

Danish Implementation Plan for CCS TSI 2018

Memorandum
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EXECUTIVE SUMMARY	3
DANSK IMPLEMENTERINGSPLAN FOR TSI CCS 2018	6
EXECUTIVE SUMMARY	6
BACKGROUND	7
0.1. Private railways	9
0.2. Rail links to other EU Member States	9
0.3 Possible limitations.....	10
ANNEX	11
0. TARGET LINES:	11
0.1. THE DANISH RAIL NETWORK.....	11
0.1.1. The Danish state rail network.....	11
0.1.2. DSB's rail infrastructure	11
0.1.3. Private railways.....	12
0.2. NATIONAL SECTIONS OF CRISS-BORDER CORRIDORS	12
0.3. LINES COVERED BY THE INTRODUCTION OF ERTMS.....	13
0.4. IMPLEMENTATION FRAMEWORK AND PRIORITISATION	14
0.5. LINES COVERED BY THE PLAN.....	15
1. TECHNICAL SPECIFICATIONS:	19
1.1. GSM-R.....	19
2.1.1 GSM-R Voice	19
2.1.2 GSM-R Data	19
2.2. Baseline 3 functions for conventional lines and stations	20
2.3. STM.....	20
2.4. ETCS LEVEL 2	21
2.5. ETCS on private railways.....	21
2.6. Øresund link.....	22
2.7 Padborg and Tønder Grænse	22
2. IMPLEMENTATION STRATEGY AND PLAN:	23
3.1.1. 2009 - end 2013: Development of STM-DK for rolling stock	23
3.1.2. Early 2010: Operational concepts	23
3.1.3. Staff training.....	24
3.1.5. 2011-2014: GSM-R Voice, roll-out project.....	24
3.1.6. GSM-R Data by 2020.....	25
3.1.7. 2015-2021 - ERTMS early deployment.....	25
3.1.8. 2018-2030: ERTMS on the Danish TEN network.....	25
3.1.9. 2018-2030: General timetable for the ERTMS project.....	26
3.1.10. ERTMS on other state railway lines	27
3.2. PRIVATE RAILWAYS' INTEROPERABILITY PLANS	28

3.3. IMPACT OF THE SWITCHOVER FOR ROLLING STOCK30



3.3.1.	30
Expected extent of rolling stock upgrading	30
3.3.2. Status of upgrades to rolling stock.....	33
3. TRANSITION STRATEGY:.....	37
4.2. INFRASTRUCTURE	38
4.2.1. Stable and safe train management	38
4.2.2. Øresund link	38
4.2.2. The future Fehmarn Belt link.....	39
4.3. TRANSITION PERIOD PROGRAMMES – A SUMMARY	39
4.3.1 Stages of roll-out on the infrastructure	40
4. MAPS.....	42
Map 1: Railways and line classes in Denmark	43
Map 2: Banedanmark's lines – line numbers.....	45
Map 3: TEN lines in Denmark	46
Map 4: Lines with train protection systems.....	47
Map 5: Electrified lines	49
Map 6: Stations on state railway lines	50

Executive Summary [in English]

On October 21st 2018 the first railway line in Denmark as well as in Europe equipped with ERTMS level 2 baseline 3 was commissioned for commercial passenger service. The line is now in regular operation and has been running without any major difficulties since commissioning.

Background

In line with Decision 2006/679/EC of March 28th 2006, Denmark sent to the Commission in September 2007 a preliminary ERTMS implementation plan. This implementation plan was based on the principle decision for the renewal of Danish signalling with ERTMS level 2.

On January 29th 2009 the Danish government and parliament decided the framework and financing of the implementation, and the updated implementation plan was informed on September 22nd 2009.

The implementation plan was updated in 2012 when the contracts for the roll out was signed and information on the updated plan was submitted to the commission in the frame of the European Rail Traffic Management System (ERTMS) conference held by the the European Commission along with the Danish Presidency of the Council of the European Union in Copenhagen in April 2012.

During 2016 the implementation plan was reviewed due to delays in development and subsequent installations of the trackside and onboard ERTMS systems and because the time and resources for tests and approval processes exceeded the planned scope. The updated plan extending the deployment to 2023 was notified to the commission in august 2016 through the Danish response on the Second ERTMS Work Plan 2016.

The plans for the deployment and commissioning of ETCS has been extended two times. The first extension was due to the extent of testing and time for approval processes. The latest extension is a consequence of delays in installing on-board equipment due to the organizational set-up, supplier problems and challenges with installation in older equipment types.

Since trains without ETCS equipment cannot run on lines where traffic is controlled by the new signalling system, one would risk standing with a new signalling system but without a sufficient number of trains to maintain the traffic. There is therefore a risk of a markedly deteriorating train transport for passengers and of delaying other ongoing infrastructure programs.

Against this background, Banedanmark developed a new strategy for the roll-out and commissioning of ETCS. Here the emphasis has been placed on stable train operation and support for the transition to electrical operation. Overall, it was considered that this strategy was the best possible alternative deployment plan if the operational stability of the railway companies was to be taken into account as much as possible.

Therefore, a new strategy for the national deployment of ETCS was approved politically in November 2017. Installing ETCS in the infrastructure has therefore been adapted partly to a more realistic installation scenario and partly to plans for commissioning new rolling stock.

The updated 2017 implementation plan is detailed in this document in the following chapters. Furthermore, there has been some minor adjustments following which are incorporated in *Trafik- og Anlægsplan 2018-2030* published on December 21st 2018.

Status

The contracts for deployment of ERTMS level 2 in the infrastructure was signed in February 2012 and for the installation in the trains in March 2012. The contracts also include new Traffic management and interlocking systems on the entire state railway infrastructure.

In October 2018, Frederikshavn-Lindholm was the first line where ETCS Level 2 Baseline 3 was commissioned for commercial passenger service. On the rail network owned by the Danish state, ETCS Level 2 Baseline 3 is commissioned line by line ending in mid 2027 west of Lillebælt and no later than mid 2030 east of Lillebælt.

When lines are commissioned with ERTMS, the class B system on the line is decommissioned and operation is converted to ERTMS only. Although class B systems will be implemented temporarily on some new lines, they will be replaced by ETCS according to the roll-out plan.

The ETCS will be installed only on the state's infrastructure (main, regional and local lines), and therefore not on private lines or the Greater Copenhagen S-bane (on the latter, CBTC is installed).

The contract for development of a STM-DK (STM ZUB123) was signed mid-2009. It has been commercially available on the market since 2016 and are now used in around 10 trains in commercial operation and in a few test trains.

The contract for the GSM-R radio system was signed in April 2010. The establishment of the GSM-R voice radio infrastructure was as

scheduled completed in December 2012. The system was put into service in February 2013 and the analogue radio network was closed in May 2017, when all Danish trains had the new radio installed.

GSM-R voice radio is used both on the state and private rail lines. The network is being upgraded to provide data radio connectivity and increased quality of service for ETCS L2 during 2017-2020.

The Scandinavian Mediterranean Corridor

The first part of the Danish Scandinavian Mediterranean Corridor will be commissioned late 2025. In mid 2029, railway companies will be able to use ETCS on the whole Danish part of the Scandinavian Mediterranean Corridor.

Danish Implementation Plan for CCS TSI 2018

Executive summary [in Danish]

ETCS level 2 baseline 3 was commissioned on 21 October 2018 on the line between Frederikshavn and Lindholm. Denmark is thus the first European country to put this version of ETCS into service.

On the state railway infrastructure, which comprises 2 323 km of railway, ETCS level 2 baseline 3 is now expected to be in service by mid-2027 west of the Little Belt (Lillebælt) and by mid-2030 east of the Little Belt.

The timetable for the roll-out and deployment of ETCS has had to be revised twice. The first extension was due to the scope of testing and the time taken for approval processes being greater than expected. The latest extension is a result of delays in the installation of on-board equipment, which is due to problems with suppliers and installation in older rolling stock.

As trains on which the required equipment has not been installed cannot run on lines controlled by the new signalling system, there is a risk of us finding ourselves with a new signalling system but an insufficient number of trains to maintain services. There is therefore a risk of both significantly reduced rail passenger services and delays in other ongoing infrastructure projects.

In the light of this, Banedanmark has drawn up a new strategy for the Signalling Programme, with an emphasis on stable rail operation and support for the transition to electrical traction. Overall, this strategy was considered to be the best possible alternative roll-out plan to ensure the highest possible operational stability for railway undertakings.

In November 2017 this resulted in a new strategy for the national ETCS roll-out. Installation of ETCS in the infrastructure is therefore adapted to a more realistic installation scenario and to plans for the deployment of new rolling stock.

Based on the new plan, railway undertakings will be able to switch over to using ETCS exclusively on the Danish section of the Scandinavia-Mediterranean freight corridor in mid-2029.

ETCS is only being installed on the state long-distance rail network and therefore not on private railways and the S-train network in Greater Copenhagen (however, CBTC is being installed on the latter).

On certain new long-distance lines, class B systems will be installed temporarily, but these will be replaced by ETCS in accordance with the roll-out plan.

The construction of infrastructure for GSM-R voice radio was completed as planned in December 2012. The system entered into operation in February 2013 and the analogue radio network was shut down in 2017, once all Danish trains had the new radio equipment installed.

GSM-R voice radio is used on both state and private railways.

Background

For information, we enclose the updated Danish ERTMS implementation plan¹, showing the changes adopted from November 2017 to December 2018.

By letter of 1 October 2007 Denmark sent the Commission the interim ERTMS implementation plan of September 2007.

The plan submitted was based on a political decision in principle taken by the Danish Parliament on 26 October 2006 (2007 transport agreement²), according to which the entire state-owned Danish rail network – and not only the TEN network – was to be equipped with ERTMS by 2020. The decision was based on the socio-economic business case ‘Signal analysis 2006’, which compared five investment options for ERTMS-based renewal of the signalling systems on the state railways in Denmark. The option based on total renewal and introduction of ERTMS level 2 gave the best return on investment and also offered a number of non-capital benefits.

Under the 2007 transport agreement, it was decided to procure a new train radio system before the end of 2014. This project, which concerned the roll-out of GSM-R Voice on the state rail network, was completed in 2014.

In the 2007 transport agreement, the Danish state infrastructure manager, Banedanmark, was mandated to draw up a final plan and draft decision for the ERTMS project. The material forming the basis for a decision on the *signalling programme* was presented to the Government in autumn 2008.

On the basis of this material, the Danish Parliament took a decision on 29 January 2009 to carry out the entire Danish ERTMS project (including GSM-R Data) covering the long-distance section of the state rail network, with completion expected in 2021.³ In addition, the Greater Copenhagen S-train network will be equipped with a modern urban network signalling system (CBTC), not covered in this plan.

As a result of delays in the design and implementation of the new signalling systems on the first lines and in the rolling stock, Banedanmark revised the timetable for the project in 2016, changing the order of the lines to be equipped and postponing the equipping of the main lines until 2022-23. The Commission was notified of the changes through the Danish response to the consultation on the Second ERTMS Work Plan 2016.

¹ Pursuant to Article 3 of Commission Regulation (EU) 2016/919 of 27 March 2016 on the technical specification for interoperability relating to the ‘control-command and signalling’ subsystems of the rail system in the European Union.

² Agreement between the Government (Venstre and Det Konservative Folkeparti), Dansk Folkeparti and Det Radikale Venstre. The agreement supplements and implements earlier agreements, including the rail traffic agreement of November 2003.

³ The formal decision was taken in conjunction with the Parliament Finance Committee’s adoption of Act 70 on 26 February 2009.

In 2017 the delays to the installation of on-board equipment owing to supplier problems and the difficulties of installation in older rolling stock represented a serious risk.

As trains on which the required equipment has not been installed cannot run on lines controlled by the new signalling system, there is a risk of us finding ourselves with a new signalling system but an insufficient number of trains to maintain services. There is therefore a risk of both significantly reduced rail passenger services and delays in other ongoing infrastructure projects.

In the light of this, Banedanmark has drawn up a new strategy for the Signalling Programme, with an emphasis on stable rail operation and support for the transition to electrical traction. Overall, this strategy was considered to be the best possible alternative roll-out plan to ensure the highest possible operational stability for railway undertakings.

In 2017 a decision was therefore taken to adjust the principles for the installation of the new signalling systems further. The new principles can be summarised as follows:

1. Installation on the lines is scheduled in accordance with when the rolling stock will be equipped.
2. The intention is that ERTMS will not be installed on older rolling stock that should be phased out within the next five to seven years. This postpones the equipping of a number of main lines where a number of types of older rolling stock operate.

Consequently, ERTMS will be deployed on the main lines, including the Scandinavia-Mediterranean corridor in 2025-30 after this older rolling stock has been replaced with new rolling stock, although the system will be deployed in 2022 on the Næstved-Nykøbing F line.

0.1. Private railways

Private railways, which include both railway undertakings and infrastructure managers on a number of local railways, are not directly covered by the agreements concluded.

However, the private railways have implemented GSM-R Voice on their infrastructure in collaboration with Banedanmark.

As the private railways also use Banedanmark's network, the majority of the private railways' rolling stock must be equipped with both GSM-R radios (Voice and Data) and mobile ETCS equipment.

0.2. Rail links to other EU Member States

The basis for the general relationship with Sweden and Germany regarding Corridor B is a 'letter of intent' signed in June 2009⁴.

In July 2009 the Danish-German state treaty on the establishment of a fixed link across the Fehmarn Belt and the associated land installations was ratified. Under the treaty, the entire railway line between Ringsted and Lubeck will be electrified and a second track will be laid. The fixed link across the Fehmarn Belt is currently expected to open in 2028.

The Øresund region represents a particular challenge for the transition to ERTMS because of the very high volume of passenger services on the fixed link across the Øresund. The transition process in that region is therefore based on close, regular contact between the Danish and Swedish railway management authorities. A written agreement⁵ has been signed between the railway management authorities in accordance with the Commission Implementing Regulation⁶.

The Swedish ETCS roll-out means that on the Swedish side of the bridge as far as Malmö ETCS will enter service in 2023/24, i.e. up to three years before Copenhagen-Peberholm, where the implementation of ETCS is planned for the end of 2025. The trains therefore need to be equipped by the end of 2022. The implications for Denmark will primarily be limited to upgrading of the rolling stock and of the current changeover zone between the two class B signalling systems so that it also works with trains equipped with ERTMS+STM.

⁴ Letter of Intent on ERTMS Deployment on Corridor B, signed by the Transport Ministers of Austria, Denmark, Germany, Italy and Sweden.

⁵ Joint project agreement concerning Øresund ERTMS Implementation between Banedanmark and Øresundsbro Konsortiet and the Swedish Transport Administration of 15 November 2013.

⁶ Commission Implementing Regulation (EU) 2017/6 of 5 January 2017 on the European Rail Traffic Management System European deployment plan.

0.3 Possible limitations

- The ERTMS equipment in the rolling stock must be upgraded to TSI 2016/919 set #3 before the infrastructure is equipped in the hub around Copenhagen Central, as the GSM-R network has limited data capacity if older versions are used that do not support ETCS over GPRS/Edge.
- If new electric multiple units and electric locomotives are not supplied as planned, this may delay the roll-out of ERTMS in the infrastructure.
- The roll-out of ERTMS on the infrastructure may be delayed if foreign railway undertakings do not equip their rolling stock in time. The border south of Padborg is a particular challenge, as freight trains are currently allowed to enter the station from the south without being equipped with the Danish train control system. If this continues, it will not be possible to equip the station with ERTMS as planned, because ETCS level 2 does not allow scheduled train operation without ETCS equipment.

Annex

1. Target lines:

1.1. The Danish rail network

1.1.1. The Danish state rail network

The state rail network comprises 2 323 km of railway – main, regional and local lines⁷ comprising 3 240 km of track⁸ – managed by Banedanmark (see Annex, maps 1 and 2). These lines are expected to be upgraded to ERTMS before the end of 2030.

On the state rail network, there are 903.5 km of TEN lines (see Annex, map 3). There is also a private TEN line of 17.8 km between Hjørring and Hirtshals. This gives a total in Denmark of 921.3 km of TEN lines.

The train control systems ATC or ATC-T are currently in operation on over 1 200 km of Banedanmark's lines (see Annex, map 4). After the transition, the entire rail network of over 2 300 km will be equipped with ERTMS.

The electrified part of the long-distance rail network is 509 km (see Annex, map 5), comprising the Padborg-Øresund line with 'detours' at each end to Sønderborg, Esbjerg and Helsingør.

Banedanmark also manages a number of freight lines, classification lines, shunting lines and loading yards which currently do not have train protection systems installed and are not expected to be affected by the transition to ERTMS.

1.1.2. DSB's rail infrastructure

The railway undertaking DSB owns and manages approximately 136 km of track across Denmark. There is no requirement for train control systems on these lines, as they are working tracks for travel to and from workshops and preparation areas, tracks for preparation/deployment and tracks for container terminals etc.

DSB's tracks currently do not have train protection systems and are not expected to be upgraded. Driving onto Banedanmark's management area will be covered by signalling and protection systems on the state rail network.

1.1.3. Private railways

Four private companies have rail infrastructure divided across 14 lines at different locations in Denmark (see Annex, map 7(1-4)). These 13 private rail network sections together comprise 459.5 km of single-track railway. Of this, 24.5 km (the Hornbæk Line) is equipped with automatic train protection (ATP). The private railways also use Banedanmark's

⁷ Various systems of numbers are used to identify sections of the railway. This plan uses line numbering and not TIB numbering as often used in other contexts (TIB stands for introductory comments to the working timetable).

⁸ *Line length*: Length of a railway line measured between the centre of the stations, regardless of the number of tracks. *Railway line*: Line between two stations (usually junction stations). *Track length*: Length of the track measured between the centre of the stations. The track length on a double-track line is twice as long as the line length.

network either for actual passenger services or for travel to workshops, light running, etc.

1.2. National sections of cross-border corridors

The Danish rail network has links to other Member States' rail networks via two land-based border crossings, a bridge/tunnel link and a ferry link.

Padborg: The border between Banedanmark's rail network and the German rail network (Deutsche Bahn) is at Padborg crossing station (km 109.7), where line number 99 in the direction of Germany, which is also part of the TEN network, ends.

Tønder: The border between Banedanmark's rail network and the German rail network, where the infrastructure manager is NEG GmbH⁹, is at the end of line number 95 south of Tønder station (km 67.9). The line is classified as a local railway. The distance from Tønder to the border is 3.9 km. The border is on the open line.

Øresund link: The state-owned company A/S Øresund owns line number 50 Copenhagen C (km 0.0) - Kalvebod - Copenhagen Airport Kastrup (km 11.8) and the line (freight link) Vigerslev - Kalvebod approx. 3 km.

Øresundsbro Konsortiet I/S¹⁰ is the owner and infrastructure manager of the line Copenhagen Airport Kastrup (Denmark) - Peberholm (km 18.2) - national border (km 23.6) (Denmark/Sweden) - Lernacken (km 29.8) (Sweden).

Trains pass the border on the Øresund link at full line speed, as it is not possible to stop or change locomotive on the link itself. Trains therefore never stop at the border¹¹.

Rødby - Puttgården ferry: Finally, it is possible to operate trains via the Rødby - Puttgården ferry link across the Fehmarn Belt. The line on the Danish side from Nykøbing Falster to Rødby (number 22) is a local line, but classified as a TEN line. The line will be upgraded to double track and electrified between Nykøbing Falster and south of Holeby before the opening of the Fehmarn Belt Fixed Link. The current single track between Holeby and Rødby Færge will be decommissioned. At present, the line is expected to enter into service in 2028 with the opening of the Fehmarn Belt Fixed Link¹².

⁹ Norddeutsche Eisenbahngesellschaft Niebull GmbH

¹⁰ The Øresund Bridge and tunnel are owned and operated by Øresundsbro Konsortiet, which is owned by A/S Øresund (owned by the Danish Government via Sund og Bælt Holding A/S) and by Svensk-Danske Broforbindelsen AB (SVEDAB), owned by the Swedish Government.

¹¹ There are special conditions on the Øresund Bridge, as the changeover between train protection systems takes place automatically on Peberholm. The switch takes place with moving trains, in accordance with Øresundsbro Konsortiet's rail safety regulations. Because of differences in traction current, train protection and radio systems, there are specific technical requirements for rolling stock that crosses the bridge. There are currently special operating rules.

¹² On 3 September 2008 a state treaty was signed between Denmark and Germany on the construction of a fixed link across the Fehmarn Belt. The treaty was ratified in Denmark with the Parliament's adoption of the 'Act on the planning of a fixed link across the Fehmarn Belt and the Danish land installations' on 26 March 2009.

1.3. Lines covered by the introduction of ERTMS

The Danish ERTMS implementation plan is part of a project to renew all the signalling systems on the state rail network – *the signalling programme* – which is being carried out by Banedanmark.

The decisions in the 2007 transport agreement and ‘A Green Transport Policy 2009’ cover the renewal of the signalling systems on the entire state rail network, including all interlockings and associated train protection systems between 2015 and 2021 and the replacement of the train radio system (voice) before 2014. The revised timetable from 2017 postpones completion until 2030 owing to organisational and technical challenges in equipping older rolling stock with ERTMS. Subsequently, some minor amendments have been made in connection with the 2018-2030 transport and infrastructure plan, which was last published on 21 December 2018.

The use of ERTMS level 2 on *all long-distance lines* enables the expensive external signalling system to be removed. The state rail network (excluding the S-train network) will thus only have ERTMS level 2 equipment and will no longer have the national class B system with ATC balises and external signals.

Øresund link

Øresundsbro Konsortiet I/S (owned by the Danish and Swedish state), which owns the infrastructure from Copenhagen Airport (Denmark) to Lernacken (Sweden), also acts as infrastructure manager. The upgrading of this line to ERTMS is taking place in close collaboration between Denmark and Sweden.

Private railways

The Danish rail network also includes five regions’ four *regional transport companies*, which in total own four private railway companies. One has separated off the operation part into a partially independent company, while the rest act both as infrastructure managers and railway undertakings.

Apart from the Jægersborg-Nærum line, these lines are all connected to the core network and will come under the comprehensive network for the purposes of renewal/upgrading.

Apart from one private railway line (Helsingør-Gilleleje), there are not currently any safety-related requirements for private railways to have train protection systems and no decisions have been taken at present to equip the private railways with such systems.

Certain private railway companies have, however, expressed an interest in ERTMS being part of future considerations for the development of traffic on their private railways.

In Germany, the treaty was ratified on 18 June 2009 with the Bundestag’s adoption of an act approving the treaty on a fixed link across the Fehmarn Belt. On 10 July 2009 the Bundesrat (upper house of the German Parliament) approved the treaty.

Denmark is paying for and will receive all revenue from the 19-kilometre fixed link and will be the owner of the link. The revenue from the link will finance the development of the Danish land installations. Germany is paying for the development of the rail and road installations on the German side. A German regulatory approval document for the project, ready to be signed, was completed on 28 December 2018.

The private railways have made use of the option to install GSM-R Voice in the infrastructure as part of Banedanmark's contract for the roll-out of GSM-R Voice on the long-distance rail network. These railways are therefore now equipped with GSM-R Voice like the rest of the state railway network.

1.4. Implementation framework and prioritisation

The analogue radio system was obsolete and in 2007 a decision was taken to replace it. The construction of infrastructure for GSM-R Voice radio was completed in December 2012. The system was deployed in February 2013 and at first was used for communication with Øresundstog trains and freight trains from Sweden and Germany. This scope was expanded up to the end of 2014 as the system was installed on other Danish trains.

ERTMS will be introduced on the whole of the state rail network in 2030, as the current ATC train protection system and around 50 % of the other signalling elements have exceeded their useful life. The quality of the GSM-R network will be expanded for ETCS use (GSM-R Data project) across the network at the same time as the roll-out of ETCS level 2 on the first lines.

1.5. Lines covered by the plan

The implementation plan for ERTMS will cover the Danish part of the trans-European rail network (TEN), which comprises the following lines:

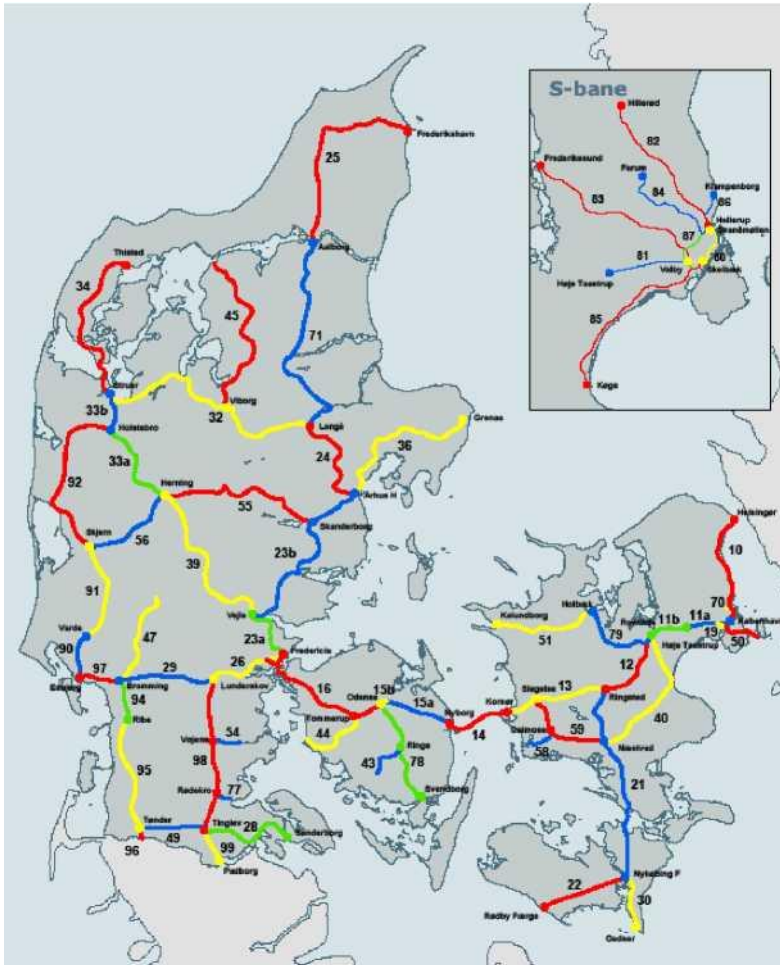
Table 1. Danish TEN lines¹³

Line number *)	Main, regional and local lines			Line
10 ^a		R		Copenhagen C - Østerport - Helgoland - Klampenborg
11	M			Copenhagen C - Hvidovre Fjern - Høje Taastrup - Roskilde
12	M			Roskilde - Borup - Ringsted
13	M			Ringsted - Slagelse - Korsør
14	M			Korsør - Nyborg
15	M			Nyborg - Odense
16	M			Odense - Snoghøj - Fredericia/Taulov
19	M			Copenhagen Gb - Vigerslev - Hvidovre Fjern
21		R		Ringsted - Næstved - Vordingborg - Nykøbing F
22			L	Nykøbing F - Rødby Færge
23	M			Fredericia - Vejle - Skanderborg - Århus H
24	M			Århus H - Langå
25		R		Aalborg - Lindholm - Hjørring - Frederikshavn
25.1.2	Private railway			Hjørring - Hirtshals **)
26	M			Fredericia - Taulov - Lunderskov
29	M			Lunderskov - Bramming
36			L	Århus H - Århus Containerhavn
50	M			Copenhagen C - Kalvebod/Kalvebod - Vigerslev/Kalvebod - Kastrup - Peberholm (ØSK)
71	M			Langå - Randers - Hobro - Skørping - Aalborg
97	M			Bramming - Esbjerg
98	M			Lunderskov - Vamdrup - Vojens - Tinglev
99	M			Tinglev - Padborg

Notes: *) TIB lines are broken down by line number (Banedanmark lines only). **) The Hjørring-Hirtshals line is a private railway and therefore is not included in the upgrade plans.

Line numbering: The number before the first point indicates the line number to which the private railway line is connected. The next number is the private rail company's serial number and the final number is a serial number for the line at the company. For stations on the line, see Annex, map 6.

¹³ The new Vigerslev-Ringsted railway line is not shown in the table, as it will not enter operation until mid-2019 and does not yet have an official line number in the TIB.



Map of line numbers¹⁴

¹⁴ Line No 49 is closed. Lines Nos 54, 77, 44, 43, 58 and 59 are disused.

Other regional and local railway lines included in the Danish implementation plan:

Table 2 Regional and local railway lines.

Line number	Main, regional and local lines			Line
10b		R		Klampenborg - Nivå - Snekkersten - Helsingør
28		R		Sønderborg - Tinglev
32		R		Langå - Viborg - Skive - Struer
33b		R		Holstebro - Struer
33a		R		Holstebro - Herning
34			L	Struer - Thisted
39		R		Herning - Vejle
40			L	Roskilde - Køge - Næstved
51			L	Holbæk - Kalundborg
55		R		Skanderborg - Silkeborg-Herning
56			L	Herning - Skjern
70				Lersøen - Østerport
78			L	Odense - Ringe - Svendborg
79		R		Roskilde - Lejre - Tølløse - Vipperød - Holbæk
90			L	Esbjerg - Varde
91			L	Varde - Skjern
92			L	Skjern - Ringkøbing - Vemb - Holstebro
94			L	Bramming - Ribe
95			L	Ribe - Tønder
96			L	Tønder - Tønder Grænse

Private lines referred to in the plan:

Table 3 Private railway lines

Private railway connected to line number	Private railway number *)	TEN	Line	Railway
25	25.1.1		Skagen - Frederikshavn	NJ
25	25.1.2	TEN	Hirtshals - Hjørring	NJ
31	31.2.1		Vemb - Lemvig - Thyborøn	MJ
36			Århus Containerhavn - Hornslet - Grenå	ÅL
31	31.3.1		Varde - Nørre Nebel	VNJ
13+79	13/79.4.1		Slagelse - Høng - Tølløse	L
79	79.4.2		Holbæk - Nykøbing Sj.	L
22	22.4.3		Nykøbing F - Sakskøbing - Maribo - Nakskov	L
40	40.4.4		Køge - Hårlev - Rødvig /- Faxe Ladeplads	L
86	86.5.1		Jægersborg - Nærum	L
82	8.5.2		Hillerød - Frederiksværk - Hundested	L
82	8.5.3		Hillerød - Kagerup - Gilleleje/Kagerup - Tis-vildeleje	L
9	9.5.4		Hillerød - Snekkersten - (Helsingør)[Lille Nord]	L
10	10.5.5		Helsingør - Hornbæk - Gilleleje	L

NJ: Nordjyske Jernbaner A/S; MJ: Midtjyske Jernbaner A/S; ÅL: Århus Letbane; VNJ: Varde-Nørre Nebel Jernbane; L: Lokaltog; R: Regionstog A/S; HL: Hovedstadens Lokalbaner
Note *) *Private railway number*: The number before the first point indicates the line number to which the private railway line is connected. The next number is the private rail company's serial number and the final number is a serial number for the line at the company.

2. Technical specifications:

The most important technical specifications for the implementation of the Danish ERTMS strategy are set out below.

2.1. GSM-R

GSM-R plays two important roles in ERTMS: firstly as a telephone network for voice communication between locomotive drivers and signallers, and secondly as a data network for transfer of data to ETCS. The network used is basically the same, but the standard required for the two networks is different. The GSM-R project was therefore divided into two parts – GSM-R Voice and GSM-R Data.

2.1.1 GSM-R Voice

It is a general safety requirement that communication between trains/locomotive drivers and control centres must be possible.

The pan-European digital train radio system GSM-R was introduced to replace analogue train radio on the state rail network. A network of radio masts at intervals of less than 7 km was constructed to ensure reliable communication with the rolling stock.

The installation of GSM-R Voice equipment in rolling stock took place during a period following the deployment of GSM-R Voice on the infrastructure. The transition strategy was based on the analogue train radio and GSM-R both being available alongside each other for a period of two years (2013 and 2014).

2.1.2 GSM-R Data

As train control on the infrastructure is based on ETCS level 2, higher ETCS data quality was established on the GSM-R network as an upgrade of GSM-R Voice. GSM-R Data was implemented in parallel with the roll-out of ETCS level 2.

The improvement to the GSM-R network required to achieve ETCS data quality will require the construction of further radio masts in addition to those erected for GSM-R Voice and the establishment of redundancy in the core components.

When the ETCS level 2 signalling system is enhanced to use ETCS over GPRS¹⁵ (packet switching), which is likely to be after 2021, packet switching will be a pre-requisite for the required train capacity at the network's nodes.

GSM-R terminals for ETCS data are installed at the same time as the rest of the ERTMS equipment in the rolling stock.

¹⁵ General Packet Radio Service for ETCS was incorporated into the ETCS specifications in Commission Regulation (EU) 2016/919.

2.2. Baseline 3 functions for conventional lines and stations

The earlier version of the software used for ERTMS on existing lines in Europe is based on SRS 2.3.0d¹⁶. In terms of safety and functions, that version did not completely cover all conditions on the Danish infrastructure.

A number of *change requests* were therefore required. Examples include securing level crossings, flank protection (as Denmark does not generally have train protection on tracks joining a main line), the use of GSM-R incorporating packet radio for ETCS (ETCS over GPRS) and the desire to continue using the established brake model in accordance with UIC-544 for rolling stock.

This and a number of other changes were laid down in the years 2008-2016 in the ERTMS specifications, the current version of which can be found in Commission Regulation (EU) 2016/919.

2.3. STM

As the Danish roll-out strategy is based on a line-by-line upgrade to ETCS level 2, the transition strategy is based on the flexibility of the rolling stock during the conversion period. A Danish STM¹⁷ (STM-DK¹⁸) must therefore be used for train management in the transition period.

Before the first lines with ETCS can be opened, the rolling stock that will operate on the lines must be upgraded to mobile ETCS and GSM-R Data radio, as well as the Danish STM-DK for traction equipment that is also used on lines with ATC¹⁹.

On trains that will operate on the Øresund link, a Swedish STM (STM-SE) must also be installed for the Swedish class B system (ATC 2).

A contract for the development of STM-DK was signed on 29 June 2009 with Siemens Denmark, and STM-DK became available in 2016. It is used operationally by around ten multiple units and by five test trains.

As no German STM-DE has been developed, there are at present only supplier-specific integration solutions, which are not supported by the ERTMS on-board equipment being rolled out in Denmark. This will be a problem for Danish trains equipped with ERTMS if they are to be able to run on German class B lines.

¹⁶ SRS: System Requirement Specification. The SRS 'version' mainly relates to software functions and should not be confused with the 'level', which mainly relates to hardware configuration.

¹⁷ Specific Transmission Module

¹⁸ STM-DK is a translation module that enables the ETCS equipment to read instructions from the Danish ATC system.

¹⁹ Rolling stock that is currently used without ATC in accordance with SIN13 is not intended to be equipped with STM. This is the case for Nordjyske Jernbaner's rolling stock, for example, including trains of type Lint41 and Desiro.

2.4. ETCS LEVEL 2

The political agreements state that a signalling system will be established on long-distance lines based on the European standard 'ERTMS level 2'²⁰.

In connection with upgrading the lines to ERTMS, the infrastructure will be adapted to optimise train management (adjustment of block sections etc.) in order to take advantage of the possibilities under ERTMS to increase line capacity, speed and regularity on the busiest lines.

2.5. ETCS on private railways

There are a number of private railways in Denmark. At present, a train protection system has only been required and installed on one private railway, on the basis of a risk assessment. However, a different pattern of traffic may lead to a requirement for train protection systems on more private railways.

The individual private railway will decide what type of ERTMS to install if a common European train protection system is introduced on private railway lines.

2.6. Øresund link

The Øresund link requires separate solutions during the transition period.

Trains that cross the Øresund link today are equipped with a special mobile train protection system – Danish-Swedish ATC. This system is linked to a special changeover area on the island of Peberholm. The railway installations on the link are connected to an independent interlocking.

In connection with the roll-out of ETCS on the two sides of the Øresund, the rolling stock must be equipped with ETCS and, for material that will be used on lines with class B systems, an STM-DK and/or STM-SE.

For example, non-upgraded trains from Denmark to Sweden can use the existing class B changeover area during the transition period. Upgraded trains will switch from STM-DK using the mobile ETCS equipment (EVC) to STM-SE.

2.7 Padborg and Tønder Grænse

In connection with the roll-out of ETCS in Germany and from Denmark across the border at Padborg and Tønder, the rolling stock must be equipped with ETCS and, for rolling stock that will be used on lines with class B systems, an STM-DK and/or STM-DE.

Non-upgraded trains between Denmark and Germany can use the existing class B changeover at the platform in Padborg during the transition period. At Tønder Grænse, trains between Denmark and

²⁰ Agreement between the Government (Venstre and De Konservative), Dansk Folkeparti, Socialistisk Folkeparti, Det Radikale Venstre and Liberal Alliance on 'A green transport policy', 29 January 2009, p. 10.

Germany can continue to operate using Danish ATC. Upgraded trains are expected to switch from STM-DK via the mobile ETCS equipment (EVC) to ETCS or STM-DE. Germany plans to install ETCS level 1LS from Flensburg to Padborg in 2020.

3. Implementation strategy and plan:

After the adoption of the Signalling Programme in early 2009, the Danish roll-out plan was reworked by Banedanmark into tender documentation.

3.1. General phases of the plan

The general phases of the roll-out plan with the selected technology were as follows:

3.1.1. 2009-end 2013: development of STM-DK for rolling stock

The strategy for transition from class B (ATC/ZUB123) to class A (ETCS) is based on the flexibility of the rolling stock in relation to two train protection systems on the infrastructure during the transition period. The transition strategy therefore requires the trains to be upgraded to mobile ETCS and the installation of an STM-DK.

STM-DK baseline 3 (developed by Siemens) has been installed on a number of trains and approved for commercial operation at level STM-DK.

3.1.2. Early 2010: Operational concepts

Owing to the transition to cab signalling and in order to take full advantage of the new signalling systems, it has been necessary to draw up entirely new operational rules for the long-distance rail network so that staff know how to deal with situations that the system cannot cope with or problems caused by human behaviour.

The drawing up of *Regler for driften* (the Danish application of the *Operational rules*) to replace the existing rules – SR 75²¹ etc. – formed part of the overall upgrading project. The work was started by the Danish Transport, Construction and Housing Authority in 2005, but responsibility was transferred to the Signalling Programme following its launch.

The new operational rules take the common European rules (TSI Operation and Traffic Management) as their point of departure and are based on a thorough rethink of the regulation of rail traffic on the basis of the new signalling systems.

The new operational concepts were included in the tender for the new ERTMS signalling systems in 2011. During the design phase in 2012-2014 these framework rules were translated into operational rules, known

²¹ Safety regulations 1975, most recently amended in 2018.

as OR-F (operational rules long-distance rail network), which are to be used directly by operational staff.

The Signalling Programme collaborates with and supports the rail passenger transport undertakings that run public service contracts by producing their company-specific part of the new operational rules. At the same time, the programme supports the companies' approval process.

The company-specific rules are approved by the Transport, Construction and Housing Authority before the companies are allowed to operate on lines with the new signalling systems.

3.1.3. Staff training

The introduction of ERTMS requires staff education and training in order to ensure they can operate new signalling equipment and comply with new operational rules.

Overall, over 50 000 training hours are required, spread across a large number of different courses ranging from a few hours to 30 days.

There are individual training specifications for all the different categories of staff to be trained. These have been approved by the Transport, Construction and Housing Authority where they relate to rail safety. It is also the first time in Denmark that railway training integrates extensive use of simulators.

These staff work for Banedanmark, all the Danish railway undertakings and a large number of private contractors.

There are at least 3 700 staff, of whom around 2 200 are train drivers, around 300 are signallers and around 1 200 are other staff, including shunting staff, system operators and maintenance staff.

3.1.5. 2011-2014: GSM-R Voice, roll-out project

The analogue train radio system that was previously used on the state railway infrastructure had been replaced by 2014 with the common European train radio system GSM-R.

The private railways' GSM-R Voice projects were included as an option in the tender documentation.

The analogue train radio system and GSM-R Voice were used in parallel during the two-year transition period.

The rolling stock was upgraded as a direct extension of the launch of the GSM-R Voice network.

3.1.6. GSM-R Data by 2020

When using ETCS level 2 as the train protection system, authority to proceed is received via radio signal. This data communication takes place over the GSM-R network. The requirements for ETCS with regard to reliability and capacity mean that the GSM-R Voice network needs to be upgraded to meet the requirements of ETCS data transmission. The possible use of packet switching (GPRS) will also have a major impact on the requirements placed on the upgrading of the existing GSM-R Voice network.

GSM-R Data has already been installed on the ETCS early deployment lines – Lille Syd (Roskilde-Køge-Næstved) and Lindholm-Hjørring-Frederikshavn – at the same time as the installation of GSM-R Voice.

3.1.7. 2015-2021 – ERTMS early deployment

Given the complexity of the project as a whole, ERTMS will be *deployed early* on two lines in order to gather experience of the construction and operation of the system in preparation for its more extensive deployment on other lines.

The following lines, which do not currently have train protection systems, have been selected for this purpose:

1. Roskilde - Køge - Næstved (line number 40) is a local line but in a busy area with a mix of freight and passenger services.
2. Lindholm - Hjørring - Frederikshavn (line numbers 71 and 25). This line forms part of the Danish TEN infrastructure.

The deployment will be carried out such that ETCS level 2 will open in 2018-2021 on the two lines.

3.1.8. 2018-2030: ERTMS on the Danish TEN network

The roll-out across the state railway network, including the TEN network, is expected to be carried out over 12 years (2018-2030).

The rate of the roll-out is given in *table 5 and table 6*, which indicate the timeframe for the shift from ATC (class B) to ERTMS (class A) on the individual lines.

The roll-out of ERTMS on the state railway network is expected to be completed by the end of 2030.

3.1.9. 2018-2030: General timetable for the ERTMS project

In addition to the transition to the standardised European train protection and radio systems, ERTMS level 2, the project also entails the replacement of all centralised traffic control equipment and interlockings with the associated software across the state railway network.

Table 4. The Signalling Programme's latest general timetable

'09 '10 '11	'12 '13 '14 '15	'16 '17 '18 '19 '20 '21	'22 '23 '24 '25 '26 '27 '28 '29 '30
Tender and contract (3 years)	Design (4 years)	Testing and trials, incl. early deployment (4 years)	Roll-out phase (up to 11 years)

The long-distance part of the signalling programme covers 2 323 km of railway.

The roll-out rate on the TEN network is expected to be as shown in *table 5* below. This includes an early deployment line, which will enter service in 2018.

The planned roll-out on the core corridor will take place in 2023-2030. This is not in line with the European ERTMS deployment plan, according to which the entire Danish section of the ScanMed corridor is assumed to be equipped with ERTMS by 2023. Line number 22 to the Fehmarn Link and Germany will be equipped in line with the expected completion of the fixed link under the Fehmarn Belt, which is dependent on when Germany gives the final regulatory approval. Likewise, ETCS will be deployed on line numbers 13, 14, 15, 16, 26, 98 and 99 in 2027-2028.

Table 5. ERTMS roll-out on the TEN network²².

Line number	Main, regional and local railways	ERTMS deployment / end of class B operation	Line	Line length in km
71	M	End-2024	Langå - Randers - Hobro - Skørping - Aalborg - Lindholm	96.7

²² The new Vigerslev-Ringsted railway line is equipped with ERTMS, but is not shown in the table, as it will not enter operation until mid-2019 and does not yet have an official line number in the TIB.

25			R		*) 21 October 2018	Lindholm - Hjørring - Frederikshavn	84.9
24	b	M			End-2024	Århus H - Langå	45.8
23		M			End-2025	Fredericia - Vejle - Skanderborg - Århus H	108.5
12**)		M			End-2028	Roskilde - Borup - Ringsted	32.6
13**)		M			End-2028	Ringsted - Slagelse - Korsør	44.4
14**)		M			End-2027	Korsør - Nyborg	23.3
15**)		M			End-2027	Nyborg - Odense	28.0
16**)		M			End-2027	Odense - Snoghøj - Fredericia/Taulov	65.2
10	a		R		Mid-2030	Copenhagen C - Østerport - Helgoland	
					End-2028	Helgoland - Klampenborg	13.3
11 **)		M			End-2029	Copenhagen C - Hvidovre Fjern - Høje Taastrup - Roskilde	31.3
19 **)		M			2025-29	Copenhagen Gb - Vigerslev - Hvidovre Fjern (deployment in stages)	7.3
21 **)			R		End-2024	Ringsted – Næstved	
					Mid-2022	Næstved - Vordingborg - Nykøbing F Vest	83.0
22 **)				L	Adapted to entry into service of Fehmarn Belt Fixed Link	Nykøbing F - south of Holeby	36.4
50 **)		M			End-2028	Copenhagen C - Kalvebod/Kalvebod - Vigerslev/Kalvebod	
					End-2025	Vigerslev/Kalvebod - Kastrup - Peberholm (ØSK)	23.0
26		M			Mid-2027	Fredericia - Taulov - Lunderskov	33.2
98		M			Mid-2027	Lunderskov - Vamdrup - Vojens - Tinglev	62.5
99		M			Mid-2027	Tinglev - Padborg	14.4
29		M			End-2026	Lunderskov - Bramming	39.3
97		M			End-2026	Bramming - Esbjerg	16.4
25.1.2.		Private railway			No plans	Hjørring - Hirtshals	17.8

As mentioned above, the signalling project also covers the roll-out of ERTMS on the rest of the long-distance rail network outside the TEN network.

3.1.10. ERTMS on other state railway lines

The plan for the roll-out on the rest of the state network is set out in *table 6* below. These lines are covered by the interoperability requirement under Commission Regulation (EU) 2016/919.

Table 6. Roll-out of ERTMS on regional and local railways

Line number		Main, regional and local railways			ERTMS deployment / end of class B operation	Line	Line length in km
40				L	*) Mid-2019 Mid-2021	Roskilde - Køge N - Køge N - Køge - Næstved	61.4
10	b		R		End-2028	Klampenborg - Nivå - Snekkersten - Helsingør	32.9
28			R		Mid-2027	Sønderborg - Tinglev	41.2
32			R		End-2020	Langå - Viborg - Skive - Struer	102.4
34				L	Mid-2020	Struer - Thisted	73.6
33	b		R		End-2020	Holstebro - Struer	15.5
33	a		R		Mid-2021	Holstebro - Herning	41.2
39			R		Mid-2021	Herning - Vejle	73.0
56				L	End-2023	Herning - Skjern	40.7
55			R		Mid-2022	Skanderborg - Silkeborg - Herning	71.2
90				L	End-2023	Esbjerg - Varde	17.5
91				L	End-2023	Varde - Skjern	42.4
92				L	End-2023	Skjern - Ringkøbing - Vemb - Holstebro	71.0
94				L	End-2026	Bramming - Ribe	16.7
95				L	End-2026	Ribe - Tønder	47.3
96				L	End-2026	Tønder - Tønder Grænse	3.9
78				L	Mid-2021	Odense - Ringe - Svendborg	48.2
70					Will not be equipped with ETCS	Lersøen - Østerport	5.6
79					Mid-2026	Roskilde - Løjre - Tølløse - Vipperød - Holbæk	35.8
51			R	L	Mid-2026	Holbæk - Kalundborg	43.5

Note: *) = Early deployment

**) = ScanMed Corridor

3.2. Private railways' interoperability plans

The Danish private railways are both infrastructure managers and railway undertakings. The current traffic on the private railways does not, with one exception, entail a requirement for train protection systems on safety grounds.

The day-to-day operation of the private railways will, however, be affected by the switchover to ERTMS on the state railway infrastructure, insofar as rolling stock travelling to and from private railways will have to be equipped with ERTMS.

Table 7. ERTMS roll-out phase on state infrastructure that connects to private railways and the private railways' current plans

The private railway is connected to lines with line numbers:	Private railway number	Definite ERTMS infrastructure plans	ERTMS deployment on connecting lines	Line	Line length in km	Railway
25	25.1.1	None	2018	Skagen - Frederikshavn	39.7	NJ
25	25.1.2	None	2018	TEN: Hirtshals - Hjørring	17.8	NJ
31	31.2.1	None	2023	Vemb - Lemvig - Thyborøn	56.9	MJ
36	36.2.2	None	2025	Odder - Århus H	26.5	MJ
31	31.3.1	None	2023	Varde - Nørre Nebel	37.6	VNJ
13+79	13/79.4.1	None	2028 +2026	Slagelse - Høng - Tølløse	50.8	L
79	79.4.2	None	2026	Holbæk - Nykøbing Sj.	49.6	L
22	22.4.3	None	2022	Nykøbing F - Saksøbing - Maribo - Nakskov	50.2	L
40	40.4.4	None	2021	Køge - Hårlev - Rødvig /- Faxe Ladeplads	42.6	L
86	86.5.1	None	-	Jægersborg - Nærum	7.8	L
82	8.5.2	None	-	Hillerød - Frederiksværk - Hundested	36.3	L
82	8.5.3	None	-	Hillerød - Kagerup - Gilleleje/ Kagerup - Tisvildeleje	42	L
9	9.5.4	None	End-2028	Hillerød - Snekkersten - (Helsingør)	19.9	L
10	10.5.5	None	End-2028	Helsingør - Hornbæk - Gilleleje	24.9	L

*) *Private railway number*: The number before the first point indicates the number of the line to which the private railway connects. The next number is the private rail company's serial number and the final number is a serial number for the line at the company.

The private railways' rolling stock will be equipped with ERTMS during the implementation plan project, insofar as the rolling stock travels on the state railway network.

As stated, an option was included in the GSM-R Voice contract for the installation of GSM-R on the private railways' infrastructure. The private railways all made use of that option and have been equipped with GSM-R since 2014.

The positions of the individual railways are described briefly below.

Nordjyske Jernbaner A/S manages two lines:

Frederikshavn - Skagen

TEN line Hjørring - Hirtshals

The undertaking has no plans to introduce train protection systems on its own infrastructure.

Midtjyske Jernbaner A/S manages the line:

Vemb - Lemvig - Thyborøn Jernbane A/S

The undertaking has no plans to introduce train protection systems on its own infrastructure.

Varde-Nørre Nebelbanen A/S manages the line:

Varde - Oksbøl - Nørre Nebel.

Operation of the line is subcontracted to Arriva A/S. There are no plans to introduce a train protection system on the line.

Lokaltog A/S manages eight lines:

Slagelse - Tølløse - Holbæk - Nykøbing Sj.

Nykøbing Falster - Nakskov (Lolland Line).

Køge - Rødvig/Fakse Ladeplads (Østbanen).

Hillerød - Frederiksværk - Hundested (Frederiksværk Line)

Hillerød - Kagerup - Tisvildeleje /- Gilleleje (Gribskov Line)

Helsingør - Hornbæk - Gilleleje (Hornbæk Line)

Hillerød-Helsingør (Little North Line)

Jægersborg - Nærum (Nærum Line)

The Helsingør - Hornbæk - Gilleleje line is equipped with the ATP system, while the other lines have no train protection system. There are no plans to introduce ERTMS on these lines.

In conclusion, the private lines are equipped with GSM-R, but there are no plans to roll out ERTMS.

3.3. Impact of the switchover for rolling stock

3.3.1. Expected extent of rolling stock upgrading

In order to obtain a volume discount for all railway undertakings that operate in Denmark, Banedanmark originally tendered together with 38 other contracting entities for a framework contract to supply ETCS on-board equipment for trains used in Denmark. The tender was won by Alstom. If railway undertakings want to purchase equipment, installation work, etc. under this framework contract, they must conclude a direct contract with the supplier.

This model still applies for rail freight undertakings and contractors, for example.

Later, a model was chosen in which Banedanmark (the Signalling Programme) concluded contracts with Alstom for the installation of equipment on the railway undertakings' trains that are used for public service contracts. This contractual arrangement means that Banedanmark has agreed in its contracts with Alstom on, for example, the number of trains that the railway undertakings are to make available for Alstom to install on-board equipment, while still being able to maintain their operations at the same time.

The current model for installing on-board equipment on trains used for public service contracts requires close dialogue between the Signalling Programme and the railway undertakings. The Signalling Programme pays for the installation, while the railway undertakings are to inspect Alstom's work once it is completed before Banedanmark formally approves it.

There are currently around 400 multiple units/driving van trailers and a few locomotives used in public service contracts that are to be equipped (of which almost 300 under Banedanmark's framework contract), see table 8 below. There are also an additional 46 on-track machines owned by Banedanmark and a few on-track machines owned by other infrastructure managers. It is expected that 111 multiple units (MU) used in regional cross-border public service contracts between Denmark and Sweden will be equipped on the basis of a Swedish-led tender.

Owing to a contractual dispute with Banedanmark's supplier of on-board equipment (Alstom) over which ETCS version can be authorised for the on-board units supplied, the Transport, Construction and Housing Authority notified the EU Agency for Railways in July 2017 and March 2018 of a derogation from the rules on the use of applicable TSIs. The derogation lists a number of vehicle types and the number of each type, and the derogation therefore applies only to those trains.

It will not be immediately possible to use rolling stock covered by the derogations abroad. Likewise, the on-board equipment will have to be updated to baseline 3.6.0 from 2025 if it is to be used in the Greater Copenhagen area.

The dispute has since been settled and it will therefore be possible to purchase on-board equipment with version 3.4.0.

When purchasing new rolling stock, railway undertakings must ensure that it has ETCS and can be approved in accordance with the applicable rules. That on-board equipment is expected to be baseline 3.4.0 or 3.6.0.

Table 8. Planned equipping of passenger stock with ETCS

Class ID	Type	Operator	ETCS
Lint 41 AR	DMU	Arriva	43
ER (IR4)	EMU	DSB	44 ²³
MK	Diesel Shunter	DSB	1
MR	DMU	DSB	5
MF (IC3)	DMU	DSB	96
MQ (Desiro)	DMU	DSB	20
ABs - batch 1	Steering cars	DSB	7
ABs - batch 2	Steering cars	DSB	18

²³ A decision will be taken on equipping the IR4 series in late 2019. Until then, the work on the design of the trains continues.

ET (Øresund Train) ²⁴	EMU	DSB (34) + Swedish owners (77)	111
MX	Diesel Loco	Midtjyske Jernbaner	1
DM (Desiro)	DMU	Nordjyske Jernbaner	8
LINT 41	DMU	Nordjyske Jernbaner	13
IC2	DMU	Lokaltog	13
LINT 41	DMU	Lokaltog	41
MX	Diesel Loco	Lokaltog	4
MY	Diesel Loco	Lokaltog	1

In mid-2018 DSB ordered 26 Vectron electric locomotives²⁵, which are expected to enter into service in 2021. At the same time, DSB launched a tender for around 150 new multiple units²⁶ that will be put into service from 2024. In addition, regional railway undertakings are expected to purchase a smaller amount of new stock.

As mentioned above, rail freight undertakings and contractors are to conclude their own contracts for the installation of ETCS on their rolling stock. This is expected to apply to around 60-70 Danish-owned freight locomotives and a number of Danish-owned on-track machines, all of which are used commercially.

In 2017 the European Commission approved a support scheme under which rail freight undertakings may be compensated with up to 50 % of the cost of purchasing and installing the new train protection equipment. The compensation is granted on application and over DKK 57 million has been earmarked for the scheme.

Both STM and ETCS equipment are eligible for support. A maximum of DKK 1.246 million in compensation can be granted for equipping the first in a series of freight locomotives (first-of-class) and DKK 0.519 million for each subsequent locomotive in the series. Within the above amount, the proportion of support for Danish STM may not exceed DKK 286 000. If Danish STM is purchased in addition to existing ETCS equipment, the support may only cover 50 %.

Banedanmark is not aware that Danish rail freight undertakings have concluded contracts for the supply and installation of ETCS on freight traction equipment (all locomotives have GSM-R Voice).

The above does not include any assessment of the impact of the possible entry of new railway undertakings onto the Danish rail infrastructure in the coming years. However, in 2017 a closer analysis was carried out of the extent to which passenger stock will be removed from service over the coming years for upgrading. The amount of stock that does not need to be upgraded or cannot be upgraded is unclear.

²⁴ It is expected that the ET multiple units (Øresund trains) used in regional cross-border public service contracts between Denmark and Sweden will be equipped on the basis of a Swedish-led tender.

²⁵ DSB has the option of acquiring up to 18 further Vectron locomotives.

²⁶ DSB's tender documentation includes the possibility of purchasing a further 100 multiple units.

This mainly concerns a small number of shunting locomotives and on-track machines.

3.3.2. Status of upgrades to rolling stock

Upgrading rolling stock to ETCS, or supplying new stock with ETCS installed, could only start from the beginning of 2014 when STM-DK became available if the stock was to be used on lines with ATC. The first newly acquired stock with ERTMS on-board equipment was approved in 2018 (Nordjyske Jernbaner's Lint 41 MU). New stock is expected to be purchased with ETCS equipment, as will be the case for the DSB Vectron locomotives and new multiple units for DSB and Midtjyske Jernbaner.

Banedanmark is currently in negotiations with Alstom on a new production plan, as Alstom is significantly delayed in respect of the Signalling Programme's original schedule. However, the negotiations are taking longer than expected. We would emphasise that a new agreement is not crucial at present to progress on the on-board equipment. The roll-out plan still has some margin between the latest production plan from Alstom and Banedanmark's requirements for when the different types of train are to be equipped.

The project for on-board equipment does not have one single critical path, rather several depending on the type of train and geographical roll-out. The focus for on-board equipment is therefore threefold:

- 1) IC3
- 2) Desiro and Lint trains
- 3) Other types of train

The overview of train classes therefore shows estimates from Alstom's schedule and/or dates estimated by Banedanmark on that basis. We would emphasise that the estimates are uncertain.

For each train class, the following milestones have been set:


- APIS for FoC: Authorisation for deployment of prototype (first-of-class)
- Start of series: Start of series equipping
- End of series: Completion of series equipping
- First line: First date/line where the type of train will be used.

Usually, the entire series would not be used on the first line, as is also shown in the table below.

In the years 2022-2024 DSB is expected to remove existing class ME diesel locomotives from service and replace them with Vectron locomotives that are supplied equipped with ERTMS. Likewise, in the period 2024-2028 DSB is expected to put 150 new electric multiple units into service to replace existing IC4 diesel multiple units.

For the sake of completeness, we would point out that a decision will be taken at the end of 2019 on equipping the IR4 series, on the basis of the Transport Plan and the Development Plan. Until then, work on the design of the trains continues.

Table 9. Status end-October 2018 of equipping of trains for the first line

Class	Status of equipping of FoC and series²⁷	Number of trains for the first line	APIS FoC²⁸	Start Series	End Series
 8 NJBA DM	FoC: 1/1 Series: 7/7	8 for Lindholm-Frederikshavn October 2018	Achieved	Completed	Completed
13 NJBA Lint41	13/13 ²⁹	13 for Lindholm-Frederikshavn October 2018	Achieved	Completed	Completed
 96 DSB IC3 (incl. 17 IC3 Indusi)	FoC: 1/3 ³⁰ Series: 0/93	5 for Vejle-Struer when Struer-(Langå) enters into service at the end of 2020. All 96 in 2023.	Achieved	JUN 2019	79 IC3 ³¹ : JUL 2022 All 96 IC3 ³² : 2023 ³³
 DSB MQ	FoC: 1/2 Series: 1/18	12 for Roskilde-Køge May 2019 (8 for Odense-Svendborg early 2021)	<i>Achieved</i>	Started	MAY 2019 (the first 12)
 25 DSB ABS	FoC: 0/1 Series: 0/24	12 for Køge-Næstved from mid-2021	SEP 2019	OCT 2019	FEB 2021
 34 DSB E	FoC: 0/1 Series: 110	All end-2022 ³⁵	Equipped outside the Danish Signalling Programme		
 43 Arriva Lint41	FoC: 1/2 Series: 14/41	Approx. 15 for (Struer)-Thisted mid-2020.	<i>Achieved</i>	Started	MAY 2020 (all 43)

²⁷ This column indicates whether the installation of FoC has been completed (for APIS for FoC, information is instead provided in the column APIS FoC).

²⁸ Indicates APIS for the first FoC if there are multiple FoC.

²⁹ Hardware is installed at the same time as the trains are built; software is rolled out locally.

³⁰ Installation on the second FoC IC3 will begin after installation on the 79 IC3 that will not operate to Germany. The 17 IC3 that operate to Germany are referred to as IC3 Indusi.

³¹ i.e. excluding the 17 IC3 Indusi.

³² i.e. including the 17 IC3 Indusi.

³³ Banedanmark is in the process of adopting an installation plan for the 17 IC3 Indusi.

³⁴ Including the 77 Swedish-owned trains.

³⁵ The Swedish ETCS roll-out means that, on the Swedish side of the bridge as far as Malmö, ETCS will enter service in 2023, i.e. up to three years before Copenhagen-Peberholm, where it will enter into service at the end of 2025. The trains therefore need to be equipped by the end of 2022.

		All 43 for Struer- (Langå) end- 2020			
41 Lokaltog Lint41	FoC: 0/2	12 for Roskilde- Køge December 2020	APR 2020	APR 2020 for the first 12 Banedanmark is in the process of organising the production plan for the remainder.	
	Series: 0/39				

4. Transition strategy:

The overall strategy for the ATC-ERTMS transition is 'on-board first'. This means that the rolling stock is equipped so that it can operate on both types of infrastructure, following which the infrastructure is migrated.

The new systems are deployed line by line. In line with their deployment, the old signalling system and Danish ATC are decommissioned, and the physical equipment is subsequently removed.

For GSM-R, a 'network first' approach was employed. First a GSM-R network was constructed in parallel with the analogue network and then the rolling stock was upgraded. Once all old rolling stock was equipped, the analogue network was shut down.

The upgrading of the train protection system, and to a certain extent the train radio system, takes place in close connection with the total renewal of the interlockings and the changeover of the signalling system from use of lineside signals to signal displays in the driver's cab.

4.1. Rolling stock

With a line-by-line upgrade of the infrastructure to class A, without maintaining the current class B system in parallel, the entire flexibility of the transition period is based on the flexibility of the rolling stock with regard to the different train protection systems in the infrastructure.

One consequence of basing the chosen strategy on ERTMS level 2 is that the rolling stock is to be equipped with an STM-DK as an interface to the ATC. Upgraded rolling stock can thus operate both on lines with ERTMS and lines that have not yet been upgraded that have the class B system ATC (and ATC-T).

As an STM-SE will have to be installed on trains operating on the fixed link across the Øresund owing to the upgrading of the Swedish rail infrastructure, there will be a period in which trains across the Øresund Bridge will be equipped with ETCS and both STM-DK and STM-SE.

Tests of a number of trains with ETCS, STM-DK and STM-SE have been carried out in Denmark and Sweden.

A German STM-DE (STM for PZB/LZB) has not been developed, but there are various integrated system solutions that could be used depending on the supplier of the ERTMS on-board equipment. Some Danish freight locomotives and a few multiple units will require a system corresponding to STM-DE after 2025 to allow them to operate on German class B lines.

4.2. Infrastructure

4.2.1. Stable and safe train management

The roll-out plan for the transition period from an infrastructure entirely equipped with class B to one entirely equipped with class A (which is expected to last around 12 years) emphasises stable train operation and support for the switchover to electrical traction in connection with the line-by-line upgrading to ERTMS and the corresponding gradual phasing out of the existing train protection systems ATC and ATC-T.

Normal safety levels must be maintained throughout the transition.

As a number of lines are not currently equipped with a train protection system, the entry into service of ERTMS will increase safety standards across the state rail network.

4.2.2. Øresund link

On the Øresund link, which has a 2 km changeover zone between two class B train protection systems requiring trains to have a specially installed mobile train protection system, the switchover strategy will be supplemented with and based on the parallel installation of ERTMS in the infrastructure.

Dual-system multiple units and locomotives³⁶ between Denmark and Sweden currently pass the class B/B (ATC/ZUB 123 and ATC 2/Ebicab 700 & ATSS) changeover zone at normal line speed. It is not possible to stop in order to switch between systems.

Trains with the existing grouped mobile Danish-Swedish train protection system can still cross the link changing over from class B to class B, while trains equipped with mobile ETCS and an STM-DK and an STM-SE can cross changing over between level NTC and NTC.

The current class B/B changeover zone is expected to be shut down once all trains equipped with combined Danish/Swedish ATC have been upgraded to ETCS level NTC. The changeover will be decommissioned when ERTMS enters into service at the end of 2025.

4.2.2. The future Fehmarn Belt link

While a system changeover at the Danish/German border at Padborg will continue to be based on a solution using mobile ETCS supplemented with STM-DK and STM-DE or a specific integration with PZB/LZB, the Fehmarn Belt Fixed Link will be equipped with ERTMS into Germany when it opens to trains in the late 2020s.

³⁶ Power systems: Denmark (25 kV/50 Hz) and Sweden (15 kV/16.5 Hz).

4.3. Transition period programmes – a summary

The transition period from the class B systems to class A can be summarised briefly in a number of programmes:

- First programme: Construction of a GSM-R Voice network in the infrastructure. GSM-R was turned on in late 2011 and the analogue line radio (STR) was turned off in 2017. In the period from late 2011 to late 2014, all rolling stock was upgraded to GSM-R Voice.
- Second programme: The upgrading of the rolling stock began in late 2017 with the installation of ETCS with GSM-R Data on-board equipment and STM-DK. STM-SE is also expected to be installed on trains that also operate in Sweden. The mobile ATC and any other train protection systems are removed from the rolling stock. The upgrading of existing stock is expected to be completed in 2023. The upgrading of the GSM-R network's support for ETCS data traffic (GSM-R Data) will take place in the years 2018-2020, before the ETCS equipment on the lines.
- Third programme
 - Stage 1: Deployment of ERTMS on the infrastructure on the first lines (early deployment) and on branch and regional lines where the rolling stock is ready, 2018-2022.
 - Stage 2: Deployment of ERTMS on regional and main lines where the rolling stock is ready, 2023-2025.
 - Stage 3: Deployment of ERTMS on the remaining regional and main lines following supply of new electric locomotives and multiple units (2021-2025), 2026-2030.
- Fourth programme: Gradual removal of STM-DK from the rolling stock, at the latest from the end of the 2020s (timeframes for the removal of STM-SE and STM-DE are not currently known).

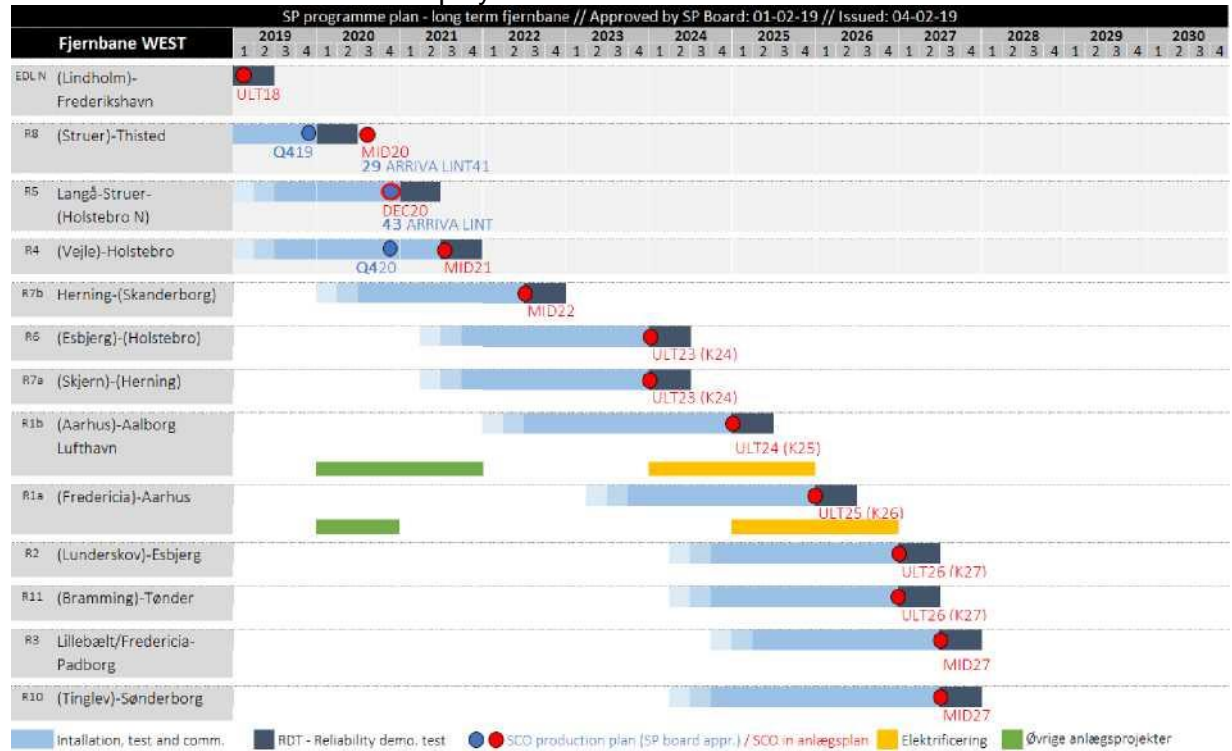
The transition phase is therefore based on a complete and relatively rapid upgrading of the rolling stock used by railway undertakings. It has proved difficult to install the equipment on some older rolling stock, and given the short remaining life of this stock, it is not expected to be equipped with ERTMS.

4.3.1 Stages of roll-out on the infrastructure

The roll-out of ETCS on the infrastructure is dependent on the equipping of the rolling stock that operates on that infrastructure. Especially on the main lines, where the number of different types of train and the number of units are high, this will mean later equipping than originally planned.

The maps below illustrate the stages of infrastructure equipping based on the plans from April 2017, of equipping of rolling stock with ERTMS and of supply of new rolling stock to replace older rolling stock that will not be equipped.

Table 10. Plan for roll-out and deployment of ETCS west of the Little Belt



5. Maps

1. Railways in Denmark
2. Banedanmark's lines – line numbers
3. TEN map – Denmark – Railways
4. Lines with train protection systems (November 2017)
5. Electrified lines
6. Stations on state railway lines
7. Private railways

Map 1: Railways and line classes in Denmark



Line classes

- | | |
|---------------|--|
| Main line | Aarhus light rail |
| Regional line | Freight line |
| S-train | Regional and private railways not managed by Banedanmark |
| Local line | |

Note: Banedanmark divides the state rail network into line classes with different requirements for level of service, depending on the transport needs served by the lines. Physical equipment on different line classes differs according to transport needs.

Main lines have the highest standards and comprise the main rail network linking the different parts of the country. They are used for a mixture of international and national services, commuter services and freight services. The line from Øresund/Copenhagen to Padborg is electrified and is referred to as the core network. Electrical traction cannot be used on the other main lines. All main lines are double-track apart from one line in Southern Jutland.

Regional lines connect large cities outside the main lines. Tinglev-Sønderborg is electrified and Copenhagen-Helsingør (the Coast Line) is electrified and double-track. A few other regional lines are double-track.

Local lines generally have a low volume of traffic and are typically found in sparsely populated areas. The Hillerød-Snekkersten local line, which is 20.8 km long, was transferred to Hovedstadens Lokalbaner on 1 January 2001 and is now classified as a private railway.

Freight lines are used only by freight trains.

Private railways are owned by the relevant regional transport companies that are in turn owned by the regions where the railways are located. The railways have varying volumes of traffic depending on the transport needs in the region.

S-train. The S-train urban rail network in Copenhagen is operationally separate from the main line. After the roll-out of CBTC it will also be functionally separate.

Metro: The Copenhagen metro is physically separate from the main line and therefore does not appear on the map.

Map 2: Banedanmark's lines – line numbers



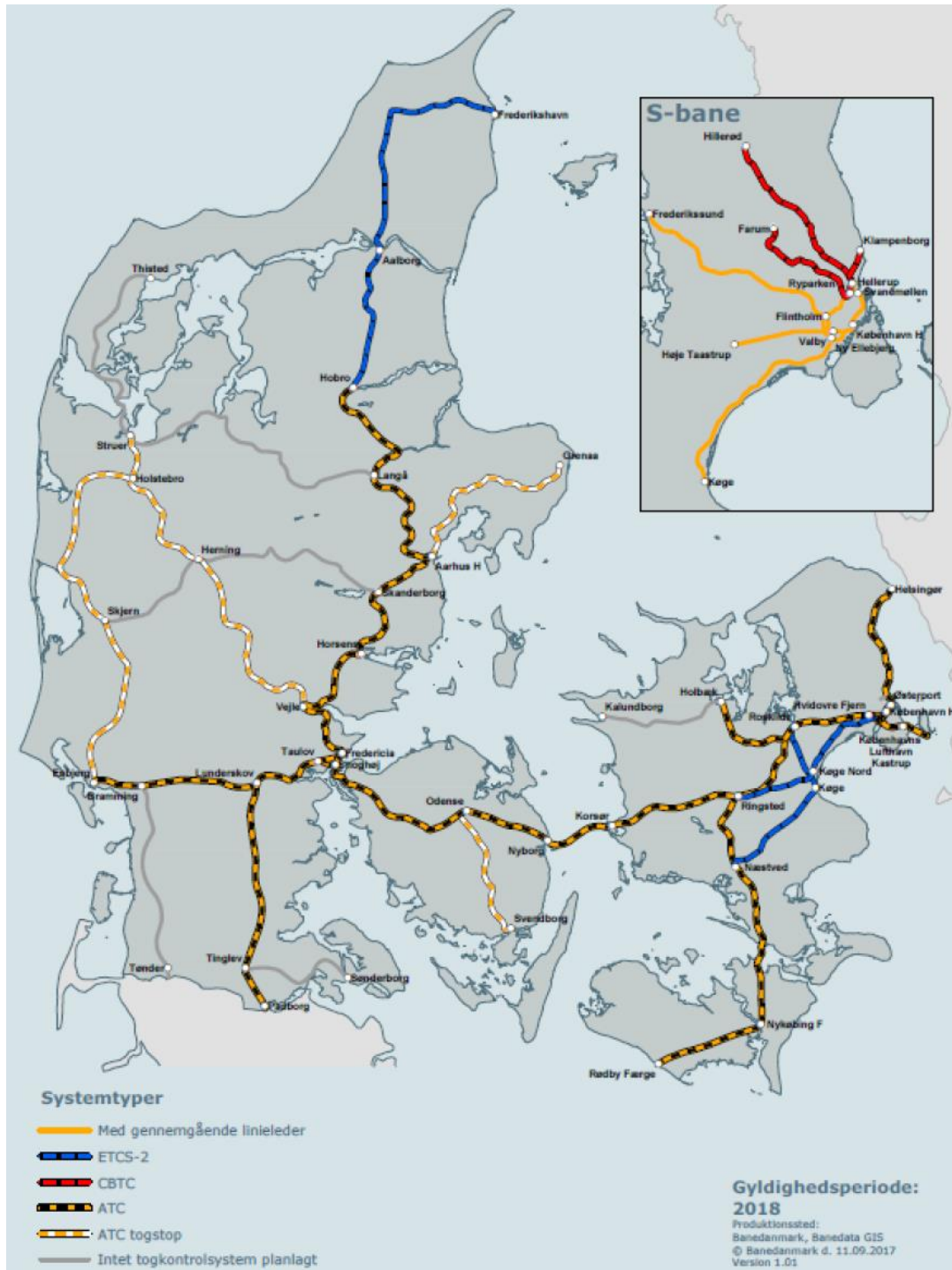
Please note that the new Copenhagen-Køge Nord-Ringsted line that is expected to enter into service in May 2019 does not yet appear on the map.

Map 3: TEN lines in Denmark



Please note that the new Copenhagen-Køge Nord-Ringsted line is expected to enter into service in May 2019 and not in 2018 as indicated on the map.

Map 4: Lines with train protection systems



- System types**
- With infill throughout
 - ETCS-2
 - CBTC
 - ATC
 - ATC train stop
 - No train protection system planned

Train protection on Banedanmark's rail network



Note: S-banen er ikke omfattet af interoperabilitetskravet

Note: The interoperability requirement does not apply to the S-train network.

Map 6: Stations on state railway lines





Map 7: Private railways

Nordjyllands Trafikselskab

1. Nordjyske Jernbaner A/S



- 1.1. Skagen Line (SB), 39.7 km
- 1.2. Hirtshals Line (HP), 17.8 km

Operator: Midttrafik

2. Midtjyske Jernbaner A/S



- Lemvig Line:
- 2.1. Vemb-Lemvig-Tyborøn Line (VLTJ), 56.9 km

Operator: Sydtrafik

3. Vestbanen



- 3.1. Varde-Nørre Nebel (VNJ), 37.6 km

Operator: MOVIA

4. Lokaltog A/S



Vestsjællands Jernbaner:

4.1 Slagelse - Høng - Tølløse (HTJ), 50.8 km

4.2. Holbæk-Nykøbing Sj. (OHJ - Odsherred Line), 49,6 km



Lolland Line:

4.3. Nykøbing F - Saksøbing - Maribo - Nakskov (LJ), 50.2 km



Østbanen

4.4. Køge - Hårlev - Rødvig /- Faxe Ladeplads (ØSJS), 49.6 km



4.5. Jægersborg - Nærum (LNJ), 7.8 km

4.6. Hillerød - Frederiksværk - Hundested (HFHJ) 39.0 km

4.7. Hillerød - Kagerup - Gilleleje /- Tisvildeleje (GDS) 16.1 km
(plus 8.6 km counted as part of the Hornbæk Line)

4.8. Hillerød - Snekkersten - (Helsingør) (Lille Nord), 19.9 km

4.9. Helsingør - Hornbæk - Gilleleje (HHGB) 24.5 km

Note: *) Hovedstadens Lokalbanel A/S (infrastructure manager)

* Lokalbanelne A/S (railway undertaking)