# S-bane Infrastructure

# BN1-212-1 Engineering Rules for S-bane

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# Engineering Rules

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# 1 Introduction

## 1.1 Purpose and contents

### 1.1.1 Purpose

| | |
|---|---|
| | This document defines engineering rules and other infrastructure constraints that apply to the Signalling System of the S-bane up to a maximum speed of 120km/h. |
| | These rules apply to railway infrastructure governed by the operating rules ORS. For areas supporting train operation with visible signals applies as specified in section 3 of these rules. |

### 1.1.2 Contents

| | |
|---|---|
| | This document is structured according to element and function categories of the infrastructure.<br><br>There may thus be cases where rules on a particular subject are divided among two or more sections. |
| | The rules in this document are categorized in the following different levels. |
| | BN1-rules:<br>Highest level of rules. Safety related or derived from legal acts and shall be approved by the authorities according to BN2-1 [3].. |
| | BN2-rules:<br>Second highest level of rules. The rules are corporate requirements according to BN2-1 [3].. |
| | This document illustrates certain rules by examples. These should not be considered exhaustive. |

### 1.1.3 Use

| | |
|---|---|
| | Engineering Rules are intended to govern design and changes of infrastructure and Signalling System in order to provide safe as well as operationally feasible solutions. |
| | Dispensation from both BN1- and BN2-rules shall as minimum be approved by the responsible person for this set of rules. |

| | |
|---|---|
| | Process for dispensation from technical rules is stated in Banedanmarks's safety management system. |
| | Rules defined in the Engineering rules have an identifier with format <section nr.>-<serial number>, e.g., "1.1.1-1". |

### 1.1.4 Relationship to other documents

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|---|---|
| | Where justification for a requirement is provided in another document, this is referenced after the requirement. All references can be found in section 4. |

## 1.2 Not in use

## 1.3 Reader's instructions

| | |
|---|---|
| | This document states rules and constraints in normal text style.<br>Such statements are marked with an ID number. |
| | This document states definitions (including rules that belong outside the Engineering Rules scope) in normal text style. Such statements are marked "DEF". |
| | This document states explanations and background information in small text style. Such statements are marked "COM". |
| | This document states which BN-level each requirement is, and which requirements are system requirements (*Syst. req.), in a separate column. |
| | This document states all rules in English. |

## 1.4 Terms and definitions

Terms and definitions are listed in Table 1.4-1 Definitions.

| Terminology | Definition |
|---|---|
| Access point | Access points are the wayside radio base stations handling the bidirectional wireless communication between the trains and the wayside CBTC system. An access point has two directive antennas (only one at track end) arranged such that each antenna is aligned to the track direction, thus, one access point covers both (or one at track end) directions of the track. The range of an antenna is limited to about 1800 m. |
| ATO | Automatic Train Operation, the part of OBCU which drives the train automatically. |
| Axle counter | Axle counters mark the borders of track vacancy sections (TVS) and are mounted on one rail, no matter which one. Wheels are detected when passing the axle counter including direction of passing.<br>The schematic shows on which rail the axle counter is mounted by placing the symbol on the corresponding side of the track. For illustration and schematic example see Figure 1.4-1 Axle counter. |
| Axle counting head | Counting head for axle counter system. |

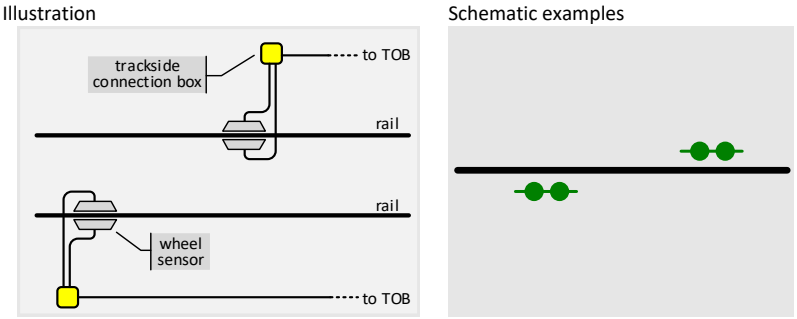



**Figure 1.4-1 Axle counter**

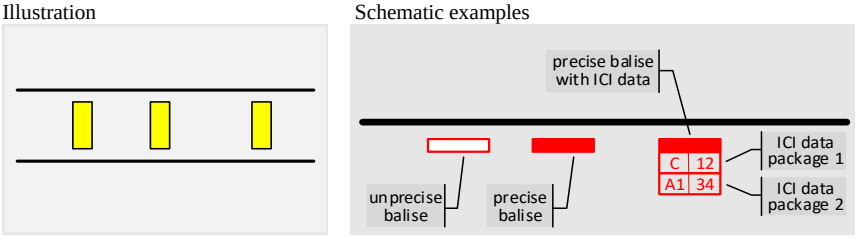
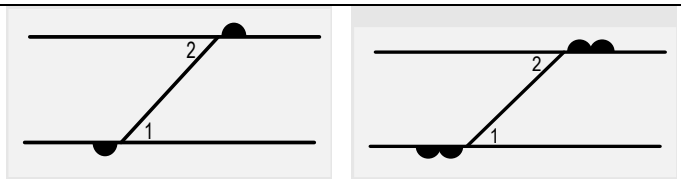
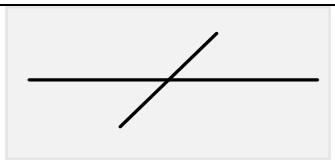
| Terminology | Definition |
|---|---|
| Balise | Balises are passive landmarks holding a specific set of data each. Trains and vehicle equipped with balise readers read the data when passing the balise in either direction. Balises are mounted in the middle between the rails, either on a sleeper or between the sleepers on a bracket.<br>Balises are mainly required for precise localisation of S-trains. The data required from the balise is the specific ID. The corresponding location is stored onboard in the TDB. To localise a train including determining direction of movement, two balises need to be read.ICI operation is based on determining location and direction of movement by reading balises, too. As the ICI does not have a TDB, balises used for ICI operation hold additional data regarding the type of ICI balise (A1, A2, R1, R2, C) and the upcoming marker board. Any balise can have up to two ICI data packages. For illustration and a schematic example see Figure 1.4-2 Balises. |
| | Illustration / Schematic examples<br>  |
| Buffer Stop | A buffer stop (short: buffer) can be installed to terminate a pocket track. |
| CBTC | Communication Based Train Control, a subsystem of the signalling system. |
| CBTC-controlled area | Tracks supporting CBTC equipped train operation. |
| CBTC train | Train equipped with an OBCU providing full CBTC functionality |
| Count-down board | On main tracks an upcoming marker board is indicated to the driver by a sequence of Count-down boards. For S-bane this is only relevant for trains equipped with ICI.<br>A count-down board may be supplemented with a warning board. |

**Figure 1.4-2 Balises**

| Terminology | Definition |
|---|---|
| Coupled points | The point machines of two points or one point and a derailer can be electrically coupled such that the two elements can only be operated with the same end position, either both right or both left. For moving to the other end position, the point machines can run either in parallel or in a sequence.<br><br>In drawings first and second running may be indicated by “1” or “2”. (This should not be confused with point numbers which have at least 2 digits.) For a schematic example see Figure 1.4-3 Coupled points at a cross-over with running sequence |
| |  <br>**Figure 1.4-3 Coupled points at a cross-over with running sequence** |
| Diamond-crossing | Simple intersection between two tracks<br>for schematic example see Figure 1.4-4 Diamond-crossing. |
| |  <br>**Figure 1.4-4 Diamond-crossing** |
| Detector locking (SMUTO) | Detector locking inhibits operation of a movable element while a vehicle is occupying or fouling the element. |
| Driver | The driver is responsible for the safety of the train or vehicle being operated. This includes both braking and monitoring of the highest allowable speed. |
| EBDC | Emergency brake deceleration curve.<br>The braking curve when the emergency brake is fully effective. |
| EBI | Emergency brake intervention |
| EBIC | Emergence brake intervention curve.<br>Triggering the emergency brake at the EBIC ensures that train movement will not pass the EBDC and in the end the train will not pass the end of movement authority. |
| Emergency stop area | An emergency stop area is a set of TVSs, , that can be set to and released from emergency stop. An emergency stop in an area withdraws all movement authorities in that area, i.e. authorities to enter routes and for CBTC controlled trains additionally authority to move further on moving block. |

| Terminology | Definition |
|---|---|
| | |
| EOA | End of authority. |
| Fixed block | A principle of railway signalling wherein the railway is divided into fixed sections (“blocks”) and no more than one train may be in any block at any one time. |
| Fouling point (FP) | A fouling point is a geometrical location between two tracks either converging or getting closer to each other, where the distance between these tracks falls below the required distance for independent train moves (“track separation distance”).<br>The location of fouling points is indicated by fouling point markers.<br>Any set of points has one and any cross-over has two related fouling points. For a cross-over the fouling points could be distinguished as approaching from north direction or approaching from south direction.<br>For schematic example see Figure 1.4-5 Fouling points and fouling point distances. |
| Headway | The minimum time between trains achievable at a given position on a railway network when there are no restrictions beyond those for normal running present. |
| HHT | Handheld terminal.<br>The handheld terminal is a device for the PICOP to control and view the status of possessions and move points within the possessions. |

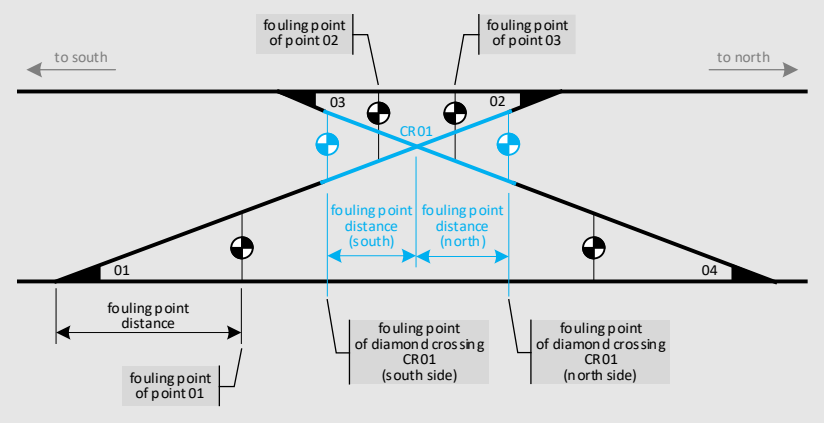
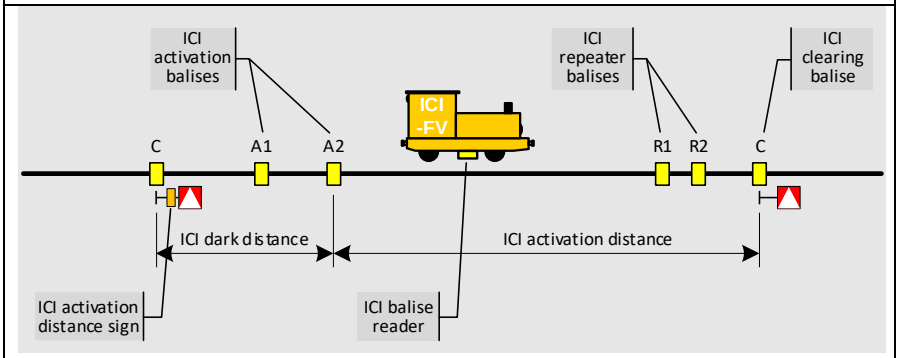
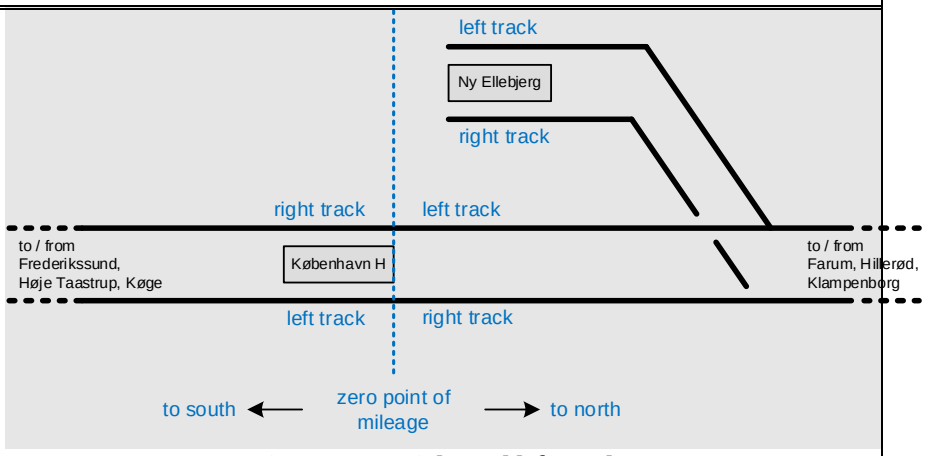



**Figure 1.4-5 Fouling points and fouling point distances**

| Terminology | Definition |
|---|---|
| ICI | In-cab-indication (ICI) is a CBTC onboard system with reduced CBTC functionality. Its purpose is to indicate the ICI movement authority at the next route start point to the driver. The ICI determines the ID of the next marker board by reading the data of two subsequent balises, either the ICI activation balises A1 and A2 or the ICI repeater balises R1 and R2. With this ID it requests the current ICI movement authority at that marker board, which is then indicated by one of three possible aspects (red, yellow, green). The indication is continuously updated until the ICI clearing balise C with same ID is detected, then it changes to dark until the ID of the next marker board is determined.<br>The length of the activation distance available up to the next marker board may be indicated at the preceding marker board by an ICI activation distance sign.<br>The purpose of the repeater balises is to provide the marker board ID even if the vehicle starts operation close to a marker board, e.g. after reversal or when leaving a possession. For schematic overview see Figure 1.4-6 In-cab indication.<br>  <br><br>**Figure 1.4-6 In-cab indication** |
| ICI balise | Balise containing at least one ICI data package (A1, A2, R1, R2, C). Refer to figures Figure 1.4-2 Balises and Figure 1.4-6 In-cab indication. |
| ICI dark distance | The distance between a clearing balise C and the activation balise A2 until the ID of the next marker board is detected, see Figure 1.4-6 In-cab indication. |
| ICI-fitted vehicle (ICI-FV) | Train equipped with ICI providing limited CBTC functionality. |
| Left track | “Right track” and “Left track” are defined as seen from the zero-mileage location at station København H. For Ringbanen right and left track are defined as seen from the terminal station Ny Ellebjerg. For schematic example see Figure 1.4-7 Right and left track. |

| Terminology | Definition |
|---|---|
| |  <br>**Figure 1.4-7 Right and left track** |
| LTE | Logical track element.<br>A partition of a track vacancy section (TVS). |
| MA | Movement authority. |
| Main track | CBTC-controlled main tracks are tracks supported by track maintenance rules for main track. In CBTC controlled areas this is currently all tracks supporting 40km/h or higher. |

| Terminology | Definition |
|---|---|
| Marker board (MB) | Marker boards are signs located beside the track indicating start and end points of routes. The marker board can be installed on right or left side of the track.<br><br>In the present document reference to marker boards are done by their location, if this is useful for defining requirements. These specific references are:<br>• Platform exit marker board<br>The marker board is located at the end of a platform track and pointing away from the platform track.<br>• Marker board on open line<br>The marker board is located on a main track but is not a platform exit or a platform entry marker board.<br>• Station entry marker board.<br>A marker board on open line in front of a TOB station, i.e. there is no further marker board up to the next platform entry or platform exit marker board of that station.<br><br>For an example of a marker board and their location see Figure 1.4-8 Appearance of marker board and accompanying signs and Figure 1.4-9 Marker boards at different locations related to a station.<br><br>Accompanying signs are:<br>- Marker board identifier<br>- ICI activation distance board<br>- Speed limit sign |

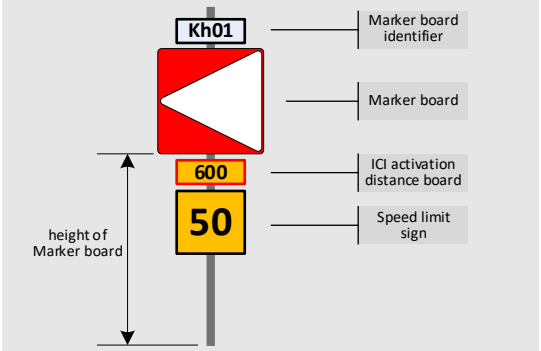
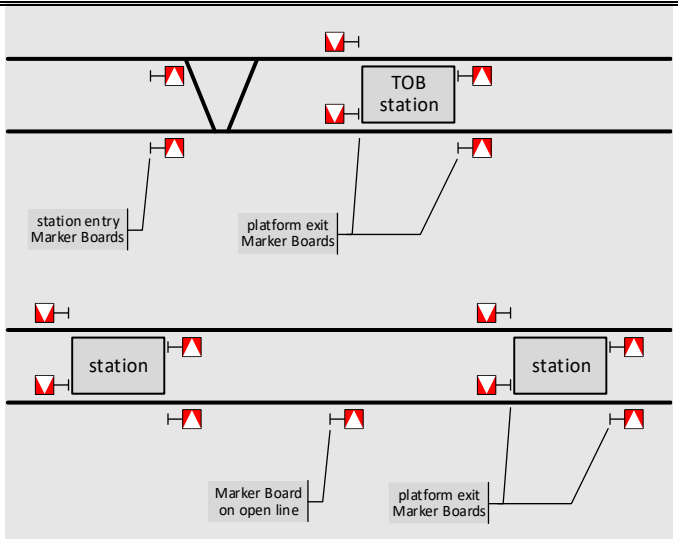



**Figure 1.4-8 Appearance of marker board and accompanying signs**

| Terminology | Definition |
|---|---|
| |  **Figure 1.4-9 Marker boards at different locations related to a station** |

| Terminology | Definition |
|---|---|
| Movable element | General term for points and derailers that can be operated remotely.<br><br>The following types of movable elements are available:<br>Figure 1.4-10 Simple set-of-points with 1 or 2 point machines<br>Figure 1.4-11 Single slip points/diamond-crossing<br>Figure 1.4-12 Double slip points/ diamond-crossing<br>Figure 1.4-12 Double slip points/ diamond-crossing<br>Figure 1.4-13 Trap points<br>Figure 1.4-14 Derailer. |

Illustration Schematic examples

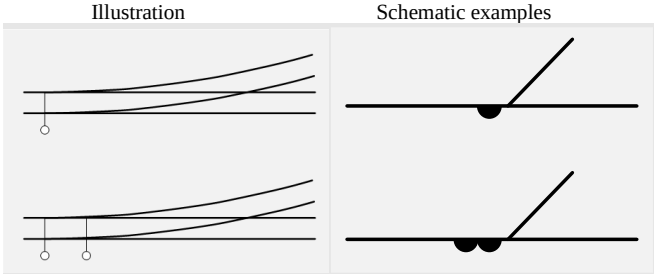


**Figure 1.4-10 Simple set-of-points with 1 or 2 point machines**

Illustration Schematic examples

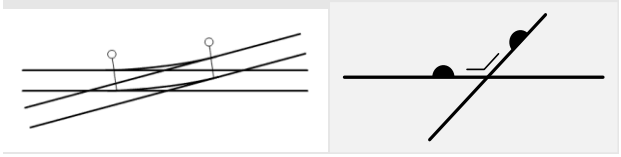


**Figure 1.4-11 Single slip points/diamond-crossing**

Illustration Schematic examples

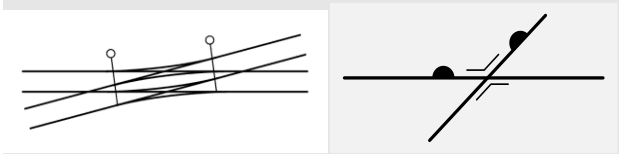


**Figure 1.4-12 Double slip points/ diamond-crossing**

Illustration Schematic examples

**Figure 1.4-13 Trap points**

Illustration Schematic examples

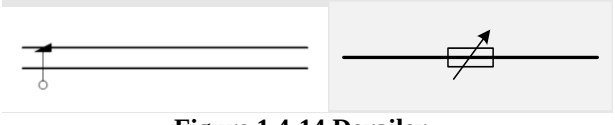
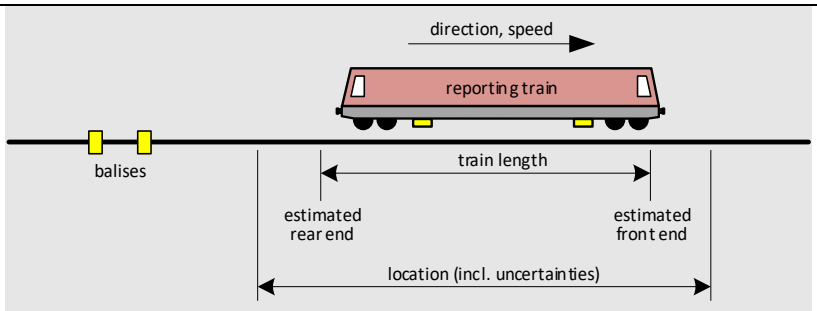


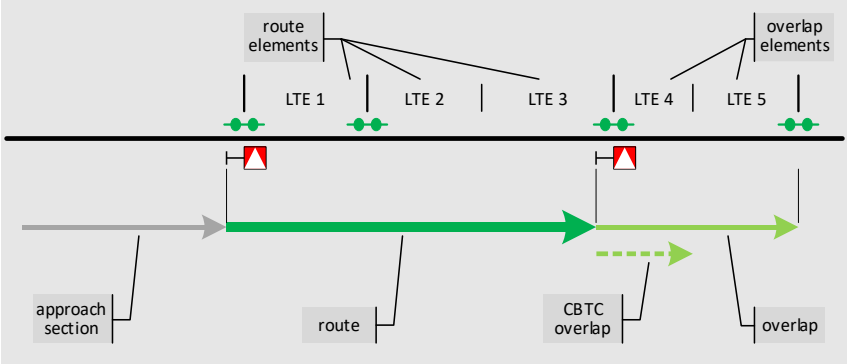
**Figure 1.4-14 Derailer**

| Terminology | Definition |
|---|---|
| Movement authority (MA) | A movement authority is the authority to enter a route at the route start point and move up to the end of the route. The interlocking provides movement authorities at marker boards and signals.<br><br>Depending on the train approaching the marker board, the movement authority is either a CBTC movement authority based on moving block level, or an ICI movement authority based on main signal level. For CBTC movement authorities the speed limit is configured in the track data base (TDB). A CBTC movement authority does not include that the track is clear, or an overlap is set. This needs to be checked by the CBTC and the movement needs to be adapted accordingly. Speed limits for ICI movement authorities are related to the signal aspect (green or yellow) configured for each route and may be supplemented by a speed limit sign at the marker board.<br><br>At signals in Hillerød a wide range of movement authorities is provided on main signal level, e.g. for shunting, and movement authorities can also be provided on call-on level. |
| Moving block | A principle of railway signalling wherein trains are kept at least braking distance apart (i.e. the "block" between trains moves as the trains move). |
| Non-controlled area | Track where no route setting is available and hence no movement authorities are provided.<br>Movable elements located in non-controlled areas are not controlled by the Signalling System. |
| Non-equipped train | Train equipped with neither CBTC nor ICI. |
| Non-main track | CBTC-controlled tracks that are not considered main track. |
| Non-stopping zone (NSZ) | A non-stopping zone is a logical interval on a track where trains should not stop with any part of the train.<br>In case of emergencies or failures of train control, stopping in a NSZ is not prevented. |
| NRT | Non-reporting train.<br>A train that doesn't send a valid position report. |
| OBCU | Onboard Control Unit, the onboard part of CBTC. |
| Operation area | An area of track that can be assigned to one signaller for controlling operation.<br>Only TVS borders can be borders of an operation area. |
| Operation mode | Trains equipped with CBTC are operated in one of the following operation modes: |

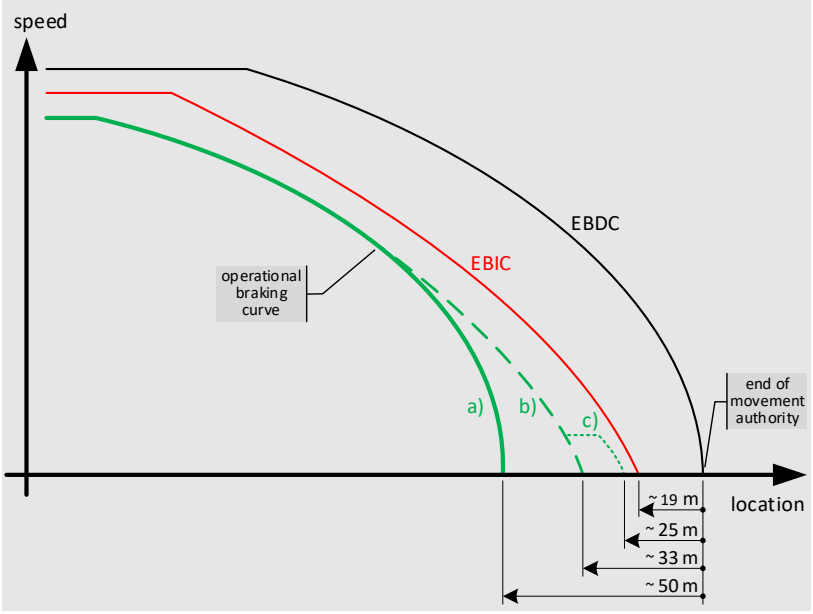
| Terminology | Definition |
|---|---|
| | • Full automatic mode (FAM)<br>Operation without driver; currently not in use<br>• Driverless Train Reversal Operation (DTRO)<br>Operation without driver, only for reversal without passengers: currently not in use<br>• Automatic mode (AM)<br>Operation under full supervision of ATP and movement controlled by ATO<br>• Supervised manual mode (SM)<br>Operation under full supervision of ATP, but movement controlled manually by a driver or running man.<br>• Restricted Mode (RM)<br>Train movement is controlled by a driver or running man. There is no movement authority available, i.e. the driver/running man supervises train movement according to operational rules. ATP only supervises mode specific speed limit of 25 or 40 km/h.<br>• Coupling Mode (CM)<br>Similar to RM but supports coupling/decoupling of trains with determining of new train consist. ATP only supervises mode specific speed limit of 25 km/h.<br><br>Trains operating under full supervision of ATP (AM and SM) are also referred to as ”automatic trains”, other trains (RM and CM) including ICI-FV and unequipped trains are also referred to as ”non-automatic trains”. |
| Operational speed | The operational speed is the nominal speed a train is expected to drive at a specific location under given operational conditions (e.g. timetable, dry/wet-setting). Typically, the real speed of a train movement will differ within a margin, e.g. caused by technical limitations.<br><br>The “operational speed limit” is the maximum operational speed defined for any specific location of the track. It is lower than the vital speed limit.<br><br>Unless otherwise mentioned, speeds and speed limits used in the present document are operational speeds. |
| Operational stopping point (OSP) | At platforms the operational stopping points for S-trains are marked with stopping markers 2, 4, 6 and S located beside the track. Appearance of these markers is shown in appendix 5.3.5.<br>Trains stop with the front end (frontmost location, e.g. coupler) at these markers according to the following scheme:<br>• Stopping marker 2<br>Stopping of train consist: SE.<br>• Stopping marker 4<br>Stopping of train consist: SA or SE+SE. |

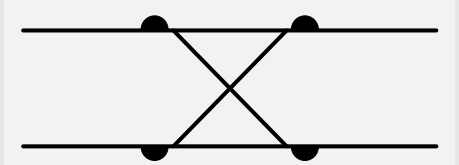
| Terminology | Definition |
|---|---|
| | • Stopping marker 6<br>Stopping of train consist: SA+SE or SE+SE+SE.<br>• Stopping marker S<br>Stopping of train consist: SA+SA or SA+SE+SE.<br><br>Stopping markers 2, 4 and 6 are optional. If a marker is not present, the train stops at the first stopping marker present for a longer train consist. Latest at the stopping marker S all trains stop that are not intended to skip the platform. |
| OH&S | Occupational health and safety. |
| Overlap | If the end point of a route is a marker board (or a signal in Hillerød), an overlap can be configured for that route. The overlap starts at the end point of the route and consists of a sequence of track sections that are locked with the route to provide a safety distance in case a train movement violates the end of the movement authority.<br><br>As train under full CBTC control need shorter overlaps than other trains or even don't need an overlap at all, the interlocking provides the possibility to configure short overlaps for moving block level and long overlaps for main signal level. |
| Partial route | A partial route is a route which start and/or end is not one of the defined delimiters of routes. It requires to combine two or more subsequent partial routes to form a complete route.<br>Partial routes are only used as described in section 3 of these rules. |
| PICOP | Person In Charge Of Possession. |
| Platform | Trains are scheduled to stop at platforms. There are two categories of platforms: real platforms and virtual platforms.<br><br>Real platforms are located beside the track and facilitate passengers to embark or disembark the train.<br><br>Virtual platforms may have facilities for running men to embark or disembark the train or are just intermediate stopping locations to reverse a train (”reversal virtual platform”) or to wait until conditions of the timetable to continue are fulfilled (”TMS virtual platform”). |
| Platform area | The section of a track located between start and end of a platform. |
| POP | Point of protection (property of movement authority). |

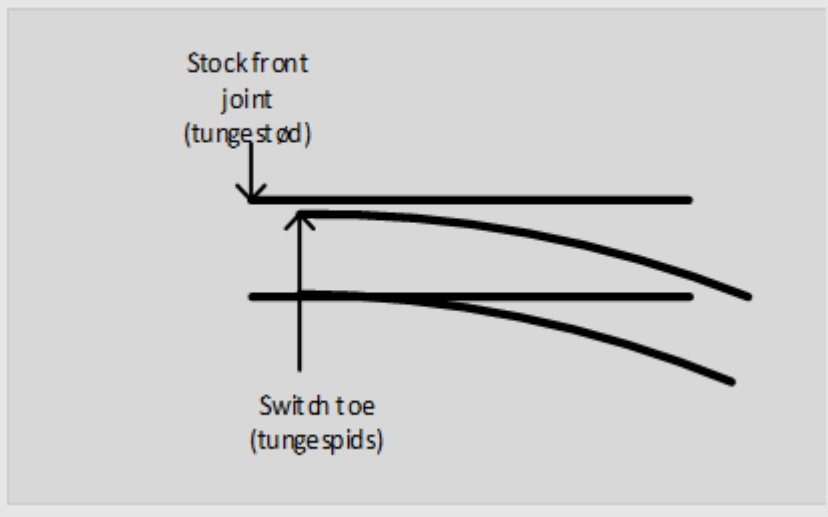
| Terminology | Definition |
|---|---|
| Position Report | Trains equipped with a CBTC onboard system detect their location on the track continuously. This starts with an initial localisation by reading two balises known in the TDB. Then the location is continuously updated by measuring moved distances and detecting further balises while considering point positions at divergencies. This is stopped when there is a reason for delocalisation, meaning that the train no longer knows its position on the track.<br>. Accuracy of detecting balises and measuring distances is limited and the respective uncertainty is also determined. Thus, front and rear of the train are estimated, but considering uncertainties the worst-case extension of the track occupied Theby the train can be determined.<br>The position report is the dataset about the current location and moving status of the train, i.e. location, location uncertainty, direction of moving and speed see explanatory Figure 1.4-15 Position Report.<br>A train transmitting a valid position report to the wayside system is a reporting train. All other trains are non-reporting trains. |
| |  <br>**Figure 1.4-15 Position Report** |
| Possession area | A set of adjacent TVS from a start point to an end point, but without any specific direction. A possession area is the basic element to define possessions. Whilst a possession is activated, all TVS of the underlying possession areas are blocked against route setting. |
| Proceed Aspect | A “Proceed Aspect” is a visible indication from a signalling system to a driver of a rail vehicle that it is safe to move past a given location. |
| Reversal track | All terminal tracks not planned for stabling including the terminal tracks used for normal passenger service (reversal platform track). |
| RFID | Radio frequency identification.<br>This identification system consists of two parts:<br><br>RFID tags with fixed data to be installed on the wayside and RFID reader. Handheld terminals are used as RFID reader.<br><br>RFID is used to prove the location of staff in the field. |
| Right track | See “left track”. |

| Terminology | Definition |
|---|---|
| Route | A route is a sequence of adjacent TVS from a start point to an end point. All TVS of the route are configured with the direction of the route from start to end point. All movable elements of the route are additionally configured with the required position.<br><br>Setting a route moves all movable elements of the route and the flank protection for these elements to the defined position and claims all elements with direction and position according to the route configuration. This also applies to the elements of the overlap, if a non-automatic train is approaching the start point. If an automatic train approaches and a CBTC overlap is configured, this part of the overlap is set.<br><br>A route has at any time one of the following supervision levels:<br>• No supervision:<br>not all route elements (between start and end point) could be claimed as required.<br>• Call-on level:<br>all route elements (between start and end point) could be claimed as required.<br>• •Moving block level:<br>all route elements (between start and end point) could be claimed as required and the flank protection for all route elements could be claimed.<br>• Main signal level:<br>all route and all overlap elements could be claimed as required and the flank protection for all route and overlap elements could be claimed and all route and overlap elements are clear.<br><br>For any level it is configurable that additional conditions need to be considered. For main signal level the signaller can request to set the route without overlap.<br><br>For schematic overview see Figure 1.4-16 Route.<br><br>  <br><br>**Figure 1.4-16 Route** |
| Route book | Document for drivers and maintenance staff providing locations of trackside signalling equipment for one or more rail lines. |

| Terminology | Definition |
|---|---|
| | |
| Route release | Route and overlap elements can be released actively or passively.<br><br>Active release is done TVS by TVS from start to end of the route while the train moves along the route and clears the TVS after passing it. Elements of the overlap are released actively in the same way when the overlap is part of the subsequent route, and the train moves on into this route.<br><br>Passive release of TVS is done without train movement were configured. In this case the route needs to be seen as built of a first part for only active release and a second part for either active or passive release (after active release of the first part).<br>Following options can be configured regarding passive release:<br>• Passive release of overlap.<br>Condition: Train reports standstill or delay time since entering second part of route expired.<br>• Passive release of second part of the route. Same conditions as for passive release of overlap.<br>• Passive release of second part of route and overlap in case of reversal.<br>Condition: Second part of route configured for reversal, route for reversal is set and train clears second part of route while entering the route for reversal.<br><br>A set route (no element yet released) that will not be used for a train movement can be cancelled, i.e. completely released in one step following one single command. Precondition is that it is not to be assumed that a train could enter the route.<br><br>Emergency release of single LTE is provided for cases where neither active release nor passive release nor cancellation is possible. |
| Route Table | The Route Table is the document where all characteristics (e.g. locking conditions, flank protection, release times) of all routes and all TVS of an interlocking are defined.<br><br>The Sicas interlocking is a tabular interlocking. All properties and conditions are customized in the Route Table. |
| Running Man | The running man has responsibility for joining and splitting the trains in depots. Also, the person that drives the train from the depot to the station and back again. |
| Safety distance | Distance between the location the train is supposed to stop when there is no movement authority to pass a marker board and the end of the movement authority, which is the location of the axle counter related to the marker board or, if present, the end of the overlap. |

| Terminology | Definition |
|---|---|
| | For CBTC equipped trains in operation mode AM or SM, the CBTC enforces a safety distance by applying the safe braking model. This defines an EBIC where the emergency brake is triggered to avoid violation of the end of movement authority. The enforced safety distance is:<br>a) about 50 m considering a time optimised operational braking curve with constant brake rate according to "dry" conditions.<br>b) about 35 m considering an operational braking curve adapted to the EBIC at low speed<br>c) about 25 m if closest possible approach to the end of movement authority is required by reducing the control margin to the EBIC at very low speed.<br>Actual distances depend on gradient of the track and uncertainties in determining the train's location.<br>CBTC applies a constant brake rate according to a), but automatically adapts to the EBIC if necessary. Closest approach according to c) needs configuration for the specific location.<br><br>For other trains the safety distance is the distance from the marker board at the end of the route up to the end of the overlap. . For diagram of safety distance, see Figure 1.4-17 Safety distance under CBTC supervision. |
| |  |
| | **Figure 1.4-17 Safety distance under CBTC supervision** |
| Scissors cross-over | Two intersecting cross-overs with a diamond-crossing in the middle. For schematic drawing see Figure 1.4-18 Scissors cross-over. |

| Terminology | Definition |
|---|---|
| |  <br>**Figure 1.4-18 Scissors cross-over** |
| Set-of-points | One pair of blades of a movable element. Often just referred to as "point", "switch" or "turnout". More complex elements contain 2 or 4 sets-of-points. |
| Signal | A signal is a device for giving a coloured light aspect to the driver. |
| Signaller | The signaller works in the Traffic Control Center and is responsible for the daily management and coordination of all railway operations within the area controlled by the signaller. The signaller controls train operations and access to maintenance work in an assigned area through traffic control systems. |
| Signalling System | The signalling system is the technical system to control train operation and ensure safe operation of trains.<br><br>The signalling system consists of the sub-systems:<br>• TMS (traffic management system),<br>• CBTC (communication based train control system) with major components ATP (automatic train protection) and ATO (automatic train operation),<br>• IL (interlocking),<br>• DCS (data communication system), consisting of the fixed transmission network and the radio system connecting trainborne equipment and wayside equipment.<br><br>The signalling system in place is supplied by Siemens and built of following major components:<br>• TMS: Vicos OC 100 with Controlguide,<br>• CBTC: Trainguard MT<br>• IL: Sicas with point machines and axle counting system |
| Single Rail Track Layout (SRTL) | The Single Rail Track Layout (SRTL) is the final design document of the CBTC. It shows the length of track and all objects relevant for the signalling system with their location in a schematic form. |
| Stabling track | Terminal track used for close parking of trains. |
| Staff crossing signal | Staff crossings support staff in crossing one or more tracks. They are equipped with staff crossing signals only where these serve particular protection needs, independent of permitted speed and number of tracks. |

| Terminology | Definition |
|---|---|
| Station | A “station” is a location with points covered by a station entry marker board. The station can be with or without platform. A “TOB station” is a station where a TOB is located, i.e. there is at least one movable element related to that station.<br><br>A “virtual TOB station” is a location where a TOB is located, but there are no platforms for passengers. |
| Switch toe | Switch toe is defined as in Figure 1.4-19 Placement of switch toe in a point. |
| |  <br>**Figure 1.4-19 Placement of switch toe in a point** |
| TOB | Technical Object Building.<br>TOB house the wayside signalling system central computers and local controllers for e.g. point machines, axle counters and access points. The related power supply and building services equipment is also installed in the TOB. |
| TOB station | See “station.” |

| Terminology | Definition |
|---|---|
| Track data base (TDB) | The TDB describes the track topology, CBTC relevant locations along the track and the gradient/altitude profile of the track. The data recorded in the CBTC track database reflect the locations defined in the Vital Track Data (VTD) and the Single Rail Track Layout (SRTL) documents.<br><br>In detail the CBTC relevant data is:<br>• length of track between reference locations<br>• longitudinal location of points (switch toe and fouling point)<br>• longitudinal location and length of platforms<br>• longitudinal location of platform stopping points<br>• longitudinal location of buffer stops<br>• longitudinal location of signalling equipment (marker boards, balises, axle counting heads)<br>• vertical position of track (altitude and gradient)<br>• longitudinal location of staff crossings equipped with staff crossing signals<br>• longitudinal location of catenary section switch, that is considered as non-stopping zone.<br><br>Not relevant for the CBTC is:<br>• curve characteristic of the track (radius)<br>• track cant.<br><br>Beside the platform stopping points and the vertical position of the track all data is transferred from the VTD to the Single Rail Track Layout (SRTL). A recourse to the VTD is not required for data shown in the SRTL. |
| Track vacancy section (TVS) | A track vacancy section is the basic entity of the wayside train detection system. The vacancy is detected based on axle counter information. Axle counters are present at all borders of a TVS that could be passed by a train.<br><br>A TVS can be on LTE or can be split in multiple LTEs. |
| Train tracking | Reporting trains are tracked by their position report. Position reports are mapped on one or more LTEs.<br>Non-reporting trains (NRT) are tracked on basis of TVS by the wayside train detection (axle counter).<br>For individual tracking of trains, each NRT should be separated from any other train by at least one clear TVS (“clear buffer block”). There is no need for a clear buffer block between reporting trains. Reporting trains can even be separated when located in the same TVS or LTE. For an example of train tracking see Figure 1.4-20 Train tracking. |

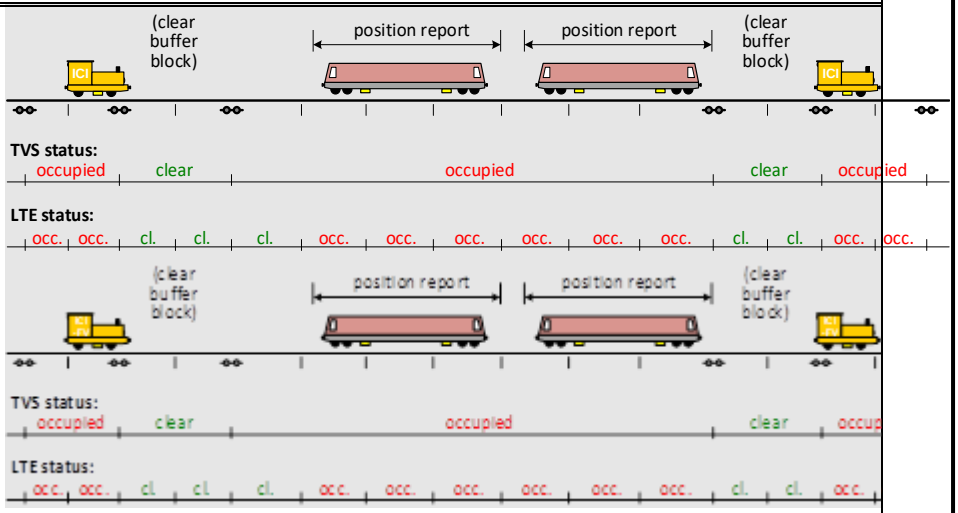
| Terminology | Definition |
|---|---|
| |  **Figure 1.4-20 Train tracking** |
| UT profile | UT = Usædvanlig transport.<br>The UT profile is the border of the cross-section above the rail that must be kept clear of fixed obstacles. |
| Virtual platform | Location with designated operational stops, however without a physical platform present. |
| Vital speed limit | The CBTC system ensures that the vital speed limit defined for any track location is for sure not exceeded by a supervised train. The vital speed limit is 12 km/h above the operational speed.<br><br>To ensure the vital speed limit, the CBTC will trip a train by triggering the emergency brake when a speed of about 6 to 8 km/h above the operational speed is reached, depending on train parameters and gradient of the track. |
| Vital Track Data (VTD) | The Vital Track Data (VTD) documents hold the valid vital and non-vital data describing the track as required for CBTC configuration. |
| Yellow ICI aspect | ICI movement authority provided by a “yellow” aspect allows driving with max speed of the mounted speed sign or max 40km/h if no speed sign is mounted on the marker board. |

**Table 1.4-1 Definitions**

## 1.5 Parameters

The parameters defined in the following Table 1.5-1 Parameters are used in calculations.

| Parameter | Value | Definition |
|---|---|---|
| $t_{ICI}$<br>$t_{ICI}$ | 1 s | ICI reaction time.<br><br>The time required by CBTC from change of the signal aspect until the new signal aspect is indicated on the ICI panel and the ICI reacts on the new signal aspect, e.g. by providing an audible warning or an alarm. |
| $t_{reaction}$<br>$t_{reaktion}$ | 3 s | Driver reaction time.<br><br>The time from when the driver gets aware of an event to react on until they apply the required reaction. |

**Table 1.5-1 Parameters**

# 2 Rules and constraints

## 2.1 Movable elements

### 2.1.1 Applicable movable element types

| | | |
|---|---|---|
| DEF | The engineering rules apply to infrastructure containing the following element types:<br>• Simple set-of-points<br>• Single slip points/diamond-crossing<br>• Double slip points/diamond-crossing<br>• Trap points<br>• Derailer | |
| COM | For definition of these elements refer to term “movable element” in section 1.4 which includes Figure 1.4-10 to Figure 1.4-14 | |
| 2.1.1-1 | A unique number shall apply to all points and derailers for the complete area of the TOB including any bordering non-controlled areas. | BN1 |
| COM | This to avoid overlapping numbers that could cause other disciplines data and maintenance to be invalid. | |
| DEF | Movable elements are intended for remote operation, either by automatic route setting or by the signaller. | |
| COM | Movable elements can be operated locally (by handheld terminal or a crank-handle) while being part of a possession. Refer to 2.7. | |
| 2.1.1-2 | Movable elements, except derailer, located on main track shall be equipped with a stationary device for clamping the tongue. This device shall be mounted close to the switch toe. | BN2 |
| COM | In case locking by point machine fails, this device enables the driver to clamp the point when instructed by the signaller according to ORS [9]. | |

| | | |
|---|---|---|
| 2.1.1-3 | The name of a point or derailer shall be defined by<br>• a prefix, which is “P_” for points and “DR_” for derailer,<br>• followed by the short name of the TOB that controls the point/derailer,<br>• followed by a unique 2- or 3-digit number,<br>• followed by a suffix “a” or “b” for coupled points/derailer.<br><br>In case the point/derailer is coupled to another point/derailer, both coupled elements share the same number, but a suffix “a” or “b” shall be added for distinction. In case of sequential running of both elements, ”a” shall be used for the first running and “b” for the second running. | BN1 |
| COM | In drawings where the element type of the point/derailer is shown by a symbol and the location is clearly given by e.g. the mileage or the station, only the number and suffix is used as identification. | |
| COM | Further information on TOB short names and numbering can be found in PN76500Q01471 [6]. | |
| COM | For meaning of sequential and parallel coupling of points refer to definition of term “coupled points”. | |
| 2.1.1-4 | Derailers shall only be installed in tracks with a speed limit of 40 km/h or lower. | BN1 |

### 2.1.2 Not in use

### 2.1.3 Point machines for movable elements

| | | |
|---|---|---|
| DEF | The number of point machines for a movable element depends on the mechanical layout and is defined for each individual track component type in their ”bladtegning”. Banedanmark can by request hand out the “bladtegning”.. | |
| 2.1.32.1.3-1 | Each movable element shall be equipped with point machines according to the ”bladtegning” for the specific movable element. | BN1 |
| COM | The following Table 2.1-1 Number of point machines is provided as guideline information only. | |

| Type (inclination) | 1:7.5 | 1:9 | 1:11 | 1:12 | 1:14 | 1:19 | Other |
|---|---|---|---|---|---|---|---|
| Single set-of-points (incl. trap points) | 1 | 1 | 1 | 2 | 2 | 2 | |
| Single slip Points | 1* | 1* | | | | | |
| Double slip Points[1] | 1* | 1* | | | | | |
| Derailer | | | | | | | 1 |

*) 2 machines total.

**Table 2.1-1 Number of point machines**

| | | |
|---|---|---|
| COM | Certain legacy point types of inclination 1:12 and 1:14 can optionally have 1 machine if permitted speed is ≤ 120 km/h. | |
| 2.1.3-2 | Each movable element shall be equipped with trailable point machines and internal or external point tip locks. | BN1 |
| COM | Trailable point machines are prescribed at lower speeds for operational reasons. | |
| COM | Internal point tip lock = integral with point machine;<br>external point tip lock = pawl lock or equivalent. | |
| 2.1.3-3 | Trailing of a point shall be detected by the point machine and/or by the interlocking. | BN1 |
| COM | For cross-overs sequentially coupled operation of two set of points is commonly used. | |
| COM | Simultaneous or sequentially coupled operation of two sets-of-points – e.g. for cross-overs – may be defined by product-specific engineering rules. | |
| COM | For sequentially coupled operation the switching time for each set-of-points depends on the sequence of running, first (1) or second (2). This is considered in the rules for detector locking (refer to section 2.1.7). See Figure 1.4-3 Coupled points at a cross-over with running sequenceFigure 2.1-1 Coupled points at a cross-over with running sequence (1/2) | |
| COM | The running sequence may be chosen to be able to fulfil the 10/20 m distance requirements for detector locking (refer to section 2.1.7). | |

[1] For double slip points/cross-overs, set-of-points = 4 blades.


**Figure 2.1-1 Coupled points at a cross-over with running sequence (1/2)**

| | | |
|---|---|---|
| 2.1.3-4 | If sequentially coupled operation of a derailer and a set of points is used, the derailer shall be first running and the set of points shall be second running. | BN2 |
| COM | Configuring the derailer as first running reduces the risk of derailing when passing a derailer. However, this may conflict with other constraints to the coupled point. | |
| 2.1.3-5 | In case of introducing new movable elements to the infrastructure, sequential coupling shall not be used. | BN2 |

### 2.1.4 Not in use

### 2.1.5 Not in use

### 2.1.6 Fouling point

| | | |
|---|---|---|
| 2.1.6-1 | Fouling point shall be as stated in BN1-154 [4]. | BN1 |
| COM | Converging tracks of points and cross-overs are equipped with fouling point markers indicating the point at which a vehicle on one track may become foul of a movement in the other track | |
| COM | A fouling point is indicated by:<br>• two markers, one next to each track, or<br>• one marker, mid-way between the two tracks.<br>• | |
| COM | Examples can be found in Figure 1.4-5 Fouling points and fouling point distances. | |
| 2.1.6-2 | When using fouling points as reference for design of TVSs, the fouling point locations shall be determined based on a normative track separation as defined for S-bane in BN1-154 [4]. | BN1 |
| COM | The actual fouling point marker locations may be wrong for historical reasons. | |
| COM | At locations with particular space constraints, a reduced normative track separation according to rules defined in BN1-154 [4] may be used. | |

| | | |
|---|---|---|
| | | |
| COM | By “fouling point location” is meant the location that the fouling point marker shall have according to BN1-154 [4] or particular approval, irrespective of the actual marker location. | |

### 2.1.7 Detector locking

| | | |
|---|---|---|
| DEF | Detector locking inhibits operation of a movable element while a vehicle is occupying or fouling the element. | |
| 2.1.7-1 | Movable elements shall be equipped with detector locking. | BN1 |
| COM | Detector locking may be overridden by the signaller according to operational rules ORS [9]. | |
| 2.1.7-2 | For points, train detection equipment shall supervise<br>- the track at least 10 m from point tip<br>See Figure 2.1-2 Supervised area for detector locking. | BN2 |
| 2.1.7-3 | For points, train detection equipment shall supervise<br>- the tracks at least 5 m from fouling point. | BN1 |
| COM | For single and double slip points, the distance from fouling point usually governs at both ends. | |
| 2.1.7-4 | For trap points and derailers, train detection equipment shall supervise:<br>- the track at least 10 m on facing side of point tip / derailer.<br>- the track at least 10 m on trailing side of point tip / derailer. | BN2 |
| 2.1.7-5 | If a point or derailer is the second running of a sequential coupling of points / derailers, the train detection equipment shall supervise the track at least 20 m from point tip / derailer instead of 10 m.<br>See Figure 2.1-3 Supervised area for detector locking (coupled point b second running) | BN1 |
| COM | The increased distance of 20 m relates to the increased switching time for the second running of a sequential coupling. It does not apply to parallel coupled points, because in this case the points start switching at the same time. Refer to definition of term “coupled points” for meaning of sequential and parallel coupling. | |
| COM | Refer to section 2.2.1 for further rules on TVSs. | |

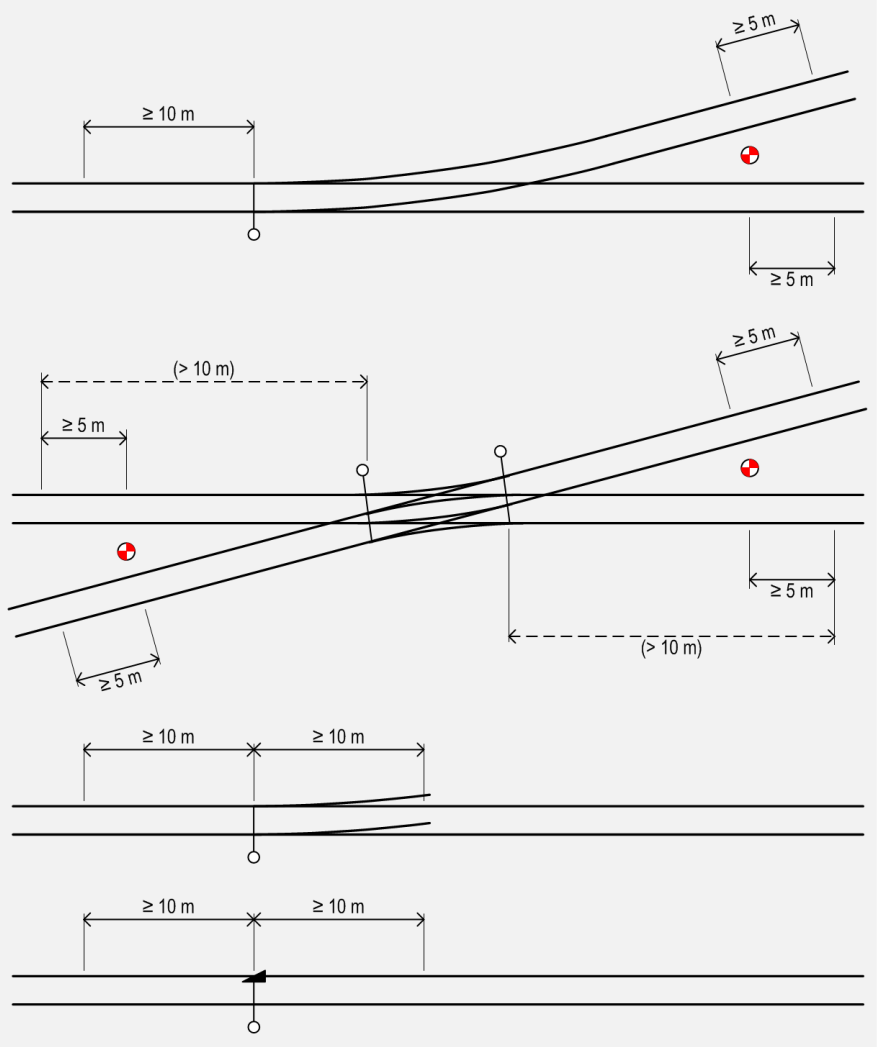



**Figure 2.1-2 Supervised area for detector locking**

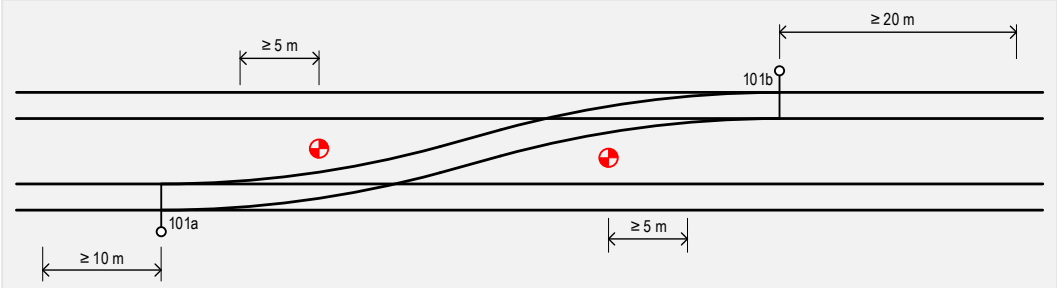



**Figure 2.1-3 Supervised area for detector locking (coupled point b second running)**

| | | |
|---|---|---|
| 2.1.7-6 | Train detection equipment shall supervise:<br>- the track at least 1 m from point tip / derailer. | BN1 |
| COM | 1 m is the absolute minimum for the system, the rules above state the preferred configuration for normal design. | |

| | | |
|---|---|---|
| 2.1.7-7 | When a marker board is located at the facing side, this is expected to reduce the risk of an unauthorised movement reaching the blades or derailer unintentionally. Therefore, the 10 m rules can be relaxed when demanded by the space constraints. See Figure 2.1-4 Reduced supervised area for detector locking.<br>Figure 2.1-4 Reduced supervised area for detector locking | BN2 |

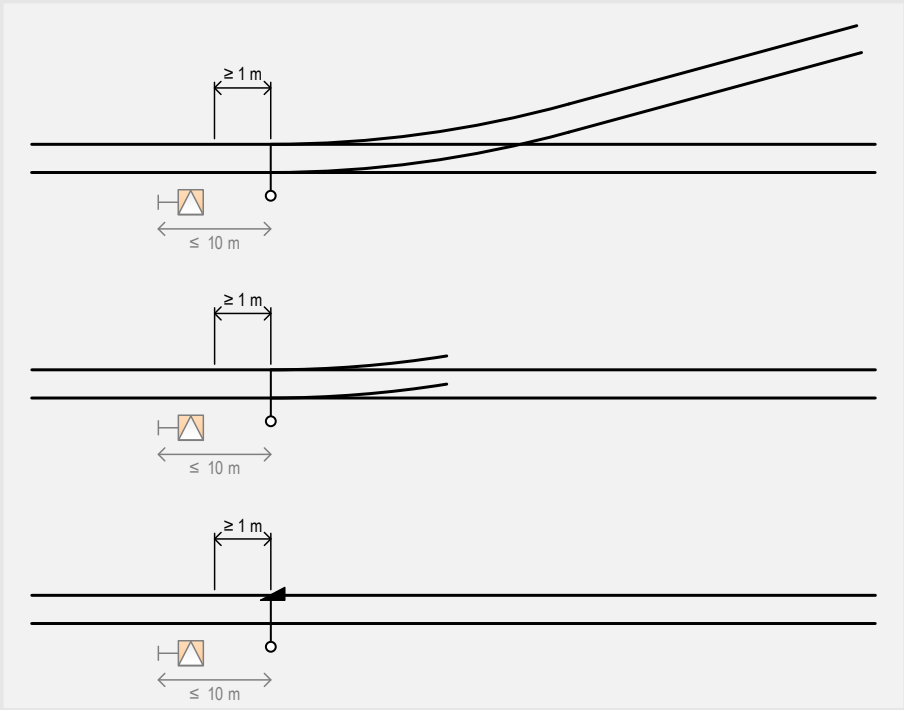



**Figure 2.1-4 Reduced supervised area for detector locking**

| | | |
|---|---|---|
| 2.1.7-8 | Supervision shall comprise one TVS if the dimensions fulfil the constraints. | BN1 |
| 2.1.7-9 | If TVS dimensions are insufficient, adjacent TVSs shall be included in the supervision for detector locking.<br>See Figure 2.1-5 Example of detector locking depending on two . | BN1 |
| COM | The required adjacent TVSs are defined in the route table. | |
| COM | Overlaying TVS particularly for detector locking is not foreseen. | |

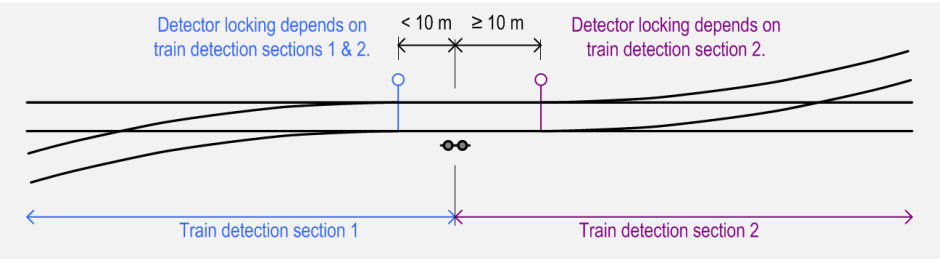



**Figure 2.1-5 Example of detector locking depending on two TVSs**

| | | |
|---|---|---|
| 2.1.7-10 | Adjacent TVSs shall be omitted from supervision for detector locking while position of other points or derailers ensure that vehicles in these sections cannot approach the supervision area. See Figure 2.1-6 Example of detector locking depending on the state of other points. | BN1 |

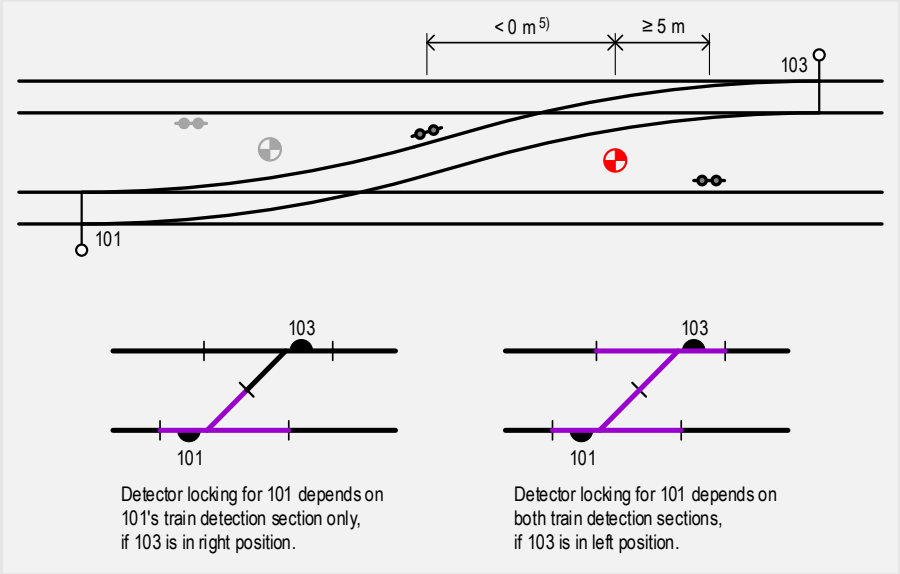



**Figure 2.1-6 Example of detector locking depending on the state of other points**

| | | |
|---|---|---|
| COM | For the related flank protection topic, refer to 2.4.3. | |

### 2.1.8 Not in use

### 2.1.9 Protection by movable element

| | | |
|---|---|---|
| 2.1.9-1 | Where non main tracks connect to main tracks with a speed above 60 km/h protection by movable elements shall be implemented. | BN1 |
| 2.1.9-2 | Where non-controlled tracks connect to CBTC-controlled tracks, protection by movable element shall be implemented at the latest before entering the main track. | BN1 |
| COM | This rule implies that necessary protection shall be installed when rebuild, if not already present. | |
| COM | This rule implies that the current solution at Hundige, which does not meet these requirements, cannot be continued after a rebuild. | |
| COM | For examples see Figure 2.1-7 Example of protecting elements located at non-main track and Figure 2.1-8 Example of protecting element located before entering the main track. | |

| | | |
|---|---|---|
| | | |

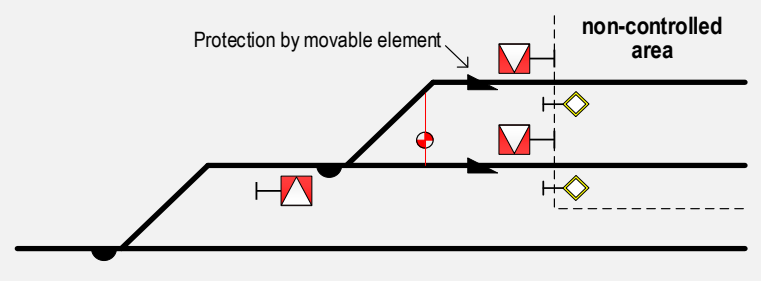



**Figure 2.1-7 Example of protecting elements located at non-main track**

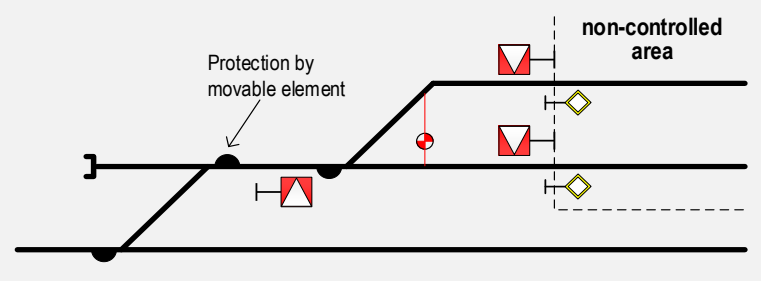
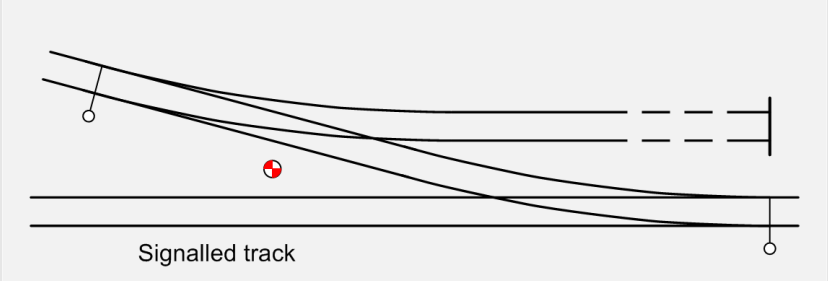



**Figure 2.1-8 Example of protecting element located before entering the main track**

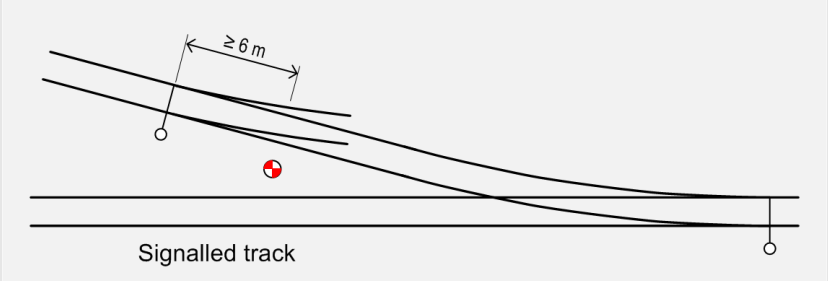
| | | |
|---|---|---|
| 2.1.9-3 | Protection of a CBTC-controlled track from a track under construction shall in all circumstances be provided by a movable element. | BN1 |
| COM | On tracks under construction, there can be both a lot of movement and a provision of equipment of various kinds. It has therefore been assessed that there is a need for some form of physical protection.<br>As tracks under construction are often not equipped with interlocking, the protecting element is permitted to be established without connection to the Signalling System. This will, however, mean that handling movements to and from the track under construction will require significantly more effort. This should go into the consideration whether the protecting element should be controlled by the Signalling System. | |
| 2.1.9-4 | Protection by movable element shall be included in CBTC-controlled tracks where suitable points are already present, or where a feasible overlap cannot be obtained without it. | BN1 |
| COM | E.g. where double track line converges into single track line. | |
| COM | This rule implies that protective elements should be used when they are present and can be set to the protective position. | |
| 2.1.9-5 | Where protection by movable element applies, the methods used shall be with no order of preference: set-of-points (1), trap points (2) or derailer (3).<br>See Figure 2.1-9 Methods of protection by movable element. | BN1 |

| | | |
|---|---|---|
| COM | In SODB [1], the solutions have been prioritized to avoid derailment after a “signal passed at danger”. This prioritization is not considered necessary as the risk of a “signal passed at danger” alarm is very low with the CBTC system implemented, since all driving is based on routes. Economically there will be benefits by using a derailer. | |
| COM | Solution (1) may be constrained by design rules for buffer stops according to BN1-95 [12]. | |
| COM | Solution (3) may be constrained by permitted track speed, refer to section 2.1.1. | |

1) Set-of-points




2) Trap points




3) Derailer

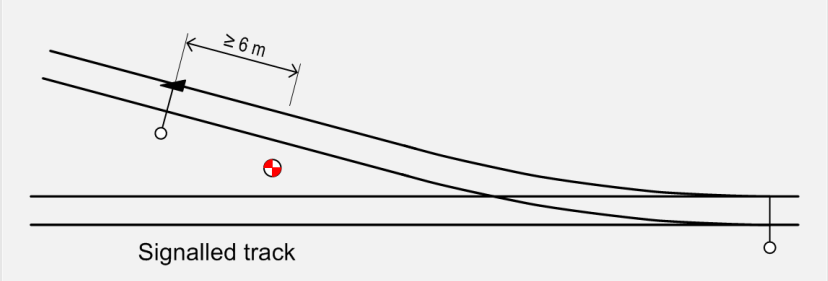



**Figure 2.1-9 Methods of protection by movable element**

| | | |
|---|---|---|
| 2.1.9-6 | Trap points and derailers shall be installed minimum 6 m from fouling point and away from the main track. | BN1 |

## 2.2 Train detection

### 2.2.1 TVSs

| | | |
|---|---|---|
| DEF | TVSs are track sections, the occupation of which is supervised by trackside equipment. | |
| COM | The trackside equipment consists of axle counter systems.<br>In principle, track circuit systems are also conceivable. | |
| 2.2.1-1 | All CBTC-controlled tracks (i.e. tracks not located in non-controlled area) shall be equipped with TVSs. | BN1 |
| 2.2.1-2 | A TVS shall have a length of at least 23 m. | BN1 |
| COM | This is to avoid a long vehicle being able to span a section undetected. The maximum vehicle axle distance is 20 m, and the installation tolerance is +/- 1 m and therefore 23 m will ensure detection. | |
| 2.2.1-3 | In exceptional cases, shorter sections may be implemented, provided that they are functionally linked to adjacent sections. The linking shall ensure that long vehicles do not produce gaps in occupation sequence. | BN1 |
| COM | Technical limitations may apply. Refer to product-specific engineering rules. | |
| 2.2.1-4 | Adjacent TVSs shall either have co-incident boundaries or be overlapping. This also applies where different types of train detection are involved. | BN1 |
| COM | An example of overlapping TVSs is at the boundary to other railways, e.g. Fjernbane. | |
| 2.2.1-5 | Every TVS shall have a unique number. | BN1 |
| 2.2.1-6 | The name of a TVS shall be defined by:<br>• the prefix "TVS_",<br>• followed by the short name of the TOB that evaluates the TVS status,<br>• followed by a unique 2-digit number.<br><br>For TVS located on main tracks odd numbers shall be used on the right track and even numbers on the left track. | BN2 |
| COM | In drawings where the element type is shown by a symbol, the prefix may be omitted. | |

| | | |
|---|---|---|
| COM | There are some recommendations for defining the 2-digit number of a TVS:<br>• on main tracks numbering should start with 01 (odd) and 02 (even) at the lowest mileage of a TOB area.<br>• within a TOB area on main tracks there should be consecutive numbers from lower to higher mileages.<br>• numbers equal to a point number located close to the TVS should be avoided, e.g. by not using the point number for a TVS.<br>However, these cannot be defined as strict rules, because changes to the Signalling System should not cause renumbering of existing elements. | |
| COM | Further information on TOB short names and numbering can be found in PN76500Q01471 [6]. | |

### 2.2.2 Movable elements

| | | |
|---|---|---|
| 2.2.2-1 | A TVS of a movable element shall, unless allowed by section 2.2.6 below, extend no further than the distances in Table 2.2-1 Maximum extent of TVSs . For examples of TVS layouts see Figure 2.2-1 TVS layout examples. | BN2 |

| | From tip of blades | From fouling point |
|---|---|---|
| Simple set-of-points | 40 m | 10 m |
| Single slip points | | 10 m |
| Double slip points | | 10 m |
| Trap points | No limit | |
| Derailer | No limit | |

**Table 2.2-1 Maximum extent of TVSs**

| | | |
|---|---|---|
| COM | If the 10 or 40 m limit cannot be met, certain restrictions on axle counter reset apply. Refer to Section 2.2.6. | |
| COM | The purpose of the 10 m limit is in general to ensure that a single vehicle cannot be parked “unnoticed” between fouling point and axle counting head.<br>This would violate protection by movable element. | |
| COM | The purpose of the 40 m limit is, together with the 10 m limit, in particular to ensure that axle counter reset using a “sweeping” vehicle cannot reasonably be performed while another vehicle is parked in the section. | |
| COM | For minimum distance requirements for movable elements see section 2.1.7. | |

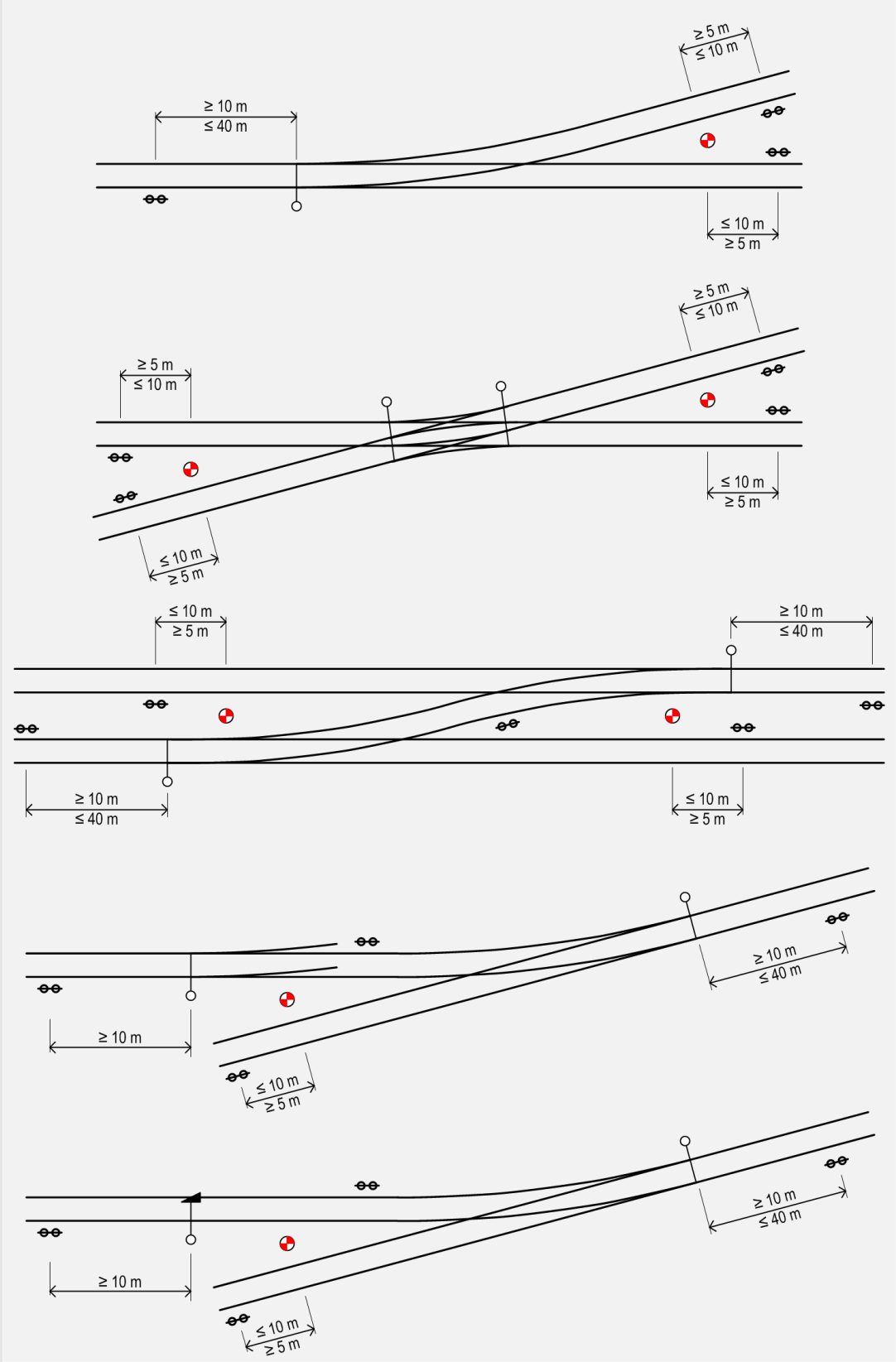



**Figure 2.2-1 TVS layout examples**

| | | |
|---|---|---|
| COM | The TVS may be smaller than the minimum extent suggested in the figure. This requires extending the detector locking by adjacent TVSs as explained in Section 2.1.7. See Figure 2.2-2 Example of shared . | |

| | | |
|---|---|---|
| COM | Two or more movable elements may share one TVS if the physical layout does not allow for parallel movements over the section. | |
| COM | In practice, this solution is useful only if the 40 m limit is not fulfilled. The rules for deviations in Section 2.2.6 apply. | |
| COM | For complex track configurations there may be no space at the rails to mount all axle counters needed to separate movable elements and diamond-crossings. Some examples of shared TVSs for these cases are given in Appendix 5.1. | |

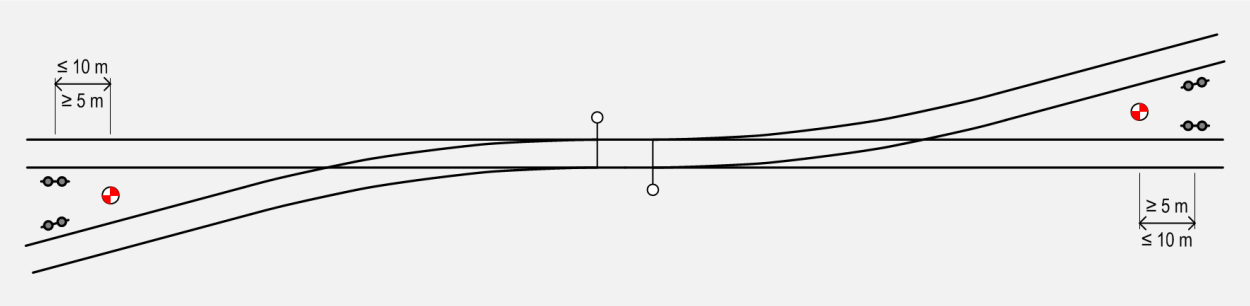



**Figure 2.2-2 Example of shared TVS**

| | | |
|---|---|---|
| 2.2.2-2 | Trap points and derailers shall have a dedicated TVS. | BN1 |

### 2.2.3 Not in use

### 2.2.4 Not in use

### 2.2.5 Terminal track

| | | |
|---|---|---|
| DEF | In a terminal track, the track segment between last axle counting head and buffer stop is a TVS with only one axle counting head. | |
| 2.2.5-1 | It shall be permitted for a terminal track that only serves as “trap”, to share a TVS with the adjoining movable element if the distance from fouling point to end of track is ≤ 12 m. See Figure 2.2-3 Shared TVS for terminal track. | BN1 |

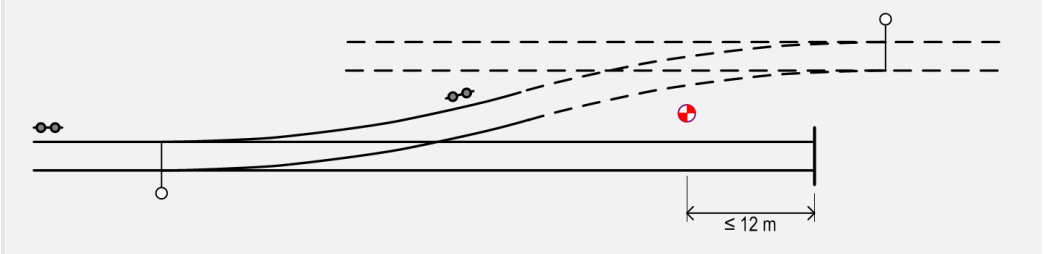


**Figure 2.2-3 Shared TVS for terminal track**

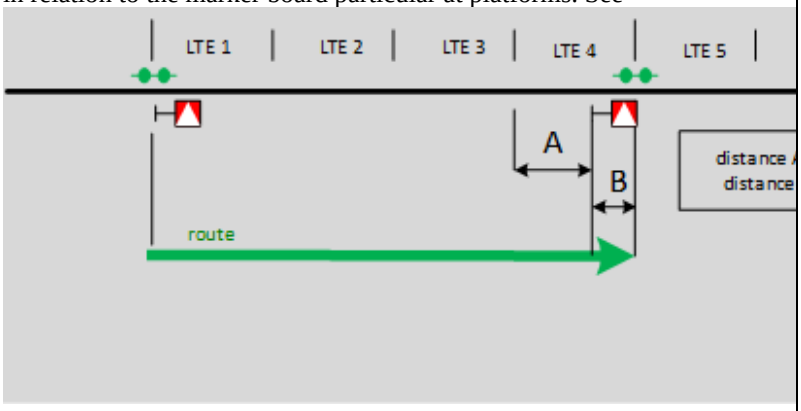
### 2.2.6 Axle counter reset

| | | |
|---|---|---|
| DEF | To recover from an axle counter, miscount a preparatory reset is started on the TVS and then technically it needs to be proved that the section is clear by a train passing the section. If this is successful, i.e. the TVS counts the same number of axles entering the section and leaving the section, the TVS is finally reset. There are three different cases:<br>I. a TVS with 2 axle counters.<br>A single train movement passing the section is required to reset the TVS.<br>II. a TVS with 1 axle counter, i.e. a terminal track.<br>A train needs to enter the TVS, reverse and leave the TVS, then the TVS is reset.<br>III. a TVS with more than 2 axle counters.<br>For this case it is configurable if one train move “passing two of the counting heads” is sufficient to reset the TVS or if multiple train moves are required and in total “all counting heads have to be passed" to reset the TVS. | |
| COM | Regarding II): The train move is not a proof that the track is clear, because the train may not have moved up to the end of the track. | |
| COM | Regarding III): “Passing two axle counter heads” are in other documentation called solution “b” and “all counting heads have to be passed” is called solution “a”. | |
| COM | Use of axle counter reset is governed by procedures defined in ORS [9]. | |
| 2.2.6-1 | If the limits defined in section 2.2.2 are fulfilled, the reset method “pass only two axle counters” shall be configured. | BN2 |
| COM | For operational reasons the type “pass all axle counters” is mandated where possible.<br>In general, this is implemented and is wanted for the future to make sure the same way of operation. | |
| 2.2.6-2 | If the limits defined in section 2.2.2 are not fulfilled, then solution “all counting heads have to be passed” shall be used. | BN1 |
| COM | To avoid axle counter miscount in case an axle stopped very close to or exactly at an axle counting head, evaluation of the axle counting head can use a function to suppress oscillating signals. However, this function is currently not proven as safe. | |

| | | |
|---|---|---|
| 2.2.6-3 | The axle counting system shall not be configured to suppress oscillating signals at the axle counting head. | BN1 |

### 2.2.7 Logical track elements (LTEs)

| | | |
|---|---|---|
| DEF | One TVS can correspond to a single or several LTEs. | |
| COM | A TVS limit is always also an LTE limit. | |
| COM | The occupation status of LTEs is determined by CBTC by combining the occupation status of TVSs and position reports received from CBTC trains. | |
| DEF | LTEs function very similarly to TVSs but without the need for additional axle counters. They are used for the following purposes:<br>– Improve performance.<br>– Displaying tracks with higher granularity to the signallers.<br>– More precise overlaps.<br>– Limiting extents of restrictions like temporary speed restrictions | |
| DEF | A TVS containing movable elements or diamond-crossings corresponds to one LTE. | |
| COM | Movable elements and diamond-crossings typically have a dedicated TVS, such that there is no need for further segmentation. | |
| COM | The Siemens TGMT system does not support splitting a TVS that contains movable elements or diamond-crossings in multiple LTEs. | |
| 2.2.7-1 | An LTE shall have a length not exceeding 400 m. | BN2 |
| COM | This limitation is a compromise of:<br>- providing sufficient granularity to define temporary speed restrictions,<br>- limiting the number of elements to be designed on the TMS screens,<br>- limiting the number of elements to be operated by the signaller. | |
| COM | There is no technical limit for the minimum length. | |
| 2.2.7-2 | LTEs shall be engineered so any marker board's physical placement is always placed inside the last LTE for the TVS in the direction of travel. | BN1 |

| | | |
|---|---|---|
| COM | This is to ensure that TMS always will indicate train position correctly in relation to the marker board particular at platforms. See<br>  <br><br>Figure 2.2-4 Location of marker board in last LTE of a route. | |
| 2.2.7-3 | Every LTE shall have a unique name. | BN1 |
| 2.2.7-4 | The name of an LTE shall be defined by:<br>• the prefix “TS_”,<br>• followed by the short name of the TOB of the related TVS,<br>• followed by the number of the TVS<br>• followed by a unique suffix “A”, “B” and so on.<br><br>The suffix shall start with “A” for the LTE at the lowest mileage in the TVS. | BN2 |

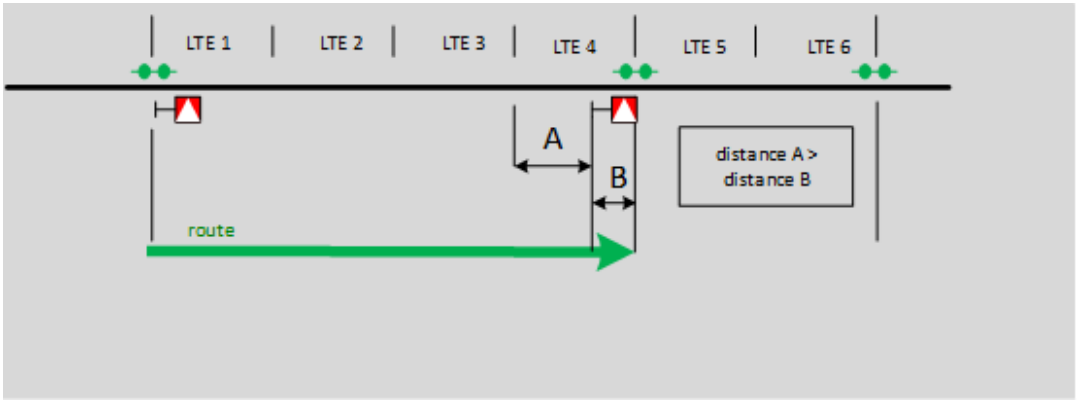



**Figure 2.2-4 Location of marker board in last LTE of a route**

## 2.3 Marker boards

### 2.3.1 Appearance of marker boards

| | | |
|---|---|---|
| DEF | Marker boards are designed according to KN76500Q01422 [7], section 2.1. | |
| COM | The appearance of the marker board is shown in appendix 5.3.5. Further information on design can be found in KN76500Q01422 [7]. Rear side of marker boards have a neutral grey appearance. | |
| COM | Generally, marker boards dimensions are 70 cm × 70 cm. For locations with particular space constraints, dimensions 50 cm × 50 cm or 33 cm × 50 cm can be used.<br>The reduced size of 50 cm × 50 cm is primarily intended for mounting "low", i.e. at top of rail level, but can also be used at normal height, e.g. under platform roofs or between adjacent tracks.<br>The reduced size of 33 cm × 50 cm is primarily intended for marker boards in tunnel areas. | |
| DEF | Marker board height is measured to lower edge of the marker. | |
| 2.3.1-1 | The marker boards shall be mounted according to BN1-166 [13], "SA-profile". | BN2 |
| 2.3.1-2 | Marker boards shall be mounted at 1.8m above rail level (see Figure 2.3-1 Marker board and supplementing boards locations) except where space or sighting does not allow this, whereby 2.3.1-3 applies. | BN2 |
| 2.3.1-3 | For locations with particular space constraints, marker board shall be mounted according to BN1-166 [13], "SA-profile" in the prioritized order:<br>1. At top of rail level<br>2. At a height above the "shoulder".<br>See Figure 2.3-1 Marker board and supplementing boards locations | BN2 |
| COM | The lights on the trains illuminate the ground ahead of the vehicle better. | |
| 2.3.1-4 | When applying 2.3.1-3, then the marker board's placement has to be measured and dispensation is required according to BN1-166 [13] if the UT-profile is not fulfilled. | BN2 |
| DEF | A number plate provides the marker board's identifier to the driver. The id plate is mounted 0 -10 cm above the marker board without the prefix: "MB_". | |
| 2.3.1-5 | For each marker board a number plate showing the marker board's identifier shall be mounted 0 – 10 cm above the marker board. | BN1 |

| | | |
|---|---|---|
| COM | Standard number plate width is 50 cm. For marker boards smaller than 50 cm the width of the number plate is the same as of the marker board. | |
| 2.3.1-6 | ICI activation distance marker (section 2.3.9) shall be mounted below the marker board. | BN2 |
| 2.3.1-7 | Where applicable, the ICI speed limit marker (refer to Section 2.3.10) shall be mounted below the marker board. If an ICI activation distance marker is present, the ICI speed limit marker shall be mounted below that activation distance marker. | BN2 |
| COM | A different placement of the ICI activation distance marker and the ICI speed limit marker can be decided by the signal sighting committee. | |
| 2.3.1-8 | The signal sighting committee shall approve dimensions and height of marker boards and supplementing boards for each individual case. | BN1 |
| COM | In case of placing boards lower than the preferred height it should be considered that they may easy get obstructed by snow, dirt or low brushes. If possible, such placement should be avoided. | |
| 2.3.1-9 | The arrow of marker boards shall point towards the track that the marker board applies to. See Figure 2.3-1 Marker board and supplementing boards locations. | BN1 |
| 2.3.1-10 | Every marker board shall have a unique name. | BN1 |
| 2.3.1-11 | The name of a marker board shall be defined by<br>• the prefix “MB_”,<br>• followed by the short name of the TOB the marker board is related to,<br>• followed by a unique 2-digit number.<br><br>For marker boards located on main tracks odd numbers shall be used on the right track and even numbers on the left track. | BN2 |
| COM | In drawings where the element type of the marker board is shown by a symbol, the prefix may be omitted. | |
| COM | There are some recommendations for defining the 2-digit number of a marker board: | |

| | | |
|---|---|---|
| | • on main tracks numbering should start with 01 (odd) and 02 (even) at the lowest mileage of a TOB area.<br>• within a TOB area on main tracks there should be consecutive numbers from lower to higher mileages<br>However, these cannot be defined as strict rules, because changes to the signalling system should not cause renumbering of existing elements. | |
| COM | Further information on TOB short names and numbering can be found in PN76500Q01471 [6]. | |
| 2.3.1-12 | The name of a marker board may use a different TOB name that is more appropriate to its location. | BN2 |
| DEF | The UT profile defined in BN1-166 [13] specifies the cross-section that must be clear of all obstacles. | |

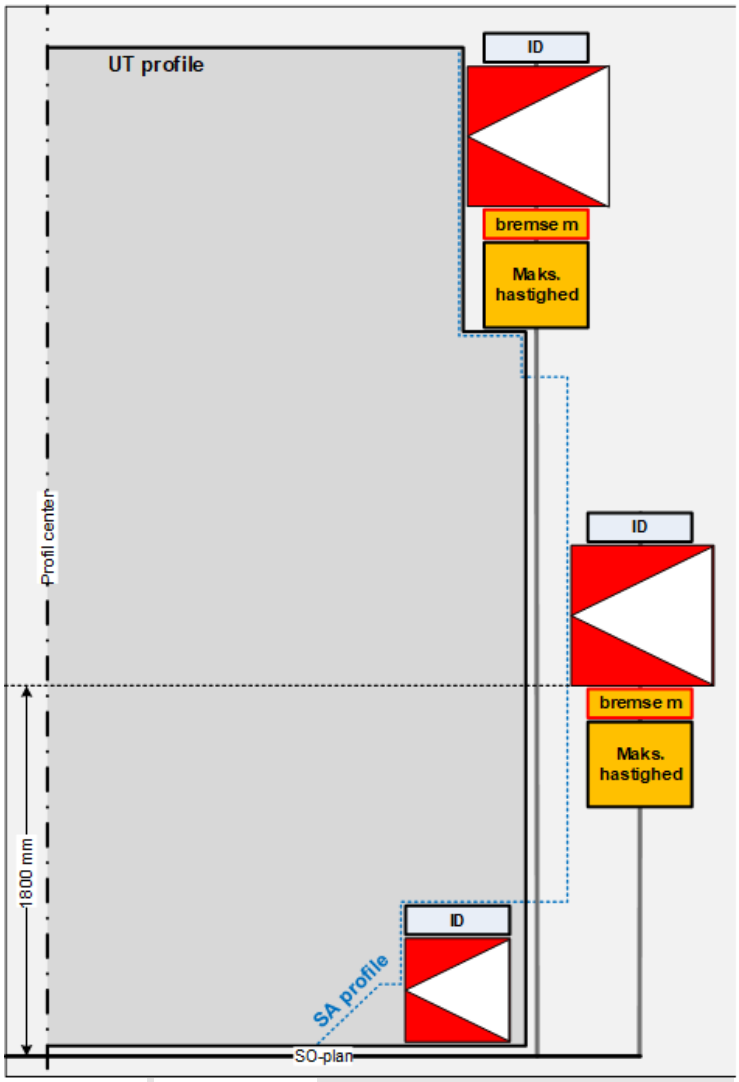



**Figure 2.3-1 Marker board and supplementing boards locations**

### 2.3.2 Location of marker boards

| | | |
|---|---|---|
| DEF | Marker boards are located according to defined routes (section 2.4). | |
| 2.3.2-1 | On single track lines, marker boards shall be located to the right of the track (in the direction of traffic). See Figure 2.3-2 Marker board locations on single track line | BN2 |

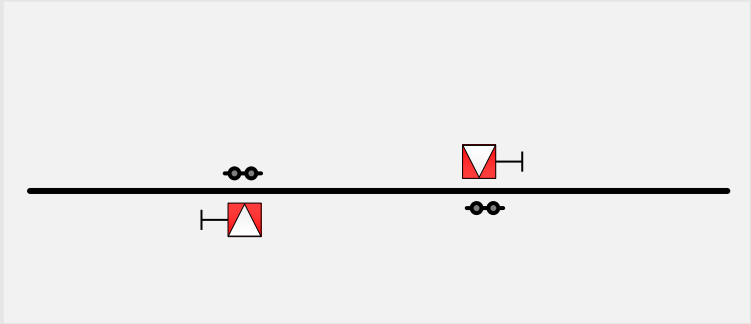


**Figure 2.3-2 Marker board locations on single track line**

| | | |
|---|---|---|
| 2.3.2-2 | On lines with two tracks, marker boards shall be located:<br>- to the right of the right track (in the direction of traffic),<br>- to the left of the left track (in the direction of traffic). See Figure 2.3-3 Marker board locations on double track line | BN2 |
| COM | It is good practice to align the marker boards for right track and left track, if possible. | |

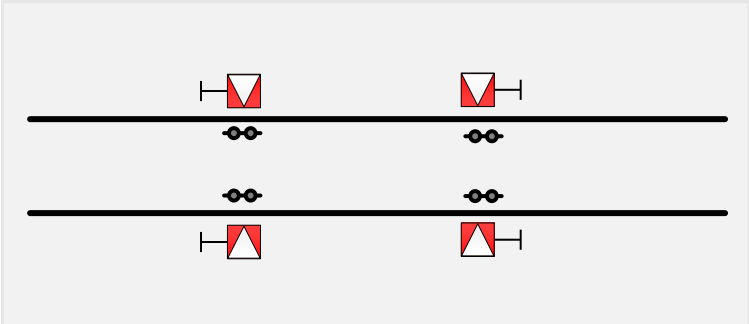


**Figure 2.3-3 Marker board locations on double track line**

| | | |
|---|---|---|
| 2.3.2-3 | In station areas with more than two tracks marker boards shall be located according to the rules as stated in rule 2.3.2-2. | BN2 |
| 2.3.2-4 | The signal sighting committee shall approve location for each individual case and can override the BN2-rules in this section. | BN1 |

| | | |
|---|---|---|
| 2.3.2-5 | Marker boards that can be end of a route shall be visible at least 136 m to support non-CBTC/non-ICI moves of 40 km/h. If this distance is not achievable or requirement 2.3.2-6 does not apply, then all marker boards with a route to the marker board shall have speed sign no higher than written in Table 2.3-1 Marker board visibility distances. | BN1 |

| Speed [km/h] | 20 | 25 | 30 | ≥ 40 |
|---|---|---|---|---|
| Required visibility distance for marker board [m] | 42 | 61 | 85 | 136 |

**Table 2.3-1 Marker board visibility distances**

| | | |
|---|---|---|
| COM | It is assumed that the driver is aware of the upcoming marker board, e.g. by observation of the count-down boards. A reaction time of 3 s and a brake rate of 0.6 m/s² is considered for determining the distance to stop in front of the marker board. | |
| 2.3.2-6 | Where two consecutive marker boards are located < 136 m apart, the second marker board need only be visible from the location of the first marker board. | BN1 |
| 2.3.2-7 | A marker board controlling departure from a terminal track (not acting as end of a route), shall be visible to the driver from the normal point of departure. | BN1 |
| COM | In this case the distances defined in Table 2.3-1 Marker board visibility distances are not applicable, because the train starts from standstill. | |
| 2.3.2-8 | A marker board controlling entry from non-controlled area shall be visible to the driver at least 50 m before the location of the marker board. | BN1 |
| COM | In this case the distance for 25 km/h as defined in Table 2.3-1 Marker board visibility distances is not applicable. | |
| COM | Approval regarding 2.3.2-8 may be possible if there is a clearly visible "start of ICI" sign available in front of the first marker board, which can act as an announcement of the first marker board. | |
| 2.3.2-9 | A marker board shall be located at least 2.5 m after the train's (front end) stopping location. | BN2 |
| 2.3.2-10 | If rule 2.3.2-9 is not fulfilled, the marker board shall be located at least 1 m after the train's (front end) stopping location. | BN1 |
| COM | The stopping locations at platforms are defined in the SRTL as the location of the platform stopping markers. | |

| | | |
|---|---|---|
| COM | A distance of 2.5 m provides best view to the marker board for the driver for all marker board mounting situations. | |
| 2.3.2-11 | If individual cases require shorter distances, these shall be approved by the signal sighting committee. | BN1 |
| 2.3.2-12 | A marker board shall be located at least 1 m, but not more than 20 m before the nearest axle counting head. | BN1 |
| COM | This 1 m distance cannot be reduced, because of the required distance between the C-balise at the marker board and the axle counting head. | |
| COM | The 20 m limit is defined to avoid vehicles hiding between the marker board and the first TVS of the route. | |
| COM | If the marker board supports ICI operation, the recommended distance is 14 m with a tolerance of 12.5 to 20 m. This ensures that the ICI-FV will not occupy the first TVS of the route with its first axle before passing the C-balise. In case of a distance shorter than 12.5 m, the ICI.FV may (depending on the mounting location of the balise reader) need to pass the C-balise within 3 s after occupying the first TVS of the route to avoid an onboard “signal passed at danger” alarm. | |
| 2.3.2-13 | A marker board shall be placed on the approach to TOB station before the first point. | BN2 |
| COM | Known as “station entry marker board”. This marker board serves as “station entry signal” to the station. | |
| 2.3.2-14 | If constraints in the field would lead to a "station marker board" violating rules in this section, a marker board at the end of the previous platform shall double as the "station entry marker board" for the next station. | BN2 |
| COM | E.g. this has been the case at Kildebakke for Buddinge, Virum for Holte track 3, and Jyllingevej for Vanløse station. | |

### 2.3.3 Catenary constraints

| | | |
|---|---|---|
| DEF | Rules in this section are related to catenary switch sections, i.e. where two contact lines run in parallel, and may become bridged by a pantograph.<br>In the context of these rules, the extent of the section is the area where bridging is possible. This depends on design and is usually 1 – 2 mast separations. | |
| COM | The constraints regarding locations of marker boards refer to trains moving on main signal level, e.g. with ICI movement authority or written order.<br>Trains moving on moving block level may stop independent of marker boards. This is considered by non-stopping zones as defined in section 2.11.1. | |
| COM | The track from København H platforms to the northern end of the boulevard tunnel is equipped with a solid contact line. For catenary switches in this area, there is technically no bridging possible, and these switches need not to be considered in the Signalling System design. | |
| DEF | Where contact lines are joined by an insulator, and thus not running parallel, there are no restrictions on marker board locations. | |
| 2.3.3-1 | A marker board shall not be located in a catenary switch section. | BN2 |
| 2.3.3-2 | A marker board shall be located at least 190 m after a catenary switch section, in the direction of traffic. | BN2 |
| COM | If the distance is less than 190 m it depends on the train length if a train in operation mode AM or SM will stop in front of the catenary switch section (longer train) or moves up to the marker board (shorter train). A train in RM will always move close to the marker board and may then stand within the catenary switch section. This may be a higher risk if the switch is normally open than if it is normally closed. | |
| COM | The 190 m distance is defined based on the longest S-bane passenger train (169 m) and the stopping distance in front of a marker board without overlap (about 21 m in case the route ends 14 m behind the marker board. | |
| COM | If a CBTC overlap is configured at a marker board, the distance can be reduced to 170 m instead of 190 m, because the train can approach close to the marker board. | |
| 2.3.3-3 | For particular lines or tracks another distance after a catenary switch section may apply if other train consists are to be considered. | BN2 |
| COM | E.g. on Ringbanen the longest passenger train is 85 m, which allows for reducing the distance to 106 m. | |

| | | |
|---|---|---|
| | | |

### 2.3.4 Route constraints

| | | |
|---|---|---|
| 2.3.4-1 | Where two consecutives marker boards are required, for the same direction of traffic, they shall be located at least one ICI overlap distance apart, unless they are combined. | BN1 |
| COM | See section 2.4.7 for length of ICI overlaps. If possible, the standard ICI overlap lengths of 500 m on main tracks and 250 m for tracks with a maximum speed of 40 km/h should be used by default. | |
| COM | If two consecutive routes are combined, i.e. the first route can only provide a movement authority if the following second route provides a movement authority, the first route does not require an overlap and the minimum distance for the following route does not apply. | |
| 2.3.4-2 | If a route ends at a platform track with a staff crossing behind the platform area, the marker board shall be located in front of the staff crossing with a minimum distance of 6 m. | BN1 |
| COM | It should be considered that an axle counter is required between the marker board and the staff crossing. | |
| COM | By placing the marker board in front of the staff crossing, the staff crossing is only claimed by the overlap and not by the route itself. Claiming the overlap does not activate the staff crossing signals. | |

### 2.3.5 Not in use

### 2.3.6 Not in use

### 2.3.7 Not in use

### 2.3.8 Not in use

### 2.3.9 ICI activation distance markers

| | | |
|---|---|---|
| DEF | Non S-trains need an in-cab-indication (ICI) onboard unit to get a movement authority for entering a route at a marker board ahead. The movement authority is available when the activation balise A2 is detected. For operational braking to the marker board in case a "red" signal aspect is indicated, the following conservative parameters are assumed:<br>• Signalling system reaction time (from passing the balise to indication of signal aspect): 1 s<br>• Driver reaction time (from indication of "red" signal aspect to start of braking): 3 s<br>• overspeed: 3.5 km/h<br>• operational brake rate: 0.46 m/s² | |

| | | |
|---|---|---|
| | • average gradient: 10 permille downhill | |
| 2.3.9-1 | A marker board located at a main track shall be supplemented by an ICI activation distance marker if the ICI activation distance to the next marker board at the same main track is:<br>- less than 800 m (790 m is tolerable) for a speed of 70 km/h or<br>- less than 300 m for a speed of 40 km/h or<br>- less than 150 m for a speed of 25 km/h<br><br>The distance is measured in the straight track, not to divergent track. | BN1 |
| COM | The ICI activation distance marker is shown in Figure 2.3-1 Marker board and supplementing boards locations with text “bremse m” and in Figure 2.3-4 Marker boards with ICI activation distance marker with correct distance as defined in 2.3.9-2. | |
| COM | The speed limit for the present marker board applies because this is the speed relevant for braking from expected start of indication of the next signal aspect to the next marker board. | |
| COM | The activation distances are defined longer than required considering the given parameters. This gives the driver about 3 s extra time for smooth transition to braking. | |

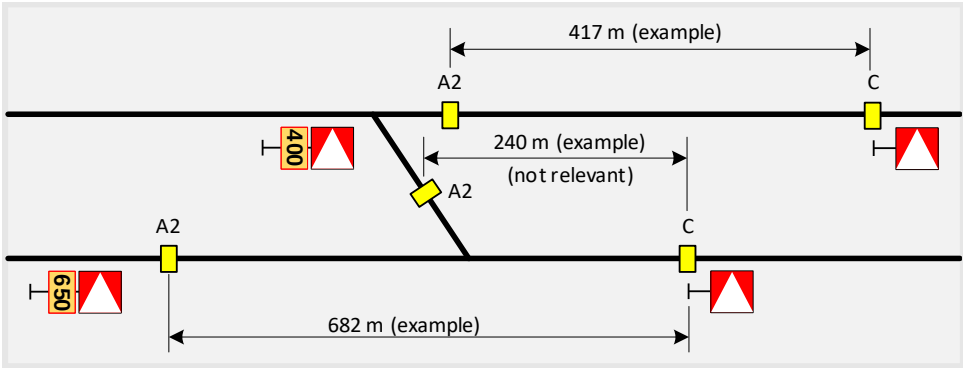



**Figure 2.3-4 Marker boards with ICI activation distance marker**

| | | |
|---|---|---|
| 2.3.9-2 | An ICI activation distance marker shall show the activation distance in meter to the next marker board at the same main track, rounded down to the next multiple of 50 m as a number without unit. Before rounding, a tolerance of 2 m shall be added to the available activation distance. | BN1 |
| COM | Possible distance numbers are 50, 100, 150, …750.<br>Example: An as-built activation distance of 498 m from A2 balise to marker board requires a “500” marker, but for 497 m the marker is “450”. The 2 m cover possible tolerances between designed and as-built location of the A2-balise. | |

| | | |
|---|---|---|
| COM | ICI activation distance marker dimensions are 50 cm × 27 cm for marker boards with 70 cm or 50 cm width and 33 cm × 27 cm for marker boards with 33 cm width. | |
| COM | The appearance of the board is shown in appendix 5.3.5. It is the same as for the warning boards below the count-down boards. | |

### 2.3.10 ICI speed limit markers

| | | |
|---|---|---|
| DEF | In general, an ICI movement authority provided by a "yellow" signal aspect allows driving with a speed under 70 km/h. | |
| COM | ICI speed limit markers are designed according to KN76500Q01422 [7], section 2.7. | |
| COM | The appearance of the ICI speed limit marker is shown in appendix 5.3.5. | |
| 2.3.10-1 | An ICI speed limit marker at a marker board shall show the operational speed limit in km/h related to a "yellow" signal aspect as a number without unit. | BN1 |
| COM | It is recommended to use only 10, 20, 25, 30, 50 and 60 km/h. For 40 km/h no speed limit marker is required. | |
| COM | The ICI speed limit is valid for all routes starting at the marker board. | |
| 2.3.10-2 | The speed limit to be considered for the ICI speed limit marker shall be determined considering all routes starting at the marker board that can provide a "yellow" signal aspect.<br>The speed limit marker is determined by the lowest of the following values:<br>- The lowest operational speed valid for any location within these routes<br>- The visibility of the destination marker board of these routes according to Table 2.3-1 Marker board visibility distances<br>- The overlap at the destination marker board | BN1 |

### 2.3.11 Count-down boards

| | | |
|---|---|---|
| DEF | On main tracks an upcoming marker board is indicated to the driver by a sequence of Count-down boards with two and three bars in a distance of 800 m and 400 m to the marker board. | |
| COM | The appearance of the boards is shown in appendix 5.3.5. | |

| | | |
|---|---|---|
| COM | The count-down board with one bar in 1200 m distance is no longer used, because the ICI braking distance from 70 km/h is no longer than 800 m and trains running faster than 70 km/h are fully supervised by CBTC including indication of the remaining length of the movement authority to the driver. | |
| 2.3.11-1 | Count-down boards are required on main tracks in front of a marker board. A count-down board with 2 bars shall be installed at 800 m (up to 860 m tolerable) distance and a count-down board with 3 bars at 400 m (up to 460 m tolerable) distance to the marker board, both on the same side of the track.<br><br>If there is a catenary mast that would obscure the count-down board within the tolerable distance, then the count-down board shall be placed in front of the catenary mast. See Figure 2.3-5 Track equipped with count-down boards (examples). | BN2 |
| 2.3.11-2 | If the location of the count-down board with 2 bars or the count-down board with 3 bars would be outside the route approaching the associated marker board it shall not be provided. | BN2 |
| COM | Mounting of the boards is defined in type drawing IN765.00Qnr.01534 [17].<br>This drawing also provides references to type drawing for dimensions of the boards. | |
| 2.3.11-3 | Count-down boards are not required for a platform exit marker board of a TOB station, if the route ending there is starting at a station entry marker board. | BN2 |
| COM | The reason for this is that there is always placement of a marker board at the platform, and this is known by the drivers. | |

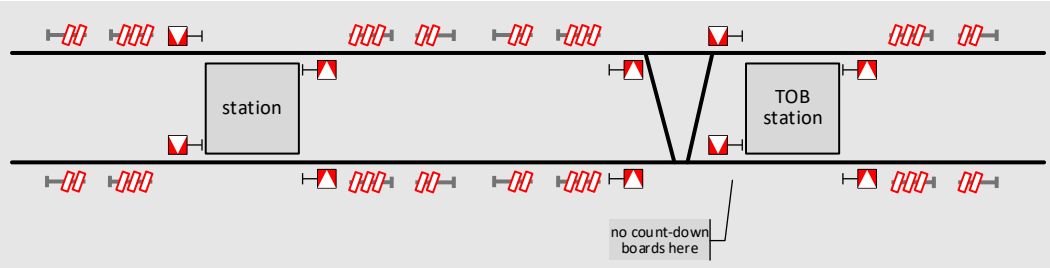



**Figure 2.3-5 Track equipped with count-down boards (examples)**

| | | |
|---|---|---|
| 2.3.11-4 | Count-down boards shall be visible for at least 3 seconds before the train passes the board. This equals a visibility distance as provided in Table 2.3-2. | BN2 |
| COM | The distance is to be calculated based on the maximum allowed speed for ICI-FV in front of the count-down board. The worst case is 70 km/h for ICI-FV. | |

| Speed [km/h] | 40 | 50 | 60 | 70 |
|---|---|---|---|---|
| Required visibility distance for count-down board [m] | 34 | 42 | 50 | 59 |

**Table 2.3-2 Count-down board visibility distances**

| | | |
|---|---|---|
| 2.3.11-5 | Count-down boards with 2 and 3 bars shall be supplemented by a warning board if the following marker board is supplemented by an ICI activation distance marker (section 2.3.9). | BN2 |
| COM | Warning board and ICI activation distance markers are exactly the same signs, but the warning board does not contain a number. | |
| 2.3.11-6 | Warning board, if present, shall be mounted below the count-down boards. | BN2 |

### 2.3.12 End of supervised area boards

| | | |
|---|---|---|
| DEF | Routes towards the border to a non-controlled area are not terminated by a marker board or signal. EOA is at the end of the last track section of the route which is the location of the related axle counter.<br>To indicate clearly to the driver where the movement authority ends, the location is marked with an “end of supervised area” board. | |
| COM | Such a border is present e.g. at the transition to a non-controlled S-train depot or to a Yellow Fleet depot area. | |
| 2.3.12-1 | At the border to a non-controlled area an “end of supervised area” board shall be installed to indicate the end of the movement authority. | BN1 |
| COM | The appearance of the “end of supervised area” board is shown in appendix 5.3.5. | |
| 2.3.12-2 | The visibility distance for a “end of supervised area” board shall be at least 35 m. | BN1 |
| COM | It is considered that the maximum speed for approaching the board is 25 km/h. | |
| COM | The signal sighting committee need not to approve the location of an “end of supervised area” board, because it can be assumed that a driver knows the location where the non-controlled area starts. | |

### 2.3.13 Signs at territory borders

| | | |
|---|---|---|
| DEF | The Signalling System for the S-bane is related to specific operational rules, called ORS [9]. Most track is equipped for use with CBTC, some track is only equipped for use with ICI. | |
| DEF | Furthermore, the S-bane has connections to other railways, e.g. Fjernbane. To indicate to the train drivers which rules are applicable or which train control system is supported, respective signs are installed at the territory borders. This is subject of section 2.8. | |
| COM | In the past CBTC and ICI signs have been placed at the borders. This is not required. | |

## 2.4 Routes

### 2.4.1 Route start and end

| | | |
|---|---|---|
| 2.4.1-1 | A route shall start at a facing marker board or boundary from Fjernbane. | BN1 |
| 2.4.1-2 | A route shall end at a facing marker board, a buffer stop, boundary to Fjernbane or “end of supervised area” board. | BN1 |
| COM | If a marker board is the end of a route, the logical end is at the axle counter following the marker board or signal. | |

### 2.4.2 Route length

| | | |
|---|---|---|
| 2.4.2-1 | A route shall have a length of at least one TVS. | BN1 |
| DEF | ICI operation needs an activation distance in front of a marker board to indicate the signal aspect and an ICI overlap behind the marker board. The ICI principle does not allow another marker board between start of activation distance and related marker board. The interlocking does not allow another marker board between start and end of overlap. | |
| 2.4.2-2 | Routes used for ICI operation shall have a minimum length that provides the required “ICI dark distance” according to 2.5.3-3 plus the ICI activation distance according to 2.5.3-7 for the applicable line speed. | BN1 |
| COM | For 70 km/h an ICI activation distance of 800 m and a dark signal aspect distance of 50 m are required.<br>A shorter ICI activation distance may apply if there is a diverging point in the route. | |
| 2.4.2-3 | Routes used for ICI operation shall have a minimum length that provides the required ICI overlap length for the preceding route. See Figure 2.4-1 Examples for route length supporting / not supporting full ICI speed. | BN1 |
| COM | This is not applicable for a route from a first marker board as there is no preceding route.<br>The ICI overlap length is defined in Table 2.4-1 ICI overlap length. | |

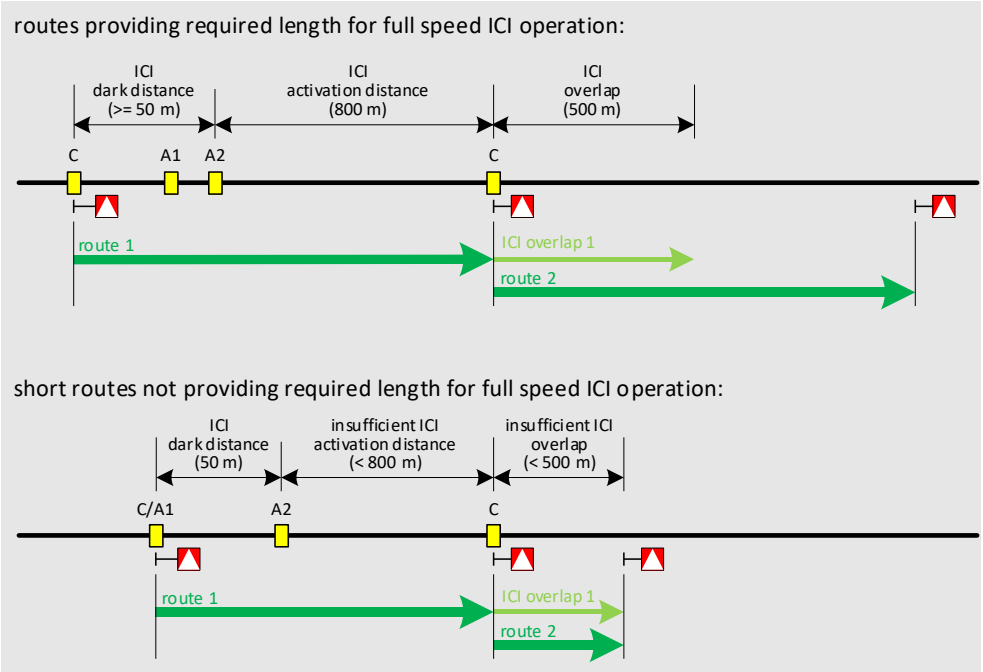



**Figure 2.4-1 Examples for route length supporting / not supporting full ICI speed**

| | | |
|---|---|---|
| 2.4.2-4 | In case a route needs to be shorter than the ICI overlap required by the preceding route, the following option may be configured:<br>An ICI overlap with reduced length (or not ICI overlap at all) is configured. Additionally, it shall be ensured by configuration of the route with the reduced ICI overlap length that a proceed aspect at the start marker board is only possible, if also the following route provides a proceed aspect. | BN1 |
| COM | Route supervision of the following route supersedes the ICI overlap. In this case it is not required to define an ICI overlap at all.<br>If it is not desired to set the following route in advance, the speed limit for the ICI-FV must be reduced to reduce the required overlap length. | |
| 2.4.2-5 | When defining the marker board locations, it shall be considered that:<br>- the total route length plus overlap length limits the headway in fixed block operation (CBTC fallback mode or ICI),<br>- the distance from start of the route to a diverging or converging point in the route limits the headway in special cases (e.g. reversal or left running),<br>- the distance from start of the route or any diverging point to the end of the route may limit the speed for ICI operation,<br>- the total route length may limit the overlap length and thus the speed for ICI operation. | BN2 |
| COM | There is no defined maximum route length. However, the marker board separation in a particular track shall support traffic capacity requirements in this track. | |

### 2.4.3 Flank and front protection

| | | |
|---|---|---|
| DEF | Flank and front protection for a route is generically provided by other vehicles not obtaining a conflicting MA from the protecting marker boards.<br><br>However, to protect a route against uncontrolled train moves without MA, specific flank protection for the movable elements and diamond-crossings of the route needs to be configured. | |
| COM | Front protection, i.e. protection against an opposing train move at the end of the route, will not be considered, because for operational reasons points could normally not be used as protecting element, but only marker boards, which anyhow are set to stop. | |
| 2.4.3-1 | For any point or diamond-crossing locked for a route, flank protection shall be provided by locking a protecting point or derailer, or if neither is possible due to the track layout alternatively by claiming one or more protecting marker boards. | BN1 |
| 2.4.3-2 | For flank protection area elements, a direction may be defined. If the element is locked for a route in this direction, the occupation of the element shall not be considered. | BN1 |
| COM | A point needs flank protection from the one leg not part of the route. A diamond-crossing needs flank protection from the two sides a foreign vehicle could violate the path of the diamond-crossing claimed for the route. | |
| COM | In case a marker board is chosen for providing flank protection, the status of this marker board need not to be checked in the flank protection conditions and it can be omitted in the route table. The reason for this is that a marker board has only logical states in the software without any hardware that could fail. The logical state is either “stop”, which is the state providing flank protection, or any “proceed” state, which is bound to a set route, and this route then ensures that the element requesting flank protection is not endangered. However, further requirements, e.g. regarding the flank protection area, need to be fulfilled as if the marker board is used for flank protection. For this reason, the omitted marker board should be stated in the route table as a comment. | |

| | | |
|---|---|---|
| 2.4.3-3 | Flank protection additionally requires that flank protection area elements, i.e. track sections between the protecting element (point, derailer, marker board or signal) and the point or diamond-crossing to be protected, shall be detected as clear of trains. Alternatively, it is tolerable for flank protection area elements not located in the fouling area of the point or diamond-crossing to be protected, that they are locked by another route, but only if the direction of locking is away from the point or diamond-crossing requiring flank protection. See Figure 2.4-2 Flank protection example and Figure 2.4-3 Flank protection table example. | BN1 |
| COM | It is assumed that a vehicle located on such a track section will move only in direction of the route locking. | |
| COM | In case there is no TVS between the protecting element and element to be protected, there is no area element at all. | |

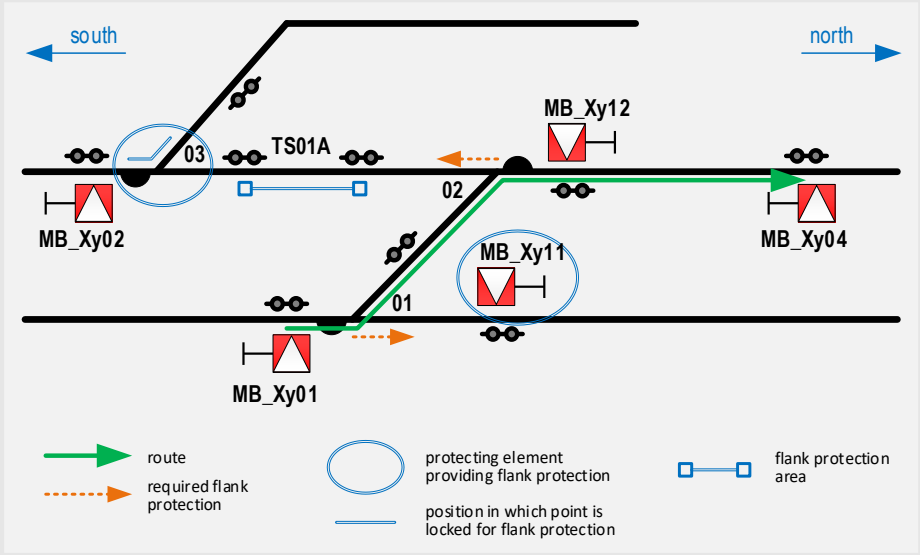



**Figure 2.4-2 Flank protection example**

| | | first level | | | | | second level | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| element requesting flank protection | | flank protection element | | flank protection area elements | | | subsitute flank protection element | | additional flank protection area elements | | |
| point or cross-over | via leg | element | position | element | position | direction | element | position | element | position | direction |
| P_Xy01 | right | MB_Xy11 | - | - | - | - | - | - | - | - | - |
| P_Xy02 | right | P_Xy03 | left | - | - | - | MB_Xy02 | - | P_Xy03 | right | south |
| | | - | - | TS01A | - | south | - | - | - | - | - |

**Figure 2.4-3 Flank protection table example**

| | | |
|---|---|---|
| DEF | Flank protection can be configured for any TVS as conditions for a “first level” and a “second level”. The first level defines a complete set of protecting elements and area elements. In the | |

| | | |
|---|---|---|
| | second level substitute elements may be configured for any element of the first level. | |
| COM | Sicas will automatically claim second level if first level element is not available. | |
| COM | If a point is claimed as protecting element either as first or second level, the claim will remain until the element to be protected is released. | |
| COM | If a marker board is claimed as first level protecting element but is later called as start signal for a new set route, the claim will automatically be released if it can be substituted by the second level. | |
| DEF | Substituting a protecting element changes the flank protection area. As a consequence, either some area elements are also substituted by the protecting element (if the area becomes smaller) or additional area elements need to be defined (if the area becomes larger). | |
| DEF | The CBTC provides movement authorities for trains in AM or SM operation modes only if flank protection is provided by the interlocking. There is no fallback based on a call-on level without flank protection. | |
| 2.4.3-4 | In case a movable element is defined as flank protection element in first level, a substitute protection element (“second level”) shall be defined, unless the protection element is coupled with the element requesting flank protection. | BN2 |
| COM | In case of coupled elements failure of the flank protection element (e.g. wrong position or position detection disturbed) need not to be considered and a second level is not required. | |
| 2.4.3-5 | In case a marker board is defined as flank protection element in first level, a substitute protection element (“second level”) shall be defined, if the marker board is start of a route that can be set independent of the route requesting flank protection. This is not required if there is no other protecting element available. | BN2 |
| COM | Figure 2.4-3 Flank protection table example provides an example of a flank protection table for the elements of the route shown in Figure 2.4-2 Flank protection example. Other routes that claim the points in same position use the same flank protection definition. | |

### 2.4.4 Route release time

| | | |
|---|---|---|
| DEF | In case of route cancellation, the aspect of the marker board at the start of the route is immediately set to danger and the route then releases either immediately or with a delay or it will not release if a train entered the route while the delay timer is not expired. | |
| COM | Configuration of route cancellation parameters is not relevant if the route is set for an approaching CBTC train (operation modes AM and SM). The CBTC will then prevent route cancellation if required for safety reasons.<br>Trains moving on written order, e.g. in operation mode RM, need also not to be considered, because a written order expires at the end of a route. All-in-all route cancellation parameters need to be designed for trains with an ICI movement authority. | |
| COM | Configuration for route cancellation needs to consider operational braking of ICI. Parameters for these trains are defined in section 2.3.9 and calculated ICI activation distances apply for the required length of the approach section for route cancellation. | |
| 2.4.4-1 | For marker boards the required length of the approach section for route cancellation depends on the maximum speed an ICI-FV can approach the marker board. For a speed up to 70 km/h the required length shall be 800 m. For a speed up to 40 km/h the required length shall be 300 m. | BN1 |
| 2.4.4-2 | The delay time for route cancellation shall be 60 s.<br>In case an ICI-FV can approach the start of the cancelled route with a maximum speed not higher than 40 km/h, the delay time may be reduced to 25 s. | BN1 |
| COM | In a worst-case scenario an ICI-FV can move at 70 km/h with an overspeed of 3.5 km/h. It may take 1 s to display the “red” aspect on the ICI panel and up to 3 s until the driver reacts on the “red” signal aspect, considering that there is an audible warning when the signal aspect is downgraded. Braking may be with lowest brake rate of 0.46 m/s² in a downhill area of 10 permille. The time from route cancellation to standstill is then: | |
| | $T = (73.5/3.6) / (0.46 - 0.010*9.81) + 1 + 3 = 60.4$ s. | |
| COM | Approach sections and delay times are configured in the route table. | |

### 2.4.5 Emergency stop areas

| | | |
|---|---|---|
| DEF | An emergency stop area is an area of track, technically a list of LTEs and marker boards or signals, wherein all movement authorities issued to trains can be withdrawn immediately by a | |

| | | |
|---|---|---|
| | single command. Issuing the command sets all marker boards or signals to danger and sets the allowed CBTC speed for all LTEs to zero. | |
| 2.4.5-1 | The entire S-bane track layout which is under control of the Signalling System shall be split into emergency stop areas. The extent of an emergency stop areas shall be equal to one or more operation areas. | BN1 |
| COM | This means that each LTE and each marker board or signal is associated to exactly one emergency stop area. | |
| COM | An operation area equals one detailed view on the signaller's HMI. | |
| 2.4.5-2 | Each TVS shall be assigned to the emergency stop area it is located in. | BN1 |
| 2.4.5-3 | Each marker board shall be assigned to the emergency stop area it is located in. In case it is located at the border of two emergency stop areas, the marker board shall be assigned to the emergency stop area it is facing into. | BN1 |
| COM | This shall prevent trains moving into the emergency stop area while the emergency stop is activated. | |
| DEF | The TMS provides a single command that activates the emergency stop, i.e. blocks all associated marker boards or signals at danger and sets the CBTC speed limit of all associated operation areas to zero. | |
| COM | There is no command to reset the area from emergency stop. marker boards or signals needs to be unblocked individually and the zero speed needs to be reset separately for any operation area. | |
| DEF | The boulevard tunnel at Nørreport needs an additional emergency function to prevent trains from entering the tunnel while trains moving in the tunnel can still proceed and leave the tunnel. | |
| 2.4.5-4 | For the boulevard tunnel at Nørreport a single command shall be provided, that blocks the marker boards at the start of all routes leading into the tunnel at danger. | BN1 |
| COM | A route leading into the tunnel is a route that starts outside the tunnel and end inside the tunnel. | |

### 2.4.6 Safety distance

| | | |
|---|---|---|
| DEF | In the CBTC area safety distances are either included in the route, i.e. trains stop latest in a safety distance in front of the end of the route or are provided by an overlap. At permanent system borders with a technical interface to another train protection system, safety distances are considered in the interface design. | |
| 2.4.6-1 | The safety distance shall be at least 50 m to the closest point of danger.<br>See Figure 2.4-4 Safety distance. | BN1 |
| 2.4.6-2 | For routes to non-controlled areas or buffer stops, there shall be no safety distance. | BN1 |
| COM | This applies to both directions of travel. For trains coming from the non-controlled area to the CBTC system border, it is assumed that these are shunt moves not requiring any overlap at the first marker board. For trains coming from the CBTC area to the border to a non-controlled area it is assumed that there is no overlap required at the end of the route (start of non-controlled area sign). | |
| 2.4.6-3 | For routes ending at the border to a non-controlled area, the speed shall be limited to 40 km/h or less. | BN1 |

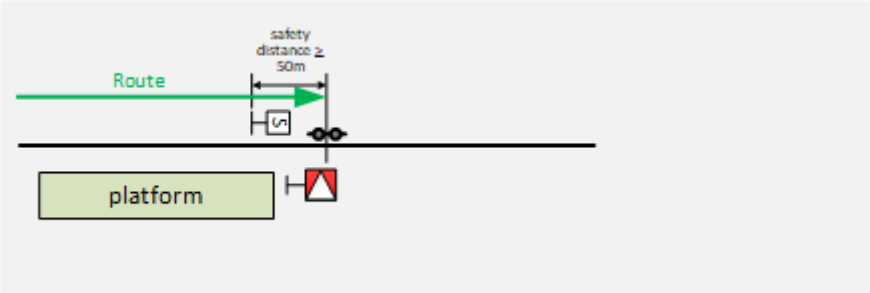



**Figure 2.4-4 Safety distance**

### 2.4.7 Locked overlap

| | | |
|---|---|---|
| DEF | For a marker board one or more overlaps may be configured, if required. An overlap provides a safety distance for routes terminating at the marker board. | |
| COM | All data of the overlap is configured in the route table. Additionally, the overlap length considered by CBTC is configured in the TDB. | |
| DEF | For CBTC trains the safety distance is normally included within the route dynamically. Where this is not possible, because the stopping point of a train is required to be closer | |

| | | |
|---|---|---|
| | to the marker board than the CBTC safety distance, then if a CBTC overlap is not provided, the next route must be set for the train to stop correctly in the platform. | |
| 2.4.7-1 | For routes ending at a platform exit marker board a CBTC overlap shall be configured where the stopping marker S for stopping at the platform is closer than 35 m to the end of the route. | BN1<br>*Syst.req. |
| COM | The logical end point of the route is the axle counter behind the marker board and this is the reference for the distance. Optimisation of runtimes is only considered for stopping at platforms. On open line stopping is not considered for regular operation, because following routes are set sufficiently in advance. | |
| 2.4.7-2 | To achieve shortest runtimes, it is recommended to configure a CBTC overlap, if the stopping marker S is closer than 50 m to the end of the route. | BN2<br>*Syst.req. |
| 2.4.7-3 | In case of diverging points within the CBTC overlap, multiple routes shall be provided, each of them with a different CBTC overlap, such that in total all possible paths for the overlap are covered. | BN2 |
| COM | Figure 2.4-5 Overlap length in TDB in case of multiple CBTC overlaps gives an example with two CBTC overlaps. | |
| DEF | In the TDB of the CBTC the overlap is configured as a length starting at the marker board independent of specific routes. | |
| 2.4.7-4 | The overlap length for a marker board configured in the TDB shall not be longer than the shortest distance from the marker board to the end of any CBTC overlap defined at that marker board. | BN1<br>*Syst.req. |

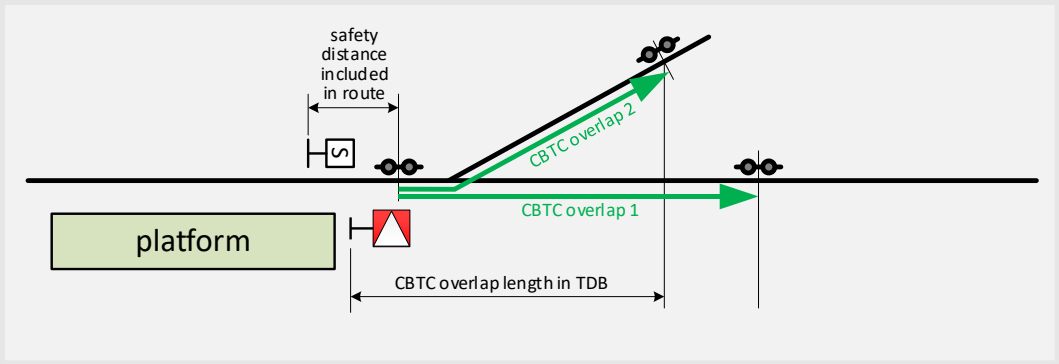



**Figure 2.4-5 Overlap length in TDB in case of multiple CBTC overlaps**

| | | |
|---|---|---|
| 2.4.7-5 | The overlap length for a marker board configured in the TDB shall not be longer than the shortest distance from the marker | BN1 |

| | | |
|---|---|---|
| | board to the fouling point of any point or diamond-crossing not locked by the overlap. | |
| COM | Figure 2.4-6 Overlap length in TDB in case of CBTC overlap reaching in fouling area gives an example, where a TVS_1 cannot provide the required overlap length. The interlocking additionally locks TVS_2 as CBTC overlap, which is foul to point P_01, but the point P_01 itself is not locked. The CBTC must ensure that the locked overlap is only used up to the fouling point for a movement authority, because the interlocking does not exclude route setting over the right leg of point P_01 unless configured as a special case in the route table. | |

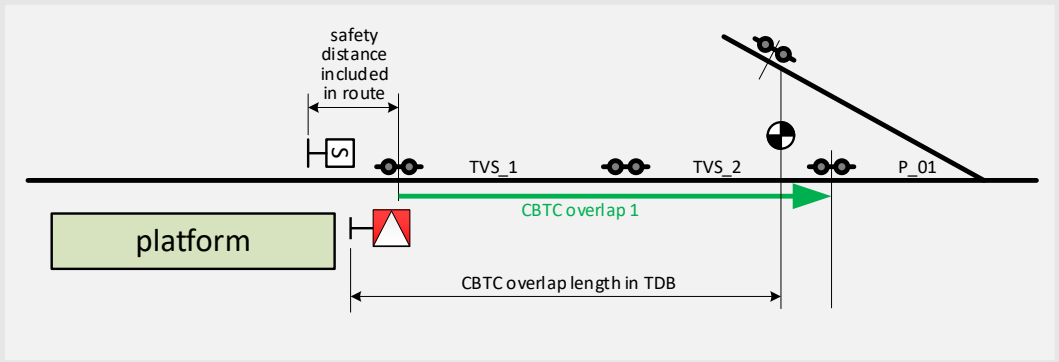



**Figure 2.4-6 Overlap length in TDB in case of CBTC overlap reaching in fouling area**

| | | |
|---|---|---|
| DEF | ICI routes ending at a marker board are configured with an overlap. As these overlaps are quite long and may span over multiple divergences, it can be the case that not the full set of overlaps towards all possible destinations is be provided. | |
| 2.4.7-6 | For routes ending at marker boards an ICI overlap shall always be configured. The length of the ICI overlap depends on the speed limit defined for the route ending at the marker board.<br>The following Table 2.4-1 shows the required overlap length depending on average gradient in the order of priority in which they shall be applied (i.e. the standard length shall be applied unless there is a need for a shorter length and the gradient adheres to the conditions stated).<br>If none of the rows in the table can be met, an individual calculation for the actual gradient and speed shall be used to determine the necessary overlap length. | BN1 |

| Max. speed in route [km/h] | 25have | 30 | 40 | 60 | 70 |
|---|---|---|---|---|---|
| Standard overlap length [m] | 118 | 157 | 250 | 365 | 500 |
| Overlap length for downhill gradient not more than 6 permille | 110 | 145 | 231 | 335 | 459 |
| Overlap length for downhill gradient not more than 3 permille | 105 | 138 | 218 | 316 | 432 |
| Overlap length for no downhill gradient | 100 | 132 | 207 | 300 | 409 |

**Table 2.4-1 ICI overlap length**

| | | |
|---|---|---|
| DEF | The relevant gradient is the average gradient between start (at marker board) and end of the overlap. | |
| COM | The standard ICI overlap length is defined for an average downhill gradient of 10 permille (N = -0.010) in the overlap area. The exact calculation for the distance s [m] based on the average gradient N is $$s = \frac{\frac{1}{2} \cdot \left[\frac{(v + dv)}{3.6}\right]^2}{(a + 9.81 \cdot N)} + (v + dv) \cdot t$$ where N = 0 … -0.010 is the average gradient in the overlap area, v [km/h] is the ICI speed limit (reduced by 10 km/h if speed is > 50 km/h), dv = 3.5 [km/h] the tolerated overspeed, a = 0.46 [m/s²] the assumed minimum brake rate and t = 4 [s] is the response time of the driver and the vehicle. For uphill gradients N = 0 is used. | |
| DEF | Overlaps can be released from route locking when the train has stopped at its destination in front of the end of the route. CBTC trains report standstill. An "overlap release timer" is provided, which gives a long enough time for an ICI vehicle to have come to a stand from the beginning of the occupation of the last TVS of the route.. | |
| 2.4.7-7 | The required duration $t_{release}$ of the "overlap release timer" shall be calculated as the time a train needs from occupying the TVS that starts the release timer until the train stops in front of the marker board considering moving with the lowest reasonable speed, braking with normal operational brake rate and additionally a safety margin of 5 s. | BN1 |
| COM | The resulting duration is $$t_{release} \geq \frac{l_{OlAppr}}{v_{min}} + \frac{v_{min}}{2 \cdot a} + 5s$$ Normally a speed of $v_{min}$ = 25 km/h (6,94 m/s) is considered as lowest speed and a brake rate of a= 0.5 m/s². $l_{OlAppr}$ is the length of the overlap approach section, from the beginning of the first TVS of that section up to the marker board. | |

| | | |
|---|---|---|
| COM | It is recommended to use standard release times of either 45 s or 60 s. The maximum length of the approach section for 45 s is 229 m and for 60 s is 333 m. | |
| 2.4.7-8 | For routes ending at a marker board at platform exit, an ICI overlap shall be released passively from route locking when the last track section of the route is occupied and the overlap release timer, started by this occupation, has expired. | BN1 |
| COM | Passive release of an element locked by a route means, that the element is released while the train did not yet pass it. | |
| 2.4.7-9 | Overlap release by timer shall not be configured if the required time $t_{release}$ calculated according to 2.4.7-7 is longer than 60 s. | BN1 |
| COM | This considers that the assumption of a minimum approach speed of 25 km/h without any stop is not justifiable for long distances, and release times of several minutes are not feasible for operation. | |
| COM | If overlap release by timer is not configured and the route is for ICI, the overlap will release actively when being passed by the train or passively after reversal. Otherwise, it can only be released manually. | |
| 2.4.7-10 | If for any ICI overlap a release by timer is not configured and there is a diverging point in the overlap, multiple routes shall be provided, each of them with a different ICI overlap, such that in total all possible paths for the overlap are captured. | BN1 |
| 2.4.7-11 | A CBTC overlap shall consist of at least one TVS. An ICI overlap shall consist of one or more TVS but cover at least one complete track vacancy section. | BN1 |
| COM | In case of the ICI overlap the track vacancy section is, beside other technical reasons, required to ensure a clear buffer block (see “train tracking”) behind the preceding train. | |
| 2.4.7-12 | For points or diamond-crossings locked as overlap, flank protection shall be provided. | BN1 |
| 2.4.7-13 | An overlap is not required in case a movement authority can only be provided if the route and also the following route is set. | BN1 |

### 2.4.8 Track for joining

| | | |
|---|---|---|
| DEF | To support joining of trains, route setting into an occupied track is provided. Existing claiming of route elements in opposite direction is released first. This is also in the same direction for routes that are not re-settable. | |
| COM | The Sicas interlocking provides “passive route release” for TVS defined as destination track of a route. The passive release (i.e. not caused by a train movement) is triggered with a delay after the track section in front of the destination track has released actively (i.e. by being passed by a train). The delay time is customised. In case of a reporting train the passive release is done when the train reports standstill. | |
| 2.4.8-1 | If the last section of a route is located at a real platform, this section shall be configured with passive release. In case the track at the platform is split into more than one section, all sections located at the platform shall be able to be released passively. | BN2 |
| 2.4.8-2 | Passive release is not required for platform tracks terminated by a buffer. | BN2 |
| COM | Passive release of an element locked by a route means, that the element is released while the train did not yet pass it. For safety reasons a point section within a route cannot release passively. Refer to definition of “Route release”. | |
| 2.4.8-3 | Passive release is not allowed if any of the sections to be released includes a point. | BN1 |
| 2.4.8-4 | The applicable delay time for passive release of a destination track shall be the same as for releasing the overlap. | BN1 |
| COM | Thus, destination track and overlap are released simultaneously. | |

### 2.4.9 Track for splitting

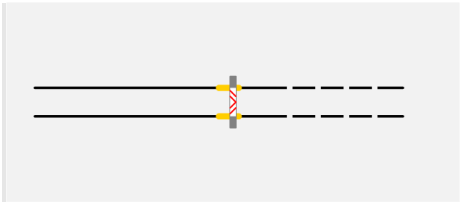
| | | |
|---|---|---|
| DEF | There is nothing specific to design to use a track for splitting. | |

### 2.4.10 Not in use

### 2.4.11 Terminal track

| | | |
|---|---|---|
| DEF | Terminal tracks are equipped with a buffer stop capable of slowing down a train hitting at 10 km/h or 15 km/h (according to buffer stop specifications).<br><br>For illustration and schematic example see Figure 2.4-7 Friction buffer stop | |

Illustration



Schematic example

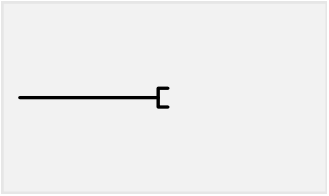


**Figure 2.4-7 Friction buffer stop**

| | | |
|---|---|---|
| 2.4.11-1 | Buffer stops shall be designed according to BN1-95 [12]. | BN1 |
| 2.4.11-2 | Buffer stops shall be marked on the facing side with a red/white self-reflecting area of at least 0,3 m². | BN1 |
| COM | The self-reflecting area can be designed as a dedicated sign according to KN06805Q1590 [30] or an adhesive label.<br>Mounting is described in IN06805V2327 [31].<br>Maintenance is defined in VN069R5563 [32]. | |
| 2.4.11-3 | The reflecting area shall be placed at least 750 mm above top of rail.<br>If the impact zone is in the centre of the buffer stop, the reflecting area shall be placed above that zone. | BN1 |
| 2.4.11-4 | A buffer stop acting as EOA shall be equipped with two red stop lights. | BN1 |
| COM | A buffer stop at the end of a terminal track that only serves as “trap” is not acting as an EOA.<br>Buffer stops in non-controlled areas are not acting as an EOA. | |
| COM | Appearance of the red lights is shown in section 5.3.4. | |

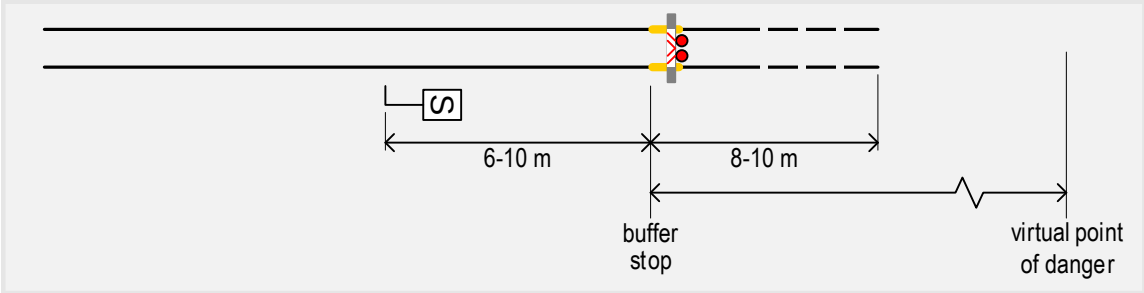
| | | |
|---|---|---|
| 2.4.11-5 | The red stop lights shall be visible to the driver in a distance defined by the following Table 2.4-2 Red stop lights visibility distances before the location of the buffer stop. | BN1 |

| Max. approach speed [km/h] towards buffer stop | 20 | 25 | 30 | 40 |
|---|---|---|---|---|
| Required visibility distance for red stop lights [m] | 56 | 61 | 85 | 150 |

**Table 2.4-2 Red stop lights visibility distances**

| | | |
|---|---|---|
| 2.4.11-6 | A stopping marker S shall be located 6-10 m before the buffer stop. For illustration and schematic example of a track layout see Figure 2.4-8 Typical terminal track layout. | BN1 |
| COM | The stopping marker S is the same as for indication of platform stopping points as defined in section 2.10.1. At many places one stopping marker S is used to indicate both the stopping point at the platform and the stopping point in the required distance in front of the buffer stop.<br>The appearance of the marker is shown appendix 5.3.5. | |
| COM | If the terminal track is designed for close buffer approach in AM/SM modes, the CBTC triggers emergency brake latest 2.5 m in front of the buffer to ensure that traction is cut-off at the buffer location. Considering typical location uncertainty of the train position of about 1.5 to 2 m, the typical trigger point is 4 to 4.5 m in front of the buffer. Considering further a control margin for ATO or the driver, a minimum distance of 6 m between stopping marker S and buffer is recommended. | |
| COM | For automatic door release the CBTC must detect that all doors of the train are located at the platform. Considering an uncertainty in location detection of +/- 1.7 m shortly after reading a precise balise and a stopping tolerance of +/- 0.3 m. | |
| COM | The compression distance of the buffer stop (> 8 m) is not considered in the safe braking model of the CBTC. | |

Illustration




Schematic example

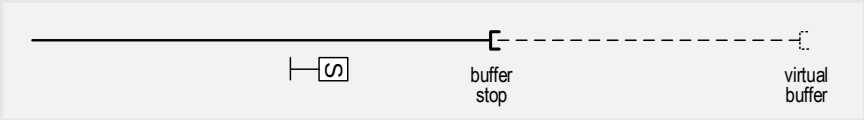



**Figure 2.4-8 Typical terminal track layout**

| | | |
|---|---|---|
| 2.4.11-7 | The speed limit for approaching a buffer stop shall not be higher than 40 km/h starting from 200 m in front of the buffer stop due to limitations in the CBTC system. | BN1<br>*Syst.req. |
| COM | A speed limit defined in the CBTC is valid for both directions. | |
| COM | This limitation is a precondition for the below CBTC specific argumentation regarding overestimation of braking distances. | |
| DEF | To enable a train approaching close to a buffer stop under CBTC supervision, i.e. in AM or SM mode, the CBTC considers a virtual point of danger behind the buffer stop. | |
| COM | "Close" means closer than the safety distance to the buffer stop would allow. Refer to definition of "safety distance" in section 1.3 and Figure 1.4-16 Route. The minimum distance to EOA is 25 m. | |
| DEF | The allowed maximum distance from buffer stop to the virtual point of danger is determined by two parts:<br>• the emergency braking distance for braking from 15 km/h to standstill (according EBDC),<br>• considering of braking distance overestimation in the CBTC safe braking model specifically for approaching a buffer stop. | |
| COM | In the CBTC the gradient of the track is configured to 0 for the last 200 m in front of the buffer. This supports reduction of unnecessary overestimation in the CBTC safe braking model. Real gradient needs to be considered when determining the remaining overestimation. This is included in the explanation below. | |
| COM | The emergency braking distance $s_{EBDCv}$ from a vital speed v to standstill, not considering gradient, is in general: | |

| | | |
|---|---|---|
| | $s_{EBDCv} = \frac{v^2}{2 \cdot GEBR}$ | |
| | Based on GEBR = 0.94 m/s², the result for speeds 15 and 10 km/h is:<br>$s_{EBDC15}$ = 9.23 m.<br>$s_{EBDC10}$ = 4.10 m | |
| COM | The safe braking model is an energy model with kinetic energy according to the measured speed and potential energy according to the difference of altitude from start to end of braking. In fact, the difference of altitude is determined from gradients plus an overall altitude error of 1.52 m. This value is a worst case based on longest braking distance from 120 km/h.<br>The braking distance is proportional to the total energy to be consumed by the brakes. For a difference Δh in altitude, the difference Δs in brake distance is:<br>Δs = f*g/GEBR * Δh<br>with f = 0.9414 (lowest ratio of a train's real mass to its total mass including rotating masses as considered in the CBTC for downhill movement), g = 9.81 m/s², GEBR = 0.94 m/s². With these values the equation is:<br>Δs ≥= 9.825 * Δh<br>The total overestimation is:<br>$\Delta h_{OE}$ = 1.52 m - N*$s_{EBICx}$<br>where $s_{EBICx}$ is the distance from EBIC to EOA for operational speed x and N is the real maximum downhill gradient (positive value) in front of the buffer stop starting in a distance of train length plus $s_{EBICx}$. For uphill gradient N=0 shall be considered.<br>To calculate the length $s_{EBICx}$ it is assumed that the train moves with vital speed x+12 km/h for a reaction time of 1.1 s until full emergency brake is applied and then follows the EBDC. The result is: | |
| | $s_{EBICx}[m] \leq \frac{\left(\frac{x+12}{3.6}\right)^2}{2 \cdot (0.94 - N \cdot 9.81)} + \frac{x+12}{3.6} \cdot 1.1$ | |
| 2.4.11-8 | In total the distance available for defining the EOA behind the buffer shall be: | BN1 |
| | $\Delta s_{EOA} = s_{EBDCv} + 9.825 \cdot \Delta h_{OE}$<br>$= s_{EBDCv} + 9.825 \cdot (1.52m - N \cdot s_{EBICx})$ | |

| Downhill gradient N [permille] | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| $\Delta s_{EOA}$ [m] for buffer with 15 km/h | 24.16 | 21.62 | 18.99 | 16.25 | 13.40 | 10.43 |
| $\Delta s_{EOA}$ [m] for buffer with 10 km/h | 19.03 | 16.49 | 13.86 | 11.12 | 8.27 | 5.30 |

**Table 2.4-3 max. distance buffer stop to virtual buffer / approach speed 40 km/h**

| Downhill gradient N [permille] | 0 | 2 | 4 | 6 | 8 | 10 |
|---|---|---|---|---|---|---|
| $\Delta s_{EOA}$ [m] for buffer with 15 km/h | 24.16 | 22.81 | 21.42 | 19.96 | 18.46 | 16.89 |
| $\Delta s_{EOA}$ [m] for buffer with 10 km/h | 19.03 | 17.68 | 16.29 | 14.83 | 13.33 | 11.76 |

**Table 2.4-4 max. distance buffer stop to virtual buffer / approach speed 25 km/h**

| | | |
|---|---|---|
| 2.4.11-9 | If a stopping point for a train in supervised operation (AM or SM) is closer than 25 m to a buffer stop, then a virtualpoint of danger behind the buffer stop shall be configured as a “virtual buffer”. The distance between stopping point and “virtual buffer” shall be at least 25 m. The distance between buffer stop and “virtual buffer” shall not be longer than defined in Table 2.4-3 max. distance buffer stop to virtual buffer / approach speed 40 km/h and Table 2.4-4 max. distance buffer stop to virtual buffer / approach speed 25 km/h. | BN1<br>*Syst.req. |
| COM | The “virtual buffer” acts as EOA for the CBTC safe braking model. | |
| COM | A distance of 29 m instead of the minimum distance of 25 m is recommended to allow for increased uncertainties in train location detection. | |

### 2.4.12 Not in use

### 2.4.13 Track for reversal

| | | |
|---|---|---|
| DEF | When a train enters a track for a reversal, the occupied route element and further route elements ahead of the train and the overlap will not actively release. In case there is no passive release, these elements will be released by the reversal function if configured. | |
| 2.4.13-1 | If in a destination track of a route reversing of trains is required for operational reasons, the related opposing reversal signal and the route elements of the destination track to be passively released by the reversal shall be configured. | BN1 |
| COM | The configuration is done in the route table. | |
| COM | An overlap, that is still not released (e.g. by expiration of the respective timer), is also released. This does not require any additional configuration. | |

## 2.5 Balises

### 2.5.1 General rules

| | | |
|---|---|---|
| DEF | Balises are mainly used for (precise) localisation of S-trains. Furthermore, they are used for determining the next upcoming marker board in ICI operation. | |
| DEF | All balises are fixed data balises. | |
| COM | Generally, balises are located in a manner balancing performance and economy.<br>In particular this means that not all fallback scenarios (e.g. first balise antenna failed and onboard system used second antenna) are considered for determining balise locations, because it is unlikely that other parameters (e.g. location uncertainty) are worst-case at the same time. | |
| COM | The CBTC uses only packet 44 of the ERTMS/ETCS standard SUBSET-040 [15]. CBTC data is the balise identifier and optionally 1 or 2 sets of ICI data. A set of ICI data consists of data for addressing the wayside control unit, the type of the balise (A1/R1, A2/R2 or C) and optionally a reference to the identifier of a linked balise. | |
| 2.5.1-1 | 'Precise balises' shall be mounted within ±20 cm of their nominal location.<br>'Non precise balises' shall be mounted within ±60 cm of their nominal location. | BN1<br>*Syst.req. |
| COM | 'Precise balises' are usually used at tracks of real platforms to enable precise stopping of S-trains.<br>Otherwise, the precision of 'non precise balises' is usually good enough. | |
| 2.5.1-2 | The longitudinal distance between any two mounted balises shall be at least 5.4 m.<br>A distance of at least 2.5 m applies where the speed is limited to not more than 25 km/h. | BN1<br>*Syst.req. |
| COM | The minimum distance prevents a train from simultaneously reading two balises. | |
| 2.5.1-3 | The lateral distance between two balises mounted on two parallel tracks shall be at least 3 m.<br>In case parallel operation on both tracks is not possible (e.g. at a point), the lateral distance shall be at least 1.4 m. | BN1<br>*Syst.req. |
| COM | The minimum distance prevents crosstalk.<br>If both balises could be simultaneously activated by trains located directly above them, crosstalk could occur, which cannot happen with only one train involved (e.g. at a point). | |

| | | |
|---|---|---|
| 2.5.1-4 | Balises shall be mounted at least 1 m from any axle counting head. | BN1<br>*Syst.req. |
| COM | This to avoid electromagnetic interferences. | |
| 2.5.1-5 | Balises shall not be mounted in curves with radii smaller than 300 m. | BN2<br>*Syst.req. |
| COM | In curves the balise antenna of a train is not located at the centre of track. This may prevent reading balises reliably. | |
| 2.5.1-6 | Every balise shall have a unique name. | BN1 |
| 2.5.1-7 | The name of a balise shall be defined by<br>• the prefix "FB_",<br>• followed by a 6-digit number.<br><br>The first 3 digits shall be equal to the station number the balise is related to. | BN2 |
| COM | Further information on station numbers and numbering can be found in PN76500Q01471 [6]. | |

### 2.5.2 Localisation / odometry correction balises

| | | |
|---|---|---|
| DEF | Every balise which is read by a CBTC train provides data allowing the OBCU to estimate the vehicle's position with good accuracy. So, all balises in areas operated by CBTC trains act as localisation and odometry correction balises. | |
| COM | 'Precise balises' allow a more precise localisation due to their more precise mounting.<br>The initial location uncertainty when reading a balise is 1.25 m for precise balises and 1.65 m for unprecise balise.<br>It further needs to be considered that a balise location can be determined by a train when it has been passed by about 1.5 m. | |
| COM | When defining balise locations, the location of the balise reader antennas at the trains need to be considered. The distance $d_{antenna}$ from front of train to balise reader is about 13.6 m if an SE is leading the train consist and about 29 m if an SA is leading the train consist. However, in case of failure other balise reader of the train may be used. | |
| COM | Trains not equipped with an OBCU do not localise themselves continuously. Hence, they do not need localisation / odometry correction balises. | |

| | | |
|---|---|---|
| DEF | Balises are used for the following functions:<br>- Localize a train<br>- Keep the localization<br>- Stop the train correct at the OSP of a real platform<br>- Detect the "fully berthed" status at a real platform<br>- Support stopping close to the end of a virtual platform | |
| COM | As trains are permanently powered up, there are no specific locations where trains localise and specific balises for a first localisation would be required. For trains coming from a workshop in a depot, the ICI repeater balises R1 and R2 are available for an initial localisation before entering the CBTC-controlled area. Refer to 2.5.2-4. | |
| 2.5.2-1 | Neighbouring balises shall be located with a spacing not exceeding 450 m. | BN2<br>*Syst.req. |
| COM | The maximum distance prevents the localisation uncertainty to become too large.<br>The CBTC tolerates a location uncertainty of up to +/- 150 m. Relative location uncertainty depends on health status of the odometry sensors and environmental conditions and may worst-case be up to 30 %, which equals +/- 135 m relative uncertainty within 450 m. | |
| 2.5.2-2 | In and near physical platform tracks, sufficient precise balises shall be installed to reduce the localisation uncertainty in order to support correct stopping at the platform's stopping points, to detect the "fully berthed" status, i.e. all doors of the train are located at the platform and, if applicable, support approaching close to a buffer.<br><br>Balises for supporting close approach to a buffer are also required for virtual platforms terminated by a buffer and dedicated for reversal in AM/SM.<br><br>See Figure 2.5-1 Determining required balises at a real platform. | BN2 |

| | | |
|---|---|---|
| COM | The “fully berthed” status at the platform can only be detected if the location uncertainty $d_{uncertainty}$ is limited such that the resulting theoretical overhang $d_{overhang}$ at front and rear end is less than 4.65 m. See Figure 2.5-1 Determining required balises at a real platform. Considering an initial uncertainty of 1.25 m when reading a precise balise and a stopping accuracy of 0.5 m, the relative location uncertainty must be less than 2.9 m. This leads to the following inequality for the distance $d_{baliseFB}$ between balise used for “fully berthed” detection and location of the onboard balise antenna when stopping at the OSP:<br><br>$d_{baliseFB} * f < \min(d_{front};d_{rear}) + 2.9$ m<br><br>f = location uncertainty factor, worst-case is 0.3 (standard value 0.04)<br>$d_{front}$, $d_{rear}$: distance of front/rear end of train to end of platform (negative if outside platform)<br><br>Example: If $d_{front} = d_{rear} = 0$, then $d_{baliseFB} < 9.67$ m. Additionally $d_{baliseFB} > 2.5$ m for reading a balise needs to be considered (2 m for reading the balise and 0.5 m for stopping accuracy).<br>Because of different mounting locations $d_{antenna}$ of the balise antenna, one balise for train consists with leading SA and one for leading SE is required, unless $d_{baliseFB}$ is big enough to cover both. Another 2 balises are required for the other driving direction. | |

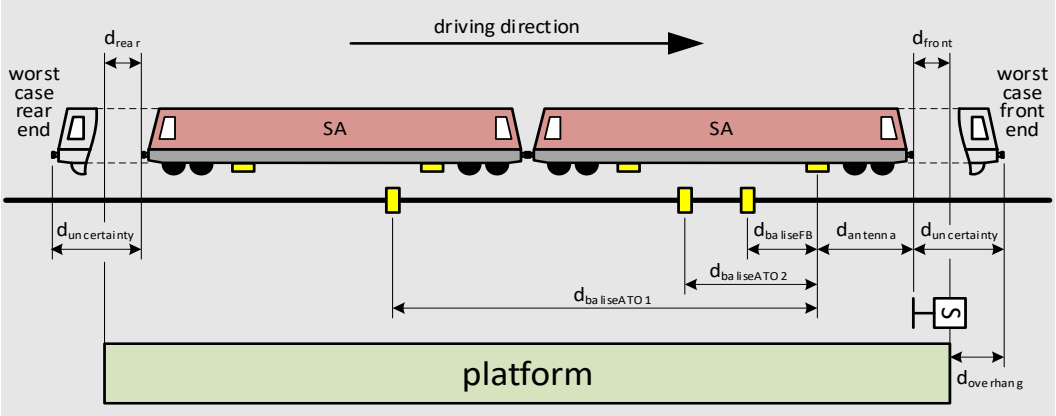



**Figure 2.5-1 Determining required balises at a real platform**

| | | |
|---|---|---|
| COM | For stopping in a terminal station in front of a buffer, only the rear end of the trains needs to be considered for determining $d_{baliseFB}$. At the front end the location uncertainty needs to be limited to provide sufficient distance between the ATO braking curve and the EBIC. A balise is required in a distance of 30 – 41 m (plus $d_{antenna}$) to the stopping marker S.<br><br>This balise is also required in reversal tracks. | |

| | | |
|---|---|---|
| COM | For supporting precise stopping at the OSP in AM, detecting precise balises is required when the train is in a distance of $d_{baliseATO1}$ = 70-120 m and $d_{baliseATO2}$ = 15-40 m to the OSP. For placing the balise $d_{antenna}$ needs to be considered. | |
| 2.5.2-3 | In stabling tracks balises shall have a spacing not exceeding 170 m. | BN2 *Syst.req. |
| COM | The 170 m is a multiple of the SA/SE train length, which provides similar location uncertainties at the stabling locations in a stabling track. It also limits the absolute value of the location uncertainty which determines how close a supervised train in AM or SM can approach to the end of the movement authority. | |
| COM | The reduced localisation uncertainty supports correct stopping at the virtual platforms stopping point(s). | |
| 2.5.2-4 | Where in special situations accurate positioning is required outside real platforms, or where trains regularly need to localise, additional balises shall be located as necessary. | BN2 |
| COM | A train must pass at least two balises to localise. The second one is needed to determine the driving direction. | |

### 2.5.3 Balises for ICI

| | | |
|---|---|---|
| DEF | ICI balises are balises containing ICI data packages and are used for operating ICI-FVs on track without signals.<br>ICI data packages can be either:<br>A1: 1st activation balise<br>A2: 2nd activation balise<br>R1: 1st repeater balise<br>R2: 2nd repeater balise<br>C: clearing balise | |
| COM | A balise can contain up to two ICI data packages. Only ICI data related to different marker boards can be combined in one balise, e.g. for different direction of travel. | |
| COM | Since all balises in areas operated by CBTC trains act as localisation / odometry correction balises, ICI balises do so too. Thus, ICI and localisation functionality can be combined in a balise. | |
| DEF | The indication of the ICI Movement authority is activated by detecting a pair of either A1/A2 or R1/R2 balises. The first balise of the pair has a link to the second balise and by | |

| | | |
|---|---|---|
| | this determines the direction of travel. When the second balise is detected, the indication of the signal aspect starts, and this lasts until the clearing balise (C) is detected. | |
| 2.5.3-1 | Between any A1 balise and the linked A2 balise as well as between any R1 and the linked R2 balise there shall be no other balise. | BN1<br>*Syst.req. |
| COM | If this is not fulfilled the ICI will not determine the ID of the upcoming marker board. | |
| 2.5.3-2 | Between any A2 balise and the related marker board as well as between any R2 balise and the related marker board there shall be no diverging point. | BN1 |
| COM | When activation is completed, the upcoming marker board must be unambiguous. | |
| 2.5.3-3 | Between a marker board as start point of a route and the first A2-balise (or R2, if there is no A2) in the route there shall be a minimum distance corresponding to 2.5 s travel time of ICI-FVs. | BN1 |
| COM | For this time interval the ICI display stays “dark”, i.e. there is no indication of a signal aspect.<br>This equals a minimum “dark distance” of e.g. 48.6 m for 70 km/h and 28.8 m for 40 km/h. | |
| DEF | The following rules apply to any marker board that is designed to provide an ICI movement authority. | |
| 2.5.3-4 | If activation of ICI in approach of a marker board is required by a pair of balises (A1/A2 or R1/R2), balise pairs shall be provided on any possible path towards the marker board. | BN1 |
| COM | Multiple pairs of balises are required in case there is more than one path because of converging points. Figure 2.5-2 gives some examples.<br>There is no functional impact, if a vehicle reads more than one pair of activation balises on its way to the marker board. | |
| 2.5.3-5 | If activation of ICI in approach of a marker board is provided by at least one pair of balises (A1/A2 or R1/R2), there shall be an ICI clearing balise at the marker board. The distance between clearing balise and marker board shall not exceed 0.5 m.<br><br>For examples see Figure 2.5-2 Examples for locations of A1-/A2-balises. | BN1 |

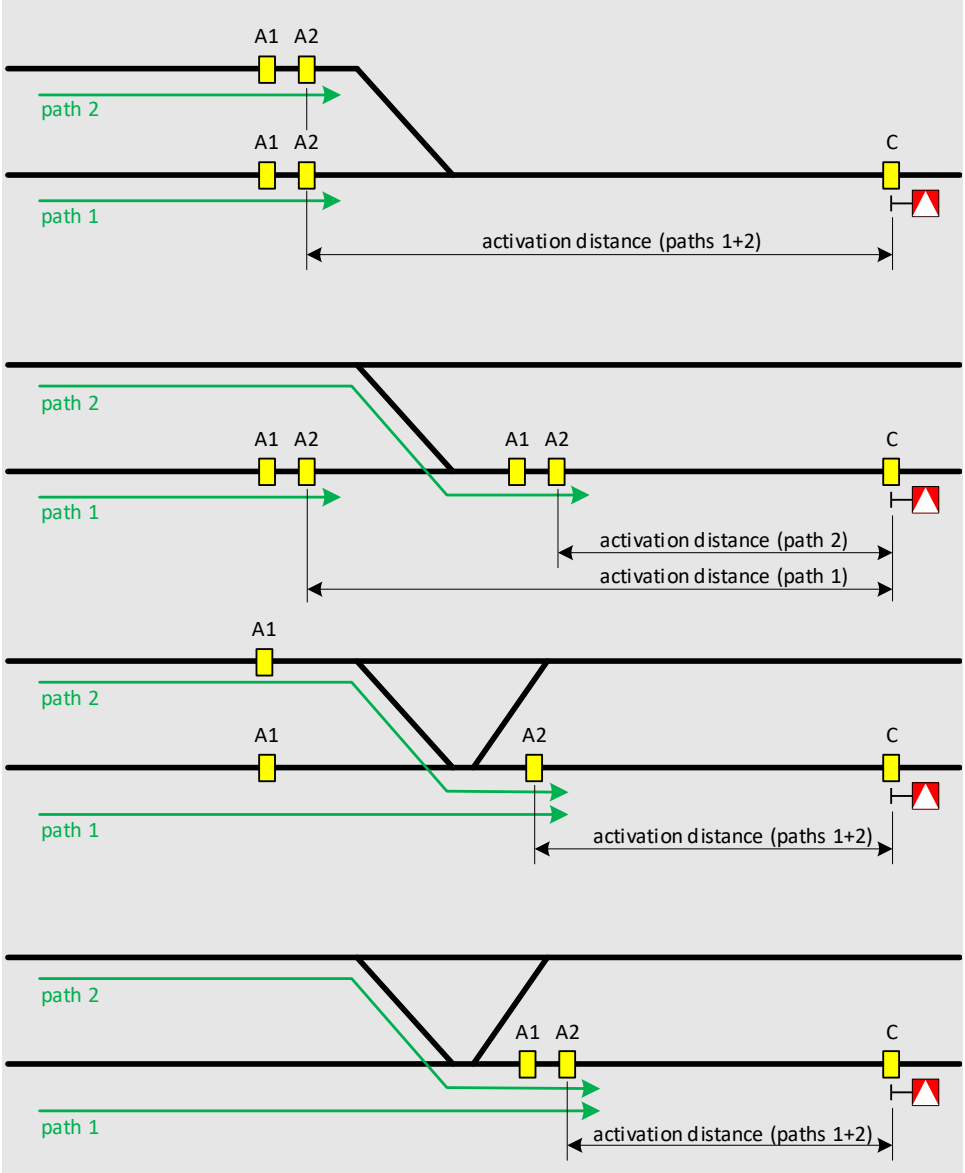



**Figure 2.5-2 Examples for locations of A1-/A2-balises**

| | | |
|---|---|---|
| 2.5.3-6 | For any marker board on track with ICI operation, a pair of repeater balises R1 and R2 shall be provided in front of the marker board.<br>R1 shall not be farther than 150 m and R2 shall not be closer than 19 m to the marker board.<br>In case the marker board is the first marker board when leaving a non-controlled depot, the R2 shall not be closer than 36 m to the marker board. | BN1 |

| | | |
|---|---|---|
| COM | The minimum distance from the R2- to the C-balise of 19 m considers up to 12 m antenna distance to front of train, 5 m stopping distance to the marker board and 2 m balise detection distance. The minimum distance from the R1- to the R2-balise is defined by 2.5.1-4.<br>Outside platform tracks the recommended distance from balise R2 to the C-balise is 20 m, from balise R1 to R2 is 6 m.<br>For marker boards at platform exit, the recommendation is to define two localisation balises installed in the platform track next to the marker board, that fulfil the minimum distances, as R1 and R2. | |
| COM | A shorter distance R2-C may be applied e.g. if at the specific location only short vehicles operate.<br>A longer distance R1-C may be applied e.g. depending on the reversal location at the marker board. | |
| 2.5.3-7 | For any marker board on track with ICI operation that is destination of a route, a pair of activation balises A1 and A2 shall be provided. These must be placed in front of any repeater balises. The activation distance from A2 to the marker board shall correspond to the operational braking distance of vehicles equipped with ICI, but not be longer than 850 m or as limited by constraints for placement of A2 balises. See Figure 2.5-3 Examples and constraints for arrangement of ICI balises. | BN1 |
| COM | For vehicles starting in pocket tracks, where the exit marker board is not an end point of a route, no A1/A2 balise pair is provided, as the start location of the train is not defined.<br>This also applies for start from non-controlled area. | |
| COM | For train moves starting outside the S-bane, e.g. in Fjernbane, the marker board may be an end point of the route and A1/A2-balises may be required to be installed outside the S-bane. | |
| COM | Operational braking distance for ICI-FVs is considered 800 m for a speed of 70 km/h, 300 m for a speed of 40 km/h and 150 m for a speed of 25 km/h. | |
| COM | Constraints for placement of A2-balises are:<br>– a diverging point, see 2.5.3-2.<br>– the minimum “dark distance” according to 2.5.3-3.<br>– mounting restrictions, e.g. at movable elements | |
| COM | The A1-balise may be combined with the C-balise of the marker board at the start of the route. | |

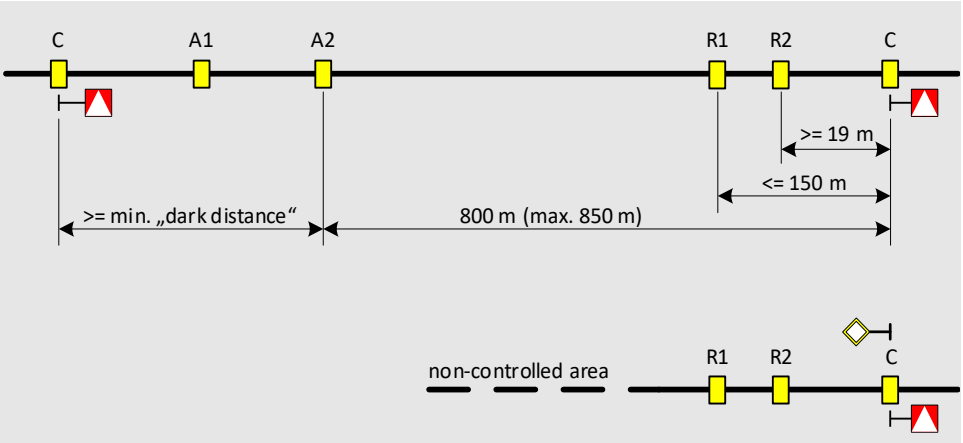



**Figure 2.5-3 Examples and constraints for arrangement of ICI balises**

# 2.6 Crossings

## 2.6.1 Not in use

## 2.6.2 Staff crossings

| | | |
|---|---|---|
| DEF | Staff crossings may be installed independent of permitted speed and number of tracks.<br>They are equipped with signals only where these serve particular protection needs. | |
| DEF | The following rules only apply to staff crossings equipped with staff crossing signals. | |
| DEF | Staff crossing signals are designed according to EN01903R2940 [18]. | |
| 2.6.2-1 | An equipped staff crossing shall have a Staff Warning System consisting of at least 2 signals, one on each side of the track. | BN1 |
| COM | For the purpose of warning the staff one signal on each side is sufficient. | |
| COM | If all signals on one side of the track fail, the CBTC system will not provide a movement authority to pass the staff crossing. To avoid written orders in case of a single signal failure, the CBTC provides two signals on each side and a movement authority is assigned to a train if at least one signal on either side is working. | |
| COM | It is not relevant on which side of the staff crossing (i.e. the walkway) the signal is located. If there is more than one signal, | |

| | | |
|---|---|---|
| | both could be on the same side or on different sides of the staff crossing. | |
| 2.6.2-2 | Where tracks are located close to each other, the staff crossing can span a group of several tracks. The signals shall be located on the outer sides of the tracks, i.e. (at least) one signal on each outer side. See Figure 2.6-1 Staff crossing equipment; examples. | BN1 |

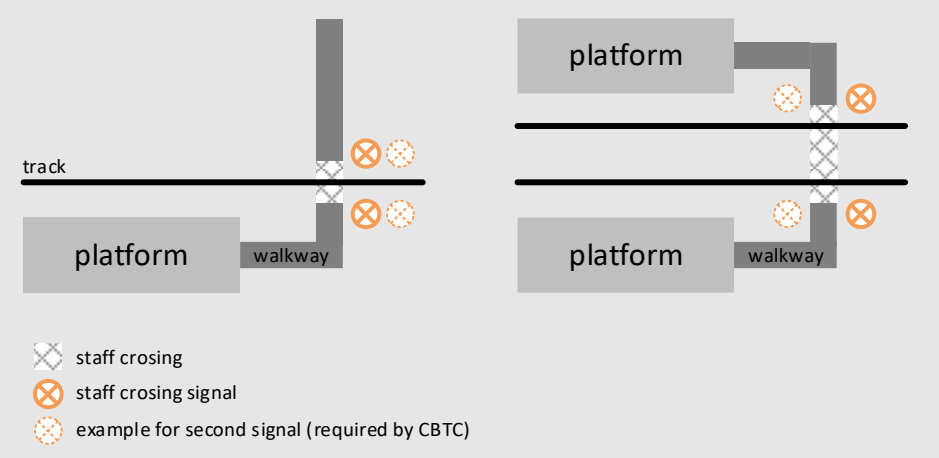



**Figure 2.6-1 Staff crossing equipment; examples**

| | | |
|---|---|---|
| 2.6.2-3 | The delimiting border of the staff crossing's TVS or LTE shall be designed for a distance of at least 5 m and no more than 250 m to the staff crossing. | BN1 |
| COM | A distance of 20 m to the staff crossing is recommended for branchless LTEs, if a minimum length of 50 m remains for the neighbouring section.<br>A not too large distance allows timely deactivation of signals after a train passed the staff crossing. | |
| 2.6.2-4 | Staff crossing signals shall be activated whilst a route is set over the staff crossing, i.e. the route element is locked for the route.<br>For equipped staff crossings spanning a group of tracks, staff crossing signals shall be activated whilst a route is set over the staff crossing on any of the tracks. | BN1 |
| DEF | An overlap is not part of the route and does not activate staff crossing signals. This to prevent unnecessary long activations. | |
| COM | Activated staff crossing signals indicate a risk for crossing the track(s). | |

| | | |
|---|---|---|
| COM | Closely located tracks must be crossed all together. Thus, a risk on any track is a risk for the whole staff crossing. | |
| 2.6.2-5 | Whilst a staff crossing signal is activated it shall show a flashing yellow light with a frequency of 1 cycle per second, split equally into 0.5 s on and 0.5 s off.<br>All staff crossing signals of the same staff warning system shall flash synchronously.<br>Whilst not activated, the staff crossing signal shall be dark. | BN1 |
| 2.6.2-6 | De-activation shall not be possible before the route element is released. | BN1 |
| COM | This means that the train must have passed and cleared the route element. It is not sufficient to just occupy the TVS or to have the preceding TVS cleared, because the train could then still be ahead of the staff crossing.<br>The deactivation condition is configured in the route table. | |
| 2.6.2-7 | In case of a malfunction of a staff crossing, the signal to enter a route over the crossing shall never show a proceed aspect on the main signal level.<br>For CBTC trains the signal may show a “proceed moving block” aspect. | BN1 |
| COM | “Malfunction” means that on at least one side of the track no staff crossing signals is working. | |
| COM | The signalling system allows CBTC trains to approach a malfunctioning staff crossing closely. The train can then pass it with a reduced speed and under restricted supervision. The driver is responsible to cross the staff crossing only when it’s safe.<br>A train not equipped with CBTC has no knowledge of the malfunctioning staff crossing and thus shall not be allowed to obtain a proceed signal aspect. | |
| 2.6.2-8 | In the CBTC TDB a “run authorisation zone” (RAUZ) shall be configured for each track where a staff crossing equipped with staff crossing signals crosses the track. The extent of the RAUZ shall ensure that in case of a malfunction of the staff crossing any movement authority of a train stops in front of the staff crossing. | BN1 |
| COM | Staff crossings have a width of about 2 - 3 m in longitudinal direction of the track. | |

## 2.7 Temporary areas

### 2.7.1 Not in use

### 2.7.2 Possession

| | | |
|---|---|---|
| DEF | Possessions block the track and forbid normal train movement in the possession area. They are used e.g. for maintenance work. | |
| DEF | Possession areas are based on routes. They can be activated and revoked again. | |
| 2.7.2-1 | A possession area shall include the same route elements as the corresponding route.<br>Elements of the overlap and the delimiting elements do not belong to the possession area. | BN1 |
| COM | A possession can consist of several possession areas, each one corresponding to one route. | |
| 2.7.2-2 | Possessions shall be configured for the following tracks, even if there is no corresponding route:<br>- Platform tracks,<br>between the opposing platform exit marker boards<br>- Tracks,<br>From buffer to platform exit marker board<br>These special possessions are called ‘possession only routes’. | BN2 |
| COM | "Possession only routes" allow setting possession areas more narrowly and thus reduce unnecessary and undesired blocking of track. | |
| COM | Figure 2.7-1 Possession areas shows an example of possession areas that can be defined based on routes and special possession only routes. | |

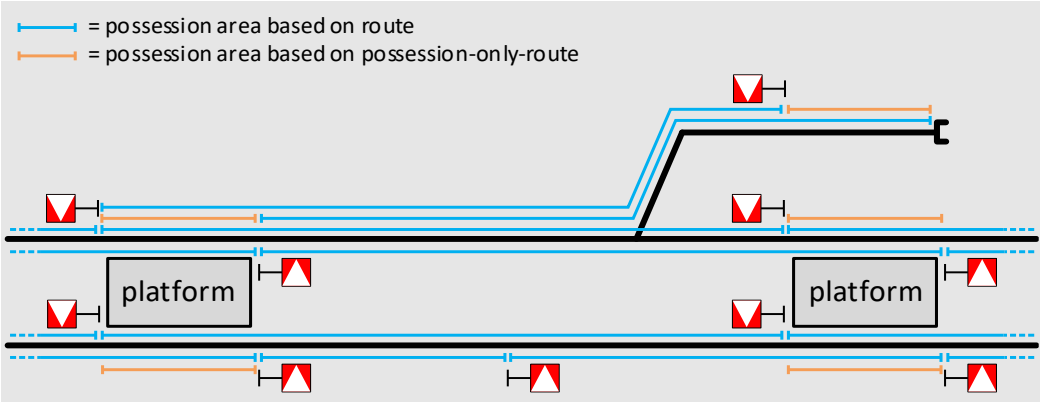



**Figure 2.7-1 Possession areas**

| | | |
|---|---|---|
| DEF | Routes which can be used for possession areas will be customised as ‘possession-capable’.<br>Other routes will not be used for possession areas. | |
| 2.7.2-3 | Only routes delimited by following well visible landmarks shall be customised as ‘possession-capable’. | BN1 |
| COM | The PICOP can identify these well visible landmarks easily, see 2.7.2-7.<br>Without a correct identification, there is a risk of establishing a possession for the wrong part of the track. | |
| 2.7.2-4 | For routes with same start and destination but different route elements (alternative routes), all variants shall be customized as ‘possession-capable’. | BN2 |
| COM | As the overlap is not part of a possession area there is no need to have several ‘possession-capable’ routes differing in their overlap only. | |
| 2.7.2-5 | At least one possession shall be available for all TVSs. | BN1 |
| COM | By relevant is meant that coverage of the track layout shall be complete, and concatenated areas shall be either pre-configured or dynamically selectable. | |
| 2.7.2-6 | At each possession area delimiter, a radio-frequency identification (RFID) tag shall be mounted close to the adjacent possession area.<br>The RFID tag serves as the localization device. | BN1 |
| COM | RFID is the wireless non-contact use of radio-frequency electromagnetic fields to transfer data, for the purposes of identifying objects. | |
| COM | If a delimiter delimits adjacent possession areas in both directions, it shall carry two RFID tags, one for each possession area. | |

| | | |
|---|---|---|
| 2.7.2-7 | RFID tags, including possession area specific data, shall be mounted at the following types of trackside equipment where this equipment delimits a possession area:<br>• Pole carrying marker board or an assisting pole related to the marker board,<br>• Assisting pole related to a Buffer Stop<br>• Buildings on platforms<br><br>If an assisting pole is required for a platform exit marker board, the existing “no access” signs on the platform, valid for same track and direction shall be used as assisting pole, unless this is impractical, in which case a separate assisting pole shall be used.<br><br>See Figure 2.7-2 RFID tag locations and Figure 2.7-3 RFID tags mounted on assisting poles. | BN2 |
| COM | The mounting location for the RFID tags has to be accessible for the PICOP. | |
| 2.7.2-8 | All mounting locations for RFID tags that are not accessible from a platform shall be agreed with a representative of OH&S. | BN2 |

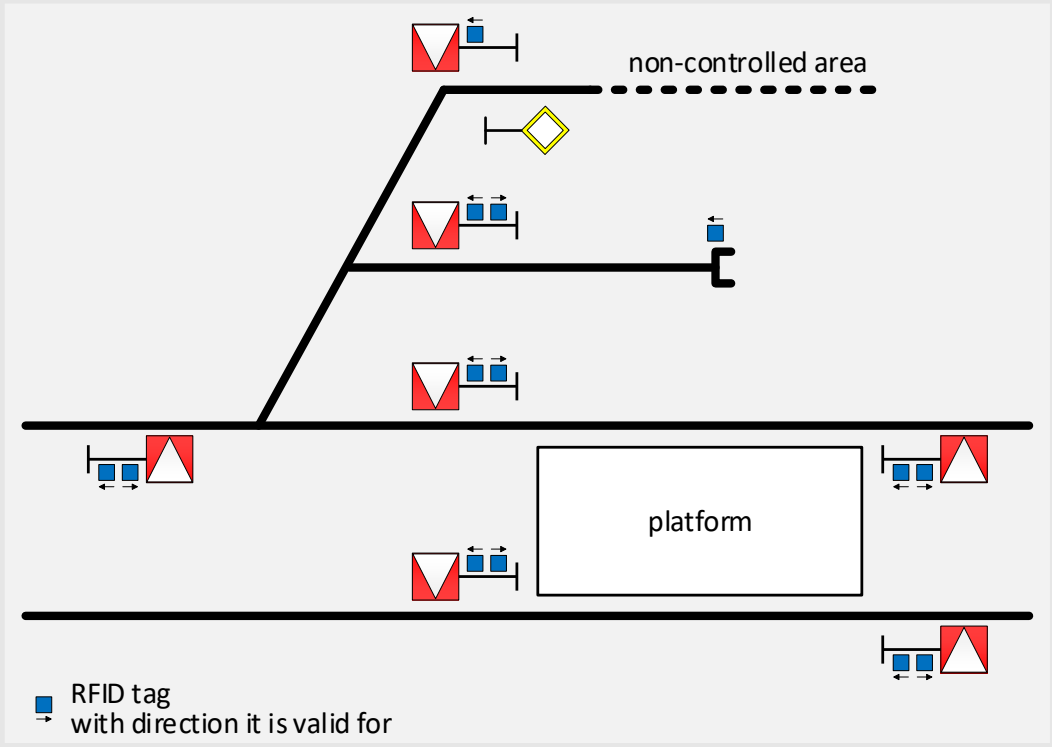



**Figure 2.7-2 RFID tag locations**

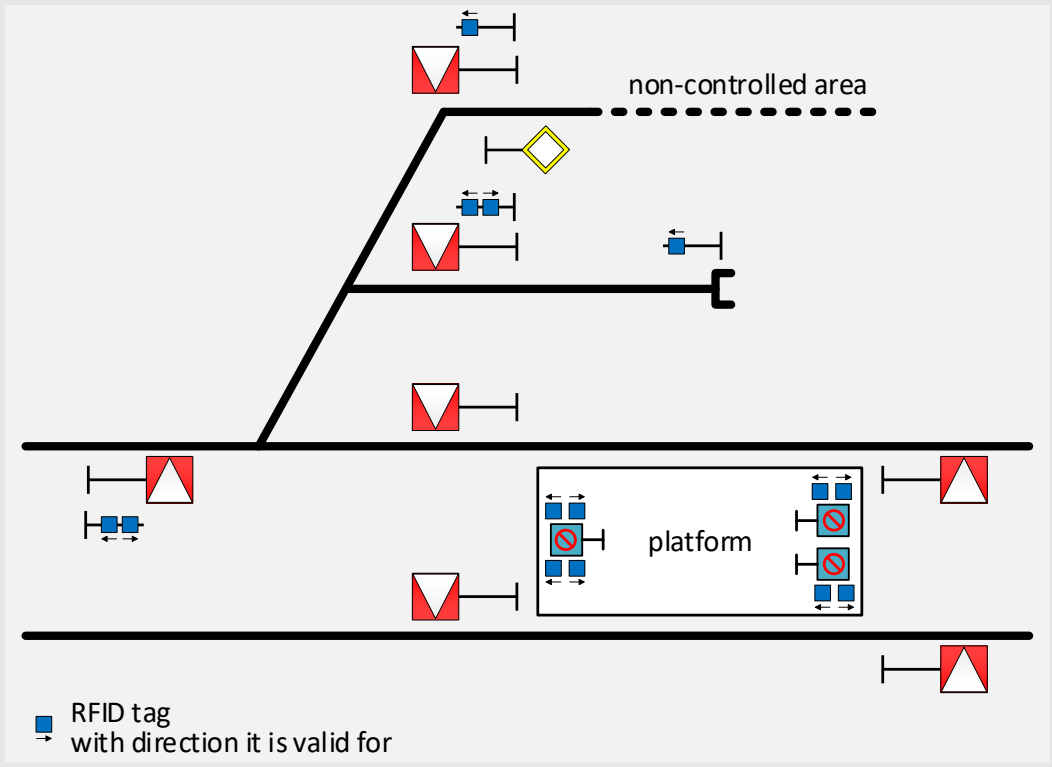



**Figure 2.7-3 RFID tags mounted on assisting poles**

| | | |
|---|---|---|
| 2.7.2-9 | The route book shall show RFID tags (or missing of tags) if one of the following situations is given:<br>• the RFID tag is mounted on an assisting pole,<br>• the RFID tag is mounted on the pole of the marker board, but access to the location must be protected by the signaller,<br>• there is no RFID tag. | BN1 |
| 2.7.2-10 | If a possession is limited by a marker board that is located foul to a point not part of the possession, that point shall be additionally protected by the interlocking as if being part of the possession. | BN1 |
| COM | However, the possession still ends at the marker board. The additionally protected point only prevents conflicting route setting regarding the fouling area. | |

### 2.7.3 Not in use

## 2.8 Adjacent areas

| | | |
|---|---|---|
| DEF | The term “adjacent areas” refers to areas of the railway network not entirely controlled by the S-bane infrastructure system. | |
| DEF | Adjacent areas are areas controlled by the infrastructure system of Fjernbane or Lokaltog, as well as “non-controlled areas”. | |
| DEF | “Non-controlled areas” are railway network areas without any technical system providing movement authorities. | |
| COM | These can be e.g. depot areas. | |
| COM | The specific minimum distance at the border of a non-controlled depot considers that an S-train may need to be localised. The antenna distance to be considered for S-trains is 29 m. | |
| DEF | In most cases, the border between an adjacent area and the S-bane area is not harsh but continuous with both systems overlapping in a border region. | |

### 2.8.1 Fjernbane area

| | | |
|---|---|---|
| DEF | The border between S-bane and Fjernbane is also a border of applicable operational rules. | |
| COM | There are transitions between S-bane and Fjernbane with a non-controlled area in between, e.g. at Østerport track 16. These are not subject of the present section 2.8.1, but section 2.8.3 applies. | |
| 2.8.1-1 | At the border to S-bane from Fjernbane a sign “start of ORS” shall be installed. See Figure 2.8-1 Signage and routes to/from border to Fjernbane. | BN1 |
| COM | For signs from S-bane to Fjernbane apply the rules for that area. | |
| COM | These signs inform the driver of a train about the applicable operational rules. Where an area with different rules starts, only the start of the area to be entered needs to be indicated, but there is no end sign for the area that is left. This contributes to limited space at these locations and reducing the number of signs. | |

| | | |
|---|---|---|
| COM | The appearance of the signs is shown in Figure 2.8-1 Signage and routes to/from border to Fjernbane (with example “SR” as applicable rules on Fjernbane) and appendix 5.3.5. | |

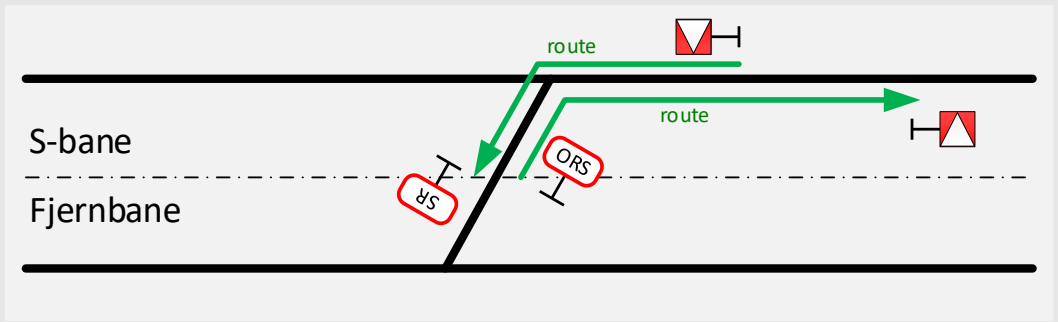



**Figure 2.8-1 Signage and routes to/from border to Fjernbane**

| | | |
|---|---|---|
| DEF | Interlockings of S-bane and Fjernbane together provide routes to pass the border. The border between the two are start and end points of routes, however, it is not intended to mark these with respective boards. | |
| 2.8.1-2 | S-bane shall provide routes that end at the border to Fjernbane. These routes shall not provide an overlap, and no marker board shall indicate the route end point. | BN1 |
| COM | Routes starting or ending at the border are routes which will be logically combined with a preceding or subsequent route on Fjernbane side. Due to this combination, no physical Marker Board at the start or end is required.<br>In the SRTL the start or end of such a route is indicated by a virtual Marker Board. | |
| 2.8.1-3 | A route towards the border to Fjernbane shall only provide a movement authority if the subsequent route on Fjernbane is set and reports that a movement authority is available. | BN1 |
| COM | The movement authority provided by S-bane is then valid up to the end of the Fjernbane route. | |
| 2.8.1-4 | S-bane shall provide routes that start at the border to Fjernbane. These routes shall not have a marker board to indicate the route start point. Movement authority for these routes is not required. | BN1 |
| COM | All other rules regarding routes are valid. | |
| COM | Not providing a movement authority in particular means that no ICI data is provided. The movement authority is given by Fjernbane only, as the route on S-bane is a subsequent route of the Fjernbane route ending at the border. | |

| | | |
|---|---|---|
| 2.8.1-5 | To control issuing of movement authorities at the border between S-bane and Fjernbane, an interface between both interlockings shall be designed which provides and receives data regarding route locking status. | BN1 |

### 2.8.2 Lokaltog area

| | | |
|---|---|---|
| DEF | Interfaces to Lokaltog are only available in Hillerød.<br>See section 3.8. | |

### 2.8.3 Non-controlled area

| | | |
|---|---|---|
| DEF | There are no technical interfaces to non-controlled areas.<br>Movement authority to enter the CBTC-controlled area is given at a marker board.<br>The movement authority towards a non-controlled area ends at the respective sign. Refer to section 2.3.12. | |

## 2.9 Movement authorities and profiles

### 2.9.1 CBTC modes governed by infrastructure and/or driver

List of CBTC modes are described in Table 2.9-1 CBTC modes.

| Abbreviation | Full name explanation |
|---|---|
| FAM | Full automatic mode<br><br>Operation without driver;<br>currently not in use. |
| DTRO | Driverless Train Reversal Operation<br><br>Operation without driver, only for reversal without passengers;<br>currently not in use |
| AM | Automatic mode<br><br>Operation under full supervision of ATP and movement controlled by ATO. |
| SM | Supervised manual mode<br><br>Operation under full supervision of ATP, but movement controlled manually by a driver or a running man. |
| RM | Restricted mode<br><br>Train movement is controlled by a driver or running man. There is no movement authority available, i.e. the driver/running man supervises train movement according to operational rules. ATP only supervises mode specific speed limit of 25 or 40 km/h. |
| CM | Coupling mode<br><br>Similar to RM but supports coupling/decoupling of trains with determining of new train consist. ATP only supervises mode specific speed limit of 25 km/h. |

**Table 2.9-1 CBTC modes**

### 2.9.2 Track dedicated to mode transitions

| | | |
|---|---|---|
| DEF | The signalling-controlled track of S-bane is equipped for operation of S-trains under full ATP supervision, i.e. moving with movement authorities provided by CBTC. | |

| | | |
|---|---|---|
| DEF | Train movements for close stabling of trains and for coupling cannot respect the safety distance between trains. Also, after decoupling there is no safety distance between trains. The CBTC provides a coupling mode (CM) to handle these movements. | |
| COM | The CBTC system restricts the use of CM to platform tracks and stabling tracks. | |
| 2.9.2-1 | Transition from AM or SM to CM shall be offered automatically for stabling tracks if a route into the stabling track is set. | BN2 |
| 2.9.2-2 | CM shall be automatically offered for reversal and/or platform tracks if coupling or decoupling is entered in the timetable or if the signaler has allowed the platform to be shared. | BN2 |
| DEF | In non-controlled depots S-trains are operated in RM. | |
| 2.9.2-3 | At the border from a non-controlled depot to the CBTC-controlled area, balises for localization and an axle counter for sieving shall be installed such that the train is ready to upgrade from RM to SM and get a movement authority while stopping in close distance to the border. | BN1 |
| 2.9.2-4 | At the border from CBTC-controlled area to non-controlled depots it shall be configured whether RM should be offered while moving or not. | BN2 |

### 2.9.3 Static speed profiles

| | | |
|---|---|---|
| DEF | The static speed profile defined in the TDB of the CBTC is always valid for both directions of travel and is applied for the entire length of a train. | |
| DEF | The train always applies the lowest speed for its location. | |
| DEF | The vital speed profile is by definition12 km/h above the operational speed profile. | |
| COM | Unless otherwise stated speeds defined in the present document are operational speeds. | |
| 2.9.3-1 | For all track equipped with CBTC the speed profile shall be configured in the TDB. | BN1 |

| | | |
|---|---|---|
| COM | Additional speed limits for terminal tracks with buffer stops are defined in section 2.4.11 and need also to be considered in the speed profile of the TDB. | |

### 2.9.4 Dynamic speed profiles

| | | |
|---|---|---|
| DEF | Temporary speed restrictions (TSR) are applied when demanded by track conditions, work area protection etc. LTEs as defined in section 2.2.7 are used to define TSR. There is no additional configuration required. | |

### 2.9.5 Not in use

### 2.9.6 Not in use

### 2.9.7 Not in use

# 2.10 Platforms

## 2.10.1 Passenger Platforms

| | | |
|---|---|---|
| DEF | The public area for passengers meant for the following requirements is the part of the platform edge where it is safe to embark / disembark a train and where the passenger doors of a train may open. | |
| 2.10.1-1 | A CBTC public area shall be defined and agreed with the responsible in charge for each passenger platform. | BN1 |
| 2.10.1-2 | If there is a fence or railing limiting access to trains, the end of the public area shall be defined up to 0.5 m inside the fence/railing area. | BN1 |
| COM | This considers that it is very unlikely (only in case of worst-case error in location measurement) that the CBTC will ever release the doors in this area and even if it did, more than 50% of door width is still available while there is no risk of falling down from the other part of the door.<br>See Figure 2.10-1 Public areas of a platform (examples). | |
| COM | The public area is normally defined by a yellow dotted line along the platform edge.<br>Additionally, “do not pass” signs may limit the public area, but such signs may not in all cases relate to the limit of the public platform edge, but to other limitations.<br>Further there may be areas at the end of a platform where the distance between track and platform exceeds the tolerances defined in BN1-49 [28]. These do not count as public area in regard to the CBTC. | |

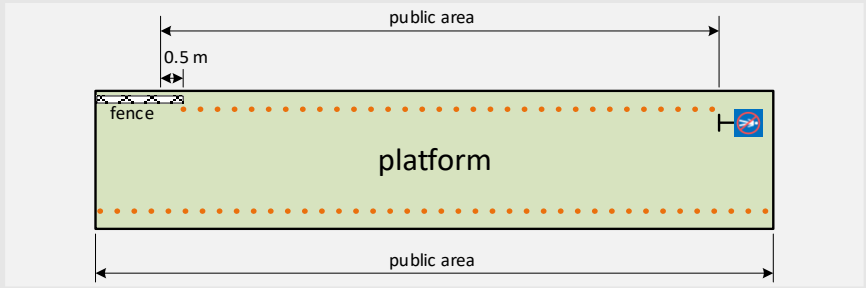



**Figure 2.10-1 Public areas of a platform (examples)**

| | | |
|---|---|---|
| DEF | Platform stopping markers “2”, “4”, “6”, “S” beside the track defines where a train of the respective length is supposed to stop when moving in the direction the marker is facing to. The marker “S” defines the location, where all trains are supposed to stop at the latest. If a specific marker | |

| | | |
|---|---|---|
| | is not present, trains with the respective length stop at the marker with the next higher number. | |
| COM | Locations of the stopping markers mainly consider passenger comfort, but may also consider safety constraints, restrictions of the platform construction and technical restrictions of the CBTC. | |
| DEF | The nominal position of the platform stopping marker is where the front of the related train consist is supposed to stop. | |
| 2.10.1-3 | Nominal positions of platform stopping markers shall be agreed with the signal sighting committee considering passenger comfort, safety constraints and the technical restrictions mentioned in the present section 2.10.1. | BN1 |
| COM | Nominal positions are documented in the SRTL. | |
| 2.10.1-4 | An “S” marker is required for normal running and for left running. | BN1 |
| 2.10.1-5 | Platform stopping markers “2”, “4”, “6” and “S” shall be installed beside the track for all stopping positions defined for a platform. The tolerance is +/- 2 m to the nominal position.<br>If two or more markers could be installed at the same location and the sequence of stopping is not irregular, only the marker for the longest train length need to be installed.<br><br>For left running specific markers may be omitted if agreed by the signal sighting committee for each specific case. | BN2 |
| COM | If there is e.g. a distance of 3 m between the nominal positions of the “4” and the “6” marker, it is an option to install only a “6” marker in the middle between the nominal positions. This fulfils the 2 m tolerance to both nominal locations. | |
| COM | An irregular sequence is given when a shorter train stops closer to the end of the platform than a longer train, e.g. first stops “6” and then “4”. This should be avoided whenever possible. | |
| DEF | Platform stopping markers mounted between two tracks are valid for both tracks. | |
| 2.10.1-6 | The OSP shall be defined such that the end of the last door of the train is at least 2.0 m inside the platform. | BN1 |

| | | |
|---|---|---|
| COM | The CBTC is not able to configure OSP outside the public area of platforms. If it is necessary to place a platform stopping marker outside the public area, CBTC can define an OSP related to the centre or rear end of the train, if the stopping marker is only used for one train length while other trains stop at stopping markers located inside the platform. | |
| COM | In terminal tracks further restrictions for the location of the stopping marker S in relation to the buffer stop apply. Refer to section 2.4.11. | |
| COM | This means that the distance between stopping markers in opposing direction equals the respective train length.<br>For 4th generation of S-trains the distances are 42.58 m (single SE-train), 83.78 m (single SA-train), 126.36 m (coupled SA+SE-train) and 167.56 m (coupled SA+SA-train). Slight differences in length for train consists with two SE-trains instead of an SA-train are taken into account by the CBTC system. | |

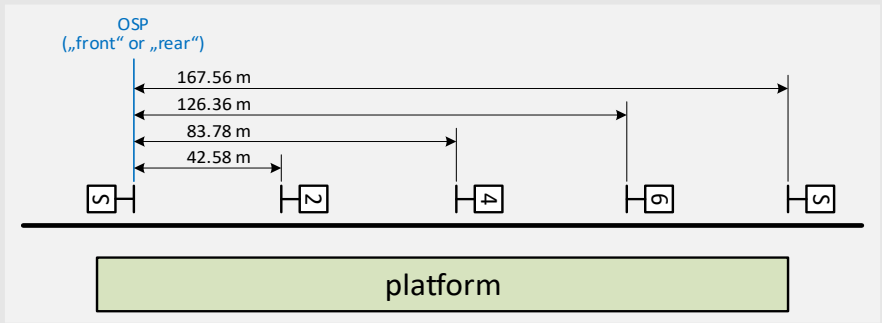



**Figure 2.10-2 Full alignment of stopping markers for a front or rear OSP**

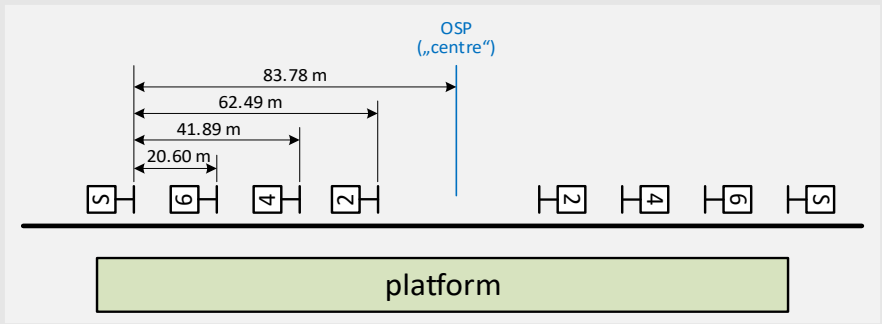



**Figure 2.10-3 Full alignment of stopping markers for a centre OSP**

| | | |
|---|---|---|
| DEF | The CBTC provides three OSP per platform track. At the OSP called “front”, assigned train consists stop with their front end aligned. At the OSP called “centre”, assigned train consists stop with their centre aligned. At the OSP called “rear”, assigned train consists stop with their rear end aligned.<br>As there are four different train lengths, at least two train lengths need to be assigned to the same CBTC OSP. | |

| | | |
|---|---|---|
| COM | "Front" and "rear" are seen in direction of ascending mileage. See Figure 2.10-2 Full alignment of stopping markers for a front or rear OSP and Figure 2.10-3 Full alignment of stopping markers for a centre OSP. | |
| COM | This is e.g. fulfilled if there are not more than three of the four stopping markers "2", "4", "6" and "S" used per direction. If all four markers are used, then for at least two train lengths the stopping trains need to be centre or rear (in direction of travel) aligned. | |
| DEF | At platforms where the driver is not able to oversee all door areas of the train when looking out of the side window, monitors provide pictures of the not visible areas. This is especially applicable for long train consists at convex curved platforms. | |
| 2.10.1-7 | Adjustment of monitors shall be such that best visibility from the platform edge is 1.7 m (+/- 20 cm) in front of the related nominal location of the platform stopping marker. See Figure 2.10-4 Relation of monitors to platform stopping markers. | BN2 |
| COM | The 1.7 m is the distance between the middle of the side window of the driver's cab and the front end of the train. | |

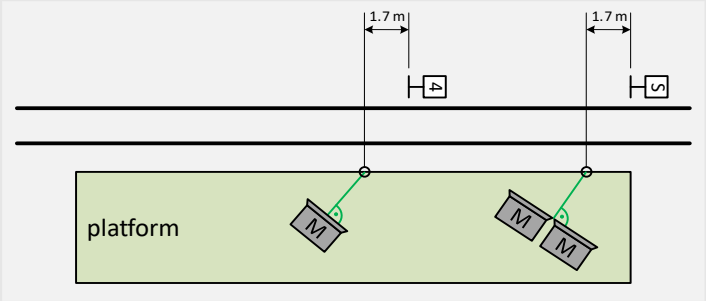



**Figure 2.10-4 Relation of monitors to platform stopping markers**

### 2.10.2 Passenger and Staff Platforms for reversal and stabling

| | | |
|---|---|---|
| 2.10.2-1 | Tracks terminated by a buffer stop shall be configured as either reversal or stabling track. | BN1<br>*Syst.req. |
| 2.10.2-2 | Tracks not ending at buffer stop but having a staff platform shall be configured as either reversal or stabling track. | BN1<br>*Syst.req. |

| | | |
|---|---|---|
| COM | If stabling is needed on a regular basis in reversal tracks, then LTEs are added to support train separation on the TMS. In that case the requirements for reversal will still be used by the system as this supports greater level of automation. | |
| COM | Stabling is used to park multiple trains or used if the usage of CM is needed to fit the whole train within the siding. | |
| 2.10.2-3 | Terminal tracks used for passenger service shall be configured as reversal track. | BN1 |
| COM | This to ensure full automation is available for all passenger operation. | |
| DEF | A virtual platform is defined for all reversal and stabling tracks which is used as start and destination of a timetabled move. | |
| 2.10.2-4 | A stopping marker S shall be placed at least 10m in track ending with a buffer stop. | BN2 |
| 2.10.2-5 | A stopping marker S shall be placed no closer than 6m to a buffer stop in track configured as reversal tracks. | BN1 |
| COM | The purpose of platform stopping markers is to optimize the reversal move, i.e. limit train move to the distance necessary for reversal. | |
| 2.10.2-6 | A stopping marker S shall be placed no closer than 1m from a buffer stop in track configured as stabling track only. | BN1 |
| 2.10.2-7 | All tracks configured as stabling shall be illustrated in the route book as parking tracks. | BN1 |

### 2.10.3 Virtual Platforms for timetabling only

| | | |
|---|---|---|
| DEF | Additional virtual platforms can be defined as logical locations without any platform equipment if needed to support timetabled moves. | |
| COM | A virtual platform for timetabling is often used only for one direction of travel, e.g. in front of diverging or converging points, but may also be used for both directions. | |
| DEF | When applied these virtual platforms are applied to all parallel tracks so the train will pass same number of real and virtual platforms independent of which track is used. | |

## 2.11 Zones and areas

### 2.11.1 Non-stopping zones

| | | |
|---|---|---|
| DEF | Non-stopping zones are implemented to prevent trains moving on moving-block level to stop at a specific section of track with any part of the train. | |
| COM | The major application of a non-stopping zone is to avoid stopping in a catenary switch section. | |
| COM | Catenary switch sections are defined in section 2.3.3. | |
| DEF | Non-stopping zones are a kind of fixed block section for extension of the movement authority. This may affect the design headway especially when located close in front of platforms. | |
| COM | There is a significant effect on the design headway only if the distance between non-stopping zone and start of platform is less than 100 m for a line speed of 120 km/h, 150 m for 100 km/h, 200 m for 80 km/h or 250 m for 60 km/h. | |
| 2.11.1-1 | Catenary switch sections shall be configured in the CBTC as non-stopping zones if bridging of the contact lines by the pantograph of a train is possible. | BN2 |
| COM | For performance reasons it may be desirable to not configure a non-stopping zone for a catenary switch section. This will require a dispensation from 2.11.1-1.<br>In case of not configuring a non-stopping zone it should be either unlikely that trains stop in this area or there should be a deterministic stopping location such that the pantographs of the train are not at a critical position for bridging contact lines. | |

## 2.12 Access points

### 2.12.1 General rules

| | | |
|---|---|---|
| DEF | Access points (APs) provide the radio communication between the wayside and the onboard CBTC system. | |
| DEF | Access points and associated antennas shall be arranged on both sides of the track corridor such that radio communication to trains equipped with CBTC or ICI-FV is provided in the CBTC-controlled area. | |

| | | |
|---|---|---|
| COM | This includes also stabling tracks, but not non-controlled depots. | |
| DEF | For the sake of redundant radio coverage of all tracks, access points are placed at a distance of around 600 m apart. | |
| COM | This distance considers that one AP may fail and, thus, the distance between two working APs is up to 1200 m. | |
| COM | Locations with curved track and stations, bridges, or buildings near the track in general require smaller distances between APs to fulfil this requirement. | |
| COM | In a curved track corridor APs should preferably be placed on the outer side of the curve. | |

### 2.12.2 Specific placement of Access Points

| | | |
|---|---|---|
| DEF | Locations for APs can only be determined by a site survey considering the specific environment. | |
| 2.12.2-1 | The minimum distance from the center line of the track to the front edge of the AP foundation shall be 3,0 m. | BN2 |

## 2.13 Determining track data

### 2.13.1 General

| | | |
|---|---|---|
| DEF | Track data for track with CBTC operation needs to be determined with high accuracy. This data is stored in the CBTC track data base (TDB). The TDB is part of the CBTC wayside Control Units (WCU) and the CBTC Onboard Units (OBCU). | |

### 2.13.2 Length of the track and location of objects

| | | |
|---|---|---|
| DEF | In general, the (longitudinal) location of an object is the location with regard to the centre line of the track. See Figure 2.13-1 Object and reference point locations in regard to centre line of the track.<br>The distance between objects is the distance measured along the centre line. This also applies for the length of a track, as a track starts or ends at specific objects, e.g. switch toe or buffer stop. | |
| DEF | The CBTC uses reference locations to determine locations of all objects.<br>Any switch toe is a reference location.<br>For any physical platform there is one reference location, which is the start/end of platform either on the south or on the north side. The SRTL defines which side is used as reference. | |
| DEF | Depending on the location, either the CBTC or the Banedanmark mileage system is applied. | |
| COM | The CBTC mileage system uses an accuracy of 1 mm. Mileages are given as kk+mmm.xxx, where “kk” are the kilometre, “mmm” are the meter and “xxx” are the millimetre.<br>The Banedanmark mileage system uses an accuracy of 1 m. Mileages are given as kk+mmm.<br><br>BDK mileages can be used where S-trains cannot run. | |

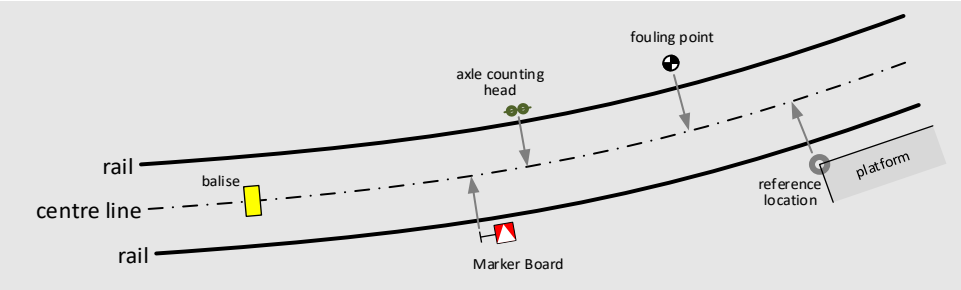



**Figure 2.13-1 Object and reference point locations in regard to centre line of the track**

| | | |
|---|---|---|
| 2.13.2-1 | In the signalling layout the location of an object on or beside the track shall be defined as the location in regard to the centre line of the track. | BN1 |
| 2.13.2-2 | In the signalling layout any distance between any reference location and any object shall be defined along the centre line of the track. | BN1 |

| | | |
|---|---|---|
| 2.13.2-3 | The location of precise balises shall always be determined to the closest platform reference location. See Figure 2.13-2 Reference locations for balises and axle counting heads (examples). | BN2 |

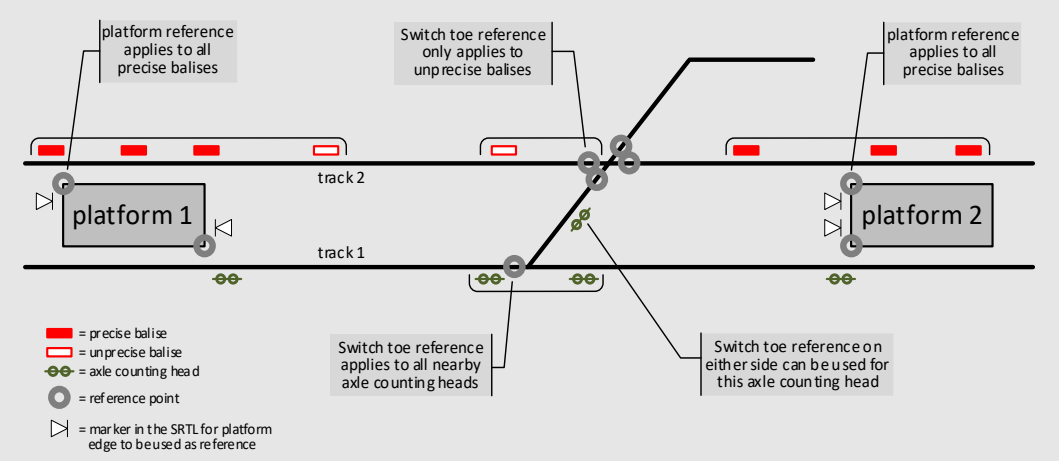



**Figure 2.13-2 Reference locations for balises and axle counting heads (examples)**

### 2.13.3 Altitude and gradient of the track

| | | |
|---|---|---|
| DEF | In general, the altitude of the track is the altitude with regard to the centre line measured at top of rail level of the lowest rail. | |
| COM | Gradient of all track has been measured with specific measurement equipment installed on a train when constructing the CBTC. Altitudes have been calculated from measured gradient data. Both altitudes and gradients are stored in the CBTC TDB.<br>However, this data is not appropriate as a demand for track construction work. | |
| 2.13.3-1 | Banedanmark's gradient and altitude data documented as "Længdeprofil" according to BN1-18 [29] is still valid and measurement of altitudes and gradients shall follow BN1-18 [29] for all track works. | BN1 |
| 2.13.3-2 | Coordinates shall be delivered in KP2000. | BN2 |
| DEF | The CBTC functionality doesn't depend on absolute altitudes, but on altitude differences of locations within any area of up to 1 km length. A tolerance for the altitude difference of 40 cm is provided. It is assumed that this tolerance covers all effects of track works and environmental impact and there is no need for checking altitudes and gradients after track work regarding CBTC | |

| | | |
|---|---|---|
| | tolerances. Only a replanning of the track needs consideration. | |
| 2.13.3-3 | In case the planned data of the ”Længdeprofil” is changed, the TDB data of the CBTC needs to be checked in regard to any required adaptations. | BN1 |

## 2.14 Nordbanen line Jægersborg to Hillerød

### 2.14.1 General

| | | |
|---|---|---|
| DEF | The Signalling System was first deployed on the Nordbanen line between Jægersborg and Hillerød. At that time the Engineering Rules were not present and in particular the conditions for protecting movable elements were not applied as later required. These deviations from current rules have been in general accepted to the extent defined in the following section. | |
| COM | Rules for movable elements are defined in section 2.2.2.<br>The 10 m limit and the 40 m limit for placement of axle counters are not applied for many movable elements of the Nordbanen Line between Jægersborg and Hillerød. Also, some derailer are not separated from the coupled point by an axle counter. | |

### 2.14.2 Exceptions for protection of movable elements

| | | |
|---|---|---|
| COM | Rules for movable elements are defined in section 2.2.2. | |
| 2.14.2-1 | The rules in section 2.2.2 shall apply in areas under reconstruction/track renewal.<br><br>The current deviations can remain as designed in unaffected areas. | BN1 |

### 2.14.3 Exceptions for installing balises

| | | |
|---|---|---|
| 2.14.3-1 | The maximum distance between neighbouring balises of 450 m as defined in 2.5.2-1 does not apply. A distance of up to 650 m can be accepted. | BN2<br>*Syst.req. |

# 3 Rules and constraints for Hillerød station

| | | |
|---|---|---|
| DEF | Hillerød station is part of the CBTC-controlled area. However, as Hillerød is connected to three Lokaltog lines, on some tracks Lokaltog trains operate to stop at or pass Hillerød station. Lokaltog trains are neither equipped with CBTC nor with ICI. | |
| DEF | To support Lokaltog Operation at Hillerød station, the tracks used by Lokaltog are equipped with signals instead of marker boards. This also applies to tracks that are used by both S-trains and Lokaltog trains ("mixed operation"). SODB [1] has been used in the development and safety approval of the existing arrangements.<br>Figure 3-1 Track Layout Hillerød shows the track layout and the usage of tracks and platforms for Hillerød station. | |

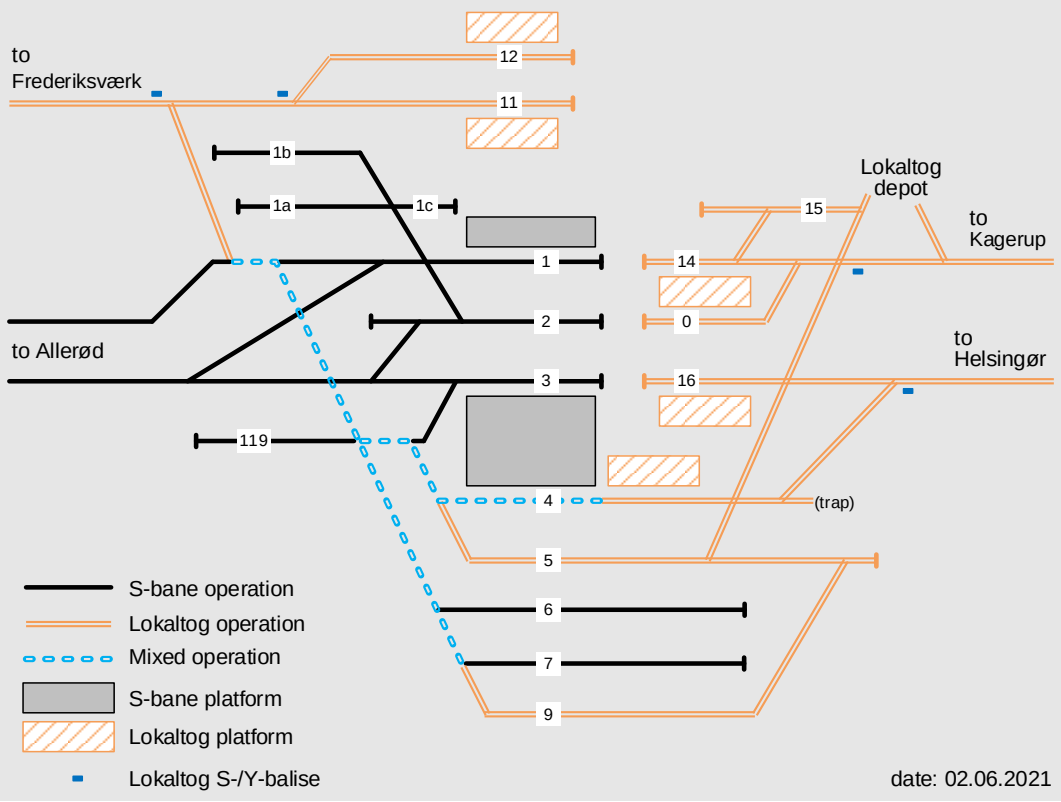



**Figure 3-1 Track Layout Hillerød**

| | | |
|---|---|---|
| 3-1 | If rebuilding track layout, moving/placing new signals on mixed operation or Lokaltog track, SODB [1] shall be followed. | BN1 |

| | | |
|---|---|---|
| 3-2 | If moving a buffer stop or placing a new buffer stop on mixed operation or Lokaltog track, BN1-95 [12] shall be followed. | BN1 |
| COM | The SICAS interlocking is designed according to SODB [1], BN1-95 [12] and TM19 [14] to allow lineside signals in operation.<br>Dispensations are handled according to SODB [1], BN1-95 [12] and TM19 [14]. | |

## 3.1 Movable elements

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.1 apply. | |
| DEF | There are no additional rules for Hillerød station. | |

## 3.2 Train detection

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.2 apply. | |
| DEF | Sub-section 2.2.7 is only applicable for track with S-bane or mixed operation. For other track, track sections and LTEs are equal, as track sections cannot be split in case there is not CBTC equipment. | |
| DEF | There are no additional rules for Hillerød station. | |

## 3.3 Marker boards and signals

### 3.3.1 Appearance of marker boards and signals

| | | |
|---|---|---|
| DEF | For all track used only by S-trains, marker boards are used as defined in section 2.3. | |
| DEF | For track used by Lokaltog or mixed operation signals are used to indicate movement authorities to train drivers. Signals are designed according to KN76500Q01425 [8]. | |
| 3.3.1-1 | For track with Lokaltog operation or mixed operation in Hillerød the following signals shall be used. | BN1 |

| | | |
|---|---|---|
| | Main signals:<br>• PU-signal (platform exit signal)<br>• U-signal (station exit signal)<br>• I-signal (station entry signal)<br>Distant signal:<br>• F-signal (distant signal for I-signal)<br>Shunt signals:<br>• DV-signal (shunting signal) | |
| COM | A PU-signal can also act as a shunt signal. | |
| COM | The appearance of the signals is shown in appendix 5.3.1, 5.3.2 and 5.3.3. | |
| 3.3.1-2 | Every signal shall have a unique name. | BN1 |
| 3.3.1-3 | The name of a PU-, U-, I- or DV-signal shall be defined by<br>• the prefix "S_",<br>• followed by the short name "Hi" of the TOB Hillerød,<br>• followed by a capital letter "A", "B" and so on<br>• optionally followed by a number of up to 3 digits<br>• optionally a lower-case letter "a" and so on. | BN2 |
| COM | It is recommended to use the capital letters starting with "A" at the lowest mileage and following letters according to increasing mileage. For signals with same mileage on parallel tracks it is recommended to use the same capital letter followed by the track number.<br>It is further recommended to use the letter "D" exclusively for DV-signals. | |
| 3.3.1-4 | The name of a F-signal shall be the same as for the related I-signal, but with a lower-case instead of a capital letter. | BN2 |
| COM | In drawings where the element type of the signal is shown by a symbol, the prefix may be omitted. | |

### 3.3.2 Location of marker boards and signals

| | | |
|---|---|---|
| DEF | For all track equipped with marker boards rules defined in section 2.3.2 apply. | |
| DEF | Signals are normally placed on the right side of the track close to the UT envelope. | |
| 3.3.2-1 | The visibility distance for a signal shall fulfil the requirements defined in SODB [1], section 5.3. | BN1 |

| | | |
|---|---|---|
| 3.3.2-2 | The signal sighting committee shall approve location and visibility for each individual case and may decide location to the opposite side of the track where feasible. | BN1 |
| 3.3.2-3 | The distance for a signal (I, U, PU, Dv) to the next axle counting head shall be 1-5 m's. | BN1 |

### 3.3.3 Catenary constraints

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.3.3 apply. | |
| COM | In track for Lokaltog operation only there is no catenary. | |
| DEF | There are no additional rules regarding signals for Hillerød station. | |

### 3.3.4 Route constraints

| | | |
|---|---|---|
| COM | See section 3.4.1 for length, section 3.4.6 for Safety distance and 3.4.7 for locked overlap. | |

### 3.3.5 Not in use

### 3.3.6 Shunting area constraints

| | | |
|---|---|---|
| DEF | Shunt routes are used for all Lokaltog shunt moves on track in the CBTC-controlled area. In normal operation it is not intended to do shunt moves without route. | |
| 3.3.6-1 | Shunt routes shall be provided as defined in SODB [1], section 6.1. | BN1 |

### 3.3.7 Not in use

### 3.3.8 Catenary markers

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.3.8 apply. | |
| COM | In track for Lokaltog operation only there is no catenary. | |
| DEF | There are no additional rules for Hillerød station. | |

### 3.3.9 ICI activation distance markers

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.3.9 apply. | |
| COM | In track for Lokaltog operation only there is no ICI operation. | |
| DEF | There are no additional rules for Hillerød station. | |

### 3.3.10 ICI speed limit markers

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.3.10 apply. | |
| COM | In track for Lokaltog operation only there is no ICI operation. | |
| COM | In Hillerød it needs to be considered that the shunting speed is limited to 20 km/h. | |
| DEF | There are no additional rules for Hillerød station. | |

### 3.3.11 Count-down boards

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.3.11 apply. | |
| COM | For Lokaltog operation count-down boards are only used to indicate the distance to an I-signal. For routes within a station towards a PU- or U-signals count-down boards are not used as the signal locations are known to the drivers. | |
| 3.3.11-1 | Count-down boards are required in front of I-signals. A count-down board with 2 bars shall be installed in 800 m (up to 860 m tolerable) distance and a count-down board with 3 bars at 400 m (up to 460 m tolerable) distance to the marker board, both on the same side of the track. | BN1 |
| COM | For Lokaltog operation there is limited speed because no train control system is present, and hence no 1200 m board is required. | |

### 3.3.12 End of supervised area boards

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.3.12 apply. | |
| DEF | There are no additional rules for Hillerød station. | |

| | | |
|---|---|---|
| | | |

### 3.3.13 Signs at territory borders

| | | |
|---|---|---|
| 3.3.13-1 | At the border to S-bane from Lokaltog a sign “ORS” shall be installed. | BN1 |
| 3.3.13-2 | At the border to Lokaltog from S-bane a sign “SR” shall be installed. | BN1 |

### 3.3.14 Shunt limit boards

| | | |
|---|---|---|
| DEF | Shunt Routes are only defined for Hillerød station. At locations where only reversal is required, e.g. to shunt from one platform track to another, the shunt route can be terminated by a shunt limit board rather than by a signal. | |
| 3.3.14-1 | At locations dedicated only for reversal of shunt moves, a Shunt Limit Board shall be installed to indicate the end of the shunt route. | BN1 |
| COM | The appearance of the Shunt Limit Board is shown in appendix 5.3.5. | |
| 3.3.14-2 | The location of the Shunt Limit Board shall be in a distance beyond the point used for reversal, that allows for reversing of the longest train used in operation. | BN2 |
| 3.3.14-3 | The visibility distance for a shunt limit board shall be at least 35 m. | BN1 |
| COM | It is considered that the maximum speed for approaching the board is 25 km/h. | |
| COM | The signal sighting committee need not to approve the location of a shunt limit board according to SODB [1]. | |

## 3.4 Routes

### 3.4.1 Route start and end

| | | |
|---|---|---|
| 3.4.1-1 | A route shall start at a facing marker board or at a signal. | BN1 |
| COM | In Hillerød Lokaltog trains operate. These trains are neither equipped with CBTC nor with ICI and, hence, signals are | |

| | | |
|---|---|---|
| | required for supervised operation. In the area with mixed operation of S-bane and Lokaltog, signals are also to be observed by S-bane. | |
| 3.4.1-2 | A route shall end at a facing marker board, a signal, a buffer stop, a shunt limit board, or a border to a non-controlled area. | BN1 |
| COM | The rules above apply to routes set for any purpose. | |
| COM | If a marker board or signal is the end of a route, the logical end is at the axle counter following the marker board or signal. | |
| COM | Shunt limit boards are only used in Hillerød. | |
| DEF | For Lokaltog operation there are main routes and shunt routes. | |
| COM | For both types of routes, the relevant supervision levels of the interlocking are “call-on level” and “main signal level”. Call-on level requires the route elements between start and destination signal being claimed and movable elements being locked in the required position for the route. Main signal level additionally requires the configured overlap being set, flank protection provided and all route and overlaps elements being clear. These conditions apply to both main and shunt routes, but for shunt routes there is in general no overlap configured. | |
| DEF | Main routes for Lokaltog can be “exit routes” from a platform track to the station border or “entry routes” from the station border to a platform track. | |
| COM | Tracks 5 and 9 are also engineered as platform tracks even though there are no platforms. | |
| COM | Exit routes technically end at the station border, although this endpoint is not marked by a signal or a sign. This is required to control the adjacent line block. From the rules perspective the exit route is limited by the U-signal. | |
| COM | Entry routes end at the buffer stop or the PU-signal at the end of the destination platform. | |
| COM | The following Figure 3.4-1 Types and examples of main routes at Hillerød provides an overview of all types of main routes including splitting into partial routes as defined below. | |

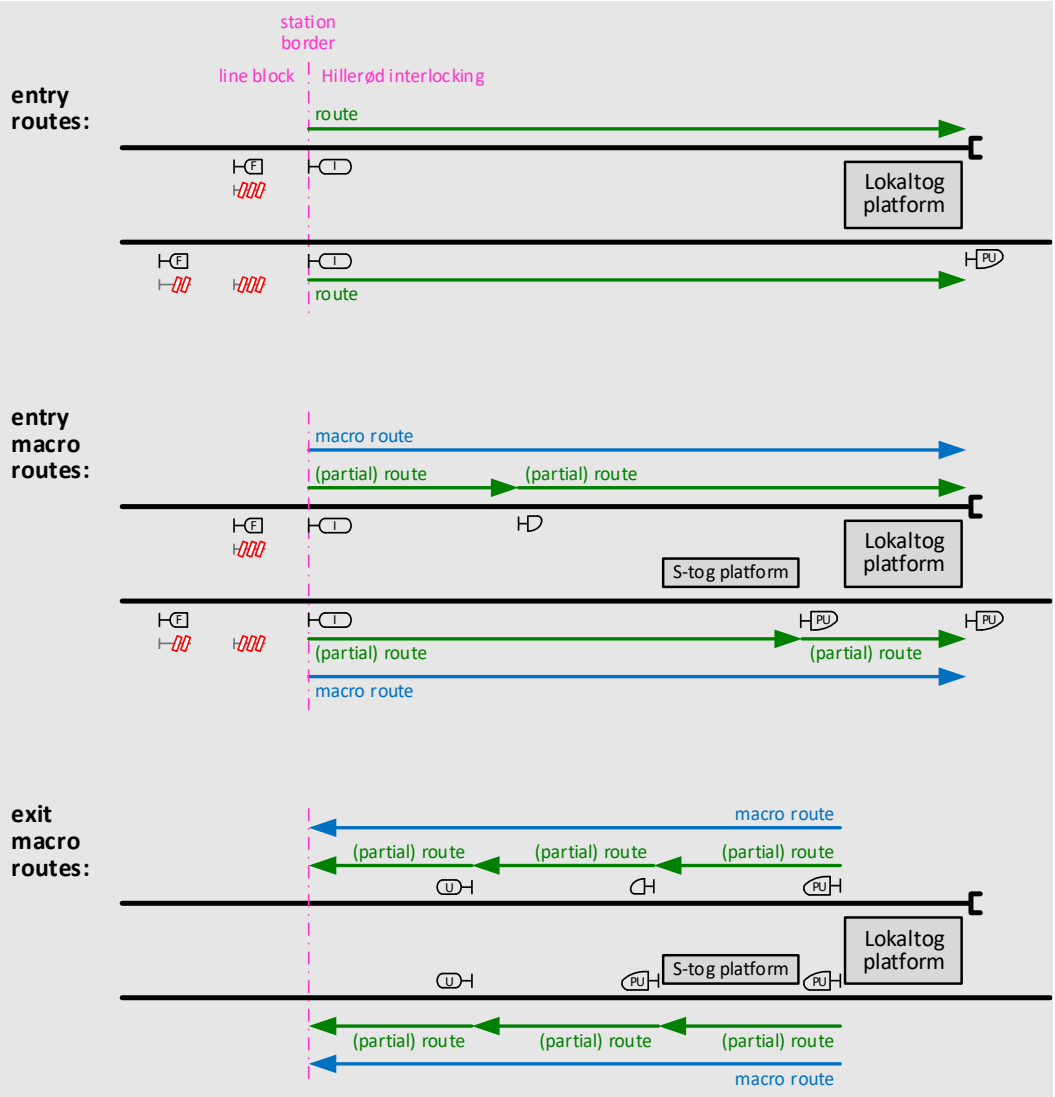



**Figure 3.4-1 Types and examples of main routes at Hillerød**

| | | |
|---|---|---|
| 3.4.1-3 | In Hillerød station, entry routes shall be provided as main route from any station border for Lokaltog to any directly accessible Lokaltog platform. | BN1 |
| 3.4.1-4 | In Hillerød station, exit routes shall be provided as main route from any Lokaltog platform to any directly accessible Lokaltog station border. | BN1 |
| DEF | Although a shunt signal is not an end point of a main route, the interlocking considers any signal as termination of a route. This leads to splitting main routes into “partial routes” delimited by intermediate shunt signals. The combined partial routes of a main route is a “macro route”. | |
| COM | Exit routes and entry routes are split into a combination of subsequent partial routes, forming a macro route, if there are intermediate signals (U, PU or DV) between start and end. | |

| | | |
|---|---|---|
| COM | The combination of the partial routes is implemented by a dependency of the signal aspect of the main signal at the start of the route from the signal aspects of the intermediate shunt signals. The combination needs also to be considered for route cancellation, refer to section 3.4.4. | |
| 3.4.1-5 | For all partial routes of a macro route, the signal aspect shall not indicate a higher signal aspect than the subsequent signal. | BN1 |
| DEF | Shunt routes start at a shunt signal and end at another shunt signal, a buffer stop, a shunt limit board, or a border to a non-controlled area. | |
| COM | A PU-signal can act as a main signal or a shunt signal. | |
| COM | If the destination of a shunt route is a shunt limit board, there may be a U-signal between start and end of the shunt route. This U-signal is not relevant for a shunt route, although it shows a stop aspect. | |

### 3.4.2 Route length

| | | |
|---|---|---|
| DEF | For track used by S-bane and by mixed operation of S-bane and Lokaltog the rules defined in section 2.4.2 apply. The following rules defined for Lokaltog track are additionally valid for track with mixed operation. | |
| 3.4.2-1 | Any route starting at a signal shall have a length of at least the overlap required for the previous route ending at that signal. | BN1 |
| COM | With route is also meant a partial route of a main route in Hillerød station, starting at a main signal, and ending at the next shunt signal. | |
| COM | With route is also meant a route through a line block ending at an I-signal of Hillerød station. | |
| 3.4.2-2 | There is no defined maximum route length. However, the signal separation in a particular track should support traffic capacity requirements in this track. | BN2 |

### 3.4.3 Flank and front protection

| | | |
|---|---|---|
| DEF | For all track at Hillerød the requirements for flank protection defined in section 2.4.3 apply. | |

| | | |
|---|---|---|
| COM | Signals can provide flank protection the same way as marker boards. | |
| 3.4.3-1 | In case a PU-signal is configured to provide flank protection, the signal aspect shall be “stop” (a steady red light) if flank protection is requested by a main route (including all routes for CBTC) or “do not pass” (two white lights placed horizontally) if flank protection is requested by a shunt route. | BN1 |
| 3.4.3-2 | If a PU- or DV-signal is configured to provide flank protection for any route, the signal shall either be located at least 50 m distance to the fouling point of the element requesting flank protection, or the signal shall not be an end point of a route while it provides flank protection. | BN1 |
| COM | Not being available as end point of a route requires to define a route exclusion in the interlocking. | |
| 3.4.3-3 | If a PU- or DV-signal is configured to provide flank protection, but the 50 m distance defined above is not fulfilled, the signal shall be marked in the SRTL and on the signaller’s screen. | BN1 |
| COM | This is usually marked with an “R” or a red line under the identifier. | |
| COM | This marking indicated that there are restrictions for route setting, SODB [1]. | |
| 3.4.3-4 | Front protection for the end of the route shall be provided by claiming an opposing signal or locking a protecting point behind the end of the route in diverging position. This is required only for routes ending at a signal, which is not a shunt signal. | BN1 |
| COM | This is not required in the area of S-train operation, because there all trains are equipped with a train control system. | |
| 3.4.3-5 | Front protection additionally requires that track sections between the protecting element (signal or point) and the end of the route to be protected, are either detected as clear of trains or are locked by another route. | BN1 |

### 3.4.4 Route release time

| | | |
|---|---|---|
| DEF | For routes starting at marker boards the rules defined in section 2.4.4 apply. For all other routes the conditions for emergency release are defined in the following rules. | |
| DEF | For Lokaltog operation a minimum brake rate of 0.6 m/s² is considered. | |
| 3.4.4-1 | For shunt routes the route release time shall be 25 s. | BN1 |
| 3.4.4-2 | For main routes starting at a PU-signal and ending at a destination for Lokaltog operation the route release time shall be 45 s. | BN1 |
| COM | This applies to all partial routes of a main route because these shall release as if it is one route although a train may only approach the first partial route. | |
| 3.4.4-3 | For main routes starting at a PU-signal and ending at a destination for S-bane operation (i.e. a marker board) the route release time shall be 25 s. | BN1 |
| 3.4.4-4 | For main routes starting at an I-signal the route release time shall be at least the sum of<br>- driving time at line speed from the latest visibility location of the F-signal or, if there is no F-signal, the previous main signal, to where the I-signal is visible,<br>- driver reaction time of 3 s,<br>- braking time to standstill, considering a brake rate of 0.6 m/s². | BN1 |
| COM | This applies to all partial routes of a main route because these shall release as if it is one route although a train may only approach the first partial route. | |
| COM | The latest visibility location is 30 m in front of a signal. | |
| DEF | The interlocking system can additionally consider an approach section for route release, which is defined in front of the start signal of the route. If no approach section is configured, the route release time always applies. If an approach section is configured, the route will release immediately, i.e. the release time does not apply, if the approach section is clear when the route is cancelled. | |
| 3.4.4-5 | To optimise route cancellation an approach section for route release may be configured. The approach section shall start at least at the distance in which a train can be expected to be moving during the route release time. | BN1 |

| | | |
|---|---|---|
| COM | At I-signals there is no train detection in front that could be used as approach section. | |

### 3.4.5 Emergency stop areas

| | | |
|---|---|---|
| COM | Rules defined in section 2.4.5 consider both CBTC and non-CBTC operation. Outside the CBTC-controlled area the CBTC functionality to cancel movement authorities is not available. Outside the CBTC-controlled area only setting signals at danger is used to emergency stop trains. | |
| DEF | Rules defined in section 2.4.5 apply with the following exceptions. | |
| 3.4.5-1 | Each marker board or signal shall be assigned to the emergency stop area it is located in. In case it is located at the border of two emergency stop areas, the marker board or signal shall be assigned to the emergency stop area it is facing into. | BN1 |
| 3.4.5-2 | For track at Hillerød only used by Lokaltog, LTEs shall not be assigned to emergency stop areas. | BN1 |
| COM | The assignment of LTEs to emergency stop areas is technically only possible in the area defined in the TDB. | |

### 3.4.6 Safety distance

| | | |
|---|---|---|
| DEF | For operation with CBTC section 2.4.6 applies. For main routes in Hillerød the safety distance at the destination signal is provided by an overlap. Shunt routes do not need a safety distance behind the destination. | |
| DEF | Relevant destination signals of main routes in Hillerød that require a safety distance beyond are I-signals, U-signals and PU-signals. | |
| DEF | The safety distance at a I-, U- or PU-signal is defined as the distance from signal location to the next point of danger beyond the signal. The point of danger could be the end of the safety distance of an opposing signal, the end point (DV-signal or shunt limit board) of an opposing shunt route, the switch toe or fouling point of a point not locked as overlap or a buffer. | |

| | | |
|---|---|---|
| COM | This definition is independent of the specific splitting of the track into track vacancy sections and, thus, also independent of locking of track sections as overlap. | |
| 3.4.6-1 | For I-, U- or PU-signals at Hillerød that are defined as end of a main route, a safety distance beyond the signal shall be required. The length of the safety distance depends on the maximum operational speed according to SODB [1], section 7.2. | BN1 |
| COM | It is assumed that a train will not pass a signal at danger at line speed, but is already braking, because the driver noticed the upcoming signal. This is supported by defining minimum visibility distances for signals and additionally by providing count-down boards for I-signals. The defined lengths of the safety distances correspond to a speed of 30, 40 and 50 km/h at the signal location, considering a brake rate of 0.6 m/s². | |
| 3.4.6-2 | For speeds above 60 km/h the sum of safety distance beyond the signal and visibility distance to the signal shall be at least 450 m. | BN1 |
| COM | This means that a longer safety distance is required if the visibility distance is shorter than the standard. | |
| 3.4.6-3 | At U-signals a reduced safety distance, but not less than 50 m, may be applied if setting the route to the U-signal and setting the route to the opposing I-signal at the same time is technically excluded.<br>For reducing the safety distance at the U-signal it shall be assumed that an opposing train move to the I-signal will only require a safety distance of 50 m beyond the I-signal. | BN1 |
| COM | The reason is that due to the route exclusion an opposing train move towards the I-signal could only be on a signaller authority with a speed limit of 40 km/h if the route is set towards the U-signal.<br>A typical example is that both the line speed to the U-signal and to the I-signal are higher than 60 km/h. At both signals a safety distance of 150 m would apply. The safety distance at the U-signal can be reduced to 50 m. In consequence only 200 m instead of 300 m between both signals are required. | |
| 3.4.6-4 | The safety distance shall be protected such that:<br>- movable elements are locked in a specific position and<br>- it is not possible to use it for another route (including safety distance beyond respective destination) and<br>- that flank protection is provided. | BN1 |

| | | |
|---|---|---|
| COM | This is typically implemented by a locked overlap. | |

### 3.4.7 Locked overlap

| | | |
|---|---|---|
| DEF | For routes terminating at marker boards the rules defined in section 2.4.7 apply. For routes terminating at signals, rules for overlaps are required as defined in the present section. | |
| COM | The safety distance at I-signals is not locked as an overlap, as there is no route terminating at an I-signal. In consequence this means that no movable elements and diamond-crossings are allowed within the safety distance beyond an I-signal. | |
| 3.4.7-1 | For main routes terminating at a PU- or U-signal an overlap shall be configured locking all movable elements and claiming all movable elements and diamond-crossings located within the safety distance required beyond the destination signal. | BN1 |
| COM | All partial routes of a main route except the last one does not have an overlap. | |
| 3.4.7-2 | For points or diamond-crossings locked as overlap, flank protection shall be provided. | BN1 |
| 3.4.7-3 | In case of a diverging point in the overlap, overlaps for both positions of the point shall be provided. | BN2 |
| 3.4.7-4 | The overlap shall release passively, when the track section in front of the destination signal or in case the destination is at a platform any track section at the platform becomes occupied and a respective timer expires. | BN2 |
| COM | The platform may be an S-tog platform for routes starting on S-bane track or a Lokaltog platform for routes starting at Lokaltog track. | |
| COM | Determining the duration of the timer is defined in section 2.4.7. | |
| 3.4.7-5 | The locked overlap may be used for another route if this route is an extension beyond the current destination. | BN2 |

### 3.4.8 Track for joining

| | | |
|---|---|---|
| DEF | For tracks with S-bane operation the rules defined in section 2.4.8 apply. | |
| DEF | For Lokaltog operation main routes or shunting routes may be used for joining, however, for both types a route can only be set if no route element is still claimed by another route yet not completely released. | |
| 3.4.8-1 | For routes terminating at a Lokaltog platform, the passive release of destination track shall be configured for track sections at the platform after the last point. | BN2 |
| COM | In contrast to S-bane tracks, this is also required if a buffer stop is terminating the route, because passive release is required for coupling from same and from opposing direction. | |
| COM | Points cannot be released passively. Hence a route for joining cannot be set if the first train that entered the platform track did not release all points. | |

### 3.4.9 Track for splitting

| | | |
|---|---|---|
| DEF | There is nothing specific to design to use a track for splitting. | |

### 3.4.10 Route set for shunting

| | | |
|---|---|---|
| DEF | Special shunting routes together with shunting signals are provided for Lokaltog operation only in Hillerød. | |
| DEF | Start and end of shunt routes is defined in section 3.4.1. | |

### 3.4.11 Terminal track

| | | |
|---|---|---|
| DEF | For S-bane track all rules defined in section 2.4.11 apply. | |
| DEF | For Lokaltog track only rules 2.4.11-1 and 2.4.11-2 defined in section 2.4.11 apply. | |

### 3.4.12 Not in use

### 3.4.13 Track for reversal

| | | |
|---|---|---|
| DEF | For S-bane track all rules defined in section 2.4.13 apply. | |
| DEF | For Lokaltog track there are no specific rules for track for reversal. | |

## 3.5 Balises

### 3.5.1 General

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.5 apply for S-bane track and track with mixed operation. | |
| DEF | There are special fixed data balises for Lokaltog: S-balises trigger a stop, Y-balises allow the train to speed up to line speed when leaving the station. | |

### 3.5.2 Lokaltog balises

| | | |
|---|---|---|
| 3.5.2-1 | Lokaltog balises shall be installed right of the track in direction of travel. | BN1 |
| COM | Placement of installed balises is described in 47 nr. 4514 [19] and 49 nr. 0568 [20]. | |
| 3.5.2-2 | To support stopping before a buffer stop. S-balises shall be installed according to TM19 [14]. | BN1 |
| 3.5.2-3 | Y-balises shall be installed according to rules for ATP according to BN1-72 [5]. | BN1 |
| COM | Y-balises support speeding up of Lokaltog trains when leaving Hillerød station. | |

## 3.6 Staff Crossings

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.6 apply. | |

## 3.7 Temporary areas

### 3.7.1 Not in use

### 3.7.2 Possession

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.7.2 apply. | |
| 3.7.2-1 | In Hillerød, signals, optionally including assisting poles, shall be used to delimit possessions or to carry RFID tags in the same way as marker boards. | BN2 |

## 3.8 Adjacent areas

### 3.8.1 Not in use

### 3.8.2 Lokaltog / S-bane area

| | | |
|---|---|---|
| DEF | The Lokaltog area of Hillerød station interfaces the block sections to the neighbouring Lokaltog stations. Lineblock equipment of type E80 (towards Slotspavillonen and Brødeskov) and type 91FST (towards Fredensborg) are in use. Routing trains into the lineblock sections and control of the lineblock areas require a technical interface to Lokaltog interlocking. | |
| 3.8.2-1 | Hillerød interlocking shall provide a technical interface to the adjacent Lokaltog lineblock systems. | BN1 |

### 3.8.3 Non-controlled area

| | | |
|---|---|---|
| DEF | Nothing specific as outlined in section 2.8.3. | |

## 3.9 Movement authorities and profiles

| | | |
|---|---|---|
| DEF | For S-bane track and track with mixed operation standard rules as defined in section 2.9 apply. | |
| DEF | There are no specific rules for Lokaltog track. | |

## 3.10 Platforms

| | | |
|---|---|---|
| DEF | At Hillerød there are platforms for S-bane and platforms for Lokaltog, but no shared platforms, i.e. S-trains and Lokaltog do not stop at the same locations. This is also valid for stabling locations and possible intermediate stops for timetabling. | |
| DEF | For platforms used by S-trains the rules defined in section 2.10 apply. | |
| DEF | There are no specific rules for Lokaltog platforms. | |

## 3.11 Zones and areas

| | | |
|---|---|---|
| DEF | For S-bane track and track with mixed operation standard rules as defined in section 2.11 apply. | |
| DEF | Zones and areas are not applicable for track used by Lokaltog only. Lokaltog operates only on routes and movement can only be controlled at the start signal of the route. | |

## 3.12 Access points

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.12 apply for S-bane tracks and tracks with mixed operation. | |
| DEF | There are no access points at track only for Lokaltog operation. | |

## 3.13 Determining track data

| | | |
|---|---|---|
| DEF | Standard rules as defined in section 2.13 apply. | |
| 3.13-1 | For tracks only for Lokaltog operation Banedanmark mileages shall be used. | BN1 |

# 4 References

References can be found in Table 4-1 References. The referred documents shall aways be according to the latest version in force:

| Ref. no. | Ref. ID |
|---|---|
| 1 | SODB Anlægsbestemmelser<br>Sikringsanlæggene og deres betjening |
| 2 | SR (Sikkerhedsreglement af 1975) |
| 3 | BN2-1 Struktur, udseende og udvikling af Banenormer |
| 4 | BN1-154 Sporafstand og frispormærker |
| 5 | BN1-72 ATC-Togstop Anlægsbestemmelser |
| 6 | Naming Conventions<br>PN76500Q01471 |
| 7 | Subsystem Description IL - Component Marker Boards<br>KN76500Q01422 |
| 8 | Subsystem Description IL - Component Signals<br>KN76500Q01425 |
| 9 | Operationelle Regler for S-banen (ORS) |
| 10 | Afstandsmærker, Mærke nr. 17.1.2, 17.1.4, 17.7.1.6 17.2.2, 17.2.4, 17.2.6<br>EN06302R5634 |
| 11 | Rangergrænsemærke, Mærke nr. 17.10<br>EN06401R5594 |
| 12 | BN1-95 Sporstoppere |
| 13 | BN1-166 Fritrumsprofiler (læsseprofil og kinmatiske referencelinjer) |
| 14 | TM19 Supplerende Regler til ATC anlægsbestemmelser i forbindelse med sporstoppere |
| 15 | UNISIG ERTMS/ETCS specification:<br>SUBSET-040 Dimensioning and Engineering Rules, issue 3.4.0 |
| 16 | Gyldighedsmærke (Svensker pil) for hovedsignal Mærke nr. §6 1.1.2<br>KN06202Q04638 |
| 17 | Installationsprocedure – Afsnitsmærker<br>IN 765.00 Q nr. 01534 |
| 18 | Staff Crossing Signal<br>EN01903R2940 |
| 19 | Hele Landet: Oversigt over separat udlagte ATC Y-baliser<br>47 nr. 4514 |
| 20 | Hillerød: Sikring af sporstopper med ATC-balise |

| | |
|---|---|
| | 49 nr. 0568 |
| 21 | Standsignaler, signal nr. 16.22<br>EN04001R5572 |
| 22 | Mærke ORS Starter/Slutter<br>KN76500Q01228 |
| 23 | Mærke SR starter fra Seri-Q-Sign<br>KN76500Q01229 |
| 24 | Platform markers<br>EN6802R5568 |
| 25 | Mærke ICI fra Seri-Q-Sign<br>KN76500Q01225 |
| 26 | Talplader<br>EN04401R5578 |
| 27 | Not in use |
| 28 | BN1-49 Indbyrdes placering af spor og perron |
| 29 | BN1-18 Opmåling af genstande indenfor profilgrænserne |
| 30 | Tavle for tydeliggørelse af sporstopper<br>KN06805Q1590 |
| 31 | Montering af tavle eller reflekser til tydeliggørelse af sporstopper<br>IN06805V2327 |
| 32 | Eftersyn og vedligeholdelse af faste mærker samt tal- og bogstav skilte<br>VN069R5563 |
| 33 | Kilometermærke<br>Blad 6015 |
| 34 | Standsningsmærker. Mærke nr. 17.18-17.24<br>EN06802R5568 |
| 35 | Høje afstandsmærker. Mærke 17.1.1-17.1.6<br>EN06301R5560 |
| 36 | Lave afstandsmærker. Mærke 17.2.1-17.2.6<br>EN06301R5561 |
| 37 | P-spor begynder<br>KN76500Q02109 |
| 38 | P-spor slutter<br>KN76500Q02110 |
| 39 | ECTS L2 mærke 420 X 320 mm<br>KN63212QNR07216 |
| 40 | Installationsprocedure ”Ingen adgang”<br>mærkeIN76500Qnr01540 |
| 41 | Afsnitsmærke 700 X 700 mm |

| | |
|---|---|
| | KN76500Q02317 |
| 42 | Afsnitsmærke 500 X 500 mm<br>KN76500Q02318 |
| 43 | Afsnitsmærke S-bane 500 X 330 mm<br>KN76500Q02319 |
| 44 | ID til Afsnitsmærke S-bane<br>KN76500Q02320 |

**Table 4-1 References**

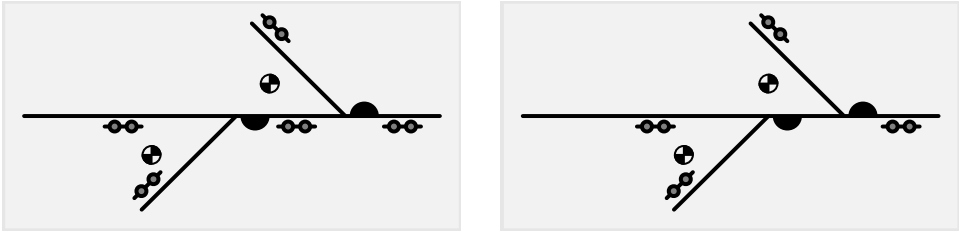
# 5 Appendices

| | | | |
|---|---|---|---|
| DEF | The appendices are intended for reference information that can be updated independently of the Engineering Rules. | | |

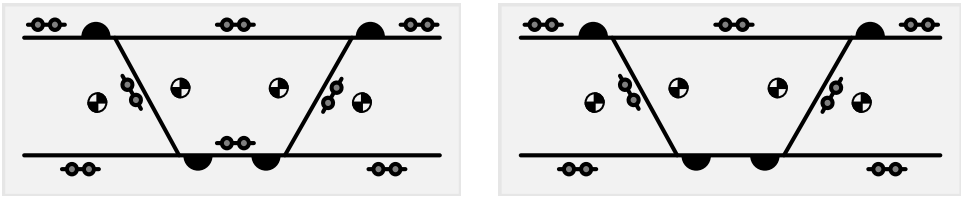
## 5.1 Complex track configuration examples

| | | | |
|---|---|---|---|
| | This appendix provides information on certain track configurations that are found in Banedanmark's infrastructure, and should be manageable by the S-bane Signalling System | | |
| | The TVS's shown are examples of solutions. The examples are not exhaustive.<br>In all examples the picture on the left side shows the preferred solution without common isolation of points and cross-overs, while the picture on the right side shows an optional configuration of axle counters in case of space constraints for mounting the counting heads. The optional configuration may require acceptance by the TSA in charge, if defined in section 2.2. | | |

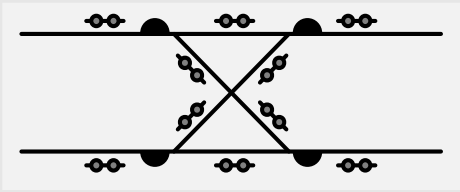
### 5.1.1 Points closely spaced

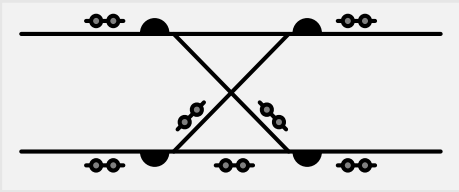


### 5.1.2 Cross-overs closely spaced



### 5.1.3 Scissors cross-over





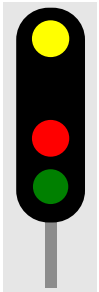
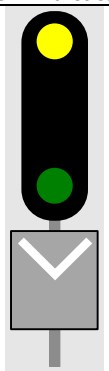
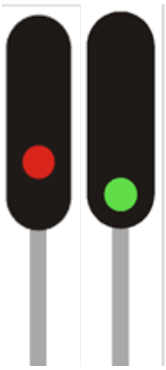
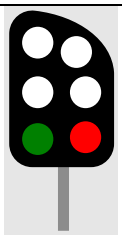
## 5.2 Not in use

## 5.3 Appearance of signals, indicators and boards

| | | | |
|---|---|---|---|
| | This appendix explains “signal aspects” in accordance with ORS [9] definitions and SR 75 [2] (as applicable). | | |

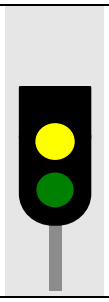
### *5.3.1* Main signals

| | | | |
|---|---|---|---|
| | Only applicable at Hillerød. | | |

| | without indicators | with indicators | |
|---|---|---|---|
| I-signal |  |  | KN76500Q01425 [8] |
| U-signal |  | | KN76500Q01425 [8] |
| PU-signal |  | | KN76500Q01425 [8] |

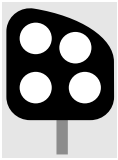
### *5.3.2* Distant signals

| | | | |
|---|---|---|---|
| | Only applicable at Hillerød. | | |

| | | | |
|---|---|---|---|
| F-signal |  | | KN76500Q01425 [8] |

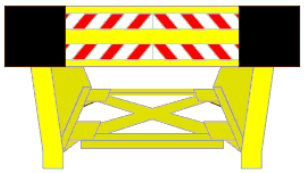
### *5.3.3* Shunting signals (DV-signals)

| | | | |
|---|---|---|---|
| | Only applicable at Hillerød. | | |

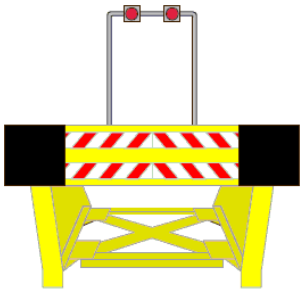
| | | | |
|---|---|---|---|
| DV-signal |  | | KN76500Q01425 [8] |

### 5.3.4 Buffer stops, *ORS [9]*

Without stop lights

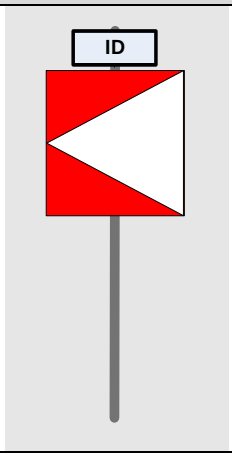
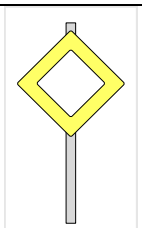
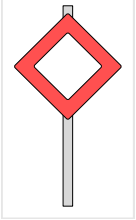
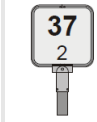


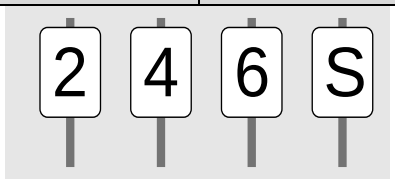
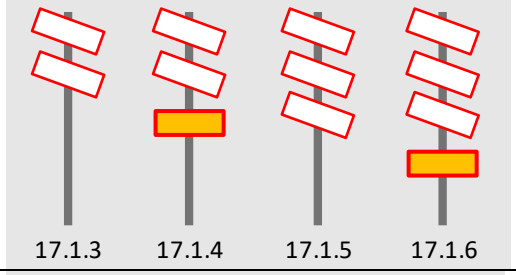
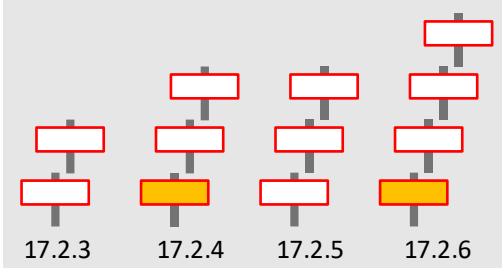
With stop lights



### 5.3.5 Marker boards

In Table 5.3-1 below, where the board/sign is already known to SR75 [2], the SR number is referenced below the board/sign.

| Markers defined by Operational Rules | | | Reference |
|---|---|---|---|
| Marker board |  | | KN76500Q01422 [7]<br>KN76500Q02317 [41]<br>KN76500Q02318 [42]<br>KN76500Q02319 [43] |
| ICI activation distance sign |  | | EN06302R5634 [10]<br>IN765.00Qnr.01534 [17] |
| ICI speed limit marker |  <br>16.2.2 | | EN04401R5578 [26]<br>EN04001R5572 [21] |
| End of supervised area Board |  <br>17.17 | | ORS [9]<br>EN06401R5594 [11] |
| Shunt Limit Board (only in Hillerød) |  <br>17.10 | | SODB [1]<br>SR75 [2] |
| Kilometre (location) marker |  | | ORS [9]<br>Blad 6015 [33] |
| Fouling point marker |  <br>17.14 | | ORS [9] |

| Markers defined by Operational Rules | | | Reference |
|---|---|---|---|
| Platform markers |  17.18 and 17.19 | | EN6802R5568 [24] EN06802R5568 [34] |
| ORS / SR area markers |  |  | KN76500Q01228 [22] KN76500Q01229 [23] |
| ETCS L2 |  | | KN63212QNR07216 [39] |
| ICI area marker |  | | KN76500Q01225 [25] |
| Count-down boards ("tall" design) |  | | ORS [9] EN06301R5560 [35] |
| Count-down boards ("low" design) |  | | ORS [9] EN06301R5561 [36] |
| Depot track markers *(only in København H)* | Start  | End  | KN76500Q02109 [37] KN76500Q02110 [38] |
| "do not pass" sign |  | | IN76500Q01540 [40] |
| Arrow |  | | KN06202Q04638 [16] |

| Markers defined by Operational Rules | | | Reference |
|---|---|---|---|
| ID Marker Board | |  | KN76500Q01422 [7] KN76500Q02320 [44] |

**Table 5.3-1 Boards and signs**

## 5.4 Guidelines for signalling layout design

### 5.4.1 Marker boards, TVS and LTE at platforms

The following Figure 5.4-1 Marker boards, TVS and LTE at platforms shows where to place axle counters and Marker Boards at a platform and how to divide the TVS at the platform into up to four LTE (A, B, C and D). Part a) is the standard configuration for platforms with typical distances. Part b) shows the configuration if there are constraints by a staff crossing or a point located close to the platform and provides minimum distances to be considered. If then the minimum length of 5 m for the LTE at the Marker Board cannot be achieved, because the distance between platform edge and axle counter is less than 8 m, this LTE is combined with the neighbouring one at the platform. In general, the LTEs of a TVS are enumerated from A to Z starting with A at the lowest mileage.

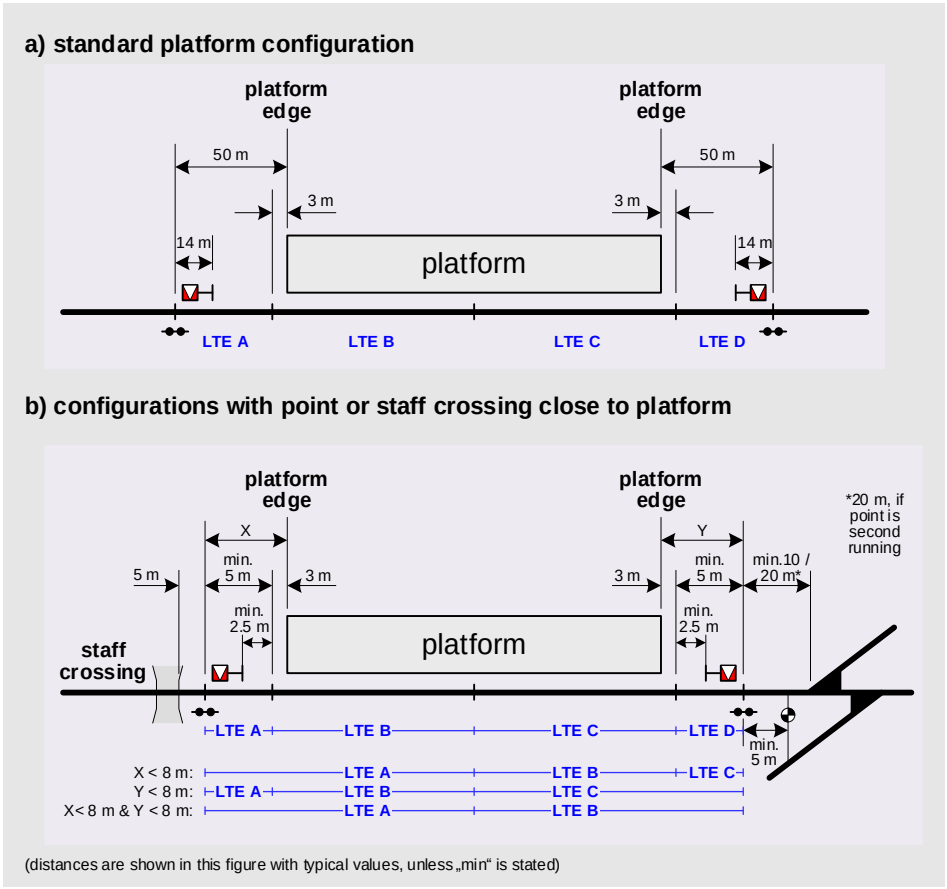



**Figure 5.4-1 Marker boards, TVS and LTE at platforms**

### 5.4.2 Marker boards at station entry

The following Figure 5.4-2 Marker boards at station entry shows the additional Marker Boards with related axle counters at the entry to a TOB station. Marker Boards are required in front of switch toe or fouling point, either on one side of station (A and B or C and D) or on both sides, depending on track layout. As the distance limits between axle counter and switch toe are different from the distance limits between axle counter and fouling point, the Marker Boards (e.g. A and B) are typically not aligned.

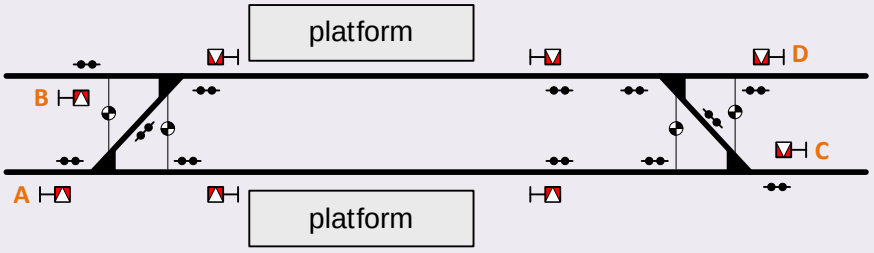



**Figure 5.4-2 Marker boards at station entry**

### 5.4.3 TVS and LTE in sidings

The following Figure 5.4-3 TVS and LTE in sidings shows how sidings are divided into TVS and LTE. The basic length E of an LTE equals the length of an SE-train, which is 42.5 m.

In reversal tracks trains stop when entering with rear end at the OSP, which is the reference for defining LTE. The first LTE shall be longer by UR, which covers the front location uncertainty of up to 5 m assumed in reversal tracks. A train stopping in the reversal track then occupies as many LTE as equal to SE-train lengths.

In stabling tracks, trains are normally stabled from the buffer. The total number T of LTE equals the stabling capacity of the track (train units: SE-train = 1 unit; SA-train = 2 units). The required length L of the stabling track is L > T * E. The last LTE at the buffer shall be longer by US, which covers the rear location uncertainty of up to 15 m assumed in stabling tracks. Additionally, there is a separate TVS 1 at the beginning of the stabling track that indicates, if clear, there is still space for an SA-train. The first LTE of the second TVS (LTE 2A in the figure) may be shorter than E, depending on the total available length L. Its length is L - T*E - X - US.

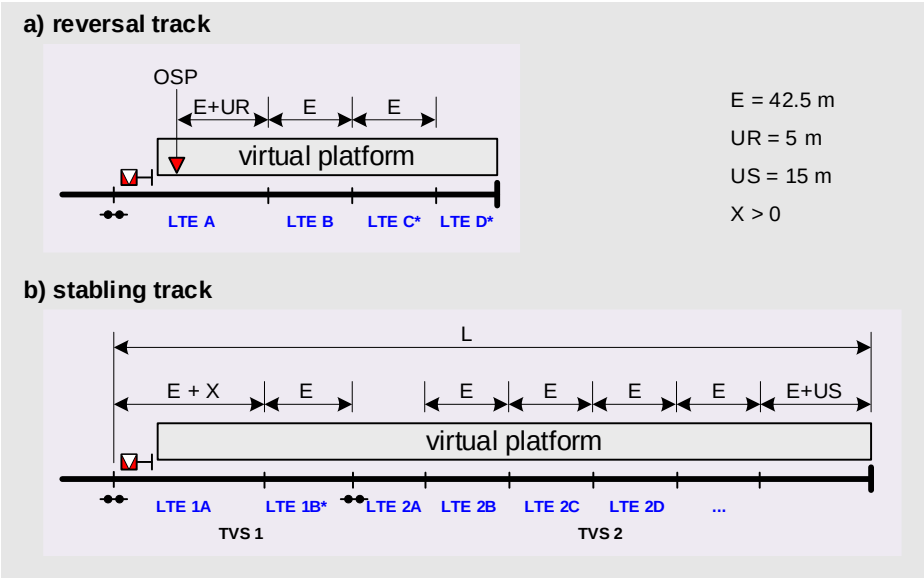



**Figure 5.4-3 TVS and LTE in sidings**

For Ringbanen, the LTEs marked with an * in the figure may not apply, if the design considers an SE-train as the standard train length and an SE+SE-train as the maximum train length.