SRS analysis and functions

Preface

The goal of this memorandum is to summarize the requirements given in the ETCS SRS (starting with subset026, chapter 3), and to define (not yet to describe) detailed functions which shall fulfil the SRS requirements. Therefore the functions shall refer to the SRS requirements, data structures etc.

The structure per item (paragraph or a number of paragraphs in the SRS) is:

- Overview of definitions of information
- Summary of the requirements (shall be exhaustive in the final version)
- List of functions realizing the requirements (with references to the SRS requirements, eventually via the summary of requirements)

Balise linking, Passing direction and balise consistency

Paragraphs subset026 v3.3.0: 3.4 and 3.16.2

Definitions:

- OBU: the train borne equipment realizing the ERTMS functions as specified in the SRS
- RBC: radio block centre: device realizing the infrastructure part of the radio communication between OBU and ERTMS track side installations as specified in the SRS
- Balise: Beacon sending information from the ERTMS track side installations (a Telegram) to the OBU
- Balise Group (BG): Set of maximum 8 beacons whose Telegrams together form one Message
- Internal Number: number of a Balise within a BG
- Duplicated balise: Balise sending the same Telegram as another balise in the same BG. (but will be recognized as different balises because of their Internal Number within the BG
  It is indicated in the Telegram if the Balise is the duplicate of the next or previous one)
- Balise Coordinate System: Passing Direction of the BG and location reference (= balise 1)
- Single Balise group: BG consisting of one Balise or a BG consisting of two duplicate Balises of which one was missed.
- Linked Balise Group: BG which sends information that it is linked
- Announced BG: BG identity and further information (expected orientation, distance,….) of BG's which are not yet detected and whose "window of expectation" has not been passed.
- Window Of Expectation: area (nominal position +/- location accuracy) where an announced BG shall be detected.
- List of announced BG's: registry of announced BG's
- Expected BG: The nearest (first to detect) BG in the List of announced BG's.
- Detected BG: BG from which the message is received by the OBU
- Missed Balise: Balise which is installed trackside, but which was not detected (correctly).
- Relevant BG: BG which is used in linking information, and which is known by the RBC. The identity of the BG can therefore be used in communication between RBC and OBU
- LRBG: The last detected Relevant BG
- Previous LRBG: from the moment a new BG being a Relevant BG is detected the up to that moment LRBG becomes "previous LRBG".
- Infill information: Information for which an announced BG is used as reference location.
- Repositioning information: update of the distance till the end of the current section.

- Expectation window: Area where an announced BG shall be found, taking into account (location accuracy of the BG installation (Q_locacc), the position inaccuracy when reading a BG and the inaccuracy of the odometer).
- on-board over-reading and under-reading amount: odometer accuracy plus location detection (of a BG) accuracy.
- Estimated front end position:
- Maximum safe front end position:
- Minimum safe front end position:
- Minimum safe rear end position: Minimum safe front end position reduced with the train length.
- Safe train length: Estimated front end position reduced with the Minimum safe rear end position.

determining the balise orientation (passing direction)

- Balises in a BG are located in order from one to (maximum) eight in the nominal direction. If a BG is detected the Passing Direction shall be determined from the order in which the Balises are detected (except for single BG's).
- If an announced and linked single BG is detected, the Passing Direction shall be taken from the announced Passing Direction if available, if the information is not available the Passing Direction shall be "not known".
- (level2/3 only:) If the Passing Direction is not known (single BG, not announced) then the OBU shall report the LRBG (being the detected single BG) and previous LRBG (if available) in a position report to the RBC.
  The RBC shall (on reception of such position report) assign a Passing Direction to the single BG and sent it to the OBU.

The directional information is (and shall be reported in the position report as) unknown in the following cases:
- A not announced single BG is detected and the previous LRBG is not known.
- A single BG is detected while the driving direction has changed (once ore more often) since the previous LRBG was detected.

Linking
BG's can be announced by previous BG's. The announcement shall contain the identity of the announced BG, the distance to the announced BG (from the announcing or, in case of radio message, from the reference BG), and the Passing Direction of the announced BG (relevant for single BG's).

The distance is used to be able to convert location related information to a new reference position (LRBG) and to reset the confidence interval for the train position.

The real distance between the BG's is needed for the latter purpose because previously sent information is used with the previous BG as a reference. If the real distance is not available, then the measured distance can be used for converting the location related information, however in that case the inaccuracy of the position cannot be reset.

The (safety) consequence of missing a BG depends on the design of ETCS-track side installations. Therefore the (safe) reaction in case the BG is not detected ("linking reaction") is also specified in the announcement (train trip, service brake or no reaction).

Each Telegram contains the information if the BG is linked. BG's which are not linked might not be known to the RBC. However it can be useful to install a (temporary) BG to impose additional restrictions (f.e. during maintenance or installation work at the track). The information sent by those BG's shall therefore be taken into account. To be able to determine the Passing Direction of an unlinked BG (not announced and not known by the RBC), an unlinked BG shall at least consist of two balises.

In some cases (for example after start up, a change of driving direction,..) the list of announced BG's is empty (in "SRS vocabulary": "no linking is used").

Consistency of information received via balises

Information received from a BG shall be taken into account if the information is valid for the passing direction and:

1. The BG is unlinked and the message is consistent (*).
2. The BG is linked and the BG contains repositioning information and the ID of the expected BG is unknown and the BG is passed in the expected direction (therefore the direction has to determinable from the BG itself) and the message is consistent (*).
3. The BG is linked and "no linking is used" (i.e. the list of announced BG's is empty) and the message is consistent (*).
4. The BG is linked and The BG is found within its expectation window and the BG is passed in the expected direction and the message is consistent (*).
   The window where a repositioning BG can be expected shall cover the whole area, i.e. start from the previous linked BG.

In the latter case (4) the BG will also become the LRBG. Will a BG fulfilling "3" also be used as LRBG???????

(*)   A message is consistent if: all telegrams are received completely without errors (e.g. CRC faults) and no variables with a value "spare" are received and the telegrams belong to the same message (relevant for switchable balises).

A telegram is also assumed to be received completely if it was missed or damaged, but duplicated in a well-received balise and the passing direction can be determined or is not necessary.

If a message from a linked BG (when "linking is used") is not consistent the linking reaction shall be applied (+ in case of train trip or service brake: information to the driver and withdrawal from location based information)

If a message from an unlinked BG or from a linked BG (when "no linking is used") is not consistent the service brake shall be commanded (+ information to the driver and withdrawal from location based information) unless one of the received telegrams contains the information "inhibition of BG message consistency reaction").

If the expected BG (with a known ID) is passed in the direction opposite to the announced direction the train shall be tripped.

If one announced BG is found in rear of the expectation window, not found in the expectation window or the next announced BG is found then the linking reaction shall be executed.

If the expected BG or the next expected BG is detected then the BG following the detected BG shall become the expected BG.

If two consecutive announce BG's are missed the service brake shall be commanded, the driver informed and the MA+trackdescription withdrawn. (3.16.2.7.1.1), i.e. no BG will become the expected BG.

If an announced BG (possibly with ID unknown) containing repositioning information is found twice within the expectation window and before another linked BG is found then the service brake shall be commanded (+ information to the driver and withdrawal from location based information).

Functions:

- Determine the direction in which a received BG was passed.
- Store information concerning announced BG's in a list of announced BG's.
- Check the BG consistency
    - Determine if the information/ which information shall be taken into account based on linking rules

- o   Determine if the message is consistent (complete, without errors, etc.)
- o   Determine if the linking reaction must be executed (plus additional actions)
- o   Determine if the service brake has to be commanded (plus additional actions)
- Execute linking reaction (+……)
- Command service brake (+…..)
- Update announce BG list
- Update expected BG
- Guard if a repositioning BG is found twice within the expectation window.

Location Principles

Paragraphs subset026 v3.3.0: 3.6

Summary of location principles

If a BG is detected, the list of LRBG's (>= 8) shall be updated including the assigned co-ordinate system or "previous LRBG", and the location accuracy. A received BG shall be used as LRBG if (and only if):

- The BG is linked and "no linking is used" (i.e. the list of announced BG's is empty) and the message is consistent (*).
- The BG is linked (and the ID is known in advance?) and The BG is found within its expectation window and the BG is passed in the expected direction and the message is consistent (*).

If a BG is detected which is used as a new LRBG, all location related information stored on-board (ETCS) shall be relocated using the known distance between the "previous LRBG" and the new "LRBG" or (if that information is not available) with the measured distance between those BG's.

If a BG is detected which is used as a new LRBG, the "on-board over-reading and under-reading amount shall be reset to the error in detection of the BG location reference" (which is…?) .

If geographical position information (packet 79) is received the distance from an already passed BG or a BG in advance to the reference location (D_posoff) shall be stored. Whenever a reference location of one of the stored "geographical reference locations" is passed the related track kilometre reference

shall become applicable (replacing the previous one, if any).

The maximum number of reference locations to be stored (in advance) seems not to be specified.

If a radio sent packet 79 refers to a BG, it shall be a BG stored on board, thus a LRBG???, this is however not specified???

On driver request the geographical position shall be calculated and displayed to the driver. The calculation is based on the "estimated front end position" (related to the LRBG), the reference location, the track-km given for the reference location and the counting direction.

Functions:

- Update the list of LRBG's if a BG is detected
- Relocate all location related information stored at the ETCS on-board, if another BG becomes LRBG.
- Reset the confidence interval for the train position if a linked and announced BG is detected.
- Determine geographical position information
    - Update the list of "geographical reference locations" if a packet 79 is received
    - Determine if a new reference becomes applicable
    - Calculate the geographical track km based on the applicable reference location
- Display the "geographical track km" if requested by the driver.

Movement authority

Paragraphs subset026 v3.3.0: 3.7 and 3.8

Definitions:

- Movement authority (MA): Authorisation to run
- End of authority (EOA): location (related to a LRBG) to which the train may move
- Section: part of the distance in rear of the EOA.
- Section time out: The time (T_SECTIONTIMER) between receiving the MA (level2/3: time stamp, level 1: detecting first balise in the BG) and reaching the "section timer stop location", after which the authority to enter the section becomes invalid.
- Section timer stop location: location given by the distance from the entry of the section (D_SECTIONTIMERSTOPLOC) where the section timer is stopped.

- End section: the last section of an MA
- End section time out: The time (T_ENDTIMER) between passing the end section timer start location and the moment the train is assumed to have reached standstill.
  (What's the use of this timer ??????, I don't understand it from 3.8.1.5b)
- End section timer start location: location given by the distance in rear of the end of the end section (D_ENDTIMERSTARTLOC) where the end section timer is started.
- Limit of authority (LOA): an EOA with a target speed different from zero.
- LOA timer: Time (T_LOA) for which the target speed is valid from the moment it is received (level2/3: time stamp, level 1: detecting first balise in the BG).
- Target speed: maximum allowed speed at the EOA.
- Danger Point: ultimate location beyond the EOA which can be reached without risk. The Danger Point is given as a distance beyond the EOA (D_DP).
- Overlap location: ultimate location beyond the EOA which can be reached without risk until the train has stopped. The overlap location is given as a distance beyond the EOA (D_OL).
- Time out for overlap: Time (T_OL) given together with the overlap location, giving the time the overlap is valid after the overlap timer start location has been passed.
- Overlap timer start location: location given by the distance in rear of the overlap location (D_STARTOL) where the overlap timer is started
- Release speed: Speed under which braking curve monitoring is ceased. The speed can be based on given from trackside based on danger point and overlap (V_RELEASEDP and V_RELEASE_OL), can be calculated on-board based on danger point and overlap (D_DP and D_OL) or a national value can be used.
  (There can be two release speeds, one for the DP and one for the OL. Which one shall than be used the highest or the lowest? And what if one is calculated and the other fixed or national value?)
- Signalling related speed restriction (for level 1, V_MAIN): Extra speed restriction valid in case of ETCS level 1.
- Supervised location (SvL): The location which can be reached without risk (i.e. the overlap location; if no overlap is available, then the danger point is the SvL; if no overlap and no danger point are defined, then the EOA is the SvL; if the EOA is a LOA then there is no SvL).
- Infill MA: an MA given by an infill device (loop, balise of infill radio), sent in combination with the ID of the BG from which the MA is applicable.
- Repositioning information: A new value for the remaining length (at the location of the sending BG) of the current section of the MA.

Summary of movement authority

The RBC shall sent (when?, when initializing the connection????) parameters (conditions) for requesting a new MA:

- Cyclic: Time given by T_CYCRQST (or never: special value)
- Before a section time out: T_TIMEOUTRQST (no request: special value)
- Before reaching the indication point: T_MAR (no request: special value)

The ETCS on-board shall store the MA request parameters given above, if packet 57 is received. As long as no packet 57 has been received the default value for the (cyclic) time after which a new MA has to be requested (T_CYCRQST) is defined as a fixed value (A3.1, T_CYCRQSTD) and the other parameters shall indicate "no request".

The ETCS on-board shall request an MA
1. according to the parameters sent by the RBC (or default values),
2. in level 2/3 at the start of mission,
3. in level 1 if the track ahead is free up to a level 2/3 transition location.

If the ETCS on-board receives an MA and the MA can be accepted (i.e. static speed profile and gradient profile are available), then:
1. Existing MA information shall be replaced (for infill only beyond the referred BG)
2. In case of an infill-MA a new section shall start at the location of the referred BG (i.e. if the former section borders do not coincide, the section including the referred BG is split at the location of the referred BG).
3. If the new SvL is in rear of the previous SvL (no SvL is assumed infinite) then the location based information shall be deleted according to A3.4.1.2b.
   {a new MA with LOA has no SvL and can thus never lead to fulfilling this condition (3.8.5.2.4)}

Section timer
Start: The section timer shall start at the moment the message is received (i.e. L2/3: time stamp, L1: first balise).
Stop: The section timer shall stop if the section timer stop location is reached or if a new MA is received.
Ended: If a section time out is superseded before the section timer stop location for the timer is reached the MA shall be shortened to the entry point of the section, and location based information shall be updated according to A3.4.1.2c.
(What is the use?, the train can already be in the section. If the location is chosen well, entering the next section can be prevented….)

End section timer

Start: The end section timer shall start if the end section start location is reached.

Stop: The end section timer shall stop if the end section is no longer the end section (i.e. MA extension) SPECIFICATION NOT FOUND!!.

Update: The end timer time-out value shall be updated if a new MA with the end timer starting location in rear of the maximum safe front end of the train is received, while an end section timer is running.

Ended: If the end section time out is superseded then the MA shall be shortened to the current position of the train (for this specification this is assumed to be the max. safe front end position), and location based information shall be updated according to A3.4.1.2e.

If the end timer information is received while the starting location has already been passed and no end section timer is running, then the system reaction shall be in accordance to the reaction when the timer ends. Remark concerning 3.8.4.1.4: It had been more logical if this requirement had only been valid if the starting location of the timer remains the same.

Limit of authority timer

Start: The LOA timer shall start at the moment the message is received (i.e. L2/3: time stamp, L1: first balise).

Stop: The LOA timer shall stop if the LOA is no longer the EOA (i.e. MA extension) SPECIFICATION NOT FOUND!!!!!

Ended: If the LOA time out is superseded then the target speed shall be set to zero and location based information shall be updated according to A3.4.1.2n.

Overlap timer

Start: The overlap timer shall start if the overlap timer start location is reached.

Stop: The overlap timer shall be stopped if the MA is extended beyond the overlap (SPECIFICATION NOT FOUND!!!!).

Update: The overlap time-out value shall be updated if a new MA with the end timer starting location in rear of the maximum safe front end of the train is received, while an overlap timer is running.

Ended: If the overlap time out is superseded then the SvL shall become the danger point (if any) or the EOA, the target speed (at the EOA) shall be set to zero, and location based information shall be updated according to A3.4.1.2d.

If the train has come to a standstill or if the overlap timer information is received while the starting location has already been passed and no timer is running then the system reaction shall be in accordance to the reaction when the timer ends.

Relocation

In case the exact route is not known prior to a (set of) switch(es) the distance to and the identity of the next main signal BG cannot be given. In those cases a BG sending "repositioning information" (i.e. a new remaining length for the current section) together with the identity of the next BG (linking information) and an updated track description (ONLY FOR THE CURRENT SECTION OR FOR THE COMPLETE MA?, THIS IS NOT CLEAR FROM 3.8.5.3.5.4) is sent by a BG containing repositioning information. This information cannot be given together with an MA, because the MA also gives the length of the first section, which would immediately be overruled. As an infill MA is not giving the length of the first section, it can be combined with repositioning information.

{As the information give, before reaching the BG containing repositioning information, shall be based on the most restrictive route, repositioning can never lead to shortening the MA(3.8.5.2.4)}

The expectation window for a BG containing repositioning information shall always start at the location of the previous linked BG, the end shall be based on the farthest possible BG containing repositioning information.

Co-operative shortening of an MA

In level 2/3 an MA (packet 15) can also be sent as a request to shorten the current MA (message 9).

If (and only if) the point where according to the requested MA an Indication (braking curve monitoring 3.13) shall be given, is not yet passed by the train front end position (NOMINAL?) then the MA shall be accepted and be taken into account and location based information shall be updated according to A3.4.1.2f. The on-board shall inform the RBC about the decision.

Functions:

- Sent MA request parameters (packet 57) { RBC function }
- Store MA request parameters (packet 57) {EVC function}
- Request an MA
    - Build message 132 (8.6.3)
    - (Re)start cyclic timer to trigger MA request
    - Check all section timers and the LOA timer

    {MA requests at start up, if the track description has been deleted and in the transition to level 2/3 shall be triggered from other functions respectively "start of mission", "update location based information", "transition to level2/3".}

- Build and sent an MA {packet 12: BG, packet 15: RBC function}
- Process the MA (normal, infill or request) {EVC function}

- If the MA is requested: calculate the indication location based on the requested MA, decide if the MA is taken into account and inform the RBC.
- Store information concerning sections, end section, signalling related speed restrictions (level 1), danger point, and overlap, related to the LRBG (i.e. infill information related to announced BG beyond the train shall be converted)
- Determine the supervised location (SvL)
- reset and start timers for the EOA and sections using the correct starting time.
- reset the end section timer if the previous end section is no longer the end section.
- Reset the overlap timer if the new EOA location is beyond the previous overlap location.
- Update already running overlap and end section timers with the new time out values.
- Check if the end timer start location has been passed while no end timer is running and if so trigger the withdrawal of the EOA to the current position.
- Check if the overlap timer start location has been passed while no overlap timer is running and if so trigger the withdrawal of the SvL to the EOA or danger point.
- Start timers for the EOA and the sections
- Trigger the update of location based information if the MA was shortened.
- Update the MA if repositioning information is received; i.e. adjust the length of the current section.
- Update the MA (if no new MA was received but a distance has been travelled) {EVC function}
  - Start end section and overlap timers if the start location has been passed (estimate the exact time of passing the location)
  - Stop section timers for sections whose section timer stop location has been passed.
- Process ending timers
  - Update the MA according to the specifications associated with the specific timer
  - *Trigger the update of location based information according to A3.4.2.1.c,d,e and n*