SRS analysis and functions

Content

1. Preface

The goal of this memorandum is to assign requirements to functional blocks and define an architecture for the functional block (define and briefly described detailed functions with their relations). Therefore functional blocks are described:

- Requirements relevant for the realization of the functions grouped in the block with references to the “ERTMS language”.
- References to the input documents (ERA documents, Alstom API, ……..)
- References to input variables.
- Definition of internal and output variables
- List of functions realizing the requirements including a short descriptions

The finalized functional blocks will be imported in proR (requirement management tool). Therefore in proR the structure drawn below will be created:

{figuur met structuur invoegen}

To guarantee that requirements are described clear and unambiguously the following writing rules shall be used:

Functional analysis: Description of functions with references to the SRS requirements.

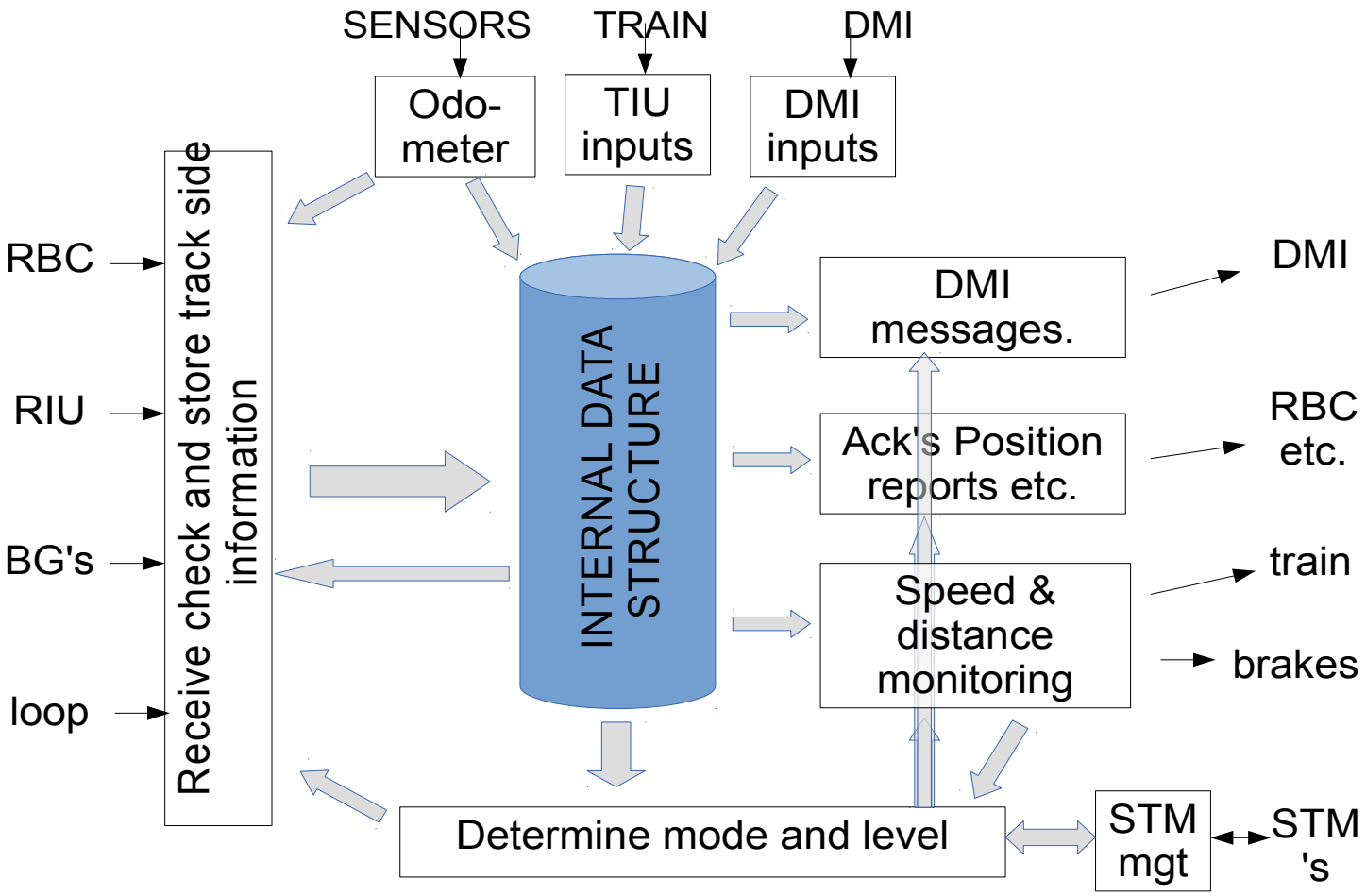
Results per functional block:
function names, plus input, output and a description (abstract of what the function should do) of the relation input and output (with reference to the SRS requirements). Plus (optionally) extra constraints (requirements).

10-10-13 Braunschweig.

- High level and bottom up functional structure.
- Finding parts of the SRS which can be modelled directly
- Evaluating of first version ProR
- Data dictionary (EFS)
- Assigning functions to modelers

2. Functional structure

The functional blocks shall be assigned to the high level architecture (functional structure):



3. 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
- A Telegram: set of data sent by one balise.
- 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.
  ISSUE: IN 3.4.4.1.2/3.4.4.1.2.1 IT IS WRITTEN THAT A BG IS LINKED IF IT IS KNOWN IN ADVANCE. THIS SEEMS TO BE IN CONFLICT WITH LATER USE OF THE INFORMATION, I.E. A BG CAN BE LINKED EVEN IF THE "LIST OF ANNOUNCED BG'S" IS EMPTY (*"NO LINKING IS USED"*)
- 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.
- Expectation window: area where an announced BG shall be detected (inaccuracy of the position of the BG plus inaccuracy of the train localisation) (3.4.4.4.3.2)
- 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).
- 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).

- OBU 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.
- Balise Co-ordinate system: The position reference (i.e. the position of balise number 1 IS THIS N_PIG =0 OR N_PIG =1??????????? THE LATTER WOULD BE DIFFICULT AS A SINGLE BG HAS ONLY ONE BALISE WITH N_PIG =0. HOWEVER 3.4.2.2.1 GIVES THE IMPRESSION N_PIG SHALL BE 1.)
  Further it is assumed number 1 means N_PIG = 0) and the nominal direction (for BG's with more than one balise: the direction in which N_PIG increases, for single BG's: the direction given by linking or by the RBC in relation to the passing direction of the train).
- Passing Direction: The direction in which a train has passed a certain BG (identified by NID_BG and NIC_C): nominal or reverse.
- 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 OBU 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.
- LRBG: The last detected BG to be used as a reference for location and/or profile data.
- Previous LRBG: from the moment a new BG being a Relevant BG is detected the up to that moment LRBG becomes “previous LRBG”.

4. Balise linking, Passing direction and balise consistency

Paragraphs subset026 v3.3.0: 3.4 and 3.16.2

• determining the balise orientation (passing direction)

BG's are used as location references. Further the information sent by BG's might be valid for one direction only. Therefore the direction in which the BG was passed shall be determined. If the BG is used as a location reference the passing direction shall be stored in the “list of LRBG's” (see xxxx).

Requirements:

- 3.4.1.1Balises in a BG are located in order from one to (maximum) eight in the nominal direction. 3.4.1.2 Each balise shall send the relative position inside the BG (internal number: N_PIG, 8.4.2.1), the number of balises (N_TOTAL) in the group and the identity of the group (NID_BG and NID_C). 3.4.2.2.1-2 If a BG is detected the OBU shall determine (and store) the Passing Direction from the order in which the Balises are detected (except for single BG’s).
- 3.4.2.3.2.1-2 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” (until it is received from the RBC).
- 3.4.2.3.3.1.1 / 3.4.2.3.3.6.1 The RBC shall (on reception a position report based on two BG's, i.e. on packet 1) assign a Passing Direction to the single BG and sent it to the OBU (using message 45).
- 3.4.2.3.3.6 If a Passing Direction is received from the RBC (message 45) then the Passing Direction shall be stored for the concerning BG in the “list of LRBG's”. Unless: 3.4.2.3.3.8/3.4.2.3.8.1 the concerning BG is a single BG stored in “list of LRBG's” and it was passed more than once. (see storing LRBG's).

3.4.2.3.2.3 IF A BG WITH “PASSING DIRECTION” UNKNOWN MAY NOT BE USED AS A REFERENCE FOR LINKING DATA AND MAY BE USED FOR LOCATION AND PROFILE DATA, THEN THE LRBG CAN BE DIFFERENT FOR LINKING DATA THAN FOR LOCATION AND PROFILE DATA. IS THIS REALLY THE INTENTION???????????

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.

Functions:

- Determine the passing direction of a BG when it is passed:
    - *see above requirements*
- If information concerning the passing direction of a BG stored in “the list of LRBG's” is received (PACKET ??????????????????) then the passing direction is updated. If the concerned BG is the actual LRBG all location and profile related data stored on board shall be updated.

• Receiving linking information

BG’s can be announced by previous BG’s or by RBC's using packet 5. 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 missed (“linking reaction”) is also specified in the announcement (train trip, service brake or no reaction).

(3.6.1.1, 3.4.4.2.1) Packet 5 contains the following information:

- the identity of the announced BG (NID_BG and NID_C). Might be “unknown, but containing repositioning information” (3.4.4.2.2)
- the distance to the announced BG (from the announcing or, in case of radio message, from the reference BG: D_LINK),
- the Passing Direction of the announced BG (relevant for single BG’s and for consistency checks). (Q_ORIENTATION: nominal or reverse)
- The required reaction from the OBU in case the BG is missed (or not consistent). (3.4.4.2.3: Q_LINKREACTION: train-trip, service brake, none)
- The accuracy of the positioning of the BG (Q_LOCACC)

Variables

A data structure shall be defined to store a “list of announced BG's” (in the order in which they will be passed). Per BG the following information shall be stored:

- The identity of the BG (given by NID_BG and NID_C), might be “unknown but containing repositioning information”
- The distance from the reference location (LRBG) to the announced BG
- The accuracy of the location. (= Q_LOCACC)
- The direction in which the BG will be passed.
- The required reaction if the BG is missed.

If a BG is found or missed it will be deleted from the list. Therefore the rearmost announced BG is the expected BG. The expectation window for the **expected BG** is from (rearmost) the distance from the LRBG minus Q_LOCACC minus L_DOUBTOVER till (furthest) the distance from the LRBG plus Q_LOCACC plus L_DOUBTUNDER. Exception: infill BG's shall be expected from the position of the LRBG.

Requirements:

- New linking information shall replace all stored linking information from the LRBG in case of non-infill information or from the reference location (i.e. next main signal) in case of infill information. (3.7.3.1 m,n).

Functions:

"Store announced BG's": If a packet 5 is received then:

- The "list of announced BG's" will be cleared.
- The distance from the actual LRBG shall be calculated for each of the announced BG's (in case the location reference given in the message is not the same as the actual LRBG).
- The resulting data shall be stored in the "list of announced BG's"

• Check the linking consistency

A balise message is build from balise Telegrams. Each telegram header contains the information if the BG is linked (Q_LINK, 8.4.2.1). If a linked BG is received then it shall be checked against the "list of announced BG's". Exception: when the "list of announced BG is empty", i.e. there is no "expected BG", then the consistency is not checked.

Variables

- A flag indicating if the received BG shall be taken into account according to "linking consistency" (WHAT DOES THIS MEAN??????).
- A flag indicating that the linking reaction shall be executed.

Requirements

- A message received from a BG shall be taken into account = not ignored (i.e. the flag indicating that the information shall be taken into account shall be set), if (one or more of the following conditions are fulfilled):
  - 3.4.4.4.1 The "list of announced BG's" is empty ("no linking is used OBU") **or**
  - 3.4.4.4.2 second part; the BG is marked as unlinked. **or**
  - 3.4.4.4.2 The BG is marked as linked and
    the identity of the BG is equal to the identity of the identity of any of the announced BG's and
    the BG is found within the "expectation window" (3.4.4.4.3) and
    the BG is passed in the expected direction. **or**
  - 3.4.4.4.2.1 The BG is marked as linked and
    the identity of the expected BG is unknown and
    the identity of the detected BG is unknown and
    The passing direction of the BG can be determined (i.e. not a single BG) and
    the BG contains repositioning information valid for the train orientation and
    the BG is passed in the direction indicated for the expected BG and
    the BG is found within the "expectation window" (3.4.4.4.3)

  3.16.2.4.3: negative requirement, fulfilled with the above positive requirements.
- NOT SPECIFIED WHAT TO DO IF NOT ALL BALISES IN A BG SEND THE SAME Q_LINK??: A BG is marked as unlinked if at least one of the balises in the group sends the information "unlinked" (Q_LINK=0, 8.4.2.1).
- ENGINEERING RULE: 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 (3.4.4.3.2, INFRASTRUCTURE ENGINEERING RULE).
  It seems not to be specified what the on-board shall do if an unlinked single BG is detected. Therefore an extra requirement is added to "check message consistency"
- *3.4.4.2.1.1 information; 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").*
- The rearmost announced BG shall be the expected BG.
- 3.4.4.4.3.1; The expectation window (see definitions) shall start at the first possible location according to the position of the expected BG and the accuracy of the given locations (exception: see 3.4.4.4.4). *When checking if the BG is found in the expectation window, also the accuracy of the train position shall be taken into account.*

- 3.4.4.4.4 If the expected BG is announced with “identity unknown and containing reposition information” then the expectation window shall start at the previously passed BG (i.e. in rear of the train).
- 3.16.2.3.1 The linking reaction shall be executed if:
  - A BG is detected with an identity equal to the identity of the expected BG and the current location is in rear of the expectation window **or**
  - The end of the expectation window is reached and no BG with an identity equal to the identity of the expected BG has been detected **or**
  - A BG is detected with an identity different from the identity of the expected BG and the current location is inside the expectation window.
- 3.16.2.3.2 If the expected BG (with a known ID) is passed in the direction opposite to the announced direction the train shall be tripped.
- The expected BG shall be deleted from the “list of announced BG's” if:
  - 3.4.4.4.6.a; The BG detected is the “expected BG” and the BG is found inside the expectation window. **or**
  - 3.4.4.4.6.b; If one (or more) of the conditions for executing the linking reaction is fulfilled.
- 3.4.4.4.6.1; The next expected BG shall be deleted from the “list of announced BG's”, if the next expected BG is detected.
  As this implies a consistency error, according to 3.4.4.4.6.b also the expected BG shall be deleted from the “list of announced BG's”
- 3.16.2.7.1.1 ; If two consecutive (successive) announced BG’s are missed, i.e.
  - the expectation window of the expected and the next expected BG are passed, **or**
  - a further next expected (another announced) BG is found

  then
  - all announced BG's will be deleted from the “list of announced BG's” **and**
  - the OBU shall command the service brake **and**
  - the driver shall be informed **and**
  - at standstill the location based information stored on-board shall be shortened to the current location (A3.4.1.2h)
- 3.16.2.7.2.1 WHAT DOES “KEEP LOOKING FOR” MEAN?????????????????? SHALL THE DETECTED BG STILL BE THE EXPECTED BG???? THIS COULD LEAD TO A LINKING CONSISTENCY ERROR!!!!!!!!!
- 3.16.2.7.2.2 If an announced BG (announced as “ID unknown and 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:

- "check if information received from a BG shall be taken into account according to linking"
  (See above requirements, including trip if the BG is passed in the wrong direction)
- "Check if the linking reaction shall be executed",
  (See above requirements, including the reaction if two consecutive BG's are missed)
- "Update the list of announced BG's if a BG is detected".
- Guard if a repositioning BG is found twice within the expectation window.

• Check the message consistency

A message received from a BG is consistent if:

- 3.16.2.4.1 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 (i.e. have the same value of M_MCOUNT, see below).
- 3.16.2.4.2/3.16.2.4.4.1 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.

In case of switch able balises, the telegrams might be updated while a part of the balises has been detected, but not all. To check if all telegrams belong to the same message, a message counter (M_MCOUNT) is defined in the Telegram header (8.4.2). All telegrams shall have the same message counter otherwise the message is not consistent. (3.16.2.4.5).

To allow fixed balises inside a BG with switch able balises a special value for M_MCOUNT is defined, indicating that the telegram always belongs to the message sent by the BG (3.16.2.4.6). Further a special value for M_MCOUNT is defined, indicating that the telegram never belongs to the message sent by the BG (3.16.2.4.6.1). (WHAT IS THIS GOOD FOR??????????????????)

Requirements

3.16.2.4.1/3.16.2.4.4 /3.16.2.5 If a message from a BG is accepted according to "linking consistency" (see "check the linking consistency") then a message is assumed to be inconsistent if:

- A balise is missed inside the group (1). **or**
- All balises are detected, but one or more telegrams are not decoded (1) **or**
- One or more variables in the BG message have invalid values (i.e. “spare”). **Or**
- The message counters of the different balises inside the BG do not match, i.e. more than one value (different from 255, see 3.16.2.4.6) are found for M_MCOUNT or one of the values of M_MCOUNT in the message is 254 (see 3.16.2.4.6.1).

(1):

3.16.2.4.2./3.16.2.4.4.1/3.16.2.5.1 If the missed balise is duplicated or a balise telegram is not decoded, the message can still be consistent if the balise was duplicated and the duplicated balise is detected and decoded correctly and:

- The BG is linked and the “list of announced BG's” was not empty (i.e. linking was used OBU) **or**
- The BG is unlinked, but the direction can still be evaluated (HOW?? IS IT ALLOWED TO USE PARTLY DECODED INFORMATION FROM A BALISE, THUS ACCEPTING THE BALISE NUMBER, OR IF IT IS DETECTED THAT THE MISSED BALISE CAME BEFORE OR AFTER THE DETECTED AND DECODED BALISE, IS IT THEN ALLOWED TO BASE THE DECISION ON THE VALUE OF N_PIG OF THE DETECTED BALISE ONLY??????????????????????????) **or**
- The BG does not transmit information valid for only one direction **and/or**
- The BG does only transmit data to be used outside the ETCS OBU.

THE ABOVE SEEMS TO BE IN CONFLICT WITH 3.4.2.4.1:
IF AN UNLINKED SINGLE BG IS RECEIVED WHICH IS NOT LINKED (I.E. NO PASSING DIRECTION CAN BE ASSIGNED) IT SHALL NOT BE REJECTED, BUT IF FROM AN UNLINKED BG WITH TWO BG'S DUPLICATING EACHOTHER ONE BALISE IS MISSED THEN THE SERVICE BRAKE SHALL BE APPLIED 3.16.2.4.4.1.
ACCORDING TO 3.4.4.3.2 AN SINGLE BG'S MAY NOT BE UNLINKED. IT IS HOWEVER NOT SPECIFIED WHAT THE ON-BOARD SHALL DO IF AN UNLINKED SINGLE BG IS DETECTED. AS ACCORDING TO 3.4.2.4.1 THE OBU SHALL REACT ON A BG WITH TWO DUPLICATED BALISES OF WHICH ONE IS MISSED THE SAME AS IT REACTS ON A SINGLE BG, THE FOLLOWING SHALL APPLY FOR A SINGLE BG:

- If an unlinked single BG is detected, the OBU shall react as if a balise in an unlinked BG was missed.

3.16.2.4.4/ 3.16.2.5.1 If a message from an unlinked BG or from a linked BG (when the “list of announced BG's is empty) is not consistent and no telegram from the BG contains the information “inhibition of BG message consistency reaction” (i.e. packet 145) then:

- the service brake shall be commanded

- the location based information stored OBU shall be shortened according to A3.4.1.2g,m (reference for unlinked BG's to 2.16.2.4.4.2 and 2.16.2.5.2)
- The driver shall be informed (3.16.2.4.4.3/3.16.2.5.3) about the reason of the intervention (i.e. text message XXXXXXXXX shall be displayed).

3.16.2.4.1/3.16.2.6 If a message from a linked BG is not consistent while the "list of announced BG's" is not empty (i.e. linking is used OBU) then the OBU shall react according to the linking reaction, i.e.:

- if the linking reaction (as stored from Q_LINKREACTION) in the "list of announced BG's" = "train trip" then ??????????????????????????????
- if the linking reaction (as stored from Q_LINKREACTION) in the "list of announced BG's" = "service brake" then
  - the service brake shall be commanded
  - the location based information stored OBU shall be shortened according to A3.4.1.2h (reference for linked BG's to 2.16.2.6.2)
  - The driver shall be informed (3.16.2.4.4.3/3.16.2.5.3) about the reason of the intervention (i.e. text message XXXXXXXXX shall be displayed).

Functions:

- Check the BG message consistency
  - Determine if the information/ which information shall be taken into account based on linking rules
  - Determine if the message is consistent (complete, without errors, etc.)
  - Determine if the linking reaction must be executed (plus additional actions)
  - Determine if the service brake has to be commanded (plus additional actions)
- Execute linking reaction (+……)
- Command service brake (+…..)

• Accept, Reject or Store received information

Subset026, v3.3.0, chapter 4.8,

Not all information received shall be used:

- 3.4.3.2 Information may only be for one direction (Q_DIR)
- The acceptance of information depends on the actual level and mode (4.8)

If information is received which becomes valid only after a level transition or an RBC-RBC handover, certain information shall be stored and evaluated after the transition or handover.

Requirements

- 3.6.2.2.2.3; If the OBU receives a message from an RBC with the LRBG-ID (variable) “unknown” then:
  - The OBU shall accept the message if the OBU has reported an unknown position (LRBG-ID (variable) “unknown in packet 0 or 1) and since than no message with LRBG-ID different from “unknown” has been received.
  - The OBU shall accept the message if the OBU has reported an invalid position (HOW DOES THE OBU KNOW????) and since than no message with LRBG-ID different from “unknown” has been received.
  - In all other cases the message shall be rejected
- xxxxxxxxxx

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

• Receiving “default balise information”

RIU's, loops and (individual, not necessarily the complete group) balises can sent information indicating a fault in the underlying track side equipment. This is done using packet 254.

If the OBU receives a packet 254 then ?????????????????????????????? IT SEEMS THAT IN THE RELATED PARAGRAPHS 3.16.2.4.8-9 ONLY A PART OF THE SPECIFICATION IS GIVEN.

5. Location Principles

Paragraphs subset026 v3.3.0: 3.6

• Updating the list of LRBG's if a new BG is detected

Information related to a single point (“location data”) or position dependant track descriptions (“profiles”: speeds, gradients,....) needs a reference location to be interpretable by the OBU. Every BG can be used as a reference if the location is known in relation to the location and/or position data, i.e. the location and/or position data is transmitted by the BG used as a reference (transmitted via BG's), or a reference BG whose position is known via linking, is given in the same message as the location and/or position data RBC .

For reporting the train position to an RBC a location reference also known to the RBC is needed. Therefore all BG's marked as linked shall be known to the RBC (engineering rule), if a BG is not marked as linked, it shall not be used in position reports to the RBC.

3.6.2.2.2a/3.4.2.3.3.7.1/3.6.1.4/3.6.1.4.1; The BG used as the location reference OBU is called the “last relevant balise group” (LRBG). BG's are used as an LRBG to refer to in position reports to RBC's if (and only if):

- The BG was announced and is marked as “linked” (in the BG message) **or**
- The list of announced BG's was empty (“no linking was used”) at the time the BG was received, and the BG is marked as “linked” (in case of a single BG, this BG is now awaiting the “passing direction”: 3.4.2.3.3.7.1).

THIS MEANS THAT BG'S WHICH SENT LOCATION OR PROFILE DATA BUT ARE NOT MARKED AS LINKED CAN BE USED AS LOCATION REFERENCE OBU, BUT NOT AS THE LRBG (FOR THE COMMUNICATION TO THE RBC) !!!!!!!!!!!!. IF A LRBG (LINKED) IS AVAILABLE THEN LOCATION AND PROFILE DATA SENT BY AN UNLINKED BG SHALL BE “RELOCATED” TO THE LRBG (BASED ON THE MEASURED DISTANCE). IF NOT THE UNLINKED BG MAY BE USED AS A LOCATION REFERENCE, AND SHALL BE STORED LIKE A LRBG, BUT MARKED AS “NOT TO BE USED IN POSITION REPORTS TO THE RBC. SUCH A LOCATION REFERENCE SHALL BE FORGOTTEN AS SOON AS A NEW RECEIVED BG BECOMES LRBG (AS IT CAN NOT BE REFERED TO BY THE RBC).

SO IN ADDITION TO THE CONDITIONS FOR A BG TO BECOME AN LRBG FOR THE COMMUNICATION TO

THE RBC A BG SHALL ALSO BE STORED AS AN LRBG (BUT NOT TO BE USED IN POSITION REPORTS TO THE RBC) IF:

- The BG does not fulfil the above conditions but
  - transmits location and/or profile data, and
  - there are no other LRBG's fulfilling the above requirements stored in the “list of announced BG's”

IT WAS NOT FOUND WHAT THE OBU SHALL DO IF NO LOCATION REFERENCE (OR A LRBG NOT REMEMBERED BY THE OBU) IS GIVEN IN THE MESSAGE PROVIDING LOCATION AND/OR PROFILE DATA, ASSUMPTION:

- If no (remembered) location reference is given in the message providing location and/or profile data, the this data shall not be stored (i.e. not be used).

Variable structure

3.6.1.3 (4th dot); The LRBG's shall be contained in a data structure capable of containing 8 actual and previous LRBG's. Per LRBG the following information shall be stored:

- The identity (NID_BG and NID_C)
- Indication of the order in which the BG's were received (1 for the last received BG, 2 for the second last,...,8). (if the actual location reference is unlinked then there is no linked LRBG available)
- Distance to the actual LRBG
- Passing Direction: Direction in which the BG was passed (can be unknown) WHAT IF IT IS UNKNOWN (AWAITING ASSIGNMENT)??????? SHALL IT THEN BE USED AS PASSED IN NOMINAL DIRECTION, BUT FOR POSITION REPORTS ONLY TO BE USED IN POSITION REPORTS BASED ON TWO BG'S (I.E. PACKET 1)?????????????????????? (this is suggested by figure 2b)
- Marker “known to RBC”: Indicator if the LRBG may be used in position reports to the RBC (this can only be negative, i.e. not to be used in the communication, for the actual LRBG).
- 3.4.2.3.3.7 Indicator if the BG is a single BG which was passed two times (after each other) without having a Passing Direction assigned.

If the actual LRBG shall not be used in position reports to the RBC then the 2nd LRBG shall be used in the position reports. If the actual LRBG shall not be used in position reports to the RBC and a new BG becomes LRBG the previous (actual) LRBG shall not be remembered.

Requirements:

- Location and/or profile data sent by track side (RBC, RIU, BG or loop) shall be referred to the following location:
  - BG: The location of the BG
  - RBC: The LRBG sent as a reference location (packet/message ??????????)
  - 3.6.2.1.2/3.6.2.3.1; Infill information: The BG referred to using packet 136.

Functions:

- x
- x

• Speed and distance measurement

Speed and distance shall be measured based on the information received from different kind of sensors. The output shall be the speed plus an indication for the inaccuracy and the direction related to the train orientation, the distance run (in the direction of cab A), the inaccuracy in distance measurement since the last position and speed report. The information shall be given with a time stamp.
Inaccuracy in the distance measurement shall be related to a time given to the “speed and distance measurement” (the detection time of the LRBG given by “positioning”)

input variables:

- “Reference time” for the distance inaccuracy (to be given by “Positioning”).

output variables (one set belonging together):

- “Nominal Speed“
- “Minimum safe speed“
- “Maximum safe speed“
- “Running direction“ (i.r.t. the train orientation: cabA or cabB)
- “Nominal distance“ travelled since “start of mission”
- “negative distance tolerance“ on the distance since the last received “reference time”
- “positive distance tolerance“ on the distance since the last received “reference time”
- “distance tolerance start time” related to the actual tolerances in the position.
- “Nominal acceleration“.
- “Accuracy of the acceleration“ (+/-)

- Length of the “acceleration time window“ over which the acceleration was calculated
- “Time stamp for the speed and distance“ data

• Determining train position: “positioning”

The position of the train shall be determined in relation to the LRBG. Inputs to determine the train position are the position outputs from “speed and distance measurement” (“nominal distance”, “negative distance tolerance”, “positive distance tolerance”, “distance tolerance start time”). If the

THE POSITION INACCURACY OF A BG IS GIVEN BY LINKING INFORMATION.
WHAT IS THE REFERENCE FOR THE INACCURACY:

- IF IT IS THE POSITION OF THE PREVIOUS LRBG: THE INACCURACY OF THE LOCATION AND PROFILE DATA SHALL BE THE SUM OF THE INACCURACY OF THE LRBG PLUS THE INACCURACY OF THE DISTANCE BETWEEN THE LRBG AND THE NEW BG. IN THAT CASE THE INACCURACY DIFFERS DEPENDING ON THE INITIAL REFERENCE GIVEN.
- IF IT IS THE POSITION OF THE PREVIOUS LRBG THEN THE LENGTH OF THE EXPECTATION WINDOW SHALL BE THE SUM OF THE INACCURACY OF THE POSITION OF THE LRBG PLUS THE INACCURACY OF THE POSITION OF THE ANNOUNCED LRBG.

IT IS ASSUMED THAT THE LAST OPTION IS THE CORRECT ONE.

Variable

3.6.1.3 (first three dots); The train position shall be stored in a data structure including:

- Position: the distance (from the actual LRBG)
  and the orientation of the position in relation to the orientation of the LRBG (nominal or reverse side of the BG)
- The uncertainty of the position:
  - L_DOUBTOVER: the tolerance in the reverse direction (the train can have run this distance less far than assumed, i.e. the distance travelled is overestimated.
  - L_DOUBTUNDER: the tolerance in the advance direction (the train can have run this distance more far than assumed, i.e. the distance travelled is underestimated.
- 3.6.1.6; The train orientation (related to the direction in which the LRBG was passed): nominal or reverse.

3.6.1.5; *The train orientation is determined by the cab which is operated, or (if none) which was the last operated.*

- Driving direction: ACTUAL MOVING DIRECTION IN RELATION TO THE LRBG
- Reversing: indication if the driver selected a driving direction opposite to the train orientation.
- The train length (to calculate the rear end position).

• Sending a position report to the RBC

xxx

requirements

- 3.4.2.3.3.1 If the LRBG is a single BG with unknown passing direction, then the OBU shall report the LRBG (being the detected single BG) and previous LRBG (if available) in a position report to the RBC (using packet 1 in stead of packet 0 for the position report).
- 3.4.2.3.3.2 If a position report based on two BG's (packet 1) is sent, then the nominal direction shall be from the previous LRBG to the new LRBG.
- 3.4.2.3.3.4 If a position report based on two BG's (packet 1) is sent, and the running direction of the train has changed between detecting the previous LRBG and the new LRBG, then all directional information in the position report (Q_DIRLRBG, Q_DLRBG Q_DIRECTION) shall be reported unknown. IN FIGURE 2A UNDER 3.4.2.3.3.4 THE IMPRESSION IS GIVEN THAT THE TRAIN ORIENTATION CHANGED (OTHER CAB) WHILE IN THE TEXT THE RUNNING DIRECTION IS MENTIONED. WHICH ONE IS CORRECT??????
- 3.6.2.2.2.a; A BG stored as a LRBG shall only be used in a position report if it is marked as “known to RBC” (see variable structure for the “list of LRBG's).
- 3.6.2.2.2.1 If the train position is not known, i.e. no LRBG is stored on-board then the LRBG ID in the position report (packet xxx, variable xxx) shall be set to “unknown”.
- Location report during SOM: chapter 5???????

• Receiving a position report from the OBU (RBC function)

requirements

- 3.6.2.2.2.b / 3.6.2.2.2.2 If the RBC receives a position report (packet 0 or packet 1) then,

- If packet 0 is received and the ID of the LRBG is not “unknown” (variable) then the ID shall be stored and further used as a position reference in messages containing location and/or profile data.
- if packet 0 is received and the ID of the LRBG is “unknown” (variable) then “unknown” shall be stored and further used as a position reference in messages containing location and/or profile data.
- 3.4.2.3.3.1.1 If the RBC receives a packet 1 (position report using two LRBG's) with both LRBG-ID's given in the packet differrent from “unknown” then the RBC shall derive the “Passing Direction” for the LRBG which was passed last by the train (variable) and sent the passing direction to the OBU (using packet xx).
  Therefore the RBC shall know the position of all BG's including their orientation.
  Further the ID of the last passed BG (variable) shall be stored and further used as a position reference in messages containing location and/or profile data.
- If the RBC receives a packet 1 (position report using two LRBG's) with one of the LRBG-ID's given in the packet equal to “unknown” then “unknown” shall be stored and further used as a position reference in messages containing location and/or profile data.

• Determine and present geographical location information

xxx

Geographical reference locations shall be stored to be able to report the actual position (track-km) to the driver. Per geographical reference location the following information shall be stored:

- The distance from/to the actual LRBG
- The track-km at the reference locations
- The counting direction (is the track-km increasing or decreasing in relation to the train orientation?)

Reference locations in rear of the train shall be deleted as soon as a new reference location becomes valid, (i.e. the new reference location is passed). A list of reference locations shall be stored in the order in which they will be passed. Per reference location (sent using packet 79) the following information shall be stored:

- The distance from the actual LRBG to the reference location.
- Information if the reference location is valid (i.e. has been passed); this can be a special value of the distance variable.
- The track-km at the reference location.

- The counting direction in relation to the direction in which the LRBG was passed.

Requirements

If location and/or profile data is received from an unlinked BG if no (linked) LRBG is available then the unlinked shall be stored OBU as location reference not to be used in communication to the RBC (as it might not be known to the RBC). If the location reference is an unlinked BG and a BG is passed all stored and new received location and profile data will always be related to the new received BG and the previous location reference will be deleted. As soon as a linked BG is the location reference (i.e. the location reference can be used as LRBG in the communication to the RBC), no unlinked BG will be used as location reference OBU.

Unlinked BG's used as a location reference will be stored in the data structure for LRBG's with an extra indication that they may not be used in communication with the RBC.

3.6.2.2.2 c 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 a reference location and for in position reports to the RBC 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 (*).

FURTHER BG CAN BE USED ONLY AS A REFERENCE LOCATION (BUT NOT IN POSITION REPORTS TO THE RBC), IF THE BG TRANSMITS LOCATION AND/OR PROFILE DATA.

3.4.2.3.3.5 THIS REQUIREMENT GIVES AN INDICATION WHAT SHALL BE DONE IF THE LRBG WHICH IS A SINGLE BG WITH UNKNOWN PASSING DIRECTION (BECAUSE THE IMPRESSION IS GIVEN THAT POSITION REPORTS BASED ON TWO BG'S ARE USED) IS PASSED AGAIN, I.E. THE DRIVING DIRECTION HAS CHANGED. THE CONSEQUENCE IS THAT THE "LIST OF LRBG'S" SHALL NOT BE UPDATED. HOWEVER WHAT TO DO IF:

- A PASSING DIRECTION HAS BEEN GIVEN FOR THE SINGLE BG, SHALL IT THAN BE INVERTED OR SHALL THE PASSING DIRECTION BE SET TO UNKNOWN AGAIN??? OR SHALL THE BG THAN BE STORED TWICE?????
- IF A BG NOT BEING A SINGLE BG IS PASSED AGAIN??? IS IT THAN STORED TWICE IN THE LIST OF LRBG'S?

If a BG is detected which is used as a new location reference, all location and profile data stored OBU (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 was announced (i.e. the real distance between the LRBG and the detected BG is known by the distance stored in the “list of announced BG's”) the “OBU over-reading and under-reading amount (L_DOUBTOVER and L_DOUBTUNDER)shall be reset to a default value (XXXXXXXX). (ODOMETER FUNCTION).

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 actual position of the train shall be reported to the RBC if:

- ??????????

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 (and accepted), i.e.
  - Store the information describing the BG in the list of LRBG's (see structure for LRBG's) if the conditions for using the BG as a location reference OBU are fulfilled.
  - If, when a new LRBG is stored, the actual LRBG (before detecting the BG) is marked as "not to be used in position reports" it shall be deleted from the list.
  - If, when a new LRBG is stored, the actual LRBG (before detecting the BG) is marked as "to be used in position reports" and the maximum number of stored LRBG is reached, then the rearmost LRBG shall be deleted from the list.
- Relocate all location and profile data stored at the ETCS OBU, if another BG becomes the actual LRBG.
- Update the train position if a BG is detected (and accepted) (ODOMETER FUNCTION?)
  - Reset the confidence interval for the train position if the position of the detected BG was known in relation to the LRBG.
  - If the detected BG is to be used as the new location reference then set the distance to "0" at the moment the reference balise of the BG was detected, update direction information (related to the passing direction of the BG),
- 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.
- Report the position of the train in relation to the LRBG which is known to the RBC (packet 0) or in relation to the LRBG and previous LRBG (packet 1).

6. Receiving track description

Paragraphs subset026 v3.3.0: 3.7

Requirements are realized with functions defined in other paragraphs. A traceability check shall be done.

7. Movement authority

Paragraphs subset026 v3.3.0: 3.8

A movement authority (MA) is given by the infrastructure to the OBU in case the concerning part of the route is available for the train the MA is sent to. The MA is sent by the RBC on request of the OBU (using message 132).

The conditions for requesting an MA are parametrized. Those parameters are provided by the RBC to the OBU using packet 57:

- Cyclic MA request: Time given by T_CYCRQST (or never: special value)
  SHALL AN MA BE REQUESTED IN A CYCLE INDEPENDANT FROM MA REQUESTED IN RELATION WITH T_MAR OR T_TIMEOUTRQST? OR SHALL AN MA BE REQUESTED IF THE TIME T_CYCRQST IS EXPIRED SINCE ANY MA RECEPTION???????
- The time before reaching the pre-indication (T_MAR) when an MA has to be requested.
- The time before any MA-timer (section, end section, overlap timers) expires (T_TIMEOUTRQST) when an MA has to be requested.

IT'S NOT CLEAR AT THIS MOMENT IF THE PACKET 57 IS SENT ONLY AFTER SOM, OR AFTER EVERY CHANGE TO ANOTHER RBC.

The ETCS OBU 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 OBU shall request an MA if:

1. according to the parameters sent by the RBC (or default values):
   a. IF NO MA HAS BEEN REQUESTED SINCE A TIME T_CYCRQST. Or cyclic independent from the other requests. What if a MA was requested, but not received??
   b. a time T_MAR before the pre-indication point is reached (UNDER WHICH ASSUMPTIONS FOR THE SPEED TILL REACHING THE POINT: 3.13??)
   c. a time T_TIMEOUTRQST before any MA timer expires.
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.

An MA is sent using packet 12 (level 1) or packet 15 (level 2/3). The difference between the two packets is the extra information “signalling related speed restriction” (V_MAIN). Further the packets contain the following information:

- The description of an “end section” (which can be the only section):
  - the length of the end-section (L_ENDSECTION)
  - limit of authority speed and time-out value (V_LOA, T_LOA)
  - section timer: used? (indicated by Q_SECTIONTIMER), time-out value (T_SECTIONTIMER) and the location where the timer shall be stopped (D_SECTIONTIMERSTOPLOC)
  - end section timer: used? (indicated by Q_ENDTIMER), time-out value (T_ENDTIMER) and the location where the timer shall be started (D_ENTIMERSTARTLOC)
  - danger point: is information available? (indicated by Q_DANGERPOINT), distance between the EOA and the danger point (D_DP) and the release speed allowed as long the danger point is valid (V_RELEASEDP)
  - Overlap: is an overlap available? (indicated by Q_OVERLAP), the distance between the EOA and the end of the overlap (D_OL), the distance (in rear of the EOA) between the EOA and the start location of the overlap-timer (D_STARTOL), and the release speed allowed as long the overlap is valid (V_RELEASEOL).
- A number (indicated by N_ITER) of sections:
  - The length of the section (L_SECTION)
  - section timer: used? (indicated by Q_SECTIONTIMER), time-out value (T_SECTIONTIMER) and the location where the timer shall be stopped (D_SECTIONTIMERSTOPLOC)

INFILLXXXXXXXXXXXXXXX

In level 1 infill-MA's can be given using message 37. In this message packet 136 is used to define the location reference, and packet 12 is used to sent the MA.

Direction for which the MA is valid:

- 3.6.2.3.1.2; In case of infill-MA the orientation is defined in reference with
  - in case of a BG: the “Passing Direction” of the BG (variable)
  - in case of a loop: the orientation indicated by the EOLM (variable)
  - in case of an RIU (or RBC????, see original requirement): the “Passing Direction” of the LRBG (variable) (known to RIU?)
- xxx

An MA sent by trackside (normal or infill) shall be accepted if the SSP and gradient information is available OBU or was sent together (in the same Message) with the MA (for the whole length of the MA), and no emergency stop message (not yet revoked) has been accepted (3.10.2.4). If not then ???????????? ????????????????

If the ETCS OBU 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)}

Variables

The MA stored on-board shall contain:

- xxxxxxxxxxx

• 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 OBU 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 shortening 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*

8. Receiving infill information

Paragraphs subset026 v3.3.0: 3.9

Infill information is an update of the movement authority related to the BG at the next main signal. Infill is only useful in level 1 as in higher levels completely new information can be given. Infill information is sent to the OBU using packet XXXX, WITH THE VARIABLE YYY, and is referring to the next linked BG, not being an infill BG (where is this specified?).

Packet xxxxx includes the following information:

- xx

Infill devices must be announced by the infrastructure, this is done using the following packets:

- xx

3.9.1.3: If an infill device is announced by a BG (how?? packet 133 gives the RIU identity (sent by a BG), packet 134 is used to announce a loop, packet 143 is used to give a RIU identity (sent by another RIU), is this complete?) and the OBU does not include a receiver for information of the announced device then the announcement shall be ignored (i.e. the information is not stored).

3.9.2.1: A loop is preceded by an EOLM (a balise sending packet 134). If an EOLM is received the loop identity, starting location, length, direction in which the loop will be passed shall be stored (related to the LRBG) and "key" defining the spectrum in which the loop is sending, in the EVC. According to 3.9.2.1 also the end of a loop is marked HOW?????????

3.9.2.9: If (and only if) a loop message (valid for the passing direction) from a loop with the announced identity is received this loop message shall be taken into account, until (3.9.2.11) a next main signal BG is found (HOW IS A "MAIN SIGNAL BALISE GROUP" DEFINED???) or the next announced main signal BG is missed.

3.9.3.5.1: If an order to establish communication (packet 133 with Q_RIU=1) with an RIU is received from a BG and the OBU can handle one communication session at a time, the OBU shall:

1. If no communication session is existing, the OBU shall establish a communication session (message 155) at the location indicated in the order, with the RIU indicated in the order (I HAVEN'T FOUND THIS SPECIFICATION, BUT IT SEEMS LOGICAL)
2. If a communication session is existing with an RIU not indicated in the order, the OBU shall terminate the existing communication session at the location indicated in the order (Shall the trackside also sent a terminate order according to 3.9.3.16 in the same message???

Q_RIU=0????), and establish a communication session (message 155) with the RIU indicated in the order after the previous session has been terminated.

3.9.3.5.2: If an order to establish communication (packet 133 with Q_RIU=1) with an RIU is received from a BG and the OBU can handle more than one communication session at a time, the OBU shall:

1. If no communication session is existing, the OBU shall establish a communication session at the location indicated in the order, with the RIU indicated in the order. (I HAVEN'T FOUND THIS SPECIFICATION, BUT IT SEEMS LOGICAL)
2. If a communication session is existing with RIU(s) not indicated in the order, those sessions shall be terminated (IMMEDIATELY??? IF SO WHY??, IF NOT AT WHICH MOMENT THAN??? WHAT'S THE USE OF BEING ABLE TO HANDLE MORE THAN ONE SESSION IN THIS CASE??). As soon as a new communication session can be handled and no communication session exists with the RIU indicated in the order, a new communication session shall be established with the RIU indicated in the order.

3.9.3.6a: If an order to establish communication (packet 133 with Q_RIU=1) with an RIU is received from an RIU and the OBU can handle only one communication session at a time, the OBU shall ignore the order.

3.9.3.6b: If an order to establish communication (packet 133 with Q_RIU=1) with an RIU is received from an RIU and the OBU can handle two communication sessions at a time and only one communication session is existing, then the OBU shall establish a communication session (message 155) with the RIU indicated in the order (unless the indicated RIU is the same as the sending RIU, this is not specified but assumed logical)

3.9.3.6c: If an order to establish communication (packet 133 with Q_RIU=1) with an RIU is received from an RIU and the OBU can handle two communication sessions at a time and two communication sessions are existing, then the OBU shall terminate the session with the RIU('s) not related to the current infill area (THE SRS DOESN'T LEAVE THE OPTION OPEN THAT BOTH SESSIONS ARE NOT RELATED TO THE CURRENT INFILL AREA, IT IS ASSUMED THAT IF SO BOTH ARE TERMINATED)

3.9.3.8.1 ?? WHAT ARE THE DEFINITIONS, THE NAME OF PACKET 133 (ORDER TO ESTABLISH/TERMINATE A COMMUNICATION SESSION) IS "RADIO INFILL AREA INFORMATION" HOW CAN THEY NOT BE SENT TOGETHER?? WHAT SHALL THE OBU DO IF THE INFORMATION IS RECEIVED TOGETHER??

3.9.3.10/3.9.3.11 If the train enters or leaves the infill area to which a connected RIU is related, then the OBU shall inform the RIU (message 153).

3.9.3.11.1 WHAT'S "A POINT AREA"??
3.9.3.12/13/14: RIU requirement, t.b.d.

3.9.3.15 If the OBU receives infill information (an infill-MA) from the RIU related to the infill area where the train is running, then the infill-MA shall be taken into account. In all other cases the infill information shall be ignored.
3.9.3.16 If the OBU receives an order to terminate a session (packet 133 with Q_RIU=0) then the OBU shall terminate the communication session (sending message 156).

functions:

- xx

9. Receiving emergency messages

Paragraphs subset026 v3.3.0: 3.10
An emergency message can be sent using message 15 (conditional emergency stop) or message 16 (unconditional emergency stop).
Message 15 includes the following information:

- x

Message 16 includes the following information:

- x

variables

requirements
3.10.1.3.1 WHAT DOES "REPLACE THE PREVIOUS EMERGENCY MESSAGE MEAN?" IS THE FIRST ONE REVOKED, SHALL THE BRAKE BE RELEASED?...
3.10.2.2/6 If a conditional emergency stop message (message 15) is received and the trains safe front end has not yet passed the emergency stop location (given as a distance from the LRBG: D_EMERGENCYSTOP) then the emergency stop shall be accepted (i.e. the EOA and SvL are withdrawn to the emergency stop location, unless this location is beyond the current EOA) and the information shall be stored, and the information that an emergency stop is accepted shall be displayed to the driver (until the emergency stop is revoked).

(IS IT CORRECT THAT THE TRAIN IS NOT TRIPPED IF THE BRAKING DISTANCE TO THE NEW EOA IS SUFFICIENT?!?!?!)
If a conditional emergency stop message (message 15) is received and the trains safe front end has (at the time of evaluation) passed the emergency stop location, then the RBC is informed that the em. Stop has been rejected and the information is deleted. (NOT SPECIFIED BUT SEEMS LOGICAL)

3.10.2.3/6 If an unconditional emergency stop message (message 16) is received the train will be tripped immediately and the information that an emergency stop is accepted shall be displayed to the driver (until the emergency stop is revoked).

3.10.3 If a revocation message is received, the emergency stop information corresponding to the given identity (NID_EM) shall be deleted and the information (that an emergency stop is accepted) displayed to the driver shall be removed if no further emergency stops are accepted and not yet revoked. (WHAT SHALL BE DONE WITH THE EOA WHICH WAS SET TO THE EMERGENCY STOP LOCATION AND/OR THE TRAIN TRIP WHICH WAS INITIATED AFTER RECEIVING THE EMERGENCY STOP MESSAGE WHICH IS NOW REVOKED????????)

functions:

- xx

10. Receiving speed limits and gradients

Paragraphs subset026 v3.3.0: 3.11

Speed limits are given in the following manners:

- Packet 27: static speed profiles: basic, cant deficit, and international
- Packet 51: axle load profile
- Packet 52: speed restriction based on the maximum permitted braking distance
- Packet 64/65/66: temporary speed restriction
- Packet 88: speed restriction at level crossings
- Packet 12 (level 1 MA): signalling related speed restriction

- National values (specified where?): mode related speed restrictions (STM, override)
- Train data (specified where?): train dependant speed restriction

Data format to store “speed restrictions” (continuous and non continuous location dependant data, 3.6.3.2.1):

- position reference: NID_LRBG and NID_C
  According to 3.6.2 the location reference for data sent by BG's is the reference location of the BG and for data sent by an RBC the LRBG indicated in the message. 3.6.3: The first distance is the distance from the BG or LRBG ***after*** *which the first value becomes valid, i.e. in case of a continuous profile the last value is stored without end position.*
- type (SSP, Axle load, TSR,....)
- array with n rows containing:
  - “start distance”(i.r.t. LRBG) (this point will further be referred to as the a “potential target point “(PTP)),
  - “length”,
  - “indicator if the length was increased with the train length”
  - ID (given by track side, only relevant if the restriction is revocable (TSR,...), else this value shall be 255 (equal to the value of NID_TSR if the TSR is non-revocable)
  - “maximum speed”.

Functions related to “speed restrictions”:

- Update the distance information if another BG becomes LRBG. The distance information shall be corrected with the distance between the old and new LRBG given as linking information (preferred, i.e. if available) or with the nominal distance measured between the two BG's.
- Sum up all specific “speed restrictions” in one “overall speed restriction” which shall be monitored.
- Determine for every “potential target point” in the “overall speed restriction” if the indication point for monitoring this point has been passed, i.e. if braking curve calculations have to be performed for this point.
  (as the number of braking curve calculations might be bigger than the maximum the system (system specific) can handle, a reaction has to be defined if too many calculations are necessary. This can e.g. be commanding the service brake till ……
- Update all variables related to speed restrictions when a position update is received from the odometer function.

VARIABLES describing speed restrictions

Variables according to the data structure for "speed restrictions":

- Resulting overall speed restriction (end result of the profile calculations), being the most restrictive summary of: the specific "speed restrictions" (following the same structure)
  - SSP: Train specific static speed profiles
    (A MAXIMUM NUMBER SHALL BE SPECIFIED, together with the response if it is exceeded)
  - AL_SRs Train specific axle load profile (if any)
    (A MAXIMUM NUMBER SHALL BE SPECIFIED, together with the response if it is exceeded)

Further variables

- signalling related speed restriction (level 1): none, or value between 0 and 600km/h in steps of 5km/h
- STM speed
- override speed
- train specific maximum speed.

Variable defining the distance over which the SSP is available (I.r..t. LRBG)

What shall be done with stored "speed restriction" information if:

- the orientation of the train changes?
- xxxx

• Receiving static speed profile information (continous profile)

One packet 27 can contain 33 speed profiles 1 basic, 16 cant deficiency and 16 international (**3.11.3.3.1: only 15 int. ssp are possible why not 16?, the variable NC_DIFF allows 16 categories**) .

For each section in the SSP the incremental distance (D_STATIC(i)) is given, the length over which the speeds are valid is equal to this distance plus (if Q_FRONT=1) the train length. Further for each section the maximum speeds per category (basic, cant deficiency or international) are given together with the indentification of the category.

3.7.3.1a All previously received SSP data starting beyond (or equal position) the rear most section defined in the new received packet 27 shall be replaced.

The static speed profile information includes a basic static speed profile, optionally higher allowed speeds in case of canting (the “Cant Deficiency” train category) or impose lower speed limits or allow higher speeds (if the train category replaces the “cant deficiency” SSP) due to an international train category to which the train belongs. This leads to the following functional description:
If basic and train dependant SSP’s are received (packet 27) then the SSP valid for the train shall be determined:
AS PACKET 27 ALLOWS A DIFFERENT NUMBER OF SSP’S FOR EACH SECTION IN THE SSP THE FOLLOWING SHALL BE EXECUTED FOR EACH SECTION IN THE SSP (THE SECTIONS ARE EQUAL FOR ALL SPEED PROFILES GIVEN AS SSP!).

- For each section in the static speed profile (starting point defined by D_STATIC/D_STATIC(k)) the lowest of the speed values given for the train categories which match the “international train categories” (train parameters) of the train will be “the maximum speed according to international speed profiles”.
- For each section in the static speed profile (defined by D_STATIC/D_STATIC(k)) it shall be determined if there is an international train category matching one of the “international train categories” (train parameters) which replaces the “cant deficiency static speed profile” (this is indicated by Q_DIFF(k,m)=2).
- If for a specific section of the SSP none of the matching categories replaces the “cant deficiency static speed profile” then the maximum speed for this section shall be the minimum of the “maximum speed according to international speed profiles” and the speed given for the highest value of the “Cant deficiency” category below or equal to the “cant deficiency” train category (train parameter) or the basic SSP if no “Cant deficiency” category below or equal to the “cant deficiency” train category is available.
- If for a specific section of the SSP one of the matching categories replaces the “cant deficiency static speed profile” then the maximum speed for this section shall be the “maximum speed according to international speed profiles”.
  This speed shall be stored with the starting point of the section i.r.t. the LRBG, the length over which the maximum speed is valid (extended with the length of the train depending on Q_FRONT), and the speed level.

FROM THE PACKET DESCRIPTION IT SEEMS THAT THE DISCONTINUITIES IN ALL DIFFERENT SSP PROFILES HAVE THE SAME LOCATION, I.E. FOR A SPECIFIC PIECE OF TRACK DIFFERENT SPEEDS ARE GIVEN, BUT FOR DIFFERENT TRAIN TYPES NO SPECIFIC PARTITIONING OF THE TRACK IS USED: FOR ONE D_STATIC(k) SEVERAL V_DIFF(k,m)'s ARE DEFINED.
I COULD HOWEVER NOT FIND A SPECIFICATION CONFIRMING THIS.

Functions:

- Initialize an SSP (create an empty SSP) and an axle load SP (empty Axle load Speed Profile)
- Update the SSP if a packet 27 is received;
  - all already stored sections of the SSP starting beyond (or equal position) the rear most section defined in the new received packet 27 shall be deleted.
  - The length of the last not deleted section in the previous shall be update
  - Sections shall be stored with there starting location related to the LRBG and the length equal to the incremental distance of the next section (increased by the train length if Q_FRONT =1). If there is no next section given, a special value shall be stored indicating that the length shall be determined when the next packet 27 is received.
  - If a packet 27 is received then determine the maximum speed for each section of the SSP according to the steps described above in "Receiving static speed profile information", relate the starting point of each section to the LRBG and store the results according to the data format defined for "speed restrictions".
    The end position (length) for the furthest section of the already stored SSP (after sections beyond the new data were deleted) shall be set to the start location of the rearmost new received section).
    AS LONG AS THE START POSITION OF THE FIRST SECTION IN THE STORED SSP IS BEYOND THE FRONT END OF THE TRAIN, THERE IS NO VALID SSP AVAILABLE, THUS MA'S WILL BE REJECTED.

• Receiving axle load speed profile information (non-continuous profile)

3.11.4.2.1 Here it is stated that different speed restrictions can be applicable to the same distance. However it can ONLY be for the same distance, while packet 51 defines only one distance D_AXLELOAD(k) for more V_AXLELOAD(k,m)'s but not the other way around!

In packet 51 sections can be defined (incremental position, length of the section and information if the train length has to added (Q_FRONT)). For each section axle load dependant speed limits can be given.

(IT IS NOT CLEAR IF FOR EVERY SECTION THE SAME LOAD CATEGORIES SHALL BE SPECIFIED, THEREFORE IT IS ASSUMED THAT THE CATEGORIES CAN DIFFER PER SECTION).

3.11.4.3 For each section of the axle load speed profile, the OBU shall determine what is the lowest speed associated with any load category lower than or equal to the "load category" of the train.
What is meant with a load category lower than the one of the train? If it's a lower load, why is than not the first one above the one of the train used?

If an axle load dependant speed profile is received (packet 51) then the SSP valid for the train shall be determined, based on the maximum axle load of the train (train parameter):
AS PACKET 51 ALLOWS A DIFFERENT NUMBER OF AXLE LOAD DEPENDANT SPEED PROFILES FOR EACH SECTION IN THE SSP THE FOLLOWING SHALL BE EXECUTED FOR EACH SECTION IN THE SPEED PROFILE:

- The lowest speed associated with any load category lower than or equal to the "load category" of the train shall be stored with the starting distance from the LRBG, the distance over which it is valid (extended with the length of the train depending on Q_FRONT) and the maximum speed. (3.11.4.3)
- If the "load category" of the train is below the minimum axle load given in the profile, no data shall be stored. (3.11.4.4).
  if no data is stored no speed limitations will be imposed.

Functions:

- If a packet 51 is received then update the stored PBDSR's:
  - all already stored sections of PBDSR's starting beyond the rear most section defined in the new received packet 51 shall be deleted (3.7.3.1d)
  - determine for every section of the axle load speed profile, if there is a maximum speed for that section valid for the train, and if so, relate the starting point of the section to the LRBG and store the results according to the data format defined for "speed restrictions". (as described above)

• Receiving and revoking TSR's

Temporary speed restrictions (TSR's) are sent from trackside using packet 65. This packet includes the following information:

- variable indicating if the end of the TSR shall be delayed with the train length (3.11.5.3, Q_FRONT)

- an indication if the TSR may be revoked (3.11.5.6, given as a special value of NID_TSR: 255= not revocable)
- an indication if the TSR was sent by an RBC (NID_TSR in the range 127-254) or another means (NID_TSR in the range 0-126)
- The distance to the beginning of the TSR (D_TSR)
- The length of the TSR (L_TSR)
- The maximum speed of the TSR (V_TSR)

TSR's can be revoked using packet 66 if they are marked as revocable. This packet includes the following information:

- identity of the TSR (NID_TSR) to be revoked.

RBC's can sent information to the train that revocable TSR's from other sources than RBC's shall be rejected, using packet 64. This packet includes no further information.

Variables:

- REJECT_REVOCABLE_TSRS: Flag to indicate if revocable TSR's sent by other sources than RBC's shall be rejected.
- INHIBITING_RBC: ID of the (last) RBC which has sent the packet 64 leading to setting REJECT_REVOCABLE_TSRS. The default value shall be “none”.
- TSRs: All “speed restrictions” given as a TSR, according to the structure “speed restrictions”. (A MAXIMUM NUMBER SHALL BE SPECIFIED, together with the response if it is exceeded)

Requirements:

3.11.5.12-14 From the moment that packet 64 is received, until the communication session with the RBC which has sent the order is terminated, or (in case of RBC/RBC handover to another RBC), when the front end of the train crosses the RBC/RBC border, revocable TSR's sent by BG's (i.e. NID_TSR is in the range 0-126) shall be rejected.

3.11.5.9 If a TSR is received (packet 65) and the TSR shall not be rejected according to 3.11.5.12-14 then:

- If the NID_TSR is equal to the NID_TSR of an already stored TSR (different from NID_TSR=255, not revocable), then the data concerning the already stored TSR shall be deleted.
- The received TSR shall be stored, i.e. the locations shall be related to the LRBG and the length of the TSR shall be increased with the train length if Q_FRONT indicates so. Location and length shall be stored together with the speed level.

3.11.5.10 If the orientation of the train changes all stored TSR's shall be deleted.

3.11.5.8 If a revocation order (packet 66) is received and the TSR to which NID_TSR refers was not sent by an RBC (i.e. NID_TSR is in the range 0-126) then the data related to this TSR shall be deleted.

functions

- Initialize a “speed restrictions” for storing TSR's (create an empty TSRs)
- If a packet 64 is received the flag REJECT_REVOCABLE_TSRS shall be set and the ID of the RBC shall be stored in INHIBITING_RBC (replacing earlier stored RBC-ID's)
- If the connection with the RBC which has sent the packet 64 is lost then the flag REJECT_REVOCABLE_TSRS shall be reset and INHIBITING_RBC shall be set to “none”.
- If the RBC which has sent the packet 64 is no longer the responsible RBC (RBC/RBC handover) then REJECT_REVOCABLE_TSRS shall be reset and INHIBITING_RBC shall be set to “none”.
- store TSR('s)If a packet 65 is received, :
    - Ignore all revocable TSR's with an ID in the range 0-126 if REJECT_REVOCABLE_TSRS is set
    - All already stored TSR's (in TSRs) with an ID (different from 255) equal to an ID of any of new received (and not ignored) TSR's, shall be deleted.
    - Store data of TSR's which shall not be ingnored in TSRs, for each TSR the following data shall be stored:
        - “start distance” shall be set to D_TSR if the reference location given in packet 65 is the LRBG stored OBU. If not the distance shall be corrected with the distance between the LRBG and the reference given in the packet.
        - “length” shall be set to L_TSR (increased with the train length in case Q_FRONT=1)
        - “indicator if the length was increased with the train length” shall be set to Q_FRONT
        - ID shall be set to NID_TSR
        - “maximum speed” shall be set to V_TSR
- Delete the concerning TSR if a packet 66 is received, i.e. delete the information related to the TSR identified by NID_TSR if NID_TSR is in the range 0-126 (i.e. is revocable).
- Delete TSR whose end location (“start distance”+”length”) is in rear of the trains front end. MIN SAFE FRONT END OR NOMINAL??????????

• Receiving and revoking “permitted braking distance” related speed restrictions

Speed restrictions given by a maximum permitted braking distance are sent using packet 52. This packet includes the following information:

- information if the profile shall be followed (Q_TRACKINIT) **??????????????????????**
- location where the initial state shall be resumed (D_TRACKINIT) **??????????????????????**

- The start of the sections where the speed limit applies (D_PBDSR)
- The maximum permitted braking distance (D_PBD).
  The gradient to be assumed (Q_GDIR and G_PBDSR)
- The type of brake (EB or SB) to be assumed (Q_PBDSR)
- braking distance, the position where the restriction starts (D_PBDSR) and the length of the restriction. (L_PBDSR).

Variables:

- PBD_SRs : All “Permitted braking distance” dependant speed restrictions (max 33), according to the structure “speed restrictions”.
- Flag indicating that the brake parameters (characteristics) have changed.
- Variables to store the raw data for PBDSR sections (necessary because of the requirement to recalculate if braking parameters change).

Requirements:

3.7.3.1d All previously received PBDSRs starting beyond (or equal position) the rear most section defined in the new received packet 52 shall be replaced.

3.11.11.3 If a packet 52 is received the OBU shall calculate the maximum speed for all sections for which a PBDSR is given based on the available brake characteristics of the train, the type of brake indicated in the packet (EB or SB, Q_PBDSR), the gradient given in the packet and the braking distance given in the packet and the speed margins to be taken into account below the intervention speed.

3.11.11.3 Further the raw data received in the packet shall be stored (per section) until the end location of the section is passed to enable recalculation in case the brake parameters change.

3.11.11.3 If the braking parameters change then all “speed restrictions” which where based on a PBD shall be deleted, and replaced with the recalculation using the raw data stored per PDBSR.

3.11.11.4-6 *requirements for the way the speed limits shall be calculated: depending on braking curve calculation (t.b.d.)*

Functions:

- If a packet 52 is received then
- Calculate the maximum speed based on the “permitted braking distance” using the brake characteristics of the train taking the requirements in 3.11.11.4-6 into account.
- Store received and processed data in PBDSRs.

Receiving and storing gradient profiles (continuous profile, 3.11.12.2)

3.11.12.1,3 Gradient profiles are sent to the train using packet 21. This packet contains the following information describing the gradient profile:

- D_GRADIENT the incremental starting location of
- Q_GDIR variable defining if the slope is up or downhill
- G_A the gradient for the given sections

As the gradient is the safe gradient I assumed the sections have to adapted for the train length, i.e. if at a section border the gradient increases (more uphill) then the border has to be advanced with the train length. (IS THIS CORRECT? IF SO WHERE IS THIS SPECIFIED?)

3.11.12.4-6: engineering rules

IT IS ASSUMED THAT SENDING A DEFAULT GRADIENT FOR TSR SUPERVISION IS DONE WITH THE SAME PACKET (21), I.E. IT IS IRRELEVANT FOR THE OBU IF A NORMAL GRADIENT PROFILE OR A DEFAULT GRADIENT PROFILE FOR TSR IS SENT.

3.7.3.1b All previously received gradient data starting beyond (or equal position) the rear most section defined in the new received packet 21 shall be replaced.

Data structure to store gradient profiles OBU:

- position reference: NID_LRBG and NID_C
  According to 3.6.2 the location reference for data sent by BG's is the reference location of the BG and for data sent by an RBC the LRBG indicated in the message. 3.6.3: The first distance is the distance from the BG or LRBG ***after*** *which the first value becomes valid, i.e. in case of a continuous profile the last value is stored without end position.*
- array with n rows containing, Location (distance from the LRBG) where the section starts and the gradient valid from the given location (can be positive or negative). As the end of the section of the last gradient value is not known the information in GRADIENTS is only valid up to the start of the last section. THIS IS UNAVOIDABLE, HOWEVER I DIDN'T FIND IT IN THE SPECIFICATION.

Two instances of this type shall be created: “GRADIENTS” and “GRADIENTS_TRAIN_SPECIFIC”:

- “GRADIENTS” section borders as received from trackside
- “GRADIENTS_TRAIN_SPECIFIC”: section borders shifted to have the worst case gradient over the whole train length.

Functions:

- Initialize a gradient profile (create an empty GRADIENTS)
- if packet 21 is received, “update GRADIENTS”:
    - all already stored sections of GRADIENTS starting beyond (or equal position) the rear most section defined in the new received packet 21 shall be deleted.
    - The gradient sections specified in the received packet 21 shall be added to GRADIENTS with all locations stored in reference to the LRBG.
- If GRADIENTS is updated then “copy the sections from GRADIENTS to GRADIENTS_TRAIN_SPECIFIC”, if at a location the gradient increases (more uphill) then the location shall be advanced with the train length.