unit working with interlocking(s) to establish and control train separation. Receives location information via radio from trains and sends movement authorities via radio to trains.
Remotely controlled line	Line where the traffic is managed through centralised traffic control. The control centre can normally operate a number of lines.
Signalling	Function of interlocking to control and protect the operation of trains by means of movement authorities.

Speed supervision	A function for supervising compliance with speed restrictions by a given train on a given line. Is a function of signal aspects and speed profile.
STM	Specific Transmission Module. On board device which performs a translation function between the existing national system in the infrastructure (e.g. ATC) and the ERTMS/ETCS onboard system.
TEN lines (TEN map)	Trans European Network. Railway lines that in the EEA agreement are defined as parts of the European railway network.
Train detection system	System that detects the presence or absence of trains on a defined section of line, and communicates this information to the interlocking and the centralized traffic control.
TSI	Technical Specifications for Interoperability. Gives requirements technical solutions need to satisfy in order to fulfil minimum interoperability requirements.