The internal datastructure

(part of the data dictionary)

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Jan Welvaarts

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Content

Table of Contents

1 Preface

This document defines the rough structure of the internal openETCS data structure. Purposes:

- Structure the data to keep it manageable
- Create a common understanding of the structure
- Synchronize the structure for variables defined for different functions (by different groups)

Many variables contain different information, but shall be structured in the same way. The most obvious example is location based information. Locations are necessary for many data structures and shall therefore be stored in the same way. This is not guaranteed if different are defining variables independent from each other. Therefore This document will define a top level structure for the date dictionary and set requirements for more detailed variables. The structure of the internal data will be targeting the use of the data (i.e. it will not be a copy of the source).

Roughly three types of internal data are distinguished:

- Location based information describing the infrastructure.
- Description of the train (including train position).
- Status information: mode, level, dmi status etc.

The “variable categories” shown in figure 1. Variable types to be used to describe the information listed shall be decomposed down to the level of standard data types (boolean, word, integer, double,....).

The first chapter defines a number of requirements the internal data structure has to fulfill (i.e. the requirements).

The second chapter describes for each of the “variable category” which information it globally contains, where the information is coming from and what the use of the information is.

In the third chapter the individual data structures is described, starting with the “coordinate system” as the “list of passed BG's” serves as a basis for all location based information.

In the last part the internal data structure will be detailed using variables defined by the groups which are defining functions.

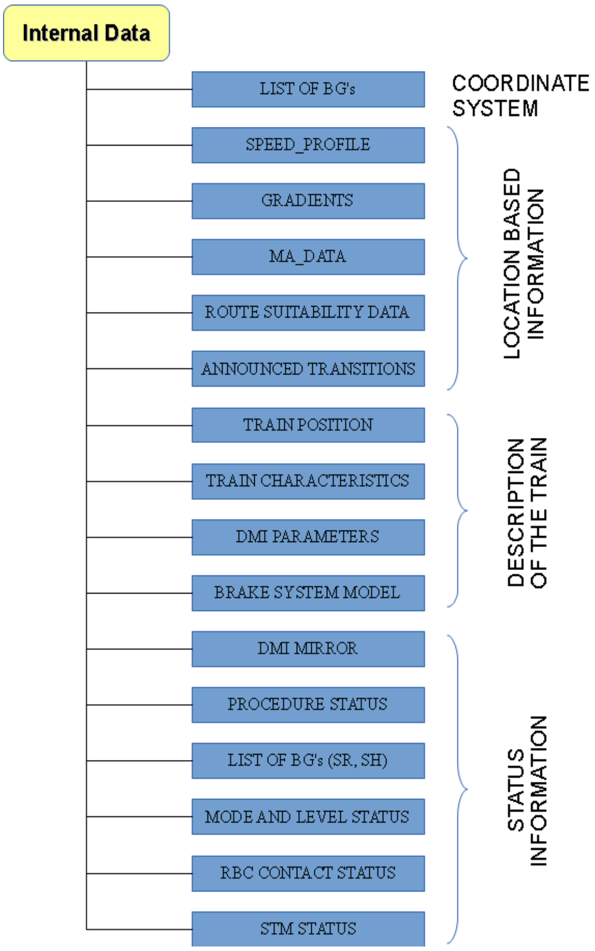


Figure 1:

High level data structure for the internal data

2 Principles

In this chapter a number of principles will be set to tune the format of the variables proposed by different groups which are defining functions:

Principle	**explanation**	**ID**
The internal data structure shall be targeted on the user of the data not primarily on the source.	The input part of the system shall translate the different formats of information to one standard to simplify the actual functionality of the system.	
The data structure shall minimize the reanalysis of data if other data is received. I.e. not shift data, avoid changing data for all stored locations if a new LRBG is detected, etc.	By avoiding peaks in the processor load when BG's are detected and/or messages are received, the system will become more predictable.	
All data in the data structure shall be accessible without searching, i.e. pointer structure shall make searching superfluous.	As all necessary entries are known, this can be realized and will safe (unpredictable) processor time.	
All data types shall be based on a limited number of standard data types. *(for now)*: Boolean, word, integer, double, text	Eases the validation	
No redundant data shall be stored.	Storing the same information more than once can lead to mistakes, requires more memory and more attention when updating data. *E.g. the accuracy of locations depends only on the BG which has sent the information plus linking and odometer information. The accuracy shall therefore be stored in the structure describing the BG.*	
Similar data shall be stored in similar structures.	e.g. a lot of data is location based. This shall not be stored partially incremental and partially from one reference. All distances in the same, all locations..., all times..., all speeds,.. etc.	
Memory is not dynamically allocated. For each type the maximum number of instances shall be determined. This number can be created at start-up	Dynamic allocation of memory increases the number of states and therefore the validation effort.	

3 Information per variable category

3.1 List of BG's

Location based information is always sent to the ETCS on-board in reference to a BG. Because the accuracy of the positioning of BG's differs, also the accuracy with which a location is known can depend on the BG which was originally sending the location based information (further called “original reference BG” for the location). In case linking information is available, the accuracy can change to the positioning accuracy of another BG which might be better or worse. In the latter case a better accuracy (and thus a further minimum safe location) can be achieved using measured distances in stead of linking distances between BG's.
Therefore announced and already passed BG's shall be known on-board.

The main function of the list of BG's is to provide the information needed to calculate the distance between the LRBG and all “locations” given in relation to any BG.

The data structure to store the BG's (announced and already passed) shall support the following functions:

- Receiving, replacing and storing linking information, i.e. announcing BG's or receiving linking information for BG's in rear of the train.
    - Replacing linking information if new linking information is received.
    - Updating linking information if linking information is sent in relation to a BG in advance of the train.
    - Updating linking information if linking information is sent for BG's in rear of the train.
- Updating information if a BG is detected
    - Determine if a BG is the next expected or a BG announced more in advance.
    - check linking information
    - if one announced BG is missed “overpass” the data structure containing the information of the missed BG.
    - Calculate the distance from all BG's in the list of BG's to the LRBG.
    - Determine which BG is the expected BG.
    - Calculate the expectation window in relation to the LRBG, i.e. the location accuracy of the “location” of the expected BG
    - Storing measured distance plus inaccuracies in distance measurement when a BG is detected.
- Assigning the direction if a passing direction (coordinate system) is assigned by the RBC.
- Calculating the distance including inaccuracies between each stored BG and the LRBG using linking information (as far as available and more accurate than measured distances) and measured

distance if necessary (e.g. in case of “linking holes”, missing linking information and unlinked BG's).

- Give the inaccuracy for a location with a specific “original reference BG”.
  The distance between the “original reference BG” and the LRBG plus the inaccuracy for locations referring to the “original reference BG” define the minimum safe, the nominal and the maximum safe distance between the LRBG and the location:
- Calculating the minimum safe, the nominal and the maximum safe distance between locations with a specific “original reference BG” and the LRBG.
- Determine if the “BG information” for a specific BG may be deleted from memory, i.e. if all locations with as “original reference BG” the specific BG have been passed with a distance more than T.B.D.
  In level 2/3 information concerning a linked BG shall never be deleted if not the information of at least eight linked BG's reported to the RBC remain available on board (because the RBC may sent location related information referring to one of the last eight reported BG's).
- Sending position reports in reference to one and to two BG's
- Determine the distance between a “Location” and the LRBG
- **Update the list of BG's in case of BG's passed during reversing T.B.D.**

The “list of BG's” shall support a type “location” to be always available in relation to the LRBG without further calculations, thus supporting all profile and location data as “gradients”, “speed profiles”, “static speed restrictions”

Locations shall be stored in reference to the BG which was used as a reference for the message in which the location based information was received (the “original reference BG) because:

- (New) linking information for BG's may be received after the BG's were detected. In that case the distance between the “original reference BG” and the LRBG can change. The distance between the Location and the LRBG will than change, thus the information which BG was the “original reference BG” shall be stored.
- To avoid the necessity of recalculating the distance for every stored location whenever a BG is becoming (new) LRBG, the link to the “original reference BG” shall be kept.
- As the inaccuracy for all locations with the same “original reference BG” is equal, this inaccuracy can be stored with the information concerning the BG to avoid redundant information. (also valid for unlinked BG's!)

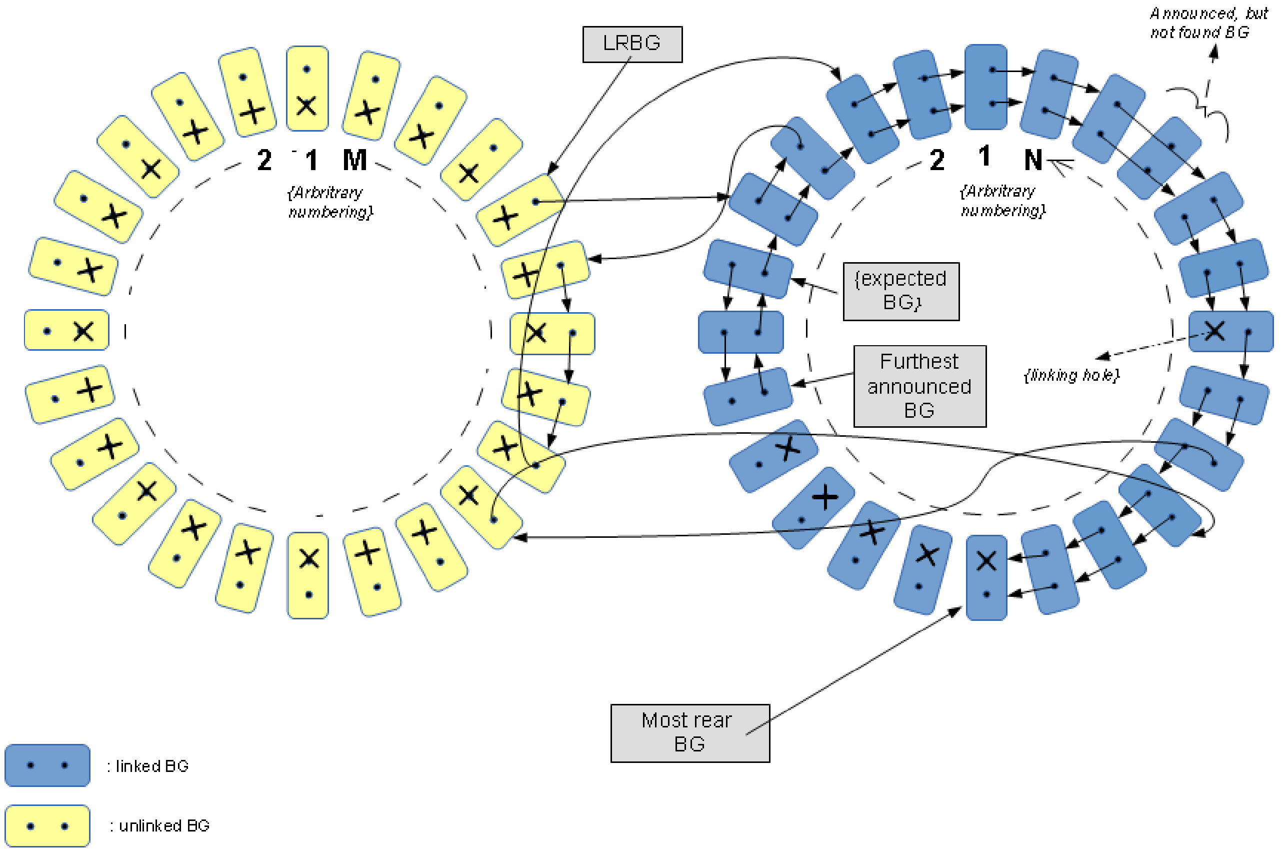
The maximum number of stored BG is to be determined.

Summarizing the structure in which BG's are stored shall support the calculation of the distance to the LRBG using linking information and using measured distance. Therefore a “chain” has to be provided able to store announced and linked BG's and unlinked BG's.

As linked BG which are not announced while other BG's are announced (in the SRS language: “linking information is used on board”) no linked BG's can be detected between already detected BG's and announced but not yet detected BG's. Therefore announced and already detected linked BG's can be stored in one list without having to insert new BG's inbetween.

Unlinked BG can be detected between already detected BG's and announced BG's. To avoid shifting data

unlinked BG's will be stored in a separate structure, coupled to the linked BG's by references to array positions (“functional pointers”, not being a standard “pointer type”, but being a “word type”).
The resulting structure is show below:



Per passed BG the following information shall be stored:

- The inaccuracy of the positioning of the BG: ***LOC_ACC***
- A link to the previous linked BG.
- The linking distance from the “previous linked BG in the chain”.
  If the BG is a repositioning BG this information can not be used, causing a “linking hole”
- A link to the previous BG, if any (this might be the previous linked BG but can also be an unlinked BG).
- The measured absolute position (an absolute position from the odometer of the distance traveled since start up) at which the BG was detected.
- The measured distance from the previous BG, including:
  - The maximum overestimation of the measured distance from the previous BG.
  - The maximum underestimation of the measured distance from the previous BG.
- The passing direction (can be unknown in case of the BG being a single BG)
- The linking reaction
- Information if the BG is linked and can thus be used in communication to the RBC.
- Information if the BG is a “repositioning BG” for which the linking distance is not exact.

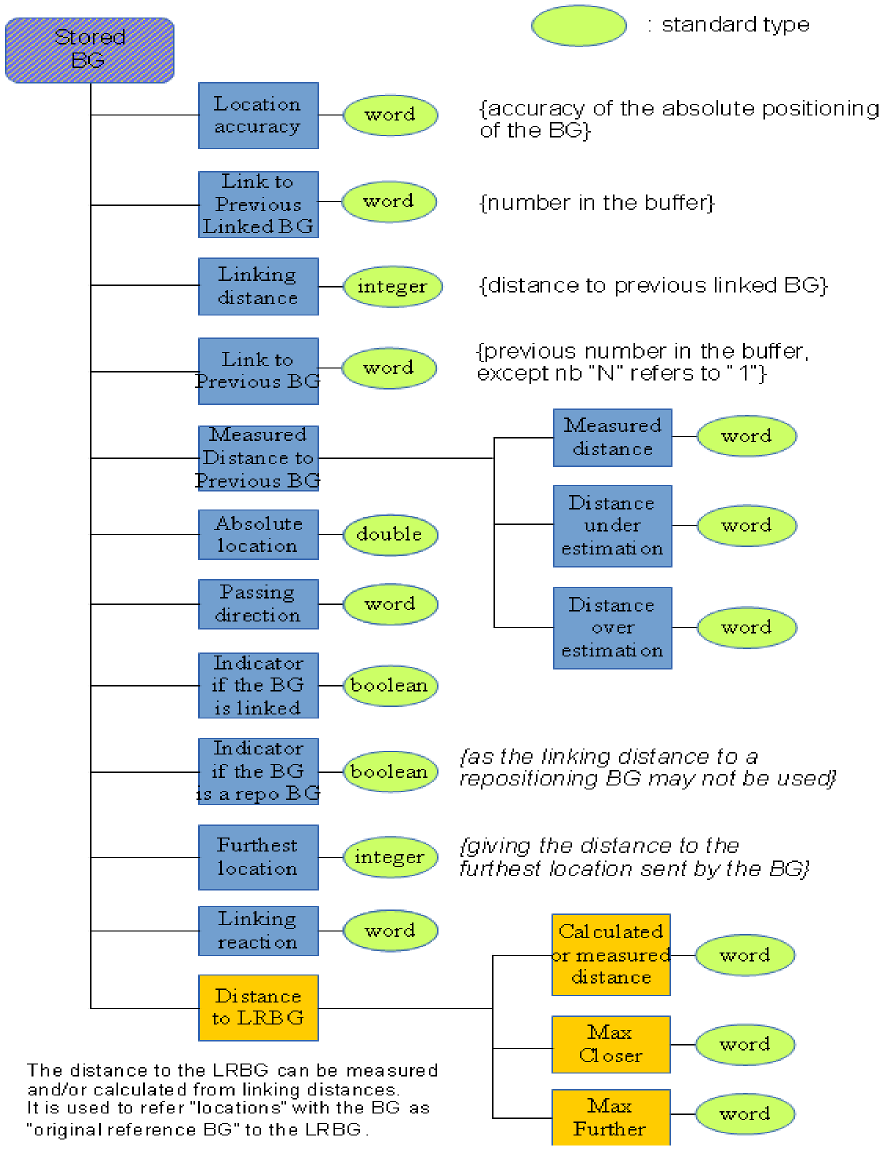
- Distance to the furthest location given by the BG: to determine if all locations given by the BG are passed, thus the BG can be deleted? (unless there are less than 8 linked BG's in memory)

The distance to the LRBG shall be calculated from linking and measured distances (minimizing the maximum safe distance).

Per announced, but not yet passed BG the following information shall be stored:

- The inaccuracy of the positioning of the BG: ***LOC_ACC***
- A link to the previous linked BG (the next one in rear), if any.
- The linking distance from the “previous linked BG in the chain”.
  If the BG is a repostitioning BG this information can not be used, causing a “linking hole”
- A link to the next linked BG (the next one in advance), if any.
- The announced passing directional
- The linking reaction
- Information if the BG is linked and can thus be used in communication to the RBC.
- Information if the BG is a “repositioning BG” for which the linking distance is not exact.
- Distance to the furthest location given by the BG: to determine if all locations given by the BG are passed, thus the BG can be deleted? (unless there are less than 8 linked BG's in memory)

The data structure per BG is shown below:


Stored BG
: standard type
Location accuracy
word
{accuracy of the absolute positioning of the BG}
Link to Previous Linked BG
word
{number in the buffer}
Linking distance
integer
{distance to previous linked BG}
Link to Previous BG
word
{previous number in the buffer, except nb "N" refers to " 1"}
Measured Distance to Previous BG
Measured distance
word
Distance under estimation
word
Distance over estimation
word
Absolute location
double
Passing direction
word
Indicator if the BG is linked
boolean
Indicator if the BG is a repo BG
boolean
{as the linking distance to a repositioning BG may not be used}
Furthest location
integer
{giving the distance to the furthest location sent by the BG}
Linking reaction
word
Distance to LRBG
Calculated or measured distance
word
Max Closer
word
Max Further
word

The distance to the LRBG can be measured and/or calculated from linking distances. It is used to refer "locations" with the BG as "original reference BG" to the LRBG .

Below it is explained how the data structure supports the functions described above.

3.1.1 Receiving, replacing and storing linking information

When new linking information is received, the linking information shall be stored in the datastructures from the LRBG (or in case of infill information from the reference location of the infill information) onwards in the (cyclic array), i.e. linking information received in rear of the LRBG shall only be stored in case no linking information was available. (ss26, 3.7.3.1.m/n).

Strategy for storing linking information in the proposed data structure once received:

- Find the reference BG: this can be a BG up to 7 linked BG's in rear of the LRBG), or in case of infill information, a BG in advance of the LRBG.

  What if no linking information is available for the infill reference BG in advance of the LRBG (i.e. the infill reference BG is not stored in the list of BG's as an announced BG)??? **assumption:** the infill reference BG in advance of the LRBG for which no linking is available to the previous BG, is stored with an unknown linking distance to the previous BG.

- For linked BG's in advance of the reference BG but in rear of the LRBG it is checked if linking information is missing, and if so if linking information is available in the new message.
- From the LRBG onwards the information is stored in the data structure for BG's,
  the “pointer” to the “expected BG” is set to the first BG in advance of the LRBG,
  and the “pointer” to the “furthest announce BG” is set to the last stored BG information.
- Per BG the linking distance (D_LINK) is stored as the distance to the previous linked BG.
- Per BG the linking reaction and the announced passing direction are stored.
- If linking information for BG's in rear of the LRBG is stored, the distances from BG's in rear of the LRBG to the LRBG is calculated for linking distances and measured distances.
- Linking distances from the LRBG to the announced BG's are calculated.

3.1.2 Detecting a BG

Xx

3.1.3 Assigning passing direction (when given by the RBC)

Xx

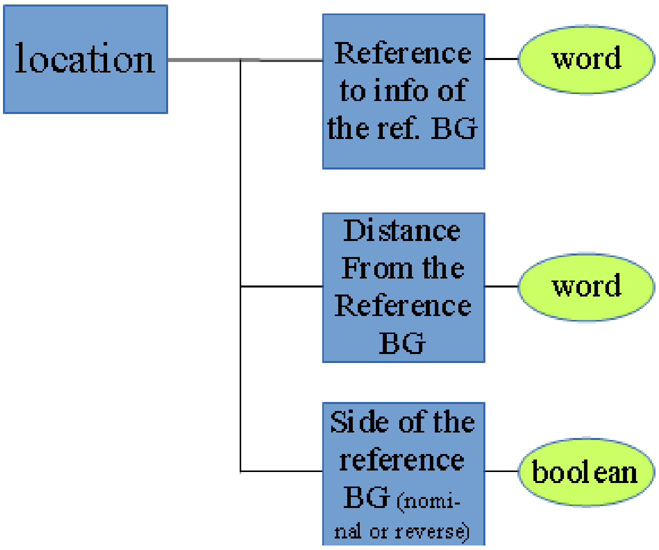
3.1.4 xxxx

Xx

3.1.5 determine a the distance between a location and the LRBG

Xx

data structure for a location:


location
Reference to info of the ref. BG
word
Distance From the Reference BG
word
Side of the reference BG (nominal or reverse)
boolean

Functions related to “location”:

- Store a location
- Delete a location
- Give distance from LRBG
- Give the negative tolerance on the distance from the LRBG
- Give the positive tolerance on the distance from the LRBG
- Give direction i.r.t. the LRBG

3.2 Movement authority (MA)

For speed and distance supervision the allowed distance to run shall be clear. This information is given, on request of the on board unit, in pieces which can all have their specific time out values. The parameters defining when an MA shall be requested by the OBU, and the structure to store the MA are part of the internal data structure.

The data structure storing the MA-request parameters shall be able to contain the following information:

- Time repeating the MA request, i.e. *an MA shall be requested if the time elapsed since the last MA request reaches this value.*
- Time, before reaching the indication point, at which an MA request shall be sent.
- Time, before any MA-timer elapses, at which an MA request shall be sent

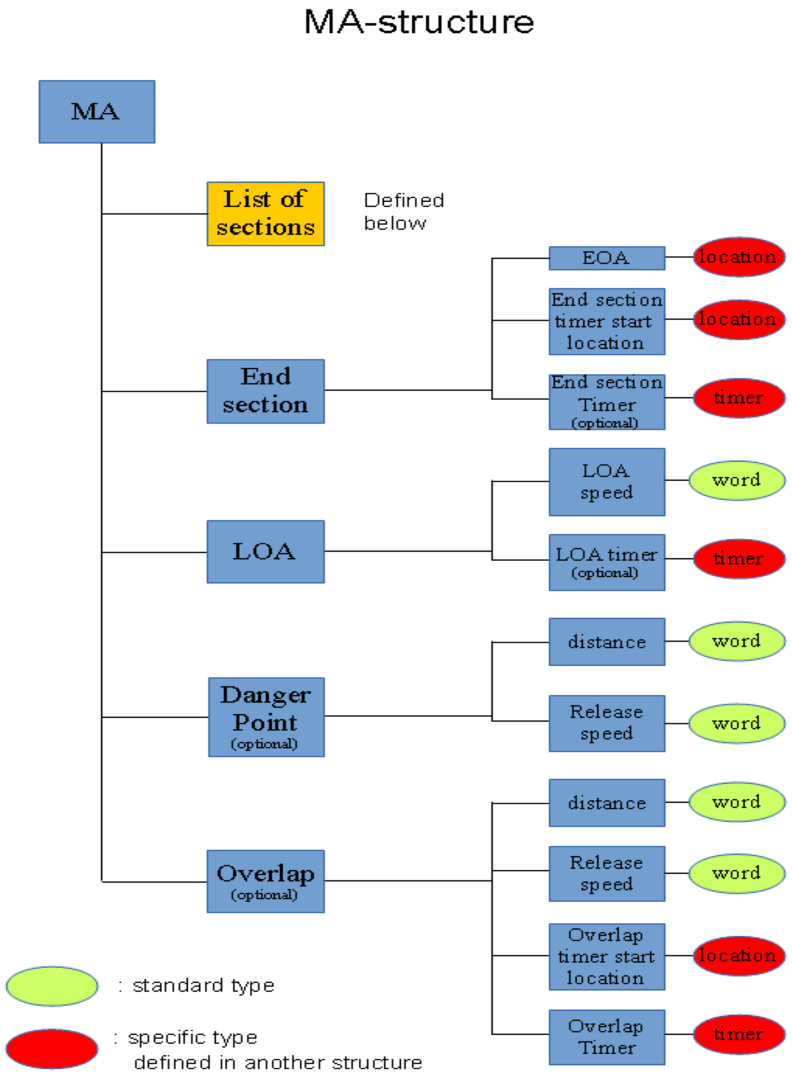
The data structure storing the MA shall be able to contain the following information:

- A number of sections with their starting location (i.r.t. the LRBG), a timer stop location and a timer.
- End section information: the length of the end section including the length, an end section timer start location and an end section timer.
- A limit of authority speed plus timer related to this speed (LOA timer)
- A danger point including the related release speed.
- An overlap including overlap timer a start location for the overlap timer and a with the overlap related release speed.

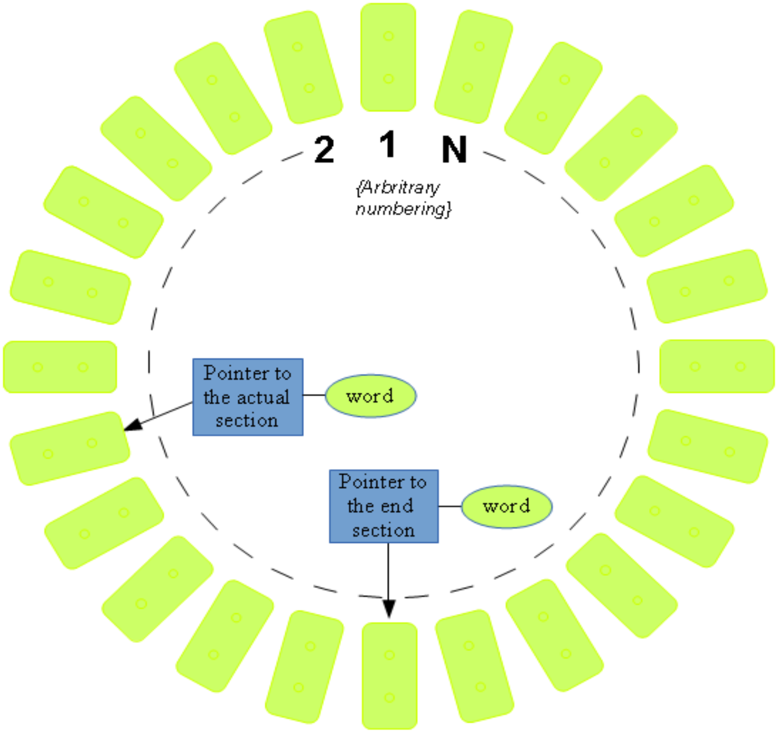
The above data structure shall enable the following functions:

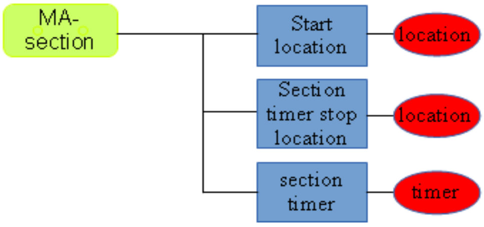
- xxxxxxxxxx

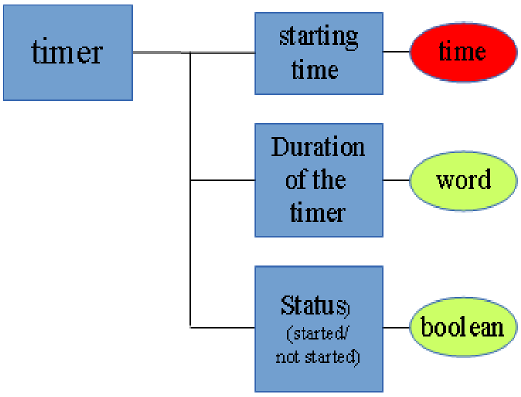
A graphical representation of the “MA-structure” is given at the next pages:



List of MA-sections







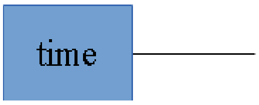
Functions related to "timer":

- Start a timer
- Update a timer (new duration)
- Give status
- Give information (ended/not ended) in response on current time

Figure xxxx: TIMER

A timer can be:

- started
- updated (set a new duration)
- ended (time-"starting time" > duration)
- removed



3.3 Speed profile

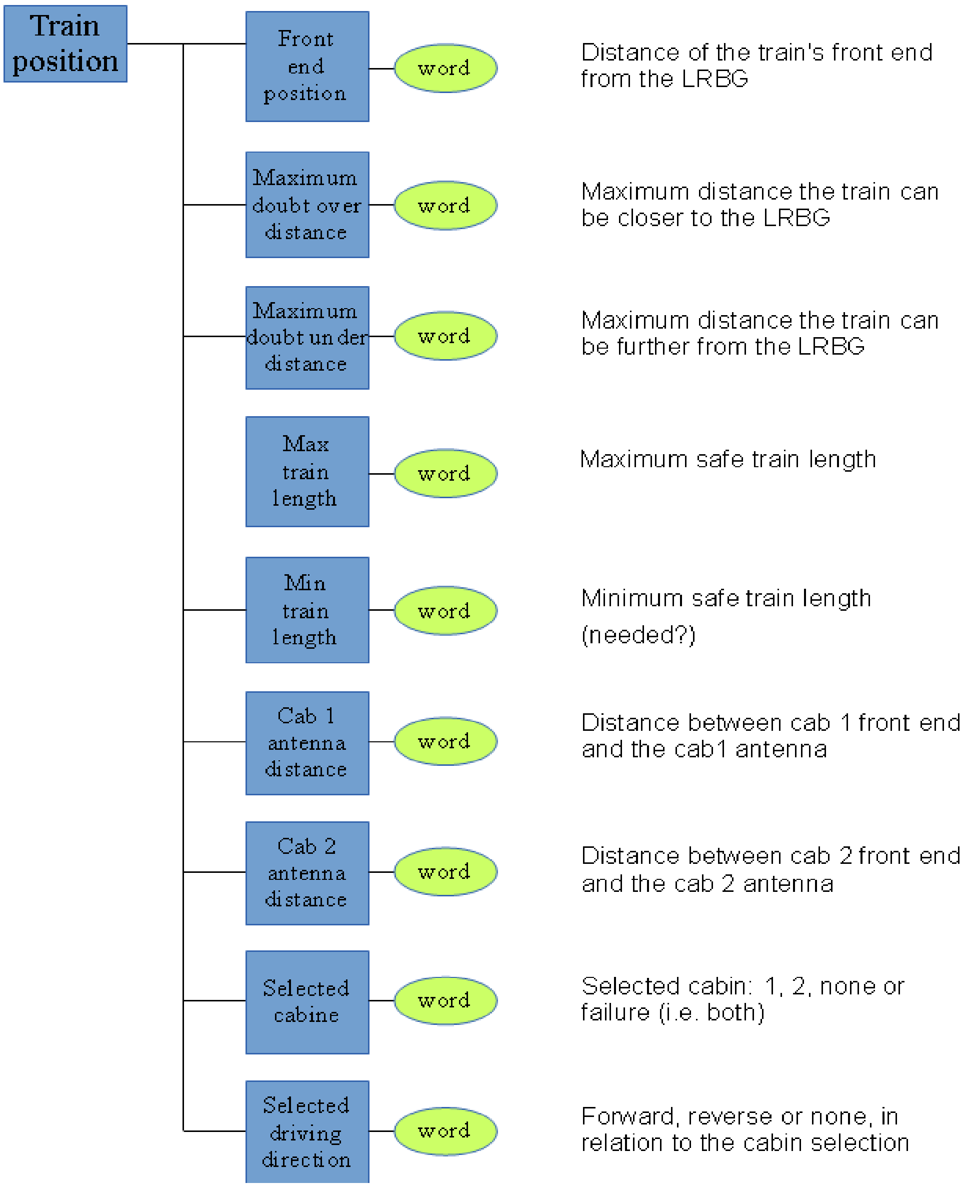
3.4 Gradients

3.5 Route suitability data

3.6 Anounced transitions

3.7 Train position

The train position shall be defined as a distance from the LRBG. The position of the LRBG has an inaccu


Train position
Front end position
word
Distance of the train's front end from the LRBG
Maximum doubt over distance
word
Maximum distance the train can be closer to the LRBG
Maximum doubt under distance
word
Maximum distance the train can be further from the LRBG
Max train length
word
Maximum safe train length
Min train length
word
Minimum safe train length (needed?)
Cab 1 antenna distance
word
Distance between cab 1 front end and the cab1 antenna
Cab 2 antenna distance
word
Distance between cab 2 front end and the cab 2 antenna
Selected cabine
word
Selected cabin: 1, 2, none or failure (i.e. both)
Selected driving direction
word
Forward, reverse or none, in relation to the cabin selection

Functions related to “Train position” (the postion is always given as an exact distance from the LRBG, the inaccuracy of BG locations is considered in the calculation of “locations”):

- Give the nominal front end distance from the LRBG (integer)
- Give the minimum safe front end distance from the LRBG (integer)
- Give the maximum safe front end distance from the LRBG (integer)
- Give the nominal rear end distance from the LRBG (integer)

- Give the minimum safe rear end distance from the LRBG (integer)
- Give the maximum safe rear end distance from the LRBG (integer)
- Give the nominal antenna distance from the LRBG (integer)
- Give the minimum safe antenna distance from the LRBG (integer)
- Give the maximum safe antenna distance from the LRBG (integer)
- Reset the distance between the nominal front end of the train and the LRBG to the distance between the antenna and the safe front end, at the time and position of the detection of a new LRBG. (for the selected cabin)
    - positive if the train orientation (not the driving direction!) corresponds to the nominal direction of the BG.
    - Negative if the train orientation (not the driving direction!) corresponds to the reverse direction of the BG
- Reset the inaccuracy of the measured distance from the LRBG to the reading inaccuracy of a BG
- Update the distance between LRBG and the trains front end (nominal) with the distance driven during the last cycle (positive if the driving direction is corresponding to the nominal direction of the BG, negative if the driving direction is corresponding to the reverse direction of the BG)
- Increase the inaccuracy of the measured distance from the LRBG if new distance information is received from the odometer
- is the inaccuracy given by the odometer as additional inaccuracy every cycle or as absolute inaccuracy since detecting the last BG????
- Set train dependant information: max/min train length, and antenna – front end distances
- inputs: train dependant parameters
- Change cab selection and/or driving direction
- inputs: operators from the TIU

3.8 Train characteristics

3.9 DMI parameters

3.10 Brake system model

3.11 DMI mirror

3.12 Procedure status

3.13 List of BG (SR and SH)

3.14 Mode and level status

3.15 RBC contact status

3.16 STM status

xxxxxxxx

4 Variables

4.1 Movement authority

Name	Definition
T_Text	*T_Definition*
8.1_1	"Parameters defining the conditions for requesting an MA"
internal_T_CYCRQST	Time repeating the MA request, i.e. *an MA shall be requested if the time elapsed since the last MA request reaches this value.*
internal_T_MAR	Time, before reaching the indication point, at which an MA request shall be sent.
internal_T_TIMEOUTRQST	Time, before any MA-timer elapses, at which an MA request shall be sent
XXX	Level 2/3 transistion information
	Marker, indicating that a level 2/3 transition has been announced
	Marker, indicating that an MA has been requested (for the level 2/3 transition)
	Marker indicating that radio communication to the RBC responsible after the transition to level 2/3 has been established.
XXX	
	Start of Mission status xxxxxxxxxx
8.2_1	MA request information
	Marker indicating that an MA shall be requested
	Indicator defining the reason for requesting an MA (3.8.2.8, 7.5.1.118.3)
8.2_2	"MA request timer" (up counter), maximum value: XXXXXXX
	"Running time" (special value for "infinite")
	"Status": "started" or "not started"
8.3_1	MA structure: one variable
	The number of sections in the MA (default 0, maximum including the end section: 34)
	Sections as defined in 8.3_3
	End section information (additional information concerning the furthest MA section): • An "end section timer start location" (related to the LRBG) (default: infinite) • An "end section timer" (see 8.3_4) • Limit of authority speed. (default: 0) • A Limit of authority "(LOA) timer (see 8.3_2) • Danger point distance: distance beyond EOA to the danger point ("0" if not available) (default: 0) • The release speed related to the danger point. (default: 0) • Overlap distance: the distance beyond the EOA to the end of the overlap (default: 0) • The release speed related to the overlap. (default: 0) • The overlap timer start location (related to the LRBG) (default: infinite) • An "overlap timer" (see 8.3_4)
	The signalling related maximum speed (only applicable in level 1)
8.3_2	General MA-timer (down counter)
	"Remaining time" (special value for "infinite") (default: infinite)
	"Status": "started" or "not started" (default: not started)
	"Status": "started" or "not started" (default: not started)
8.3_3	An MA section
	The "starting location of the section" related to the LRBG.
	The "length of the section"
	The "sender of the MA": level1 device or RBC identity
	A "section timer" (as defined in 8.3_2)
8.3_4	General MA-timer (up counter)
	"Counted time" (default: 0)
	"End time" (special value for "infinite") (default: infinite)
	"Status": "started" or "not started" (default: not started)