D4.3 System Requirements Specification (SRS)

for the development of an STM ATB

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1 Preface

Text, STMA-21198 - In the current document the requirements concerning an STM ATB are defined. The STM ATB shall, together with the ETCS on-board equipment, perform the ATBEG and ATBVv functions.
ATBEG is a function which was introduced at the Dutch Railway network in the late 1960's to enhance safety after an accident in 1962. The way-side part of the system is an addition to the "75 Hz track circuits" used for train detection. Those "75 Hz track circuits" (with a length between 50 and 1200 m) cover almost the complete network. To communicate the maximum speed at the next signal, the 75 Hz current of the track circuits is "amplitude modulated". The modulation frequency codes the maximum speed (at the next signal). On-board of the trains equipment is installed capable of detecting the 75 Hz currents in the rails and decoding the "track signal". The on-board shall calculate the maximum speed based on the "track signal". The track signal gives the minimum of the maximum speeds at the previous and the next line side signal.
If the train exceeds the maximum speed retrieved from the ATBEG code while the driver is not braking (during a situation depending time) then the ATB on-board shall apply the brakes.
The relation between the maximum speed and the ATBEG code is fixed. However alternative values are mentioned in the RIS (regeling indienststelling spoorvoertuigen), and speed levels can be changed dynamically using ATBNG technology (ATBM+ mode). The same is possible using ETCS technology.
As the distance to the next signal is not known, the train will always be allowed by the ATBEG function to proceed at a certain speed (40 km/h), independent of the ATBEG code in the track. This has led to a number of incidents were a train passed a signal at danger at low speed (<40 km/h).
To protect trains against this danger a functionality (ATBVv) was developed (and meanwhile installed at the majority of the signals) to communicate the distance to a signal at danger (at 3 m, 30 m or 120 m), using an active (not fail-safe) EM signal near the rails.

A limited number of tracks is to be considered as ATBEG area, so ETCS will activate the STM ATB, but the track is not equipped with ATBEG equipment while the maximum speed exceeds 40 km/h. For these situations a special ATBEG state "buiten dienst" is implemented in the on-board systems. However it is expected that all tracks will be equipped with ATB or ETCS in the near future. Therefore the "buiten dienst" state will become obsolete. The STM ATB shall be prepared on removing the "buiten dienst" state using a configurable parameter (STMA-2858 - Q_BuitenDienst = enabled (on) Qualifier indicating that the "buiten dienst" func...)

The current document describes the requirements as assigned to the STM ATB from:

- STMA-10707 - D3.1 Requirements from Regeling Indienststelling Spoorvoertuigen 9/2016
- STMA-6553 - D3.2 ATBvv requirements v11
- STMA-10239 - D3.4 Additional User Requirements

Requirement, STMA-14417 - In addition to the requirements listed in this SRS, the STM ATB shall comply with the following requirements:

- STMA-7149 - D4.1 Interface Requirements Specification (IRS)
- The standards concerning the profibus interface to ETCS on-board:
  - STMA-10814 - D4.7.4 Specific Transmission Module (SS035 v3.2.0)
  - STMA-11331 - D4.7.2 STM FFFIS Safe Time Layer (SS056 v3.0.0)
  - STMA-11326 - D4.7.1 STM FFFIS Safe Link Layer (SS057 v3.1.0)
  - STMA-10810 - D4.7.3 STM FFFIS Application Layer (SS058 v3.2.0)
  - STMA-7262 - D4.7.5 Performance requirements (SS059 v3.1.0)
- STMA-8548 - D4.5 Environmental Requirement Specification (ERS)

Text, STMA-21199 - Documents to be referred to are defined in STMA-10318 - P6.1 Bibliography
Definitions and abbreviations are defined in STMA-8254 - P6.2 List of abbreviations, definitions and terms

The STM shall interface with an ETCS on-board system (via Profibus) and some additional peripherals such as ATBEG

antenna's, a sound generator, circuits providing brake (sufficiently) applied information and an EB feed-back (via parallel interfaces).

Details concerning the interfaces are given in STMA-7149 - D4.1 Interface Requirements Specification (IRS) .

Text, STMA-28793 - Required legal standards and norms applicable to the STM ATB project and product are listed in document D3.0 Legal framework standards and norms

Text, STMA-43144 - THIS DOCUMENT CONTAINS REQUIREMENTS WHICH REQUIRE ADDITIONAL TRACK TO TRAIN INFORMATION TO BE COMMUNICATED USING A PACKET-44 (SS026) AND PACKET-STM45 (SS058).
THOSE FUNCTIONS SHALL NOT BE IMPLEMENTED IN THE STM ATB, THE CONCERNING REQUIREMENTS ARE MARKED AS RED TEXT.

2 Digital and analogue interfaces

Text, STMA-2186 - Parallel interfaces of the STM ATB are:

- Power supply
- Antenna signals: analogue signals containing the ATBEG+Vv track signal
- Digital input signals to detect if the driver is operating the brakes: "brake handle applied", "brakes sufficiently operated" (BHA and BSO)
- Analogue signal to detect if the driver is operating the brakes: "brake pipe pressure signal".
- Digital outputs for controlling the sound generator.
- A Profibus interface to the ETCS on-board system.

2.1 Determine the ATBEG and ATBVv track signals

Text, STMA-21519 - The STM ATB shall read the track signals as measured using "ATB coils" (also called "ATB antenna's") EM coupled with the rails via the "coil inputs" (also called "antenna inputs"). The "ATB coils" are not in the scope of the STM ATB as described in this specification.
If the STM ATB state (chapter 3.1, STMA-7147 - STM ATB state) is different from "inactive" then the STM ATB shall determine the ATBEG track signal according to chapter 10, STMA-7132 - ATBEG decoding and the ATBVv track signal according to chapter 11, STMA-7134 - ATBVv decoding
This is detailed in requirements in the chapters concerning the STM ATB states "preparing" and "responsible".

2.2 Determine brake operation by the driver

Text, STMA-21520 - It shall be determined if the driver operates the brakes from available inputs. The input information differs for existing rolling stock, depending on the ATB equipment which was previously installed. Variants are:

- A (redundant) digital signal if the driver operates the brakes.
- A (redundant) digital signal if the brake pipe pressure has dropped enough.
- Analogue signals representing the brake pipe pressure.

Combinations of the above are also possible.
The STM ATB shall be able to determine if the brakes are operated from the available input signals without requiring configuration information. If no valid information of a specific type is available, the concerning information shall be ignored.

Requirement, STMA-2761 -
The STM ATB shall determine if the driver is operating the brakes sufficiently enough to avoid an emergency brake (EB)

command due to overspeed:

If

(

- the input "BrakeHandleApplied" indicates that the driver is applying the brake or
- the input "BrakeHandleApplied" indicated a start of brake operation by the driver less than 2 s ago,
  (note: the consequence is that a pulse < 2 s will be extended to 2 s)

)

or

the input "BrakesOperatedSufficiently" indicate that the brakes are operated

or

the brake pipe pressure input gives a pressure value below a predefined threshold

then the STM ATB shall assume the brakes are operated by the driver ("DriverOperatesBrakes" is true)

else the STM ATB shall assume the brakes are not operated by the driver ("DriverOperatesBrakes" is false)

note: measures shall be taken to reduce the influence of short disturbances in the input signals.

Requirement, STMA-3301 -

If the redundant (with inverse meaning) inputs "BrakeHandleApplied" provide contradictionary information (a fault as defined in STMA-10024) **then**

the STM ATB shall take measures to ensure safety.

Requirement, STMA-3304 -

If the redundant (with inverse meaning) inputs "BrakesOperatedSufficiently" provide contradictionary information (a fault as defined in STMA-10024) **then**

the STM ATB shall take measures to ensure safety.

Requirement, STMA-7821 -

If the brake pipe pressure inputs give different information (taking into account a difference due to inaccuracies < 0.2 bar) **then** the STM ATB shall take measures to ensure safety.

2.3 Check on the EB command

Text, STMA-21516 - The communication with the ETCS on-board is "event-driven", i.e. if no new information is available no message will be sent. Therefore losing a message containing an EB command at the profibus will result in not commanding the brakes. However if the connection between the BIU and the STM is lost, then the BIU shall command the brakes.

2.4 Send acoustical information

Text, STMA-21517 - Acoustical information (sound commands) will be sent via the Profibus. However according to the concerning requirements (STMA-7262 - D4.7.5 Performance requirements (SS059 v3.1.0)) and as experienced in previous implementations, it might not be possible to meet the timing requirements of the ATBEG function. Therefore in addition to sending the commands via the Profibus, sound information shall also be sent via parallel wiring:

Requirement, STMA-2764 - Sounds via parallel wiring
The STM shall provide the following sound information using digital outputs:
- "gong": close for 100ms
- "bell": closed as long as the signals shall be given

Requirement, STMA-14963 - The STM ATB shall translate the prescribed sounds ("rembel", "losbel", "gong", "BD-signal") into commands to a "bell" and a "gong".

3 Profibus interface

Text, STMA-21514 - Most of the STM needs (apart from coil signal which are considered to be internal interfaces) shall be received via the ETCS on-board using the standardized profibus interface between STM's and ETCS on-board systems:

Requirement, STMA-2765 -
The STM ATB shall exchange all necessary data (excluding coil signals) with the ETCS on-board equipment via a profibus connection according to ERA specifications (STMA-14417), with exception of:

- Optional: sound commands may in addition to the information via the profibus may be communicated via parallel wiring because of timing requirements.
  Thus: sound commands shall be sent via the profibus **and** via parallel wiring, depending on the equipment connected and installed in the cabin the one or the other is effective. However this choice is made outside the STM ATB

3.1 General requirements

Requirement, STMA-14946 -
If data is received which is not defined in subset058 or which is defined as "unknown" **then**
the STM ATB shall disconnect from the STM controller

Text, STMA-28337 - In this paragraph the data needed from the ETCS on-board and the use of the specific data are described.

Requirement, STMA-2679 - The STM ATB shall use the following information from the ETCS on-board:

- maximum train speed
- train length
- braking percentage of the train,
  The ETCS on-board shall provide this information. For the case the ETCS on-board doesn't provide the information, an analogue configuration input (STMA-6923) shall be available at the STM ATB to provide fixed train dependent information.
- the brake type of the train (R,P or G) is called "brake position" in subset058
- the brake build up time
- Adhesion information (slippery, yes/no) *(considered as configuration data as it configures the Vv braking curve)*
- the traction cut-off time
- ATBEG code speeds plus validity in distance (if the information is available via packet-44, equivalent of ATBM+ mode using ATBNG beacons)
- Distance to the next signal at danger (if the information is available via packet-44, equivalent of ATBVv beacon information)
- The delay in commanding the emergency brake (shall be less than 200ms)
- The maximum odometer cycle and delay in producing an odometer value (sum shall be less than 800ms)
- the selected cabin
- the selected driving direction in relation to the selected cabin
- The ETCS mode and level
- The availability of the emergency brake
- speed and distance information: "estimated speed", "maximum safe speed", "minimum safe speed", "estimated distance", "maximum distance"
- Button Events: message if an ATB button is pushed or released by the driver.
- Button Event: message if the ETCS override button is pushed or released by the driver.

3.2 Current train speed and distance

Text, STMA-21515 - The current train speed to be used by the STM ATB can not always be the nominal speed as received from the ETCS on-board. If the difference between "maximum safe speed" and "nominal speed" is too big, that would be unsafe.

Requirement, STMA-2766 -

The STM shall use the received speed information to calculate the "current train speed" which is regarded for the ATB function to be correct:

The "current train speed" shall be the maximum of:

- the "estimated speed" and
- the "maximum safe speed" (upper bound of the measured speed) multiplied by 0.98.

for definitions see subset058, packet STM-8 (STMA-2351)

Requirement, STMA-2190 -

The STM ATB shall use the received distance information whenever applicable (e.g. for ATBVv braking curve calculation, ATBVv release distance, for specific distance updated speed levels,.....)

3.3 Maximum speed per ATBEG code

Text, STMA-21518 - The local maximum speed to be guarded by the STM ATB depends on the code which is received at the concerning moment, and from the maximum speed coupled to that code. The maximum speeds are defined as defaults, however they could change due to:

- The maximum speed of the train: speed levels are limited to the maximum speed as received from the ETCS on-board
- The braking percentage and train type, as the maximum speed for a train on ATBEG lines is dependent on the braking percentage of the train. This can concern all speeds or only the lowest speed level. The latter can be used to limit the speed for very poorly braked trains.
- Information received from track side. Maximum speeds may be changed by a message from track side for a specified distance.

Requirement, STMA-2249 -

The guarded speed (= maximum speed a train is allowed to drive) shall depend on the ATBEG code and the train and location specific maximum speed per code

The STM ATB shall adapt the maximum speed per ATBEG code, every time new information is received, according to:

- the maximum train speed as received from the ETCS on-board
- the braking percentage as received from the ETCS on-board (or an alternative source).
- speed levels as received from the ETCS on-board via a packet STM-45

Requirement, STMA-2867 -

Speed levels shall be adaptable using packet STM-45 (STMA-13935) for a limited distance as specified in the packet.
Default values are specified in: STMA-2250, STMA-2251, STMA-2252, STMA-2253, STMA-2254 and STMA-2255
The minimum range is given between brackets (a wider range is allowed).

Definition, STMA-2250 - code96: 140 km/h (the range for this variable shall at least include: 140, 160 km/h)

Definition, STMA-2251 - code120: 130 km/h

Definition, STMA-2252 - code147: 80 km/h (the range for this variable shall at least include: 10, 80, 100, 160 km/h)

Definition, STMA-2253 - code180: 80 km/h

Definition, STMA-2254 - code220: 60 km/h

Definition, STMA-2255 - noCode: 40 km/h (the range for this variable shall at least include: 30 and 40 km/h)

Requirement, STMA-2809 -
The speed levels shall be limited to the maximum train speed as received from the ETCS on-board, and the maximum safe speed on in ATBEG area according to the braking percentage as received from the ETCS on-board.

Requirement, STMA-2865 -
If the braking percentage as received from the ETCS on-board is lower than "LowBrakingPercentage" **then** the lowest speed level (in case of "no code") shall be limited to 30 km/h.

Definition, STMA-10773 - LowBrakingPercentage: default: 0 % (configurable between 0 and 100 %).

3.4 ATBVv braking curve parameters

Text, STMA-21852 - ATBVv needs the maximum deceleration (A_max) and the delay time to build up brake power (T_a) to be used for the ATBVv braking curve. This information shall be retrieved from the data received from the ETCS on-board system.

Requirement, STMA-3286 -
The STM ATB shall calculate the maximum deceleration (A_max) and brake build up time (T_a) to be used in the ATBVv braking curve calculation from:

- train length
- brake percentage of the train
- the brake type
- brake build up time as received from the ETCS on-board (T_BRAKE_EMERGENCY, see ss058)
- Adhesion information
- traction cut off time

The calculation method shall be comparable with the methods used for ATBNG or ETCS (both are acceptable)

Definition, STMA-15109 - A_max:
The deceleration (negative for acceleration) of the train during "emergency braking" derived from the braking percentage as received from the ETCS on-board (ss058, M_BRAKE_PERCENTAGE_STM STMA-2333 - 7.2.13 Packet STM-176: Train data traction/brake parameters to STM Subset-035 Re...).
note: If M_BRAKE_PERCENTAGE_STM is not available another source shall be chosen

Definition, STMA-15110 - T_a
The brake build up time as received from the ETCS on-board (ss058, T_BRAKE_EMERGENCY STMA-2333 - 7.2.13 Packet STM-176: Train data traction/brake parameters to STM Subset-035 Re...).

3.5 Respond on performance parameters

Text, STMA-21853 - The performance requirements (communication delays) specified concerning the ETCS on-board (ss059, STMA-7262) are not strict enough to meet the ATBEG requirements. Taking into account the worst case (slowest allowed) values would lead to a reduction of the ATB performance or safety. Therefore a maximum delay time is specified for the communication of an EB command generated by the STM ATB, and for the communication of a speed value from the odometer to the STM (including the time needed to determine the speed). If the ETCS on-board provides the information that the maximum delay times are not met, then the STM ATB shall either not become active or take measures to ensure safety in a different manner.

Requirement, STMA-3291 -
If a message is received specifying the delay in commanding the EB by the ETCS system **then**
the STM ATB shall store the data and take measures to ensure safety (D4.6, STMA-2702)
(e.g. if the delay is too long, the STM ATB can decide to not accept the responsibility thus to deactivate the ATB functions).

Requirement, STMA-3292 - If a message is received specifying the delay in measuring and sending the current train speed **then**
the STM ATB shall store the data and take measures to ensure safety (D4.6, STMA-2763).

3.6 Storing status information

Text, STMA-21844 - The STM ATB needs to know which cabin is selected, because:

- Only the coils at that side of the train shall be used.
- For distance measurement

Further the information coming from track side (coils) shall be ignored if:

- The selected driving direction is "neutral" or "backward"
- The ETCS mode is different from "system national" (SN),
  This additional condition is necessary as the ETCS on-board might command the STM ATB to "data available" (DA) if the ETCS mode is "non-leading" or "sleeping".

The STM ATB shall not show cab signals in case the EB is not available. Showing the cab signals would give the impression that ATBEG protection is active. However if the STM ATB is not able to command the brakes, then the protection is not active.

Requirement, STMA-3294 - The following status information shall be derived from the ETCS on-board information:

- the selected cabin
- the selected driving direction in relation to the selected cabin
- the ETCS mode and level
- the availability of the EB

3.7 Button operation by the driver

Requirement, STMA-14423 -
The STM ATB shall use the status information concerning buttons (operated/not operated) received from the ETCS on-board equipment:

- A release ("ontgrendel") button to release an intervention, thus end the EB command.
- An "attentie" button; a button to show awareness when entering an ATBEG area (used to test the presence of the coils and the track side signal)
- A "buiten dienst" button; a button to switch manually to "buiten dienst" (ATBEG function not active while the STM ATB is in "data available" mode), if a train starts in an area not equipped with ATBEG

note: The override button is combined with the ETCS override button

STMA-10805, External Requirement - Only the ETCS override information may be used to switch the ATBVv override status on.
I.e. the ATBVv override status shall be switched based on if a packet STM-7 is received with Q_OVR_STATUS =1 is received (and the other conditions for the transition to ATBVv state "override" are fulfilled).

3.8 EB COMMAND to be sent to the ETCS onboard

Text, STMA-21845 - The STM ATB shall not have a direct connection to the "emergency brake" (EB). In case the EB shall be commanded by the STM ATB, this is done by sending an EB command to the ETCS on-board equipment.
As the mechanism to detect the loss of messages at the profibus can be slow, a feed-back and EB command resent mechanism shall be implemented.

Requirement, STMA-2205 -
In case of an ATBEG or ATBVv intervention the STM ATB shall send an EB command to the ETCS on-board

Requirement, STMA-2206 -
If an EB command has been sent to the ETCS on-board **and**
the input "ETCS EB command" doesn't indicate that the ETCS on-board commands the brake (i.e. ETCScommandsEB = false) within 400 ms
then
The STM ATB shall resent the EB command **and**
if the EB is still not commanded after 1 s the STM ATB shall disconnect from the BIU.

Requirement, STMA-2208 -
In case the ATBEG and/or ATBVv intervention is released, the STM ATB shall send an EB release command to the ETCS on-board

3.9 DMI information to be sent to the ETCS on-board

Text, STMA-21842 - The STM ATB shall not have an own DMI, except an optional sound generator in case the communication via the ETCS on-board is not fast enough. Therefore the STM ATB shall sent all DMI information via the Profibus to the ETCS on-board. The information shall be decoded and presented to the driver by the ETCS DMI.
The ERA ETCS specification (subset035 paragraph 13.5) offers the possibility to use standardized positions and icons or to define a customisable DMI. The STM ATB will use the possibility to use a customizable DMI. Therefore a "DMI configuration table" is provided, which defines the necessary identifiers for the DMI information:

- Indicators: IndicatorID, PositionID, size, IconID and text to be displayed at the icon.
- Buttons: ButtonID, PositionID, size, IconID and text to be displayed at the icon.
- Sounds: SoundID and .wav file specifying the sound.

Requirement, STMA-2719 -
The STM ATB shall code and send DMI information to the ETCS OBU according to the "DMI configuration table" as defined in STMA-8277 according to (STMA-10814 - D4.7.4 Specific Transmission Module (SS035 v3.2.0) "recapping table").
The DMI configuration table specifies:

- Per indicator (identified with an IndicatorID) the icons, icon positions and text formats on the icons as defined in ss058 packet STM-35
- Per button (identified with a buttonID) button positions and text formats on the buttons
- Per sounds (identified with a soundID) a .wav file (gong.wav, BD signal.wav, losbel.wav, bel.wav)

For both "soft key technology" and "touch screen technology"

Requirement, STMA-2713 -
The absolete time difference between sending the new cab signal (STMA-2842) and sending the "gong" (STMA-2240) to the ETCS on-board in case of a change of the "maximum speed level" (guard speed) shall be less than 20 ms.
(note: in practice this will imply that packet 46 (sounds) and packet 35 (cab signals) shall be contained in the same message).

4 DMI

Text, STMA-21843 - In this chapter requirements concerning the indicators, buttons and acoustical signals to be used for the ATB function are defined:

- the cab signal: six indicators to be coupled to specific cab signals.
- White lamp: indicator for the information "brake sufficiently operated by the driver".
- Red lamp: indicator for an intervention.
- Blue lamp: indicator for "out of ATBEG area" and for "ATBVv overruled".
- Buttons.
- Acoustical information.

All indicators and buttons shall be displayed at a fixed position:

Requirement, STMA-2233 - For the indicators fixed positions shall be used, i.e.:
• The “indicator_ID” as sent by the STM will always be equal to the “indicator position_ID”

Text, STMA-28338 - For buttonID's the numbers 1 to 4 shall be used, therefore the positionID's shall be different (as 1 to 4 are already used for the indicators).

Requirement, STMA-14965 - If the status of one or more of the optical indicators changes a message containing the information on all indicators shall be sent.

4.1 White lamp

Text, STMA-21849 - The white lamp is displayed if the ATBEG speed monitoring is active. The white lamp is "on" if the brake is operated by the driver and "off" if the brake is not operated by the driver. Icons shall be defined in the ETCS DMI for a white ("on") and a grey ("off") rectangle. The white lamp is displayed at a fixed position.
The white lamp is identified by:

- The position: fixed (positionID)

Definition, STMA-15058 - The status of the white lamp is defined by:

- The text: none
- The color (icon-ID, corresponding to "white-on" or "white-off")
- An attribute indicating if the white lamp shall be displayed (not if the ATBEG is not guarding the speed)

4.2 Red lamp

Text, STMA-21850 - The red lamp is displayed if the ATBEG speed monitoring is active. The red lamp is "on" if the brake is commanded by the STM ATB and "off" if the brake is not commanded by the STM ATB. Icons shall be defined in the ETCS DMI for a red ("on") and a dark red ("off") rectangle. The red lamp is displayed at a fixed position.
The red lamp is identified by:

- The position: fixed (positionID)

Definition, STMA-15059 - The status of the red lamp is defined by:

- The text: depending on the source of the EB command the text on if the lamp is "on" can be "EG" or "Vv"
  if the lamp is "off" no text will be displayed
- The color (icon-ID, corresponding to "red-on" or "red-off")

- An attribute indicating if the red lamp shall be displayed (not if the ATBEG is not guarding the speed)

4.3 Blue lamp

Text, STMA-21846 - The blue lamp is displayed if the ATBEG speed monitoring is active. The blue lamp is "on" if the brake is commanded by the STM ATB and "off" if the brake is not commanded by the STM ATB. Icons shall be defined in the ETCS DMI for a blue ("on") and a dark blue ("off") rectangle. The blue lamp is displayed at a fixed position.
The blue lamp is identified by:

- The position: fixed (positionID)

Definition, STMA-15057 - The status of the blue lamp is identified by:

- The text: depending on the reason to "turn the lamp on" the text on if the lamp is "on" can be "BD" or "Vv"
  if the lamp is "off" no text will be displayed
- The color (icon-ID, corresponding to "blue-on" or "blue-off")
- An attribute indicating if the blue lamp shall be displayed (not if the option to allow "buiten dienst mode" is turned off)

4.4 Cab signals

Text, STMA-21858 - Aspects of the cab signals are, the position, the color and the indicated speed at the cab signals to be displayed. Maximum 6 cab signals are foreseen. If there are less than 6 different speed levels (if two or more codes lead to the same speed level), the cab signals with the highest position indicator will not be displayed. Maximum one of the displayed cab signals can be "on" (light color) (the one with the speed level corresponding to the current ATBEG code) the others are "off" (dark color).
The cab signal coupled to the highest possible speed is green, the other cab signals are yellow. This is not relevant for the STM as the STM will only pass an "icon id" to the ETCS on-board. This "icon id" shall be coupled to a color in the ETCS DMI.
Cab signals are identified with:

- Their position (position ID)

Definition, STMA-15062 - The status of a cab signal is defined by:

- The text (indicated speed)
- Their color (icon-ID, corresponding to "green-on", "green-off", "yellow-on" or "yellow-off")
- An attribute indicating if the concerning cab signal shall be displayed.

Requirement, STMA-3283 -
If the maximum speed for any of the ATBEG codes changes due to a new received maximum train speed, braking percentage or speed levels per code (STMA-2249) **then**
The STM ATB shall update the color, indicated speed and position of the cab signals accordingly.

4.4.1 Position

Text, STMA-21859 - Cab signals are linked to the speed level (maximum speed) they indicate.
The maximum speed corresponding to an ATBEG code depends on the speed level defined for that code, and is limited to the maximum speed of the train (as given by the ETCS on-board), and to the maximum speed on ATBEG lines depending the braking percentage (according to the "remtabellen").
More than one ATBEG code can correspond to the same speed level, thus more than one ATBEG code can correspond to the same cab signal.

Which cab signal is corresponds to which ATBEG code is determined by the speeds corresponding to the ATBEG codes:

Requirement, STMA-2810 -

Codes corresponding to the same guarded speed shall be coupled to the same cab signal

Requirement, STMA-2805 -

The positionID (= indicatorID) for the indicators coupled to the cab signals shall be such that the ordering of the indicatorID's is from low ("1") to high (=< "6") for speed levels from low to high.

4.4.2 Color and attribute

Requirement, STMA-2231 -

If a cab signal corresponds to the highest allowed speed (lowest of the maximum ATBEG speed and the maximum train speed)

then

if the status of a cab signal is "on" **then** the STM ATB shall set the color of the indicator to "green_on"
if the status of a cab signal is "off" **then** the STM ATB shall set the color of the indicator to "green_off

i.e.:

The cab signal icons "green_off" and "green_on" shall be used for the concerning cab signal.

Requirement, STMA-2232 -

If a cab signal doesn't correspond to the highest allowed speed (lowest of the maximum ATBEG speed and the maximum train speed)
then
if the status of a cab signal is "on" **then** the STM ATB shall set the color of the indicator to "yellow_on"
if the status of a cab signal is "off" **then** the STM ATB shall set the color of the indicator to "yellow_off
i.e.:
The cab signal icons "yellow_off" and "yellow_on" shall be used for the concerning cab signal.

Requirement, STMA-3271 -
If the status of a cab signal is "not displayed" **then** the concerning attribute for the cab signal in the message to the DMI shall be "not displayed" (packet STM-35).

4.4.3 Text

Requirement, STMA-2234 - The maximum speed corresponding to each cab signal shall be sent to the ETCS on-board (in multiples of 10km/h) together with the cab signal information, according to the DMI configuration table.

4.5 Buttons

Text, STMA-28339 - Maximum three buttons shall be displayed to allow the driver to operate the system. Each button shall have it's own ButtonID. As the position of the buttons is fixed, the buttons shall also have a fixed positionID.

Requirement, STMA-15063 - The STM ATB shall use a fixed positionID for each button.

Buttons to be displayed are listed in STMA-14423

Requirement, STMA-3259 -

The status of the buttons can be "displayed" or "not displayed".

If the status of one or more of the buttons changes **then**

the STM ATB shall send a message to the ETCS on-board to update the status of all the buttons.

4.6 Acoustical information

Text, STMA-21856 - Acoustical information is sent via Profibus to the ETCS on-board and in parallel provided via digital outputs (galvanically isolated outputs). There are three digital output available: "gong" and "bel", plus one reserved output. Concerning the output via Profibus a difference is made between "one-stroke signals" and "continuous signals":

- as a response on triggering a one-stroke signal the ETCS on-board shall play a predefined x.wav once.
- as a response on starting the continuous signal "bel", the ETCS on-board shall start playing cyclically a predefined y.wav
- as a response on stopping the continuous signal "bel", the ETCS on-board shall stop a predefined y.wav and play a predefined z.wav (containing the damping of the sound).

SOUNDS via Profibus

The STM shall provide the following sound information to the DMI via Profibus:

- "gong", "losbel", BD signal: one stroke signal.

- "bell" continous signal (to be switched on and off).

Definition, STMA-2787 - "Trigger the gong" is defined as:
Close the digital output "gong" during 100 ms and
Send the acoustical information "gong" to the ETCS on-board according to the DMI configuration table

Definition, STMA-2788 - Trigger the "BD signal" is defined as
Close the digital output "gong" five times during 100 ms, at 800 ms intervals (between the starting moments, i.e. 800 ms including the 100 ms during which the output is closed),
i.e. output shall be closed from 0-100 ms, 800 ms-900 ms, 1600 ms-1700 ms, 2400 ms-2500 ms and 3200 ms-3300 ms after the trigger of the BD signal.
and
Send a message to trigger the "BD signal" to the ETCS on-board and according to the DMI configuration table.

Definition, STMA-2789 - Trigger the "losbel" is defined as:
Close the digital output "bell" three times during 300 ms, starting with 600 ms intervals between the start of the 300 ms pulse (i.e. 300 ms high, 300 ms low, etc.)
(if the state of the rembel changes to "on" during this 1.5 s, then the rembel prevails) and
Send a message to trigger the "losbel" to the ETCS on-board according to the DMI configuration table.

Definition, STMA-2790 - Start the "bel" is defined as:
Close the digital output "bell" and
Send a message to start the rembel to the ETCS on-board according to the DMI configuration table

Definition, STMA-2791 - Stop the "bel" is defined as:
Open the digital output "bell" and
Send a message to stop the rembel to the ETCS on-board according to the DMI configuration table

5 (de-)Activating the ATBEG and ATBVv function

Text, STMA-21857 - The ETCS on-board is controlling the activation of the connected STMs to enable smooth transitions between ETCS area and area's equipped with national systems, and between different national systems. For this purpose the ETCS on-board can command the equipment into three different states:

- Cold Standby (CS): inactive state, but ready to start.
- Hot Standby (HS): reading track signals, but not performing the function.
- Data Available (DA): active and responsible for train movements.

Before an STM is ready to start, it has to be configured with data to be received from the ETCS on-board. During start-up the following states are defined:

- Power on (PO): Logical connections with the ETCS on-board functions are set up.
- Configuration (CO): The STM receives all (remaining, if some data was already sent) configuration data available to the ETCS on-board (including data gathered via ETCS data entry).
- Data Entry (DE): The STM has the possibility to gather further data from the driver. The STM ATB shall not use this option.

STM states are defined in detail in STMA-10814 - D4.7.4 Specific Transmission Module (SS035 v3.2.0). ATB specific requirements are defined in paragraph STMA-7146 - STM state (according to ss035).

In ss035 an option is provided to command an STM into DA-state while the concerning equipment is not corresponding to the front end of the train (ETCS modes "non-leading" or "sleeping"). This is not useful for ATB, therefore the ATB function shall remain inactive when the ETCS on-board system is in the concerning modes. Therefore a second state machine is defined which is activating and de-activating the ATB function, the "STM ATB state".

The STM ATB state can be:

- Responsible: The STM state is "data available" and the current STM ATB is the one at the front of the train, i.e. the ETCS mode is "system national" (at least different from "sleeping" or "non-leading").
- Preparing: The STM state is "hot stand-by" and the current STM ATB is the one at the front of the train, i.e. the ETCS mode is "system national" (at least different from "sleeping" or "non-leading").
- Inactive: all other situations

This state machine for the STM ATB state is defined in paragraph STMA-7147 - STM ATB state.

When the ATB function is activated, i.e. the "STM ATB" state is responsible, then the ATBEG function and the ATBVv function shall be performed. The behavior of those functions depends on state machines specific for those functions. The ATBEG state machine is described in paragraph STMA-7140 - ATBEG states and the ATBVv state machine is described in paragraph STMA-7129 - ATBVv states

Summarizing, four different state machines shall be implemented for the STM ATB:

- The "STM state" according to ss035 (PO, CO, DE, CS, HS, DA), see ERA ss035, v3.0.0, 9.2
- The "STM ATB state": see below (inactive, preparing, responsible).
- The "ATBEG state": the state of the ATBEG function when the "STM ATB" state is responsible.
- The "ATBVv state": the state of the ATBVv function when the "STM ATB" state is responsible.

5.1 STM state (according to ss035)

Text, STMA-28340 - In addition to the requirements stated in ss035 the following requirements apply to the "STM states" and transitions:

Requirement, STMA-2179 - If the STM state is CO or DE and an order to CS is received, **or if** the STM state is CS, HS or DA and an order to go to another STM state (CS, HS or DA) is received **then**
The STM ATB shall change the STM state to the requested state **and**
The STM ATB shall adapt its behavior to the new state **and**
The STM ATB shall report the new state to the ETCS on-board
within 0.5.s after the the request was received.
note: 0.5 s is more restrictive compared to the RIS, however feasible and will allow shorter transition areas.

Requirement, STMA-2180 - If the STM state changes to HS **then**

The STM ATB shall report "STM max Speed" immediately (within 0.5 s) after HS is reported to the ETCS on-board.
The maximum value shall be the minimum of:

- "Maximum ATBEG Entry speed" (STMA-10846), **and**
- The maximum speed the specific train is allowed to run at ATBEG lines (depending on the maximum train speed and the brake parameters of the train).

The reported speed shall be based on the maximum train speed and the braking percentage.

Definition, STMA-10846 - Maximum ATBEG Entry speed = 140 km/h (range: 140 km/h, 160 km/h).

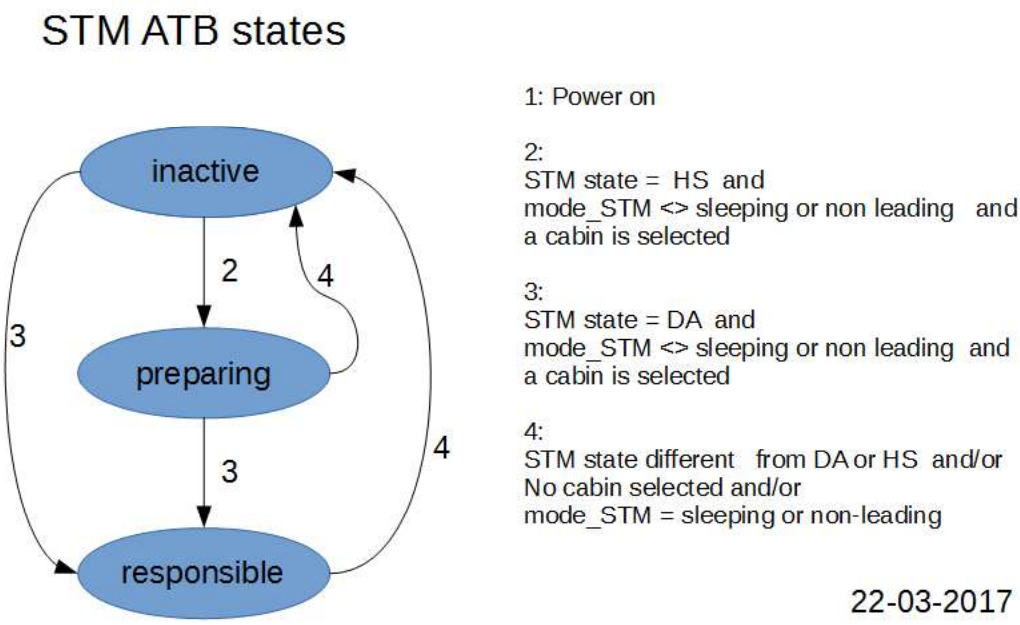
5.2 STM ATB state

Text, STMA-21854 - As described above the STM state determines if the ATBEG function and the ATBVv function shall be activated, depending on the STM state and the ETCS mode.

Definition, STMA-2824 - figure: STM ATB state machine
For he STM ATB three states plus"power off" (not shown below) are defined:

- Inactive: In the STM ATB state "Inactive" the STM ATB is not performing any function. In the STM ATB state "Inactive" the ATBEG and Vv functions are not active, therefore the ATBEG state and ATBVv states are "off"
- preparing: In the STM ATB state "preparing" the ATBEG and Vv decoding is active and ATBEG information (including cab signals corresponding to the ATBEG code) is sent to the ETCS on-board (which shall only display the information at the transition to STM state DA)
- responsible: In the STM ATB state "responsible", the STM ATB is fully responsible for the train movements. In this state the ATBEG state and ATBVv state will be different from "off"

Those states relate to the generic STM state and ETCS state as shown below:



Requirement, STMA-2675 -
The ATBEG function and the ATBVv function shall only be active in the STM state DA if the ETCS mode (mode_STM) is different from sleeping or non-leading. Therefore STM ATB states are defined:

- „Inactive“ in case the STM state (as commanded by the ETCS on-board) is different from „hot stand-by“ (HS) or „data available“ (DA),
  or
  if the ETCS mode is "sleeping" or "non leading".
  or
  if the EB is not available (according to information received from the ETCS on-board)
- „Preparing“ in case the STM state is HS and the ETCS mode is different from sleeping or non-leading
- „Responsible“ in case the STM state is DA and the ETCS mode is different from sleeping or non-leading

Text, STMA-21855 - The required behavior of the ATBEG function and the ATBVv is specified per STM ATB state in the next chapters.

6 Functions in the STM ATB state "inactive"

Text, STMA-21851 - The STM shall not guard the speed when the STM-state and/or ETCS-mode indicate that the STM is not responsible for guarding train movements and in case the EB is not available. This function is detailed in the requirements listed below in this document.
The following functions shall be performed in the STM ATB state "inactive":

Requirement, STMA-2198 -
If the "STM ATB state" is "inactive" **then** the EB is not commanded.

Requirement, STMA-3263 -
If the "STM ATB state" is "inactive" **then** the STM ATB shall set the status of the cab signals to "not displayed".

Requirement, STMA-3264 -
If the "STM ATB state" is "inactive" **then** the STM ATB shall set the status of the "WhiteLamp" to "not displayed".

Requirement, STMA-3274 -
If the "STM ATB state" is "inactive" **then** the STM ATB shall set the red lamp to "not displayed".

Requirement, STMA-14968 -
If the "STM ATB state" is "inactive" **then** the STM ATB shall set the blue lamp to "not displayed".

Requirement, STMA-3275 -
If the "STM ATB state" is "inactive" **then** the STM ATB shall set the status of the buttons to " not displayed".

7 Functions in the STM ATB state "preparing"

Text, STMA-21847 - In the STM ATB state "preparing" the STM ATB shall prepare for the switch to "responsible". I.e. the STM ATB shall start decoding the track signal (ATBEG and ATBVv) and prepare the optical DMI elements for the moment the transition to "responsible is made.
However the external behaviour of the STM ATB shall be equal to the behaviour in the state "inactive".

Requirement, STMA-2768 -
If the STM ATB state changes to "preparing" **then** the ATBEG + Vv decoder state variables and timers shall all be reset.

Requirement, STMA-3247 -
If the STM ATB state changes to "preparing" **then** D_STS shall be set to infinite.

Text, STMA-21848 - The following functions shall be performed in the STM ATB state "preparing":
In the STM ATB state "preparing" the STM ATB shall prepare for the switch to "responsible", i.e.
The STM ATB shall start decoding the track signal and prepare the optical DMI elements for the moment the transition to "responsible is made.

However the external behaviour of the STM ATB shall be equal to the behaviour in the state "inactive".

Requirement, STMA-3240 -

If the "STM ATB state" is "preparing" **then** the STM ATB shall calculate the "ATBEG code" as described in chapter STMA-7132 - ATBEG decoding

Requirement, STMA-3244 -

If the "STM ATB state" is "preparing" **then** the STM ATB shall calculate the "ATBVv code" as described in chapter STMA-7134 - ATBVv decoding

Requirement, STMA-3246 - If the STM ATB state is "preparing" **then** the ATBVv function shall determine the distance to a possible STS, i.e.

- read beacons and loops (including ATBEG signals resetting the distance to the STS, and Vv signals sent via ETCS packet 44, **STMA-13937)** , unless the "ETCS overridden status" (STMA-2325) has been set **and**
- update the distance according to distance travelled:
  - decrease in case of driving forward in relation to the selected cabin
  - increase in case of driving backward in relation to the selected cabin

Thus if an ATBVv track signal is received during preparing then the state responsible may be entered directly with ATBVv state "braking curve monitoring"

Requirement, STMA-3276 -

If the "STM ATB state" is "preparing" **then** the EB is not commanded.

Requirement, STMA-3250 -

If the "STM ATB state" is "preparing" **then** the status of the cab signals shall be determined as follows:
If the "EB is available" (information received from ETCS)
then
the STM ATB shall set the cab signal corresponding to the currently guarded speed equal to "on" **and**
the STM ATB shall set the other cab signals equal to "off"
else
the STM ATB shall set all cab signals to "not displayed"
note: the maximum number of cab signals is six, however only the necessary cab signals (number of different speed levels for the concerning train) shall be displayed.

STMA-2229

The DriverOperatesBrakes indicator (white lamp) shall be determined as follows (attributes see).

If the STM ATB state is "responsible" or "preparing"

then

- **if** DriverOperatesBrakes is true then the STM ATB shall order the ETCS on-board to display the WhiteLamp as "on" (Icon-ID = "white-on")
- **if** DriverOperatesBrakes is false then the STM ATB shall order the ETCS on-board to display the WhiteLamp as "off" (Icon-ID = "white-off")

else
the STM ATB shall order the ETCS onboard to not display the white lamp (attribute for not displayed set).

Requirement, STMA-3278 -
If the "STM ATB state" is "preparing" **then** the STM ATB shall set the red lamp off (Icon_ID = "red-off", see STMA-15059).

Requirement, STMA-14967 -
The ATB BD state indicator (blue lamp) shall be determined as follows (attributes, see STMA-15057):

- **if** the "ETCS override status" (STMA-2325) has been set

then the STM ATB shall order the ETCS onboard to display the blue lamp as "on" (icon-ID = "blue-on") with text "Vv"

- **else, if** code 75 is available in the track for at least 5s (uninterruptedly)
  then the STM ATB shall order the ETCS onboard to display the blue lamp as "on" (icon-ID = "blue-on") with text "BD"

in all other cases the STM ATB shall order the ETCS onboard to display the blue lamp as "off" (icon-ID = "blue-off")

Requirement, STMA-3279 -

If the "STM ATB state" is "preparing" **then** the STM ATB shall set the buttons to "displayed"

8 Functions in the STM ATB state "responsible"

Text, STMA-21841 - In the state responsible the STM ATB shall perform the ATBEG and ATBVv function. In this chapter the ATBEG functions are described.

Requirement, STMA-3272 -

In the STM ATB state "responsible" the STM ATB shall calculate the "ATBEG code" as described in chapter STMA-7132 - ATBEG decoding .

Requirement, STMA-3273 -

In the STM ATB state "responsible" the STM ATB shall calculate the "ATBVv code" as described in chapter STMA-7134 - ATBVv decoding.

Text, STMA-21839 -

In the STM ATB state "responsible" the outputs shall be determined depending on the ATBEG state (STMA-7140 - ATBEG states) and the ATBVv state (STMA-7129 - ATBVv states).

8.1 ATBEG states

Text, STMA-21840 - The outputs of the STM ATB are depend on the ATBEG state. In this paragraph the requirements for determining the ATBEG state are defined.
In the RIS six ATBEG states are defined. The states „uitgeschakeld“ and „stand-by“ are covered by ETCS states in which the ATBEG function is not responsible. Therefore the ATBEG states are limited to „constant“ (CONST), „braking“ (REM), „out of ATBEG area“ (BD) and „intervention“ (I).
In the figure below (STMA-2829) also a state "off" is shown. This state is valid for all situations if the "STM ATB state" is different from responsible.
The transition from "off" to another state is triggered by the STM ATB state transition to "Responsible". This transition differs from the transition from "uitgeschakeld" or "stand-by" to "const" as defined in the RIS:

- Transition from "off" to another state is performed after start-up if the driver selects "ATB" and a cabin is selected (comparable to the transition from "stand-by" to "const" in the RIS) or in case of a transition from another class B system or from ETCS area while driving (not comparable to transitions defined in the RIS).
- Transition from "uitgeschakeld" to another state (in the RIS). This transition can only be done at power on, thus being at standstill.
- Transition from "stand-by" to "const" (in the RIS). This transition can only be done when a cabin is selected.

Before a transition from "uitgeschakeld" or "stand-by" (as defined in the RIS) is made, no track information is available.
Before a transition from "off" to another state (in the ATBEG state machine) track side information (an ATBEG code) can be available. Therefore, if code75 is already found, also a transition directly to "BD" (no ATBEG area) is possible.

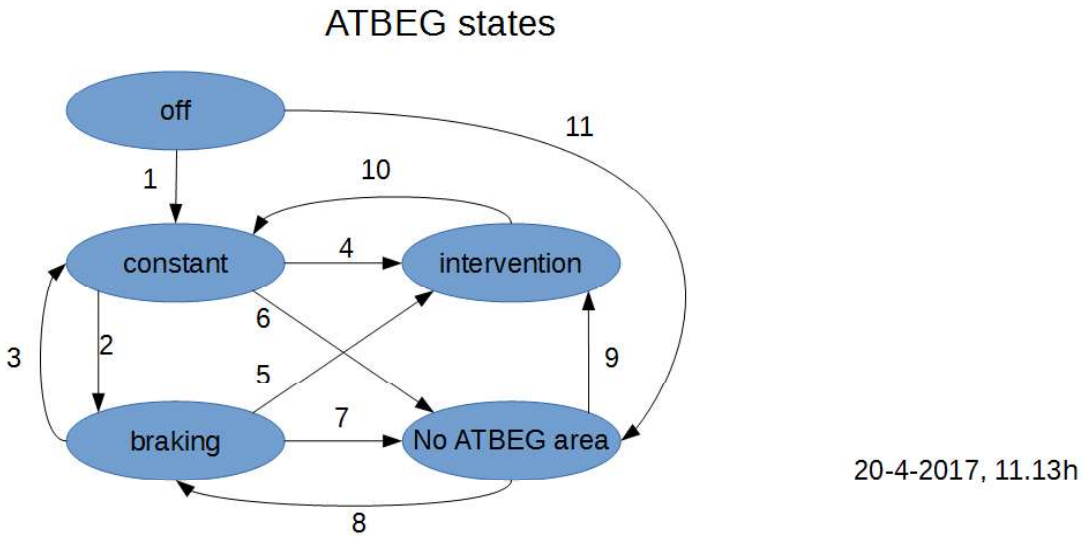
Definition, STMA-2184 -

If the STM ATB state is different from "Responsible" the ATBEG state shall be "off".
If the STM ATB state is "Responsible" then the ATB states as defined in the RIS (STMA-10707 - D3.1 Requirements from

Regeling Indienststelling Spoorvoertuigen 9/2016) are translated to "ATBEG states" as follows:

- "uitgeschakeld":
  The system is not powered, therefore the ATBEG function has not been activated, i.e. the ATBEG state shall be "off"
- "stand-by"
  No cabin is selected, therefore the STM ATBEG is not responsible for train movements, i.e. the ATBEG state shall be "off"
- I:
  The ATBEG function has commanded the EB. This state will only end by a driver action at standstill or at a transition to ETCS area (where the ETCS on-board takes over the responsibility), i.e. the ATBEG state shall be "intervention".
- CONST: constant
  The ATBEG function is monitoring a constant speed. If the speed (plus a margin) is exceeded for a specific time while the driver is still not braking to reduce the speed, the STM ATB will command the EB, i.e. the ATBEG state shall be "constant".
- REM
  The ATBEG function is monitoring braking by the driver after a decrease of the speed level (below the current train speed). If the driver doesn't brake in time, the STM ATB will command the EB, i.e. the ATBEG state shall be "braking".
- BD: No ATBEG area
  The STM ATB is still responsible for guarding the train, but the track side is not equipped with ATBEG, i.e. the ATBEG state shall be "no ATBEG area"

Definition, STMA-2829 - figure: ATBEG states
State transitions back to off are not indicated as those are triggered outside the ATBEG function. The off state is reached if the STM ATB state changes from "Responsible" to another state.



Requirement, STMA-10819 - If several conditions for a transition from one state are met, the STM ATB shall prioritize as follows:

- Transitions to "off" have the highest priority
- from off: conditions are conflicting thus no priority needed
- from constant: order of priority: 6, 4, 2
- from braking: 7, 5, 3
- from "no ATBEG area": 8, 9 (note: conditions in 8 for transitions at standstill exclude conditions for 9)
- from intervention: only one transition possible (except the transition to "off", see above)

Text, STMA-21837 - The detailed conditions for the state transitions are defined below.

Requirement, STMA-2181 - SWITCH ON THE ATBEG FUNCTION

If the "STM ATB state" changes to "responsible" **then**

- **If** no code75 has been detected in the last Tcode75 seconds
  then the STM ATB shall set the ATBEG state to "constant".
- **If** the ATBEG code in the track has been code75 for the last Tcode75 seconds
  then STM ATB shall set the ATBEG state to "no ATBEG area".

Requirement, STMA-7182 - SWITCH OFF THE ATBEG FUNCTION

If

- the STM ATB state (STMA-2824) changes from "responsible to another state, **or**
- the system is "powered off

then

the STM ATB shall set the ATBEG state to "off"

Requirement, STMA-2220 - 2: FROM CONSTANT TO BRAKING

If

- the ATBEG state is "constant", and
- the ATBEG code underneath the front of the train changes to a code corresponding to a lower maximum speed, and
- the current train speed is above the new maximum speed plus V_marge

then

The STM ATB shall change the ATBEG state to "braking"

Requirement, STMA-2221 - 3: FROM BRAKING TO CONSTANT

If

1.

- the ATBEG state is "braking" **and**
- The current train speed is below the guard speed plus V_marge

or

2. During an uninterrupted time Tlos:

- the ATBEG state has been "braking" (i.e. the timer is reset at the state transition to "braking") **and**
- The current train speed has been lower than the guard speed plus Vlos

) **then**

The STM ATB shall change the ATBEG state to "constant".

Definition, STMA-2222 - V_marge

Speed margin to be used during constant speed monitoring

V_marge = 5 km/h passenger trains (with a braking percentage of at least 113%),

V_marge = 3 km/h for other trains

Definition, STMA-2223 - Tlos =20s

Time the between the train speed underruns the maximum speed plus Vlos till switching to constant

Definition, STMA-2224 - Vlos

Speed margin to be used during braking to a lower speed level (after speed level change)

Vlos = 12 km/h for G-braked freight trains

Vlos = 5 km/h for other trains,

Requirement, STMA-2201 - 4: FROM CONSTANT TO INTERVENTION

If for an uninterrupted time longer than T_warning_constant,

- the ATBEG state is "constant" (i.e. the timer is reset at the transition to "constant") **and**
- the current train speed as received from the ETCS on-board exceeds the guarded speed plus V_marge **and**
- the brake is not operated by the driver (DriverOperatesBrakes) according to the input signals

then

The STM ATB function shall change the ATBEG state to "intervention".

Definition, STMA-2202 - T_warning_constant = 4.7 s

The time between the moment overspeed is detected till an intervention (if the brake is not operated by the driver)

note: 5 s - 300 ms (delay time in commanding the EB).

Requirement, STMA-2203 - 5: FROM BRAKING TO INTERVENTION

If

for an uninterrupted time more than T_MaxResponseOnYellow plus

- additional response time (see STMA-14843) **and**
- The time needed for the ETCS on-board to command the EB less than 300ms (i.e. 300ms - T_EB_MAXDELAY, see ss058).

After the moment the ATBEG code in the track underneath the front of the train changed to "noCode" while the current train speed exceeded the corresponding maximum speed plus V_marge:

- The current train speed exceeds the guarded speed plus V_los and
- the brake is not operated by the driver (DriverOperatesBrakes) and
- the value of the input ATBEG code = nocode.

or

for an uninterrupted time more than T_MaxResponseOnNewCode plus

- additional response time (see STMA-14843) **and**
- The time needed for the ETCS on-board to command the EB less than 300ms (i.e. 300ms - T_EB_MAXDELAY, see ss058).

After the moment the ATBEG code in the track underneath the front of the train changed to "noCode" while the current train speed exceeded the corresponding maximum speed plus V_marge:

- The current train speed exceeds the guarded speed plus V_los and
- the brake is not operated by the driver (DriverOperatesBrakes) and
- the value of the input ATBEG code = code96, or code120, or....., code220.)

then

The ATBEG function shall change the state to "intervention".

Definition, STMA-15024 - T_MaxResponseOnYellow = 4.3 s [nominal, 80 %: 4.4 s, 95 %: 4.45 s, 10 0%: 4.5 s].

(= 'Tintervention_yellow' as defined in the RIS minus the communication time available for the ETCS on-board).

The maximum time between the moment the ATBEG code underneath the front of the train changes to a more restrictive

value and the moment an EB command has to be sent in case of overspeed while the driver doesn't brake.

Definition, STMA-15025 - T_MaxResponseOnNewCode = 8.0s

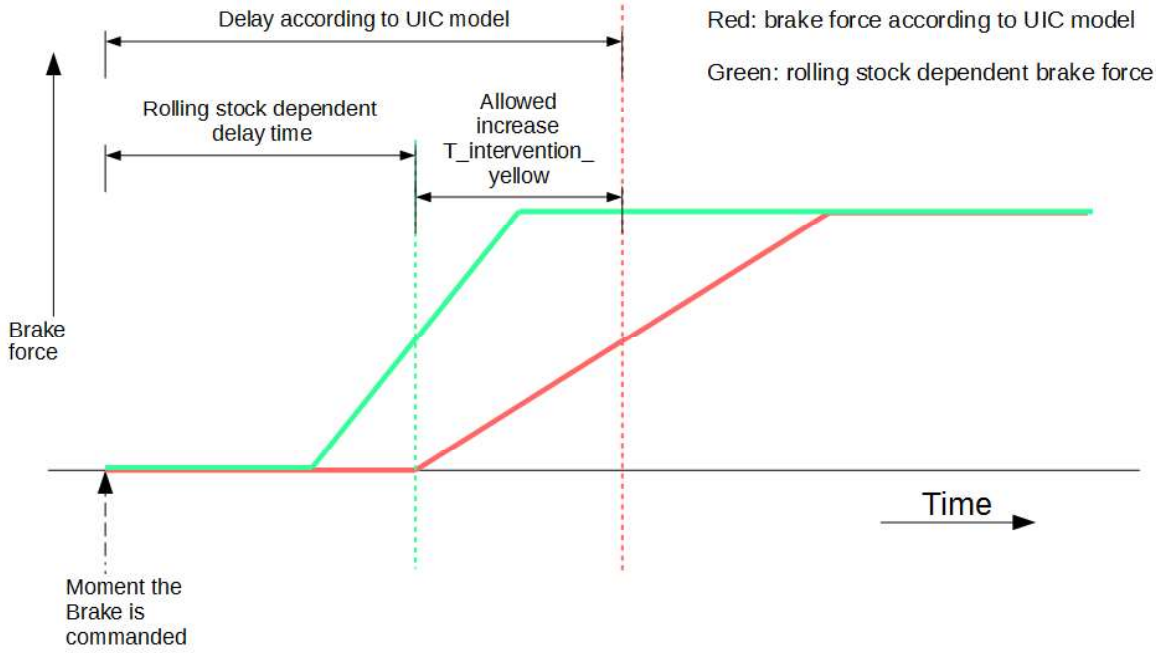
(= 'Tintervention' as defined in the RIS minus the communication time available for the ETCS on-board).

The maximum time between the moment the ATBEG code underneath the front of the train changes to a more restrictive value and the moment an EB command has to be sent in case of overspeed while the driver doesn't brake.

Definition, STMA-14843 - Figure: "Additional response time"

Calculation off additional time to command the EB if the EB responds faster than acccording to the UIC model, i.e:

The reduced braking distance (S_brake_ATB - S_EB) due to (and only due to) a shorter brake build up time after an ETCS EB command compared to the brake build up time when determining the braking percentage of the train, divided by the train speed



Requirement, STMA-2213 - 8: FROM NO ATBEG AREA TO BRAKING

If

1.

the ATBEG state is "no ATBEG area" and since the last transition of the ATBEG state to "no ATBEG area":

- the "Attention button" has been operated
  (after the state transition, i.e. the timer is reset at the state transition to "no ATBEG area") **and**
- the track signal contains/contained a code other value than "nocode" or "code75"

or

2.

- the track signal contains a code other value than "nocode" or"code75" **and**
- the train is at standstill (current train speed < 1km/h)

or

3. During an uninterrupted time T_operateBD

- the ATBEG state has been "no ATBEG area" (i.e. the timer is reset at the state transition to "no ATBEG area") **and**
- the track signal contains "nocode" **and**
- the attention button has been operated **and**
- the train is at standstill (current train speed < 1 km/h)

)

then

"The ATBEG function shall change the state to "braking".

note: not to constant because a transition to constant could lead to braking too late in case of overspeed.

Definition, STMA-2783 - T_operateBD = 2s
Time the BD and attention button shall be operated before switching to and from "no ATB area".

Requirement, STMA-2214 - 9: FROM NO ATBEG AREA TO INTERVENTION

If

1.

- The ATBEG state is "no ATBEG area" **and**
- the "Attention button" is operated after the transition to "no ATBEG area" **and**
- the track signal contains "nocode" or "code75" within the "maximum time between attention and code" after the start operation of the button

or

2.

During an uninterrupted time "maximum time between code and attention":

- the ATBEG state has been "no ATBEG area" (i.e. the timer is reset at the state transition to "no ATBEG area") **and**
- the track signal contains a code other than "nocode" or "code75" **and**
- the "attention button" hasn't been operated

then

The STM ATB shall change the "ATBEG state" to "intervention"

Definition, STMA-2779 - "maximum time between attention and code" = 4.8 s
The "maximum time between attention and code" is the maximum time the driver may push the attention button before code in the track starts.

note: value takes into account 0.2 s communication time of button operation from DMI to STM

Definition, STMA-2780 - "maximum time between code and attention" = 5.2 s
The "maximum time between code and attention" is the maximum time the driver may push the attention button after code in the track starts.

note: value takes into account 0.2 s communication time of button operation from DMI to STM and a minimum decoding time of 1 s.

Requirement, STMA-2217 - 6/7: FROM CONSTANT OR BRAKING TO NO ATBEG AREA

If "Q_BuitenDienst" is enabled and during an uninterrupted time Tcode75 (STMA-2773):

- the ATBEG state is "constant" or "braking" (i.e. the timer is reset at the state transition to "constant" or "braking") **and**
- code75 is available in the track signal

then

The STM ATB shall change the ATBEG state to "no ATBEG area".

Definition, STMA-2773 - Tcode75 = 6s

Time code75 shall be available in the track when switching to "no ATB area" (while driving)

Requirement, STMA-2218 - 6: FROM CONSTANT TO NO ATBEG AREA (AT STANDSTILL)

If "Q_BuitenDienst" is enabled and during an uninterrupted time T_operateBD:

- the ATBEG state is "constant" **and**
- The button "BD button" is operated **and**
- the train is at standstill (current train speed < 1 km/h) **and**
- the track signal underneath the front of the train contains "code75" or doesn't contain a code ("noCode")

then

The STM ATB shall change the ATBEG state to "no ATBEG area".

Definition, STMA-2858 - Q_BuitenDienst = enabled (on)

Qualifier indicating that the "buiten dienst" function shall be activated,

range: "enabled (on)", i.e. state is allowed/"disabled (off)", i.e. state is not allowed.

Requirement, STMA-2207 - 10: FROM INTERVENTION TO CONSTANT

If

- the ATBEG state is "intervention" **and**
- the input "release button" is operated (message from the ETCS on-board) **and**
- the train is at standstill (current train speed < 1 km/h)

then

The STM ATB shall change the "ATBEG state" to "constant".

8.2 ATBVv braking curve

Text, STMA-21838 - ATBVv is a function monitoring the distance to the next signal at danger. For that purpose a braking curve shall be calculated.

The distance to the next signal at danger (D_STS) shall be determined as specified in STMA-3246 (see "preparing"). If this distance is different from "infinite" (special value for the case no distance is known) then the ATBVv function shall perform braking curve monitoring.

The braking curve speed is the maximum speed from which the train will come to standstill within a distance D_STS (distance to STS), after initiating emergency braking, taking into account:

- the brake parameters (maximum deceleration, brake built up time, traction cut of time).
- the current train speed.
- the brake operation by the driver (reducing the brake build-up time, depending on the time the brake is already operated).
- the actual acceleration (will remain during traction cut off)/actual deceleration.
- D_STS

If the braking curve speed is exceeded can be determined by calculating the braking curve speed and compare it to the current train speed, or by determining the braking distance at the current train speed and check if this distance exceeds D_STS.

Definition, STMA-2285 - "The braking curve is exceeded" is defined as:

The remaining distance to the signal at danger (further D_STS) is insufficient to brake to standstill, taking into account:

- V_current: The current train speed (in km/h)

- A_current: The current acceleration (negative for deceleration) of the train (in m/s^2)

The braking distance when braking to standstill after giving an EB command is split into two phases. During the first phase the acceleration of the train is assumed to remain constant. During the second phase the acceleration of the train is assumed to be equal to " - A_max" (where "A_max" is the maximum braking deceleration of the train as defined in STMA-15109):

- D_BBU: distance during the brake build up time, i.e. during the first phase
- D_Braking: distance during braking with constant deceleration, i.e. during the second phase

T_BBU shall be assumed equal to T_delay + T_a (as defined in STMA-15110). *with T_delay is a margin for calculating and processing the EB command by the STM ATB and the ETCS on-board.*

calculation of the braking distance in the second phase: D_Braking
The starting speed for the second phase of braking to standstill (further V_braking in m/s) shall be assumed to be:
(V_current/3.6) + T_BBU*A_current. (limited to 0km/h, i.e. V_braking shall be set to "0" if a negative value was found)
D_braking shall be assumed: $D_{braking} = 0{,}5 * V_{braking}^2 / A_{max}$

calculation of the braking distance in the first phase if the speed > 0 at the end of this phase.
If V_braking > 0 then the average speed during the brake build up time (further: V_BBU in m/s) shall be assumed to be:
(V_current/3.6) + 0,5*T_BBU*A_current.
D_BBU shall be assumed equal to T_BBU * ((V_current/3.6) + 0,5*T_BBU*A_current), i.e.
If V_braking > 0 then $D_{BBU} = (V_{current}/3.6) * T_{BBU} + 0{,}5 * A_{current} * T_{BBU}^2$

calculation of the braking distance in the first phase if the speed = 0 at the end of this phase.
If V_braking =< 0 then $D_{BBU} = 0{,}5 * (V_{current}/3.6)^2 / A_{current}$,

final check on "exceeding the braking curve"
The braking curve shall be assumed to be exceeded if: $D_{STS} \leq D_{BBU} + D_{braking}$

Requirement, STMA-3171 -
The ATBVv function shall use the braking percentage and brake type as received from the ETCS on-board for calculating the brake build up time (t_a) and the EB deceleration (a). This shall be done according to the calculation method for ETCS or for ATBNG (excluding margins), both methods may be used.
The information shall be used to calculate if the "braking curve is exceeded" according to STMA-2285 .
If slippery information (ss058 M_ADHESION, STMA-2334) is received from the ETCS on-board the EB deceleration shall be limited to a value generic for all trains

8.3 ATBVv states

Text, STMA-21835 - The outputs of the STM ATB are depend on the ATBVv state. In this paragraph the requirements for determining the ATBvv state are defined.

Requirement, STMA-2287 -
If the STM ATB state is "responsible"
then the outputs shall be determined according to the ATBVv functions (see chapter STMA-7141 - Outputs in STM ATB state "responsible")
else the ATBVv function shall be reset to its default state ("Off").

Definition, STMA-2288 -
The ATBVv states are:

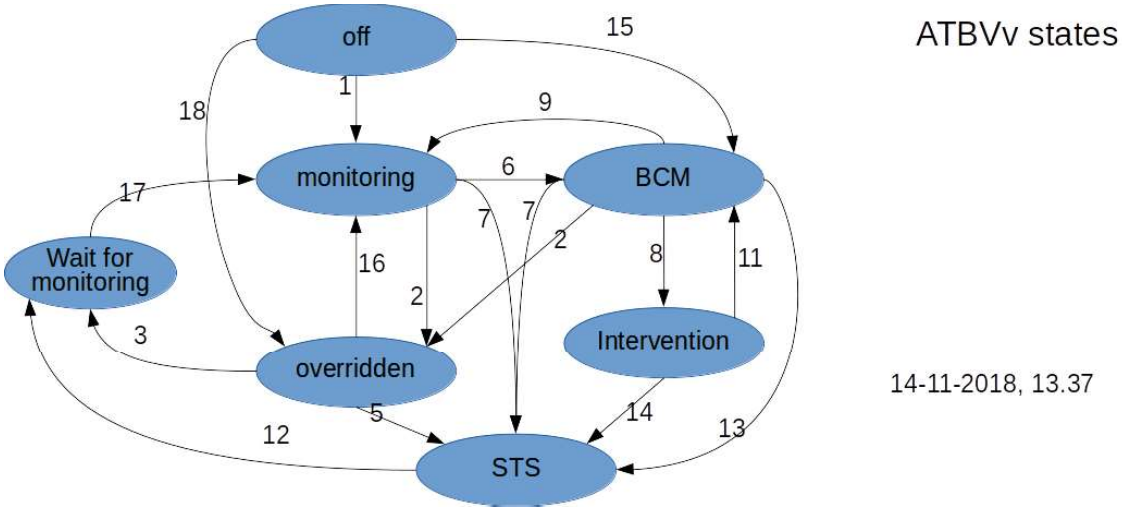
- off: the ATBVv is not active, the only way to leave this state is a change of the STM ATB state to responsible

Further states if the STM ATB state is responsible

- Monitoring: the ATBVv function doesn't have distance information and is ready to detect track side information
- BCM; the ATBVv function knows the distance to the nearest signal at danger (<120m) and is in "braking curve monitoring"
- Overridden: the driver overruled (before or after receiving distance information) the monitoring of the distance to the signal at danger. The monitoring will not be active for a predefined distance.
- Intervention: The ATBVv function commanded the brake and the "signal at danger" is not (yet) passed.
- STS: The ATBVv function commanded the brake and the "signal at danger" is passed.

note: the extra state STS is introduced to distinguish between an intervention before and after passing the STS as the response on releasing the EB shall be different.

Definition, STMA-2872 - figure: ATBVv state machine



Text, STMA-21836 - The ATBVv state transitions are defined below.

Requirement, STMA-15108 - If two conditions for a state transition are met **then** the transitiion with the lowest number shall prevail.

Requirement, STMA-2873 - 1/15: **from off to monitoring or BCM**
If the STM ATB state changes to "responsible
then

- if D_STS is infinite then the STM ATB shall set the ATBVv state to "monitoring"
- if D_STS is different from infinite then the STM ATB shall set the ATBVv state to "BCM"

and
the STM ATB shall reset all ATBVv state variables (including timers and decoding variables), except D_STS to their default values

Requirement, STMA-2874 - to off
If

- the STM ATB state (STMA-2824) changes from "responsible to another state, **or**
- the system is "powered off"

then
the STM ATB shall set the ATBVv state to "off".

Requirement, STMA-2289 - 2: **from monitoring or BCM to overridden:**

If

- the ATBVv state is "monitoring" or "BCM" **and**
- the train is at standstill (speed < 1km/h) **and**
- the "ETCS override button" is operated
  (input from ETCS: "ETCS override status changes to active",i.e. Q_OVR_STATUS becomes 1)

then

The STM ATB shall set the ATBVv state to "overridden".

Requirement, STMA-2290 - 3: Transition from overridden to "wait for monitoring":

If 1. :

- the ATBVv state is "overridden" **and**
- the input ATBVv code has the value "3m signal" (STMA-10909)

then

The STM ATB shall set the ATBVv state to "wait for monitoring" and set D_STS to infinite.

note: the state "wait for monitoring" is introduced to avoid a dead-lock when standing above a "3m beacon"

Requirement, STMA-15103 - 17: Transition from "wait for monitoring" to monitoring:

If

- The ATBVv state is "wait for monitoring", **and**
- A distance > 3m has been driven since the transition to "wait for monitoring"

then

The STMA ATB shall set the ATBVv state to "monitoring" and set D_STS to infinite.

Requirement, STMA-15102 - 16: Transition from overridden to monitoring:

- the ATBVv state is "overridden" and
- the distance run since the transition to the state "overridden" exceeds S_MaxOverridden

then

The STM ATB shall set the ATBVv state to "monitoring" and set D_STS to infinite.

Definition, STMA-3352 - S_MaxOverridden = 200 m

Distance the override function shall be active after activation by the driver.

Requirement, STMA-2291 - 4: Transition from overridden to BCM: **Deleted**

By pushing the override button again:deleted

note: the function is optional according to STMA-6553 - D3.2 ATBvv requirements v11 (STMA-2594)

note: *In the "ATBV systeembeschrijving" it is specified that if the option to allow the driver to reset overridden is used that the distance to the STS shall be remembered. As this is not required leaving overridden will always be to "monitoring" even if a distance to the STS is known. Therefore D_STS has to be set to infinite in that condition.*

Requirement, STMA-2292 - 5: Transition from overridden to STS:

If

- the ATBVv state is "overridden" **and**

- the value of the input ATBVv code is "release signal, beacon" (STMA-10910)

then

The STM ATB shall set the ATBVv state to "STS".

Requirement, STMA-2293 - 6: Transition from monitoring to BCM:

If

- the ATBVv state is "monitoring" **and**
- the value of the input ATBVv code is "30m signal" or "120m signal" (STMA-10908 and STMA-10907) **and**
- the value of the input ATBEG code is "noCode" or "code75"

then

The STM ATB shall set the ATBVv state to "BCM".

Requirement, STMA-2294 - 7: Transition from monitoring or BCM to STS:

If

- the ATBVv state is "monitoring" or "BCM" **and**
- the value of the input ATBVv code is " 3m signal" (STMA-10909) **and**
- the value of the input ATBEG code is "noCode" or "code75" (in undisturbed conditions, this requirement will always be met)

then

The STM ATB shall set the ATBVv state to "STS".

Requirement, STMA-10787 - 14: Transition from intervention to STS:

If

- the ATBVv state is "intervention" **and**
- the value of the input ATBVv signal is " 3m signal" (STMA-10909)

then

The STM ATB shall set the ATBVv state to "STS".

Requirement, STMA-2882 - 13: Transition from BCM to STS:

If

- the ATBVv state is "BCM" **and**
- The distance to the STS is a lower value than D_release_min
  (as D_release_min is a negative value, this will be after passing the STS position)

then

The STM ATB shall set the ATBVv state to "STS".

Requirement, STMA-2295 - 8: Transition from BCM to intervention:

If

- the ATBVv state is "BCM" **and**
- the current train speed is above the braking curve speed (see STMA-2285) **and**
- the current train speed is above the release speed (STMA-10906)

then

The STM ATB shall set the ATBVv state to "intervention".

Definition, STMA-10906 - The release speed is defined as (parameter)
V_release = 10km/h

Requirement, STMA-2296 - 9: Transition from BCM to Monitoring:
If

- the ATBVv state is "BCM" **and**
- the value of the input ATBVv code = release or
- the value of the input ATBEG code = code96,….,code220 (i.e. different from "noCode" and "code75")

then
The STM ATB shall set the ATBVv state to "monitoring".

Requirement, STMA-2297 - 10: **Transition from STS to "monitoring"**
If

- the ATBVv state is "STS" **and**
- the input "release button" is operated (message from the ETCS on-board) **and**
- the train is at "standstill" (current speed <1 km/h) **and**
- the value of the input ATBVv signal is not equal to "3m signal" (STMA-10909)

then
The STM ATB shall set the ATBVv state to "monitoring".

Requirement, STMA-15100 - 12**: from STS to "wait for monitoring":**
If

- the ATBVv state is "STS" **and**
- the input "release button" is operated (message from the ETCS on-board) **and**
- the train is at standstill (speed < 1 km/h) **and**
- the value of the input ATBVv signal is equal to "3m signal" (STMA-10909)

then
The STM ATB shall set the ATBVv state to "wait for monitoring"
note: the "wait for monitoring" is introduced to avoid a dead-lock when standing above a "3m-beacon".

Requirement, STMA-2298 - 11: Transition from intervention to BCM
If

- the ATBVv state is "intervention" **and**
- the input "release button" is operated (message from the ETCS on-board) **and**
- the train is at "standstill" (current speed <1 km/h)

then
The STM ATB shall set the ATBVv state to "BCM".

8.4 ATBVv functions

Requirement, STMA-2303 -
If the ATBVv state becomes "STS" from the state "overridden" (transition 5) **then**
The STM ATB shall send information indicating the reason for the intervention to the JRU (exception code = diagnostic information).

Requirement, STMA-2300 - ATBVv shall set D_STS to infinite if the state changes to "monitoring"

8.5 Outputs in STM ATB state "responsible"

Text, STMA-21861 - If the STM ATB state is responsible, the output information of the STM ATB depends on the ATBEG state, the ATBVv state and the ATBEG code.
Below the STM ATB outputs are specified depending on the current state, divided in:

- Brake commands
- Optical information to be displayed on the DMI
- Acoustical information to be sounded in the cabin

Communication of the output information shall comply with the concerning interface specifications to the ETCS on-board (relevant ERA subsets).

8.5.1 Brake commands

Requirement, STMA-2199 -
The status of the EB is determined as follows:
If
the ATBEG state is "intervention" or the ATBVv state is "intervention" or the ATBVv state is "STS"
then the status of the EB shall be "commanded"
else the status of the EB shall be "not commanded"

8.5.2 Optical indicators

Text, STMA-21862 - In case the STM ATB is responsible and the ATBEG state is "constant" or "braking", the "cab signals" shall be shown to the driver. Further information to be shown using indicators at the DMI are a BD-indicator (blue lamp), intervention indicator (red lamp) and an indicator to show if the driver is operating the brakes (white lamp).

Requirement, STMA-2842 -
If the status of one of the indicators changes **then**
the STM ATB shall send an update of all ATB indicators to the ETCS on-board.

8.5.2.1 White lamp (DriverOperatesBrakes indicator)

Text, STMA-21860 - The white lamp is used as a feed-back to the driver to show that the brakes are operated by the driver according to the input information provided to the STM ATB (as defined in STMA-2761).

Requirement, STMA-2229 -
The DriverOperatesBrakes indicator (white lamp) shall be determined as follows (attributes see STMA-15058).
If the STM ATB state is "responsible" or "preparing"
then

- **if** DriverOperatesBrakes is true then the STM ATB shall order the ETCS on-board to display the WhiteLamp as "on" (Icon-ID = "white-on")

- **if** DriverOperatesBrakes is false then the STM ATB shall order the ETCS on-board to display the WhiteLamp as "off" (Icon-ID = "white-off")

else
the STM ATB shall order the ETCS onboard to not display the white lamp (attribute for not displayed set).

8.5.2.2 Red lamp (ATB Intervention indicator)

Text, STMA-21873 - If the STM ATB commands the EB (via the ETCS on-board) **then** this shall be indicated to the driver by a "red lamp" plus a textual indication (EG or Vv) explaining **if** the intervention is due to overspeed (ATBEG) or because of braking curve monitoring (ATBVv).

Requirement, STMA-2840 -
the ATB intervention indicator (red lamp) shall be determined as follows (attributes, see STMA-15059):

- If the ATBEG state = intervention then the STM ATB shall order the ETCS onboard to display the red lamp as "on" (icon-ID = "red-on") with text "EG"
- else, if the ATBVv state = "intervention" or "STS" then the STM ATB shall order the ETCS onboard to display the red lamp as "on" (icon-ID = "red-on") with text "Vv"

in all other cases the STM ATB shall order the ETCS onboard to display the red lamp as "off" (icon-ID = "red-off")

8.5.2.3 Blue lamp (ATB BD state indicator)

Text, STMA-21870 - The blue lamp is used for two purposes:

- Indicate if ATBVv braking curve monitoring is overridden by the driver: blue lamp with text Vv
- Indicate that the train is driving in an area not equipped with ATBEG although ATB is responsible for train movements: blue lamp with EG

Requirement, STMA-14978 -
The ATB BD state indicator (blue lamp) shall be determined as follows (attributes, see STMA-15057):

- if the ATBVv state = overridden then the STM ATB shall order the ETCS onboard to display the blue lamp as "on" (icon-ID = "blue-on") with text "Vv"
- else, if the ATBEG state = "no ATB area" and the "attentieknop" has not been operated since entering the ATBEG state "no ATB area" for the last time then the STM ATB shall order the ETCS onboard to display the blue lamp as "on" (icon-ID = "blue-on") with text "BD"

in all other cases the STM ATB shall order the ETCS onboard to display the blue lamp as "off" (icon-ID = "blue-off")

8.5.2.4 ATBEG CAB signals

Requirement, STMA-21883 - The current maximum speed shall be indicated by cab signals. Each cab signal corresponds to a speed which is indicated in text (in multiples of 10km/h) at the cab signal. The cab signal corresponding to the highest speed for the specific train shall be green the other ones shall be yellow.

Requirement, STMA-2227 -
A cab signal shall be on (light color) if it corresponds to the current maximum speed. The other cab signals shall be off (dark color). Indicators which are not coupled to a speed level (i.e. not coupled to a cab signal) shall not be shown, i.e.:
The current cab signals shall be determined as follows (attributes, see STMA-15062):
If the ATBEG state = "constant", "braking" or "intervention" **and**

the "EB is available" (information received from ETCS)

then

- the STM ATB shall order the ETCS onboard to display the cab signal corresponding to the current guard speed as "on"

and

- the STM ATB shall order the ETCS onboard to display the other cab signals as "off"

else

the STM ATB shall order the ETCS onboard to not display the cab signals (attribute for not displayed set).

note: only the necessary cab signals shall be displayed. The number of cab signals necessary is equal to the number of speed levels guarded for the specific train and the defined speed level for each code.

8.5.3 Sounds

8.5.3.1 Rembel

Text, STMA-21874 - The rembel is used to warn the driver that the train speed is too high, and the ATBEG function will shortly command the EB. If overspeed arose due to a change in the speed level (which is indicated by an acoustical signal "gong"), then the rembel shall only be triggered a minimum time after the gong was triggered.

Requirement, STMA-2847 -

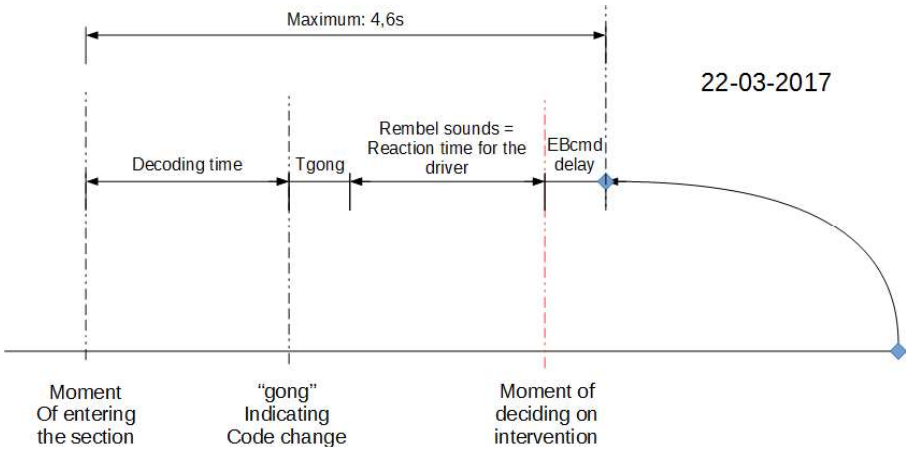
The current status of the "rembel" shall be determined as follows:
If the ATBEG state is "constant" **and** the current train speed is higher than the guarded speed plus Vmarge, **or**
if the ATBEG state is "braking" **and** the current train speed is higher than the guarded speed plus Vlos **and**
the last code change leading to the ATBEG state "braking" (if any since start-up) is detected more than T_gong-bel ago
then the STM ATB shall set the state of the "rembel" to "on"
else the STM ATB shall set the state of the "rembel" to "off".

Definition, STMA-2243 - T_gong-bel = 0.37s

T_gong-bel is the time between a "gong" and the start of the "rembel".

Definition, STMA-10022 - Figure

Phases after passing a section containing a new ATBEG code ("Tgong" = T_gong-bel in STMA-2243).



Text, STMA-21872 - As the ATB function provides a state for the "rembel" and the ETCS on-board is informed using messages (events), the STM ATB has to sent messages to start and to stop the "bel" only if the state of the "rembel" changes. The sound "bel" is used for the "rembel" and for the "losbel". Therefore "rembel" is not equivalent to "bel".

Requirement, STMA-2241 -

If the state of the "rembel" changes to "on" **then** the STM ATB shall start the "bel".

Requirement, STMA-2242 -

If the state of the "rembel" changes to "off" **then** the STM ATB shall stop the "bel".

8.5.3.2 Gong

Text, STMA-21865 - An acoustical signal "gong" is given to indicate that the cab signal has changed. The acoustical signal will trigger the sound "gong" once.

The sound "gong" is also used for the "BD signal". Therefore the acoustical signal "gong" is not equivalent to the sound "gong".

Requirement, STMA-2240 -

If the ATBEG state is "constant" or "braking" **and** the guard speed changes (e.g. due to detection of a new ATBEG code)

or

the ATBEG state changes to "no ATB area" due to operation of the BD button

then

The STM ATB shall trigger the acoustical signal "gong" (as defined in the DMI configuration table).

8.5.3.3 Losbel

Text, STMA-21866 - The losbel is an acoustical signal given to indicate that the driver may release the brakes while the speed is sufficiently decreased.

Requirement, STMA-2245 -

If the ATBEG state is "constant" **and**

the current train speed undershoots the guarded speed plus Vmarge while "DriverOperatesBrakes" is true **then**

The STM ATB shall trigger the acoustical signal "losbel" (as defined in the DMI configuration table).

note: once triggered the complete sound of the losbel (3 times 300ms bell) shall sound in the cabin. ie.

The STM ATB shall controll the digital outputs to trigger the bell three times 300ms and

The STM ATB shall send a message to the ETCS on-board leading to generation of the losbel

Requirement, STMA-2246 -

If the ATBEG state is "braking" **and**

the current train speed undershoots the guarded speed plus Vlos while "DriverOperatesBrakes" is true **then**

The STM ATB shall trigger the acoustical signal "losbel" (as defined in the DMI configuration table).

note: once triggered the complete sound of the losbel (3 times 300ms bell) shall sound in the cabin. ie.

The STM ATB shall controll the digital outputs to trigger the bell three times 300ms and

The STM ATB shall send a message to the ETCS on-board leading to generation of the losbel

8.5.3.4 BD-signal

Text, STMA-21863 - The acoustical signal "BD signal" is given to indicate that the train enters a "buiten dienst" area (i.e. the ATBEG state changes to "out of ATB area").

Requirement, STMA-2850 -

If the ATBEG state changes to "no ATBEG area" due to receiving code75

The STM ATB shall trigger a BD signal (as defined in the DMI configuration table)

note: once triggered the complete sound of the BD signal (5 times gong) shall sound in the cabin, ie.

The STM ATB shall controll the digital outputs to trigger the gong five times and

The STM ATB shall send a message to the ETCS on-board leading to generation of the BD signal

8.5.4 ATBVv information

Requirement, STMA-4884 -
The STM ATB shall not communicate the ATBVv information "distance to STS" nor "ATBVv state" to the ETCS on-board.

9 ATBEG decoding

Text, STMA-21864 - In this chapter a translation of the track signal description as given in the RIS, and the functional requirements concerning decoding are gathered.

9.1 Track signal characteristics

Text, STMA-21868 - The ATBEG track signal is defined as:

Definition, STMA-2271 - 1.
The ATB code consist of an amplitude modulated 75 Hz current through the rails in front of the first axle.
The direction of current in the left is opposite to the direction of the current in the rightrail.

Definition, STMA-2272 - 2.
The carrier frequency is 75 Hz +/- 3 Hz.
The frequency can change instantaneously (within the specified bandwitdh) at any time, however with a constant phase.
note: the phase can change maximum each 4 periods (see STMA-2278).
note: changes in the base frequency could be used for improving the quality of the train detection function

Definition, STMA-2273 - 3.
The carrier (75 Hz current) is modulated between a low and high signal level.
The modulation frequency (code frequency) represents the maximum speed to be guarded according to signal aspects.

Definition, STMA-2274 - 4.
The modulation frequencies are:

- 75 pulses/minute (code75)
- 96 pulses/minute(code96)
- 120 pulses/minute (code120)
- 147 pulses/minute (code147)
- 180 pulses/minute(code180)
- 220 pulses/minute(code220)
- "noCode": no modulation of the 75Hz signal level at the valid code frequencies, i.e. none of the above codes is positively identified

all +/- 3 pulses/minute

Definition, STMA-2275 - 5.
The high level of the ATBEG (75 Hz) carrier signal is between 6.5 A en 25 A.
The low level of the ATBEG (75 Hz) carrier signal is equal to or below 3 A.

Definition, STMA-2276 - 6.
The level of the carrier signal signal can differ up to 3.5 A between the left and right rail.

Definition, STMA-2277 - 7.
To calculate the availability of the decoding the following possibilities for the duty cycles of the signal may be assumed:
- Between 40/60 en 60/40: 99%
- Between 30/70 en 70/30: 99.9%

- Between 20/80 en 80/20: 99.99%

Outside the range 20/80 en 80/20 the signal shall be rejected

note concerning duty cycles outside 20/80-80/20: to avoid accepting a signal consisting of transients (like from a PSS_S_L = "prik spanning spoorstroomlopen" system).

Definition, STMA-2278 - 8.

The ATB infrastructure is divided in sections:

- Each ATB section is long enough to ensure in most cases the reception of at least 4 periods of the slowest ATB code in the section for a train driving at the maximum speed for that section

(if the distance is shorter measures to avoid disturbances might have been taken)

- In case the section is an "inschakelsectie" were the ATBEG state shall change from "no ATB area" to "monitoring", the length is enough for 10 s at maximum speed for that section in case of code96 and 8 s at maximum train speed in case of other codes.

- In case the section is an "uitschakelsectie" were the ATBEG state shall become "no ATB area", the length is enough for 12 s at maximum speed for that section

At transitions from one section to the next one:

- it can take up to 1.4 s until the ATB signal is "turned on" (i.e. the carrier signal is available or modulation starts)

-The phase of the carrier signal can change by any angle.

-The phase of the modulation can change by any angle.

-Any change between different codes is possible.

The phase of the modulation between different codes is random. Therefore at a code change the starting phase of the new modulation is random.

Changes in code frequency can occur at the same time with other disturbances, e.g. at a transition to another section.

Code changes are possible at any moment.

Definition, STMA-2279 - 9.

ATB currents from other sections might float in the rails (parallel in both rails or just in one).

Those currents float via rolling stock and/or substations. The currents are equal to or below 3.5 A. The currents can be coded.

Definition, STMA-2280 - 10.

The rails are also used for traction return currents. These currents float through both rails in parallel or just in one rail.

The traction return currents can contain the following components:

• A DC component up to 4000 A.

• A 50 Hz component up to 250 A

• Harmonics of the motor frequencies (up to 3 A)

• Switching frequencies of choppers, amongst others: 66.67 Hz, 100 Hz, 300 Hz, ca. 315 Hz, 400 Hz and 450 Hz. The maximum value of those currents is 5 A.

• Wide band disturbances from inverter driven traction equipment. In the frequency range from 68 to 82 Hz this current can be 2 A per train.

Harmonics of the power supply

• 50 and 100 Hz in case of asymetric rectifiers

• 300 Hz in case of 6 pulse rectifiers (including semi 12 pulse)

• 600 Hz in case of 12 pulse rectifiers (including semi 24 pulse)

Harmonics from the vehicle itself:

- 0.5 A in the range from 68 to 82 Hz (already covered) by the 2 A immunity specified above
- 225 Hz and 375 Hz components up to 1 A
- up to 10 A psophometric currents
- up to 50 A AC currents

Definition, STMA-2657 -

ATBVv signals to be taken into account:

1145 Hz.+/– 0.2 Hz with a minimum field of 4.75 Am/m +/–10% (thus minimum app. 4.25 Am/m) and

1445 Hz, 1744.5 Hz, 2353 Hz en 2670.5 Hz +/– 0.2% 15.75 Am/m +/–10% (thus minimum app. 14.2 Am/m).

Definition, STMA-2281 - 11.

The smallest curves are (radius): 350m

9.2 ATBEG decoding requirements

Text, STMA-21869 - In this paragraph requirements concerning the decoding are gathered.

Text, STMA-21908 - The ATBEG decoding derives the ATBEG code from the track signals as received from the ATBEG coils (also referred to as "antennas", which are out of the scope of the current specification).

Requirement, STMA-2833 -

If the selected driving direction is different from forward **then**

The STM ATB shall assume the ATBEG code is "nocode" (independent from the currents in the rails) **and**

after switching to forward all state variables in the decoding function shall be set to their default values.

Note: this will lead to "nocode" for at least the time needed to detect a code. this way simulating code by switching driving direction is prevented

Requirement, STMA-2834 -

If the selected driving direction is forward (thus a cabin is selected) **then**

The STM ATB shall use the ATBEG code as present in the current through the rails underneath the front end of the train (the end corresponding to the selected cabin) shall be used.

Requirement, STMA-2264 -

If the ATBEG track signal complies with the characteristics given in STMA-2271, STMA-2272, STMA-2273, STMA-2275, STMA-2276, STMA-2277, STMA-2278 and STMA-2281 provided that the disturbances are less than specified in STMA-2279, STMA-2280 and STMA-2657

then

The STM ATB shall determine the "ATBEG code" present in the track signal according to the definition in STMA-2274

Requirement, STMA-2265 -

The STM ATB shall only accept the code

If:

The code is present in both rails thus the code is found in the left and right coil signal

and

it is guaranteed that the code is not "simulated" by currents from other kinds or track circuits or currents as defined in STMA-2279 and STMA-2280, i.e.:

The source of the code is an ATB coded track circuit in the section the train is currently in.

If that is the case, **then** this can for example be recognised from

- The direction of current transmitting the code is opposite between the left and right rail current, **thus**
  - the code in the difference between the left and right coil signal is (significantly) bigger than the code in the sum of the left and right coil signal (code in parallel currents)
    and
- The phase of the modulation in the left and right coil signal is equal (or limited difference), **and**
- The difference in the code level between the left and right coil signal is limited (e.g. < a factor 2), **and**
- The duty cycle of the signal isn't exceptional (75 Hz content could be caused by a pulse signal).

Requirement, STMA-15001 - The STM ATB shall detect noCode at at least one code frequency between two adjacent codes

if the code frequency is slowly (e.g 0.01Hz/s) changed from one valid code frequency to the adjacent code frequency.

Requirement, STMA-14805 - In case no code is found in the track signal (STMA-2264) or if the code was not accepted while it was not present in both rails and/or it could not be guaranteed that the current section is the source of the code (STMA-2265), then
The STM ATB shall set the code equal to "noCode"

Requirement, STMA-7263 - When proving that the code is not "simulated", the STM ATB shall take the signal variations caused by antenna movements, EM-sources in the rolling stock and ATBEG currents floating through the wheels at the first axle. into account. The total effect of the disturbances at the code frequencies will not exceed a variation of 15% compared to the average 75 Hz level.

Requirement, STMA-2266 -
The sensitivity of the STM ATB for track currents with a base frequency in the specified bandwidth (72-78 Hz) shall vary maximum +/-5 %. Outside the band:

- Below 65 Hz and over 85 Hz the damping shall at least be 6 dB
- Below 55 Hz and over 95 Hz the damping shall at least be 20 dB
- At 50hz the damping shall at least be 48dB

Requirement, STMA-8797 -
The number of occasions in which the STM ATB does not recognize a code from a track signal containing a code (can be out of specification, but acceptable according to the specifications),
shall not exceed this number (the number of occasions mentioned in the previous sentence) for the ATBEG systems currently in use, as far as those respond according to the above safety requirements.
(A test file containing > 1500 hours of test data including the response of a currently used system will be provided), ie.

- A file with test data will be provided (1500 hours)
- This test file contains track data plus the response of an existing ATB system.
- The STM ATB shall not return "noCode" more often than the existing ATB system in cases where this is not necessary according to the specification.

Requirement, STMA-2269 -
The STM ATB shall not accept noCode within 1.4 s after the last switch between a high and low level of the ATBEG signal.

Text, STMA-28970 -
Below it is described how long the 75Hz level can be constant while both sections (the one left and the one entered) provide a valid ATBEG code. This time is the basis for requirement STMA-2565 and STMA-2510 concerning the requirement that switching on code can last 1.4 s (1.3 s is faulty) is derived.
In the drawing below (STMA-11600) :

- t1 (d1): Time to travel the distance between coil and wheel-rail contact, i.e. the time the coil is above the next section while the train doesn't occupy that section.
  t1: Section 2T is only triggered after the first axle enters section 2T. The distance between the antenna and the first axle taken into account is 1.5 m
  taking into account a speed of 11 m/s (below it's not relevant if the code is shortly rejected, i.e. the output "ATBEG code" is set equal to "noCode", while the lowest speed level is 40 km/h): = approximately 140 ms.
- t2: The code pulse in section 1T is worst case (equal to the initial level in section 2T), therefore the ATBEG on-board will "see" a constant level during t2 before entering section 2T.
  in case of code96 this time is 0.5 times 640 ms = 320 ms
- t3 (d3): The last 0.5 m of section 1T there might be no code because of the location where the cable is connected.
  taking into account a speed of 11m/s (below it's not relevant if the code is shortly rejected, i.e. the output "ATBEG code"

is set equal to "noCode", while the lowest speed level is 40 km/h): = approximately 50 ms

- t4: delay time for detecting the train: 500 ms.
- t5: switching times: 10 ms.
- t6: The first code pulse in section 2T is worst case (equal to the initial level in section 2T), therefore the ATBEG on-board will "see" a constant level during t6 after the code has been switched on in section 2T.
  in case of code96 this time is 0.5 times 640 ms = 320 ms.

The total time is therefore 1340ms.

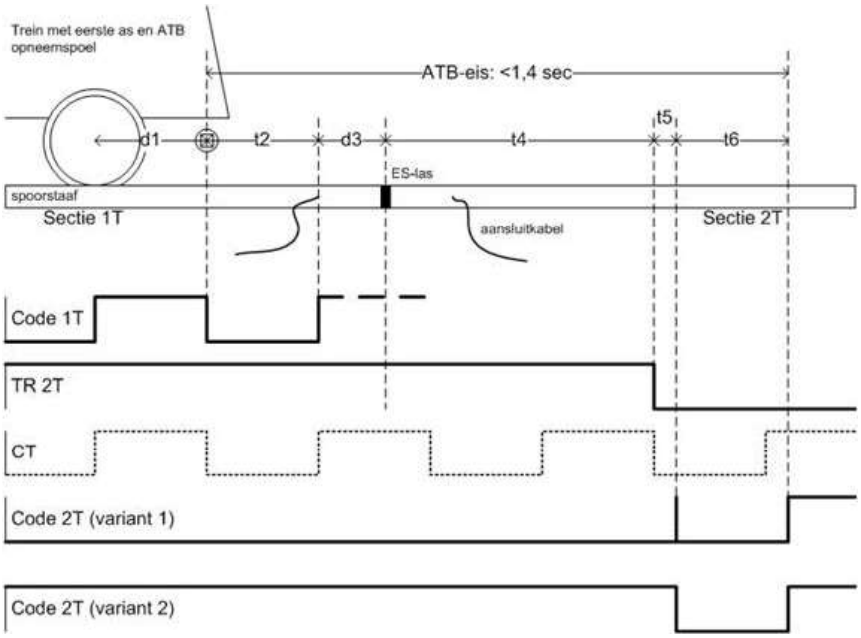
However:

- t1 is too optimistic as the distance d1 can be 4.5 m: 270 ms extra
- The duty cycle of the code96 might not be 50/50 but 40/60-60/40 (duty cycles out of this range are out of specification and therefore not taken into account, as the above calculation already adds worst case values)
  40/60-60/40 leads to 2 times 64ms extra delay (app 130 ms).

The decoder shall detect noCode within 1.9s (STMA-4752).
According to the RIS the decoder may not detect noCode if the "gap" is less than 1.4s
According to the analysis above for worst case situations this time should be increased with 340 ms (1340 ms+270 ms+130 ms =1740 ms).
This margin is not big enough, therefore not all conditions for ignoring "gaps" can be taken worst case.

Decision, see STMA-14945 - The decoder shall not detect "noCode" in case of "gaps" shorter than 1.6 s. :

Definition, STMA-11600 - Figure: Timing of ATBEG code between sections



Requirement, STMA-14905 - The STM ATB shall detect "noCode" within 2030 ms [nominal, 80 %: 2130 ms, 95 %: 2180 ms, 100 %: 2230 ms] after the the last switch between a high and low level of the ATBEG signal.
note: this includes all activities, e.g. filtering, the maximum calculation time etc.

10 ATBVv decoding

Text, STMA-21909 - The ATBVv decoding shall derive ATBVv signals from the track current provided by the right coil (antenna).

Requirement, STMA-3243 -

If the driving direction is forward **then**

The ATBVv decoding shall determine if the right coil track current, corresponding to the selected cabin, contains an ATBVv signal as defined in STMA-10907, STMA-10908, STMA-10909, STMA-10910 and STMA-10911.

else the ATBVv decoding shall always return "noSignal".

Definition, STMA-10907 - "120 m signal" is defined as

a 1744.5 Hz component in the right coil (in reference to forward direction from the selected cabin) input signal.

Definition, STMA-10908 - "30 m signal" is defined as

a 2353 Hz component in the right coil (in reference to forward direction from the selected cabin) input signal.

Definition, STMA-10909 - "3 m signal" is defined as

a 2670.5 Hz component in the right coil (in reference to forward direction from the selected cabin) input signal.

Definition, STMA-10910 - "release signal, beacon" is defined as

a 1445 Hz component in the right coil (in reference to forward direction from the selected cabin) input signal.

Definition, STMA-10911 - "release signal, loop" is defined as

a 1145 Hz component in the right coil (in reference to forward direction from the selected cabin) input signal.

Requirement, STMA-4885 -

The correct behavior of the ATBVv decoder shall not to be affected by EM-fields from other sources (than the ATBVv beacons) in the infrastructure or rolling stock.

Requirement, STMA-14986 - The ATBVv decoder shall take into account the characteristics of the ATBVv track signal as given in STMA-3223 and STMA-3224

Definition, STMA-3223 - ATBVv signal levels:

- "release signal, loop" (1145 Hz):
  7.5 A in a cable along the right rail (return via center between left and right rail)
  cable: vertical: xx cm below the right rail head, horizontal yy cm towards the left rail (from center of the right rail)
  return: vertical: zz cm below the right rail head, horizontal 71 cm towards the left rail (from center of the right rail)
- "release signal, beacon" (1445 Hz), "120m signal" (1744.5 Hz), "30 m signal" (2353 Hz), "3 m signal" (2670.5 Hz):
  40 A in a beacon along the right rail.

Requirement, STMA-3228 -

ATBVv signals (except the "release signal, loop") from the left rail (as specified in STMA-14986) shall be ignored.

Definition, STMA-3224 -

Minimum time an ATBVv beacon signal (1445 Hz, 1744.5 Hz, 2353 Hz en 2670.5 Hz) is available (taking into account a speed of 70 km/h): 38 ms.

Minimum time an ATBVv loop signal shall be available: 40 ms.

Requirement, STMA-13952 -

ATBVv equivalent signals received via ETCS (packet 44, STMA-13937) shall be handled in the same way as ATBVv signals

11 Juridical recording

Requirement, STMA-3190 -

The STM ATB shall send the following data once per second to the Juridical recorder:

- Brake operated: Yes/No (ATBEG input)
- guarded speed (ATBEG output)
- Selected Cabin: A, B, none (input from ETCS on-board)
- Selected direction: forward, reverse, neutral or other (input from ETCS on-board)
- STM-state
- STM ATB state
- ATBEG-state
- ATBVv-state
- D_STS
- ATB button operation by the driver
- ATBVv signal received.
- current ATBEG code
- irregularities of the ATBEG code
- system faults (diagnostic information)

(Note: This requirement has been aligned with the requirements from the GPvEM by means of document SID-ERTMS-001665)

12 Installation and maintenance

Text, STMA-21915 -

- The STM ATB shall not need any maintenance (other than replacement in case of defects), nor configuration in case of installation or replacement.
- To ease the retro fitting rolling stock equipped with existing (stand alone) ATB on-board equipment the STM ATB shall be able to interface with the existing peripherals.

The above starting points lead to the following requirements:

STMA-5083, External Requirement -

The STM ATB shall not need any rolling stock depending configuration at installation, i.e. all rolling stock dependent parameters shall be read from the rolling stock (and/or ETCS on-board), and no calibration of the coil signals shall be needed, and only one STM ATB version shall be needed for all rolling stock variants.
Configuration independent from the rolling stock type, like switching on/off BD, is allowed, those shall be set in the software, i.e. changing those attributes shall be handled as a software change (e.g. Q_buitendienst)

STMA-5086, External Requirement -

The STM ATB shall be able to operate with all existing ATB coils without configuration of the system. (on-board adaptations, e.g. concerning the impedance of the coil circuits is allowed)

Requirement, STMA-14948 -

The installation requirements provided by the suppliers of the ATB coils shall be taken into account.

STMA-5087, External Requirement -

The STM ATB shall be able to operate with all existing ATBEG sound generators. I.e. three digital outputs, implemented as potential free contacts, capable of switching between 24Vdc and 110Vdc (nominal) shall be available

STMA-6782, External Requirement -
The STM ATB shall be compatible with the commonly used supply voltages: 24Vdc, 72Vdc and 110Vdc nominal. I.e. the STM ATB shall be able to operate those supply voltages as specified according to SID-803, without configuration or variants.

STMA-2643, External Requirement -
The STM ATB shall not require maintenance other than repairs/replacements.

STMA-8567, External Requirement - The STM ATB shall be the smallest "line replaceable unit.
i.e. no STM ATB components shall be replaced on-vehicle.

STMA-2644, External Requirement -
All equipment necessary for loading all necessary software on new hardware instances, changing parameters and/or detection of failures in the STM ATB shall be provided, including the complete (e.g. interface specifications, hardware and software) design of this equipment. The use of standards (e.g. JTAG) is preferred.
Note: the user/customer shall be enabled to purchase maintenance equipment independent from the ATB supplier

STMA-2645, External Requirement - The STM ATB shall report deviations (from the specification) of the track side ATBEG signal in a message to the JRU.

STMA-14909, External Requirement - The STM ATB shall report diagnostic data as defined in document SID-ERTMS-001665.

13 Mechanical

STMA-7013, External Requirement - The size and weight of the STM ATB enclosure (for 19" mounting) shall allow handling and installation on-vehicle by a single person without additional tooling.

STMA-7015, External Requirement - The power consumption of the STM ATB shall not exceed 20W.

STMA-7016, External Requirement - All connectors shall be front mounted

STMA-7017, External Requirement - For the profibus connection two sub-D9 connectors shall be used

STMA-7018, External Requirement - The left and right coil signal related to the same cabin shall be connected using different, not interchangeable connectors (e.g. two sub_D15 connectors, one male, one female, for two coil signals plus the brake pipe pressure signal each).

Text, STMA-28343 - STMA-7019 Intentionally deleted.

STMA-7020, External Requirement - Interfaces used to upload software, parameters (not rolling stock dependent), etc. shall not be reachable while the STM ATB is installed.

STMA-7021, External Requirement - The STM ATB shall have LED indicators at the front to communicate fail states

14 Reliability and safety

Text, STMA-21871 - The maximum failure rates are derived from the RIS requirements taking into account the failure rates required concerning the ETCS on-board equipment. Especially the resulting MTBF requirement is not very restrictive. The STM ATB is therefore expected to perform much better. Failure costs are given below to allow the developer to optimize the MTBF.

Requirement, STMA-2258 - The STM ATB failure rate concerning failures causing an unsafe situation for maximum 3s shall be < 2*10^-6/hour

Requirement, STMA-2259 - The STM ATB failure rate concerning failures causing an unsafe situation longer than 3s shall be < 1.9*10^-8/hour

Requirement, STMA-2260 - The STM ATB failure rate concerning failures leading to unsafe false information at the DMI shall be < 1*10^-5/hour

STMA-2868, External Requirement - MTBF

The maximum failure rate of the STM ATB shall be app. 2*10^-4/hour (dependent on the "fault category", see below). However if financially justifiable (see below), a lower failure rate shall be realized.

The way faults are handled, and therefore the costs related to the faults, depend on the "Fault Category" (FCx) of the failure:

- Fc1. The problem occurs during operation and cannot be solved by available staff. The train will proceed to the next main station with a maximum speed of 80km/h therefore causing > 10 minutes delay.
- Fc2. The problem is solved by train or maintenance staff without causing a delay > 10 minutes (e.g. reset of the equipment). No further handling required.
- Fc3. The problem is solved by train or maintenance staff without causing a delay > 3 minutes. No further handling required.

Maximum acceptable fault rates:

- Fc1: < 15*10^-5/hour
- Fc2: < 20*10^-5/hour
- Fc3: < 20*10^-5/hour

The value of a reduction of fault rate with 1*10^-6/hour is determined as:

- Fc1: € 375.000,-
- Fc2: € 90.000,-
- Fc3: tbd

Requirement, STMA-3300 -

The STM ATB shall not disturbe communication between other (different from the STM ATB node) nodes at the Profibus more often than 1,2*10^-6/operational hour