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ERTMS USERS GROUP – ENGINEERING GUIDELINE

69. Automatic Track Ahead Free (B3)

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1. Introduction

1.1 Foreword

- 1.1.1.1 The Track Ahead Free request is a message sent by the RBC to an on-board which allows a driver to inform the RBC that no obstacle is on the track between the train front end and the next signal or marker board. When the message has been acknowledged by the driver, thus confirming that the “Track Ahead is Free”, then the RBC can send the Movement Authority for Full Supervision mode.
- 1.1.1.2 When using a manual TAF there is a risk that the driver incorrectly acknowledges the Track Ahead Free request and gets an FS MA while being in rear of another train. TAF acknowledgement is also considered ergonomically undesirable as it distracts the driver from observing the tracks and may promote routine acknowledgement by the driver.
- 1.1.1.3 This Automatic Track Ahead Free guideline aims at mitigating the risk of a driver incorrectly acknowledging a Track Ahead Free request.
- 1.1.1.4 The Automatic Track Ahead Free solution can be used to provide the TAF facility with no driver input through a combination of reported train position and trackside information.
- 1.1.1.5 The benefit of the ATAF function is that the responsibility for proving that the track ahead is free is moved from the driver to the trackside systems, removing the risk of an incorrect TAF acknowledgement due to routine behaviour from the driver.
- 1.1.1.6 The Trackside Approval Issues Log [4] has been checked and no issues have been identified to be linked with this guideline.
- 1.1.1.7 This guideline is part of a bundle of guidelines with the Overall ETCS guideline [6] being the main guideline which will redirect the reader to the relevant guidelines. Be aware that the Overall ETCS guideline may also include recommendations which are related to the topics addressed in this guideline.

1.2 Scope and Field of Application

- 1.2.1.1 This guideline applies for ETCS level 2 based on ERTMS/ETCS Baseline 3.
- 1.2.1.2 It is strongly recommended that any entity using ERTMS/ETCS follows the principles defined in this guideline.
- 1.2.1.3 This guideline is applicable for a trackside where the System Version is 2.Y. For trackside where the System Version is 1.Y, the on-board System Version 2.Y will react according to SUBSET-026 [1] chapter 6.
- 1.2.1.4 This guideline takes into consideration the following on-board system:
- On-board system supporting version 1.Y and 2.Y, with active System Version 2.Y
- 1.2.1.5 The ATAF methods described in this document can equally be applied in a level 3 environment with fixed virtual block or in a level 2 environment with Hybrid Train

Detection [3]. However, due to the virtual sub-division of the trackside train detection (TTD) section, the benefit of transitioning sooner to Full Supervision with ATAF diminishes because of the smaller (virtual) block section lengths present inside a TTD section. The train integrity confirmed position reports help to release virtual sub-sections (VSS) inside a TTD section.

1.2.1.6 Generally, ATAF checks proposed in this document cannot be performed at VSS borders. This is because there is no new information coming from trackside about the occupation status of the fixed virtual block inside the TTD section. Thus, at the VSS borders no comparison of the trackside information can be made against the train position reports.

1.2.1.7 The combination of reported train position information and trackside information is also for applications of level 3 with fixed virtual block useful to mitigate the hazard of having two trains in one track section, also known as the “ghost train” hazard defined in the Hybrid Train Detection concept [3].

1.3 Document structure

1.3.1.1 Chapter 1 is an introduction to the content of the document.

1.3.1.2 Chapter 2 provides the references, terms and abbreviations used in this document.

1.3.1.3 Chapter 3 provides the guideline for automatic TAF using the method based on the position report.

1.3.1.4 Chapter 4 provides the guideline for automatic TAF using the method based on the CES message.

1.3.1.5 Chapter 5 provides the guideline for automatic TAF using the method based on distance guaranteed as free.

1.3.1.6 Appendix A describes the ATAF Pre-check alternative with CES interaction diagram.

1.3.1.7 Appendix B describes an implementation of ATAF using smart axle counters.

2. References and Abbreviations

2.1 Definitions

2.1.1.1 The following table includes terms and definitions which are used in the current document:

Terminology	Definition
ATAF Distance	The distance between the ATAF Location and the replacement track section limit of the associated ATAF Marker
ATAF Location	The location at the specified ATAF distance in rear of the replacement track section limit of the associated ATAF Marker
ATAF Marker	Marker board for which an ATAF location is defined Note: For Level 2 overlay implementations, this may also be an optical signal
ATAF Marker replacement track	Track section that replaces the marker to danger
Signal	An optical signal or an ETCS marker board

2.2 Abbreviations

2.2.1.1 The following table includes acronyms and abbreviations which are used in the current document:

Abbreviation	Description
ATAF	Automatic Track Ahead Free
CES	Conditional Emergency Stop
IXL	Interlocking
RBC	Radio Block Centre
TAF	Track Ahead Free
TTD	Trackside Train Detection
VSS	Virtual sub-section

2.3 References

2.3.1.1 The following documents and versions apply:

Ref. N°	Document Reference	Title	Version
[1]	SUBSET-026	System Requirements Specification	3.4.0

Ref. N°	Document Reference	Title	Version
[2]	SUBSET-041	Performance Requirements for Interoperability	3.1.0
[3]	16E042	ERTMS/ETCS Hybrid Train Detection	1F
[4]	N/A	Trackside Approval Issues Log	5
[5]	SUBSET-113	ETCS Hazard Log	1.5.0
[6]	22E087	Overall ETCS	1-

3. ATAF using a position report

3.1 Principles for the ATAF using a position report

3.1.1 Principles

3.1.1.1 The Automatic TAF based on a position report relies on the principle that a train for which the on-board sends a position report requested by the RBC very shortly after the train entered a previously unoccupied section is the first train to enter this section. Given a limited time window, the RBC validates that the train for which the on-board has sent the position report is the first train entering this section. Trains with a valid position will receive an MA with an OS mode profile once the route from the marker board is set. The OS mode profile covers the full extent of the MA. Along with the MA, the train additionally receives an instruction to transmit a position report when the max safe front end of the train reaches the location of the replacement track section joint (D_LOC and Q_LGTLOC in packet 58).

3.1.1.2 If the position report is received inside a limited time window, the RBC can conclude that no other train is in front of the train reporting its position and can issue an FS MA.

3.1.1.3 If the position report is not received inside the limited time window, then it is possible that another train has already entered the relevant track section. The FS MA can therefore not be issued, and the train continues in OS mode.

3.1.2 Benefit of this method

3.1.2.1 The MA with the OS mode profile for its full length can be issued in rear of the marker board authorising the driver to depart.

3.1.2.2 The FS MA is only sent if the ATAF function is successful.

3.1.2.3 Drivers can expect to enter FS mode at a defined location (near the track section limit).

3.1.2.4 There is no brake application and subsequent application of a recovery procedure if the ATAF function is unsuccessful.

3.1.3 Implementation of ATAF using a position report

3.1.3.1 The following describes the principles for an ATAF function based on linking track occupancy with train position through the use of position report information.

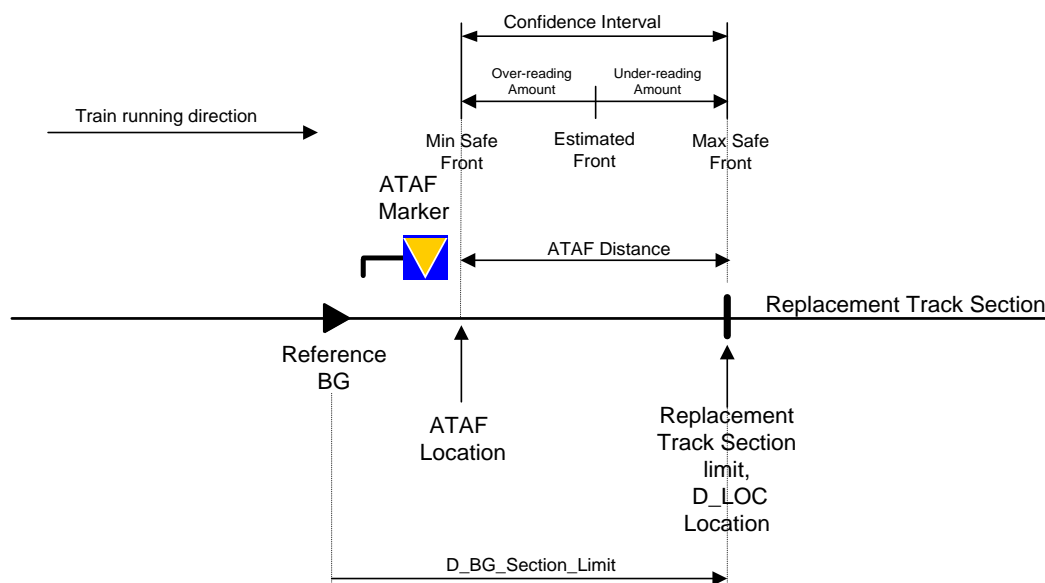


Figure 1: ATAF using a position report

3.1.3.2 The ATAF function is implemented at each marker board where a train might be required to make a transition from OS to FS movement authority (e.g. after Start of Mission, or after leaving an OS route).

3.1.3.3 Each ATAF Marker requires an ATAF Location to be defined. The ATAF Location is at a distance (ATAF Distance) in rear of the replacement track section limit of the associated ATAF Marker. The ATAF Location is not necessarily between the ATAF Marker and the replacement track section limit.

3.1.3.4 The ATAF Distance is equal to the expected value of the train position confidence interval, calculated in reference to a defined BG, when the train Max_Safe_Front is at the track section limit location, i.e. the ATAF location is the location of the train Min_Safe_Front when the train Max_Safe_Front is estimated to be at the track section limit.

3.1.4 ATAF Functionality

3.1.4.1 The ERTMS/ETCS on-board equipment is instructed to send a position report when the train Max_Safe_Front reaches the location of the replacement track section limit in advance of the ATAF Marker (the position report parameters, packet 58, with Q_LGTLOC = 1 and D_Loc = the location of the replacement section limit, being already received from the RBC). This position report is hereafter referred to as the D_LOC Position Report.

3.1.4.2 When the RBC is informed that the ATAF Marker replacement track section has become occupied, it initiates the ATAF Timer and checks that before this timer expires a position report is (or has been) received confirming that:

- 1) the Min_Safe_Front_End of the train has passed the ATAF Location, and
- 2) the Max_Safe_Front_End of the train has passed the track section limit

3.1.4.3 Both conditions must be fulfilled before expiry of the ATAF Timer for the ATAF to be successful. The value of the ATAF Timer is project specific.

- 3.1.4.4 The ATAF function ends when ATAF is successful or when the ATAF Timer expires (unsuccessful).
- 3.1.4.5 If the ATAF is successful, an FS MA is provided to the train.
- 3.1.4.6 If ATAF is not successful, the train remains in OS mode.
- 3.1.4.7 For a train in OS mode, the process can be repeated at the next ATAF Marker.

3.1.5 Interaction diagram

3.1.5.1 Figure 2 below depicts the scenario for ATAF using a position report for a train waiting at or approaching a marker board at which ATAF functionality is provided.

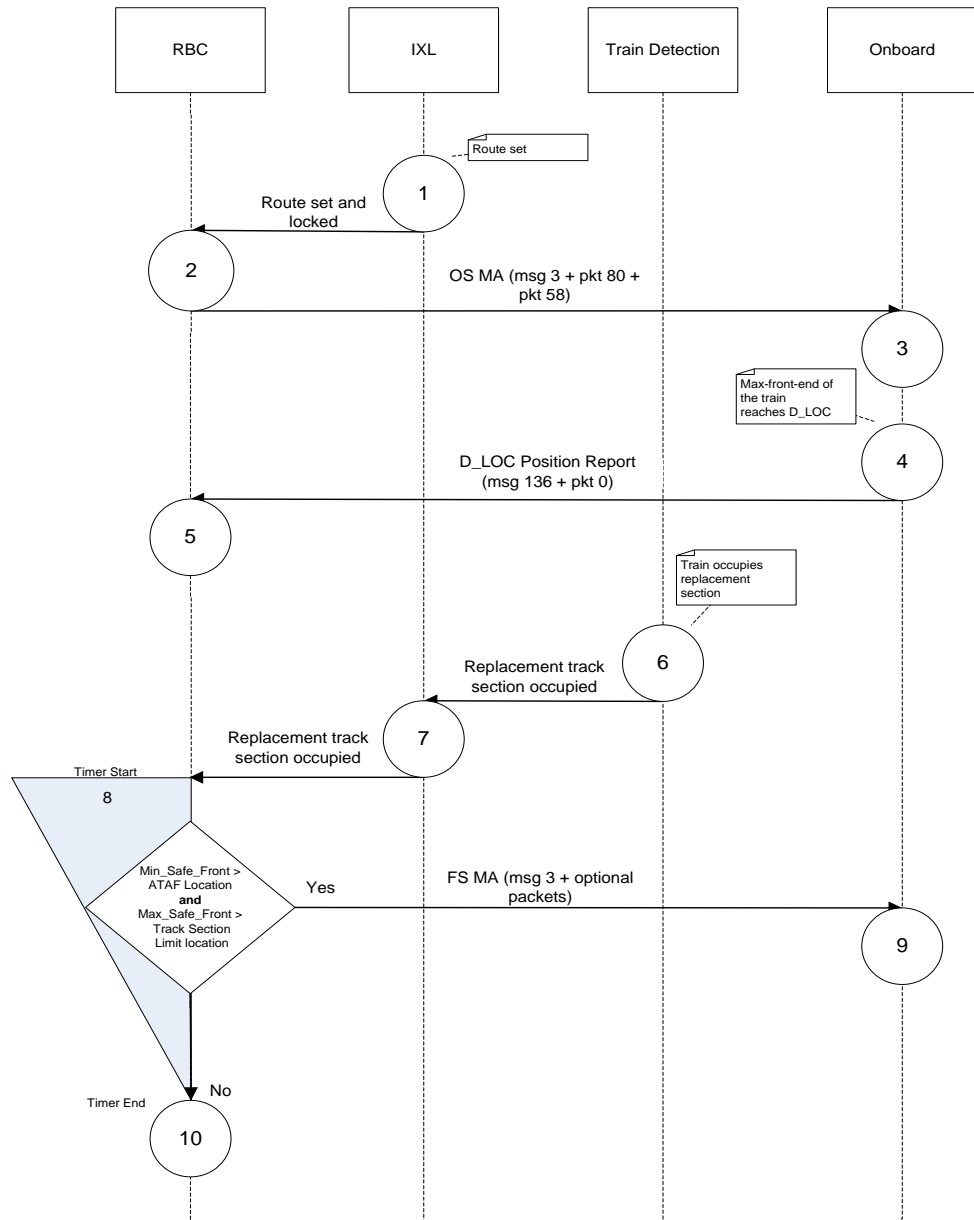


Figure 2: Interaction diagram of ATAF using a position report

3.1.5.2 Description of interaction diagram of ATAF based on position report:

Initial situation: The train is approaching the ATAF Marker. The train has a valid position, is oriented in the correct direction, and this has been reported to the RBC.

- 1) The onward route from the ATAF Marker has been set and locked by the interlocking. This route status is sent to the RBC.
- 2) With the route set and locked, and the train having reported a valid position, the RBC transmits a movement authority including an OS mode profile to the train. The OS mode profile covers the full extent of the MA. The MA includes packet 58 defining the request for a position report (the D_LOC Position Report) to be transmitted when the Max_Safe_Front of the train reaches the replacement track section limit.
- 3) The movement authority is received by the ETCS on-board. The driver acknowledges immediate entry into OS mode, proceeds and passes the marker board.
- 4) When the Max_Safe_Front of the train reaches the replacement track section limit (D_LOC as defined by packet 58), the on-board transmits the D_LOC Position Report to the RBC.
- 5) The RBC receives the position report for the replacement track section limit in advance of the ATAF marker (D_LOC Position Report).
- 6) The train occupies the replacement track section and the train detection equipment informs the interlocking.
- 7) The interlocking informs the RBC of the replacement track section occupancy.
- 8) The RBC starts the ATAF Timer and checks that a position report has been or is received before the timer expires that confirms:
 - a) The train Min_Safe_Front has passed the ATAF Location, and
 - b) The train Max_Safe_Front has passed the replacement track section limit.
- 9) If this can be confirmed before the timer expires, an FS MA is sent to the train.
- 10) The on-board receives the MA and transitions to FS mode.
- 11) If the timer expires and the RBC cannot confirm that the two conditions in point 8) above have been met, the ATAF function is unsuccessful and the train continues in OS mode for the extent of the route. The process is repeated at the next ATAF Marker.

3.1.5.2.1 Note: Event 4) and 5) can occur after event 8), for example if delays between transmission and reception of the position report information are larger than delays between track occupancy detection and the RBC being informed about it or if the confidence interval is very small. The situation when the interlocking informs the RBC about the occupation before the train reports its position is a possible hazard which is described in section 3.2

3.2 Safety Considerations for ATAF using a position report

3.2.1 Risk in using ATAF

3.2.1.1 There is a risk that the ATAF function could incorrectly provide an FS MA to a train closely following an unfitted train or any other vehicle that the RBC does not know of or cannot locate. This could be due to the ATAF Distance or the ATAF Timer value being too long.

3.2.1.2 This scenario is demonstrated in Figure 3 and described in the interaction diagram in Figure 4.

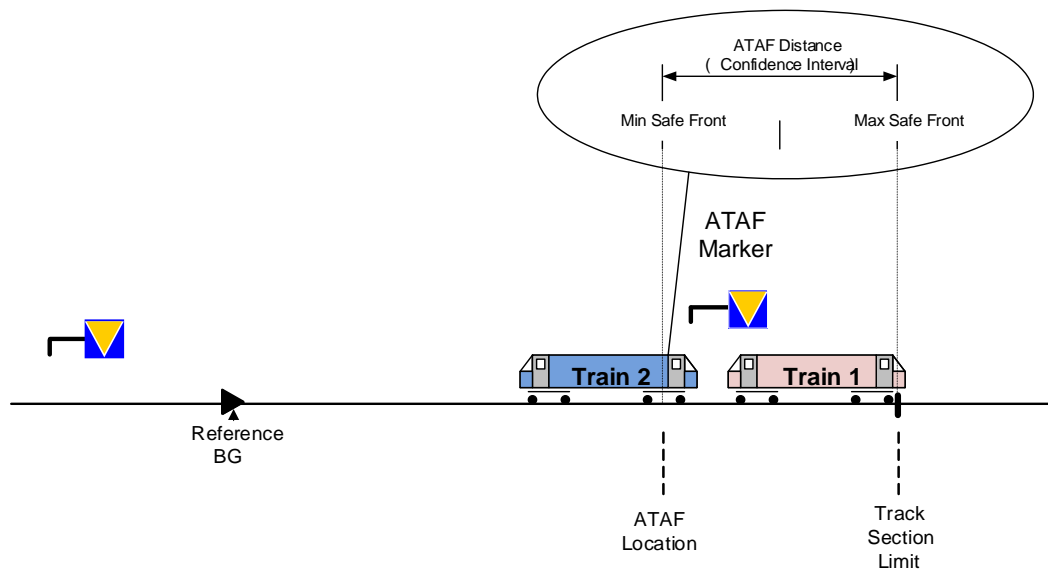


Figure 3: ATAF scenario at risk

3.2.1.3 Interaction diagram of scenario at risk

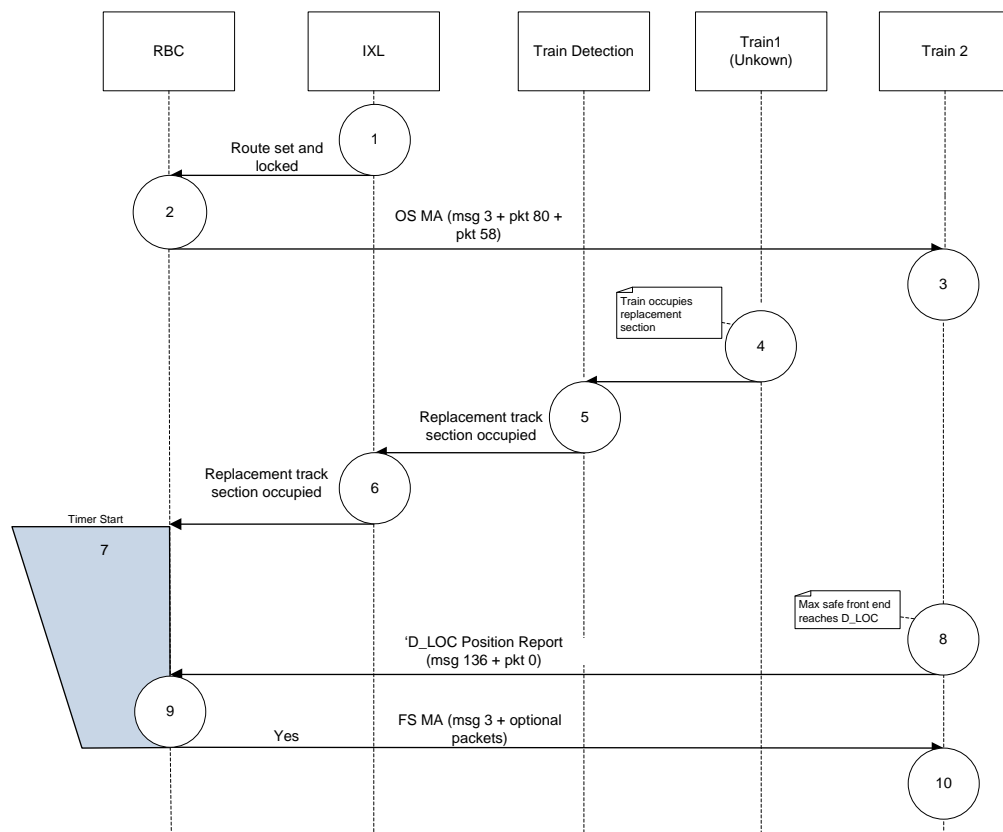


Figure 4: Interaction diagram of scenario at risk

3.2.1.4 Description of interaction diagram of ATAF scenario at risk:

Train 2 has a valid position, is oriented in the correct direction, and this has been reported to the RBC.

Train 1 is a train that the RBC does not know or cannot locate i.e. the RBC is not aware of this train at a stand at the ATAF Marker.

- 1) The onward route from the ATAF Marker has been set and locked by the interlocking. This route status is sent to the RBC. Train 1 is authorised to pass the ATAF Marker (either procedural or on an optical signal aspect).
- 2) With the route set and locked and Train 2 reporting a valid position, the RBC transmits a movement authority including an OS mode profile to Train 2.
- 3) The movement authority is received by the ETCS on-board, and the driver acknowledges immediate entry into OS mode and departs.
- 4) Train 1 occupies the replacement track section.
- 5) The train detection equipment informs the interlocking of the replacement track section occupancy.
- 6) The interlocking informs the RBC of the replacement track section occupancy.
- 7) The RBC starts the ATAF Timer waiting for the D_LOC position report.
- 8) When the Max_Safe_Front of Train 2 reaches the replacement track section limit (as defined by packet 58), the D_LOC position report is transmitted to the RBC.

- 9) The position report from Train 2 is received by the RBC and it confirms that Train 2 has met the ATAF success conditions. The RBC transmits an FS MA to Train 2
- 10) The on-board receives the MA and transitions to FS mode. There are now two trains in the same section; the rear train with an FS MA.

3.2.1.5 The two factors which affect whether this hazard is possible are the distance between the reference BG and the replacement track section limit, and the length of Train 1. If the distance from the reference BG to the replacement track section limit is sufficiently short (this affects the ATAF Distance, see section 3.4), or Train 1 is sufficiently long then there is no risk of the hazard occurring.

3.2.1.6 To reduce this risk, ATAF Distance and the ATAF Timer values must be considered.

3.2.1.7 The success rate of the ATAF function is proportional to the value of the ATAF Distance. The larger the ATAF Distance, the higher is the chance to get a successful ATAF, i.e. the train receives the FS MA and leaves OS mode. Conversely, the safety of the function is inversely proportional to the value of the ATAF Distance. The larger the ATAF Distance, the higher is the risk that a following train can successfully complete the ATAF. The value of the ATAF Distance is dependent on the following variables:

- The distance travelled from the reference BG to the replacement track section limit. This depends on the various moves that can be made (e.g. a turn back movement in rear of the ATAF marker) and on the distance between the ATAF Marker and the replacement track section limit.
- The train location accuracy used for the train position confidence interval calculation.

3.2.1.8 The ATAF Distance, and hence the ATAF Location, is a fixed value defined for each ATAF Marker in the RBC, based on an assumed train location accuracy, e.g. the train location accuracy specified in SUBSET-041 [2].

3.2.1.9 The ATAF Timer (the time during which the ATAF function is active) should be as short as possible. The ATAF Timer has to be long enough to cover the asynchronicity between the moment the RBC receives the status of the replacement track section from the interlocking, and the moment the RBC receives the position report from the train. However, the ATAF Timer has to be short enough to reduce the risk of a train incorrectly receiving an FS MA as described above. The ATAF Timer must be considered for each project.

3.3 Extension of scope to lines with optical signals

3.3.1.1 This guideline has been specified focusing on lines equipped only with ERTMS/ETCS marker boards. Therefore, in order to avoid the need for European Instructions, OS mode is used in rear of these ERTMS/ETCS marker boards. If optical signals exist, then it can replace also a written order.

3.3.1.2 The safety considerations for the ATAF are valid for the transition from SR to FS and for the transition OS to FS.

3.3.2 SoM without OS mode profile

3.3.2.1 For lines where optical signals exist, the same functionality can be achieved with the train approaching the signal in SR. See Figure 5.

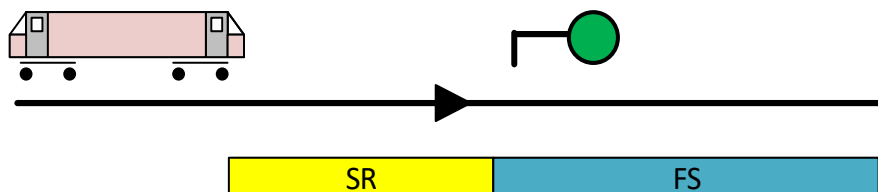


Figure 5: SoM with optical signal without using the OS mode profile

3.3.2.2 ATAF function is to be implemented at each optical signal where a train might be required to make a transition from SR to FS movement authority (e.g. after Start of Mission, having approached in SR mode).

3.3.2.3 If ATAF is not successful, the train remains in SR mode.

3.3.2.4 The process is repeated, for a train in SR mode, at the next ATAF optical signal.

3.3.2.5 The description of the interaction diagram is equivalent to the described in section 3.1.5.2 without the need for the movement authority in OS mode in rear of the optical signal.

3.3.3 SoM with OS mode profile

3.3.3.1 Another option in case the position of the train is known and the interlocking conditions set, is to send directly an MA to pass the signal which include an OS mode profile which ends at the signal. See Figure 6.

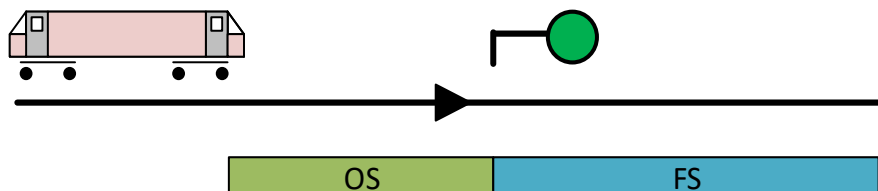


Figure 6: SoM with optical signal using the OS mode profile

3.3.3.2 If the train has a large confidence interval, it is possible that the on-board will switch to FS mode immediately due to the maximum front end already being in advance of the signal and hence in the FS area. Please consider mitigations described in SUBSET-113 [5], hazard ETCS-H0074.

3.3.3.3 If the train position is unknown, then the chapter 3.3.2 is applicable.

3.4 Technical considerations for calculating the ATAF Distance

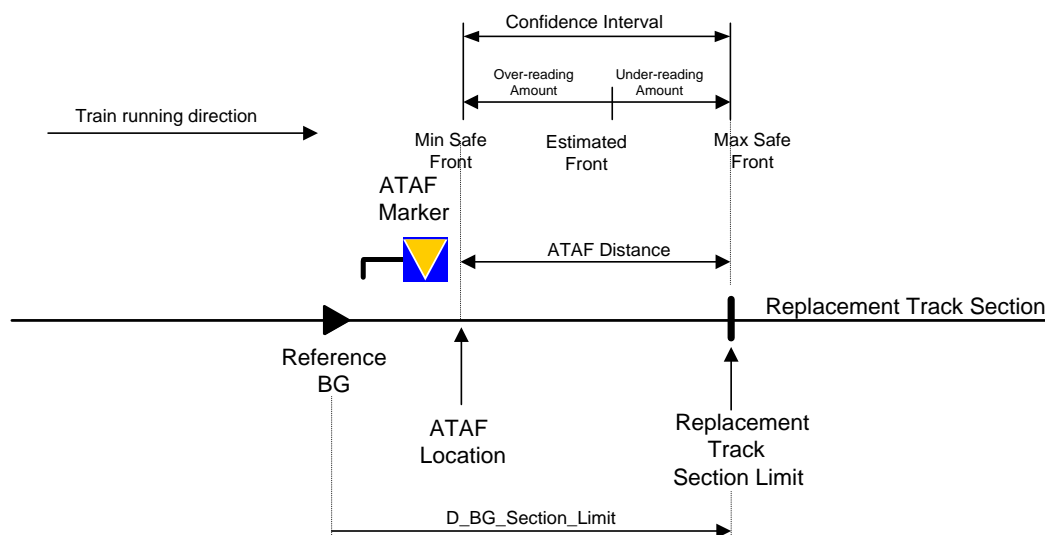


Figure 7: Determining the ATAF Distance

3.4.1.1 The ATAF Distance is based on the assumed distance travelled in reaching the replacement track section limit relevant to the reference BG (see Figure 7), hereafter referred to as $D_{BG_Section_Limit}$, as follows:

$$ATAF\ Distance = (2 \times Q_{LOCACC} + b + d) + \left(\left(\frac{a + c}{100} \right) \times \left(\frac{D_{BG_SECTION_LIMIT} - Q_{LOCACC} - b}{1 + \frac{a}{100}} \right) \right)$$

Where:

- Q_{LOCACC} = balise location accuracy
- Under-reading amount = $b + a\%(D_{LRBG})$
- Over-reading amount = $d + c\%(D_{LRBG})$

3.4.1.1.1 Note: The design of the ATAF location must consider that the value of the balise location accuracy (Q_{LOCACC}) may be determined by linking information if available, if not, by the corresponding National Value ($Q_{NVLOCACC}$), or the corresponding default value if the National Value is not applicable. If this function is required to operate where linking information is not available, the calculation must consider the National Value and default value.

3.4.1.1.2 Note: The variables a and c represent the percentage-based components, while the variables b and d represent the fixed components of the overreading or underreading amounts (see clause 5.3.1.1 of SUBSET-041 [2]).

3.4.1.2 For example, with a and $c = 5\%$, and b and $d = 5m$, then:

$$ATAF\ Distance = (2 \times Q_{LOCACC} + 10) + 0.1 \times \left(\frac{D_{BG_SECTION_LIMIT} - Q_{LOCACC} - 5}{1.05} \right)$$

3.4.1.3 When calculating the ATAF Distance, it must be ensured that the correct reference BG, and assumed distance travelled from that reference BG, $D_{BG_Section_Limit}$, is identified for the calculation of the expected train position confidence interval.

3.4.1.4 The determination of the correct reference BG and the distance travelled depends on:

- the consideration of all possible train movements up to the ATAF Marker, and the reference BG associated with each move, and
- the distance between the ATAF Marker and the replacement track section limit.

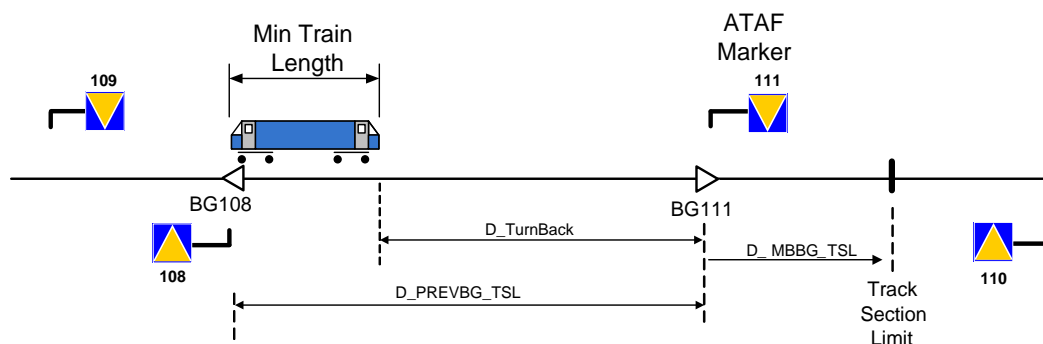


Figure 8: References for the Calculation of the ATAF Distance

3.4.1.5 With reference to Figure 8, and with marker board 111 the ATAF Marker, the ATAF Distance could be calculated relative to two reference BGs:

- 1) BG108 - For train movements from marker board 109 towards marker board 111
- 2) BG111:
 - a) for train movements from marker board 109 towards marker board 111, or
 - b) following a turnback move, i.e. the train has moved from marker board 110 to marker board 108, reading BG111 in the process. The train stops before marker board 108 without reading BG108, the driver changed ends, completes Start of Mission and moves off with the intention of passing marker board 111. The initial move towards marker board 111 could be in SR mode if the onward route from the ATAF marker 111 is not set. To pass the ATAF Marker and for the ATAF function to be initiated, the on-board must be in OS mode, and this will be sent to the train once the onward route is set.

3.4.1.6 For the train movements described above, $D_BG_Section_Limit$ could therefore take three values:

- 1) $D_PREVBG_TSL + D_MBBG_TSL$
- 2) D_MBBG_TSL
- 3) $D_PREVBG_TSL + D_TurnBack + D_MBBG_TSL$

3.4.1.7 The value of $D_BG_Section_Limit$ used has a direct influence on the safety of the ATAF function. In the situation where a fitted train is following a train that the RBC does not know or cannot locate, the risk of a successful ATAF due to occupation of the replacement track section by the unknown train and the following fitted train meeting the ATAF conditions is increased the larger the ATAF Distance.

A tolerable safe limit (D_SAFE) for the D_BG_Section_Limit used in the calculation of the ATAF Distance needs to be determined considering the following:

- The minimum length of vehicles operating on the infrastructure.
- The expected minimum separation between following trains.

3.4.1.8 The minimum separation could be assumed as the stopping distance from the OS mode speed as drivers of trains in OS mode should be driving so as to be able to stop within the distance ahead that can be seen to be clear. This maximum stopping distance is determined by the vehicles braking capability, the OS mode speed, and possibly a safety factor to allow for drivers not following the driving rules.

3.4.1.9 Considering the above, D_Safe is therefore the maximum D_BG_Section_Limit value that ensures that for all vehicles on the infrastructure it is not possible for a following train to get close enough to a preceding train for ATAF to be successful. A single D_Safe value could be calculated that applies to all ATAF Markers, or alternatively a D_Safe value could be calculated separately for each ATAF Marker.

3.4.1.10 The ATAF location is then calculated as follows:

- If the distance between the ATAF Marker balise group and the replacement track section limit, D_MBBG_TSL, is sufficiently long to ensure that, under worst case conditions, and for all possible moves, the on-board will read and process the ATAF Marker balise group and reset its odometry relative to that balise group before the D_LOC position report is triggered, then the ATAF Distance is calculated using the ATAF Marker balise group as the reference BG and D_BG_Section Limit = minimum of D_MBBG_TSL and D_Safe
- If not, then the ATAF Distance is calculated using a D_BG_Section_Limit value equal to the minimum of:
 - D_PREVBG_TSL + D_MBBG_TSL or
 - D_PREVBG_TSL + D_TurnBack + D_MBBG_TSL (if a turnback move is possible), and
 - D_Safe

3.4.1.10.1 Note: Worst case conditions are considered to be that the D_LOC Position report is sent just before the odometry reset at the marker board BG with the train located at the min safe front end, travelling at the maximum OS mode speed.

3.4.1.11 To reduce the ATAF Distance, additional balise groups may be installed as required to prevent the D_LOC position report being triggered by anything other than the distance travelled from the balise group at the ATAF Marker.

3.4.1.12 Consideration could also be given to restricting the success of the ATAF function to the receipt of a position report relative to a specific balise group, but this could limit the train movements for which ATAF will be successful.

3.5 Technical considerations for calculating the ATAF Timer value

3.5.1.1 The ATAF Timer value must be calculated such that, under worst case conditions, sufficient time is available from initiation of the ATAF Timer for the D_LOC Position Report to be received and processed by the RBC before the timer expires. This is shown in Figure 9 below.

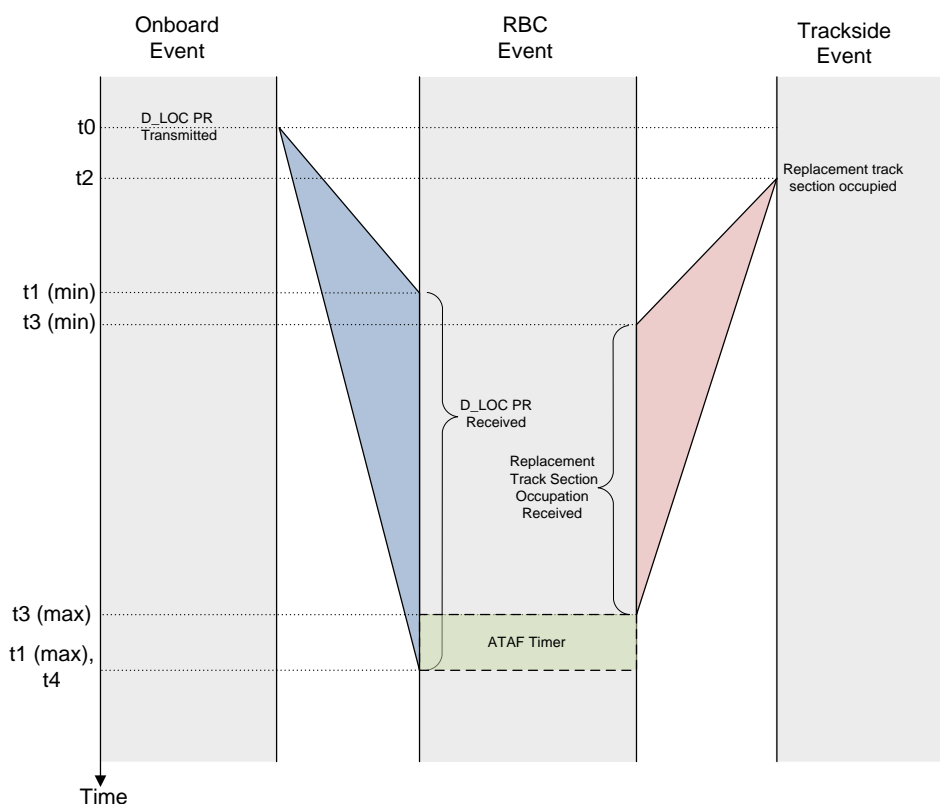


Figure 9: Calculation of the ATAF Timer Value

3.5.1.2 With reference to Figure 9, the following time related events are considered:

- t0 = The time that the Max_Safe_Front_End of the train reaches the replacement track section limit and the train transmits the **D_LOC position report**.
- t1 = The time that the **D_LOC position report** is received and taken into account by the RBC, therefore:

$$t1 = t0 + T_{PRTrainRBC}$$

- where $T_{PRTrainRBC}$ includes:

- The maximum time before the sending of a position report that the train position is estimated (see SUBSET-041 [2], section 5.3.1.3)
- The GSM-R transmission time.
- RBC reception and processing time.

- t2 = The time the first wheelset of the train occupies the replacement track section, therefore:

$$t2 = t0 + \frac{(D_{Overhang} + D_{MaxSafeRealFront})}{V_{Train}}$$

- where

- V_{Train} = train speed
- $D_{MaxSafeRealFront}$ = the distance between the Max_Safe_Front and the real front end of the train.
- $D_{Overhang}$ = distance between the real front end and the first axle.
- t_3 = The time that the occupation of the replacement track section is received and taken into account by the RBC, and the ATAF timer is activated.

$$t_3 = t_2 + T_{Detect}$$

- where T_{Detect} includes:
 - Train detection system processing and transmission time.
 - Interlocking (IXL) reception and processing time.
 - IXL to RBC Transmission time.
 - RBC reception and processing time.
- t_4 = ATAF timer expiration, therefore

$$t_4 = t_3 + T_{ATAFTimerValue}$$

3.5.1.3 To increase the rate of success of the ATAF function, $t_4 \geq t_1$.

3.5.1.4 The ATAF Timer value ($T_{ATAFTimerValue}$) is calculated according to implementation specific values for the various transmission delays and processing times, and the formulas listed above as follows:

$$T_{ATAFTimerValue} \geq T_{PRTrainRBC} - T_{Detect} - \frac{(D_{Overhang} + D_{MaxSafeRealFront})}{V_{Train}}$$

3.5.1.5 The worst case conditions referred to in 3.5.1.1 are:

- The maximum values of $T_{PRTrainRBC}$ and V_{Train} .
- The minimum values of T_{Detect} , $D_{Overhang}$, and $D_{MaxSafeRealFront}$.

4. ATAF using CES message

4.1 Principles for the ATAF using CES message

4.1.1 Principles

- 4.1.1.1 When the route is locked, the RBC can send an MA with an OS mode profile to the start of the replacement section limit. The basic function for the automatic TAF is that as soon as the RBC is informed that the section in advance of a defined track section limit becomes occupied, the RBC sends a Conditional Emergency Stop message to the train. The train ignores the CES if the CES stop location has already been passed by the min safe front end. For the CES stop location the odometer confidence interval and other location inaccuracies are taken into account (see section 4.2) to avoid the train being tripped on its own occupation of the replacement track section (see Figure 10 for a visual representation of ATAF using a CES message).

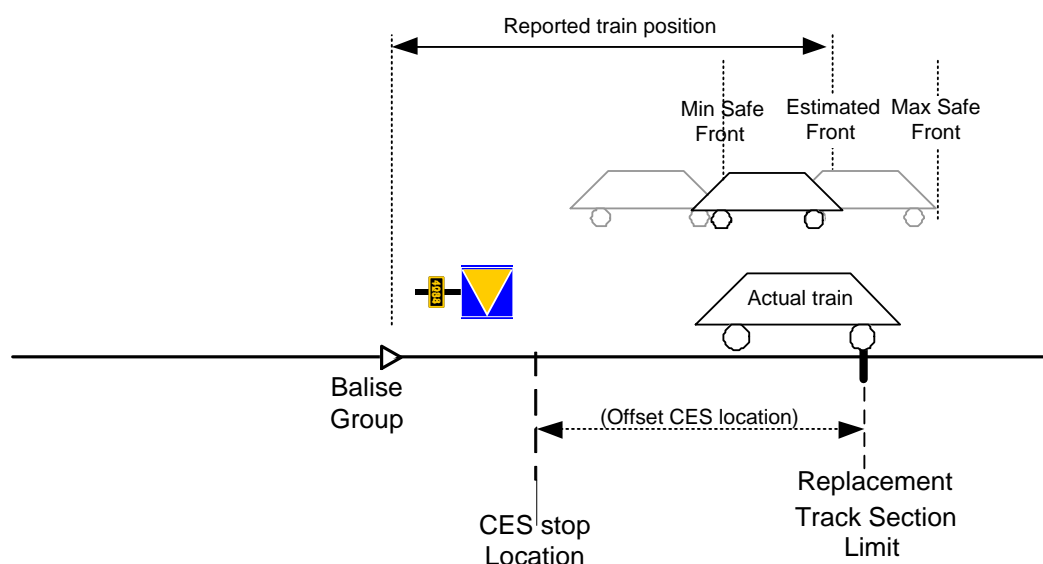


Figure 10: ATAF using CES method

- 4.1.1.1.1 Note: Depending on the safety aspects, the transmission times and the national rules the initial MA could also only contain an OS mode profile (like the ATAF of the previous section 3.1) and send an MA without OS mode profile to allow the transition to FS mode after the train has acknowledged, within a given time after the section is reported occupied, that the CES is ignored. However, this so-called pre-check for the ATAF CES method is not implemented yet and therefore is not part of this guideline but an interaction diagram of this functionality can be found in Appendix A..

4.1.2 Benefit of this method

- 4.1.2.1 When the route is locked a MA with the OS mode profile until the track section limit can be issued in rear of the marker board authorising the driver to depart.
- 4.1.2.2 The FS MA is revoked in case another train has been detected occupying the track in advance.

- 4.1.2.3 Drivers are consistently provided with the FS MA at a recognised location.
- 4.1.2.4 The stop location for the CES based on the track section occupation can be the same as for the stop location for the mitigation for the situations where an erroneous track occupation that mimic normal passage can cause the loss of route protection.

4.1.3 Interaction diagram

4.1.3.1 Figure 11 below depicts the scenario for the ATAF with a CES for a train with an OS mode profile to the section limit in advance of the marker board. In the scenario the train passes the marker board and occupies the track section in advance.

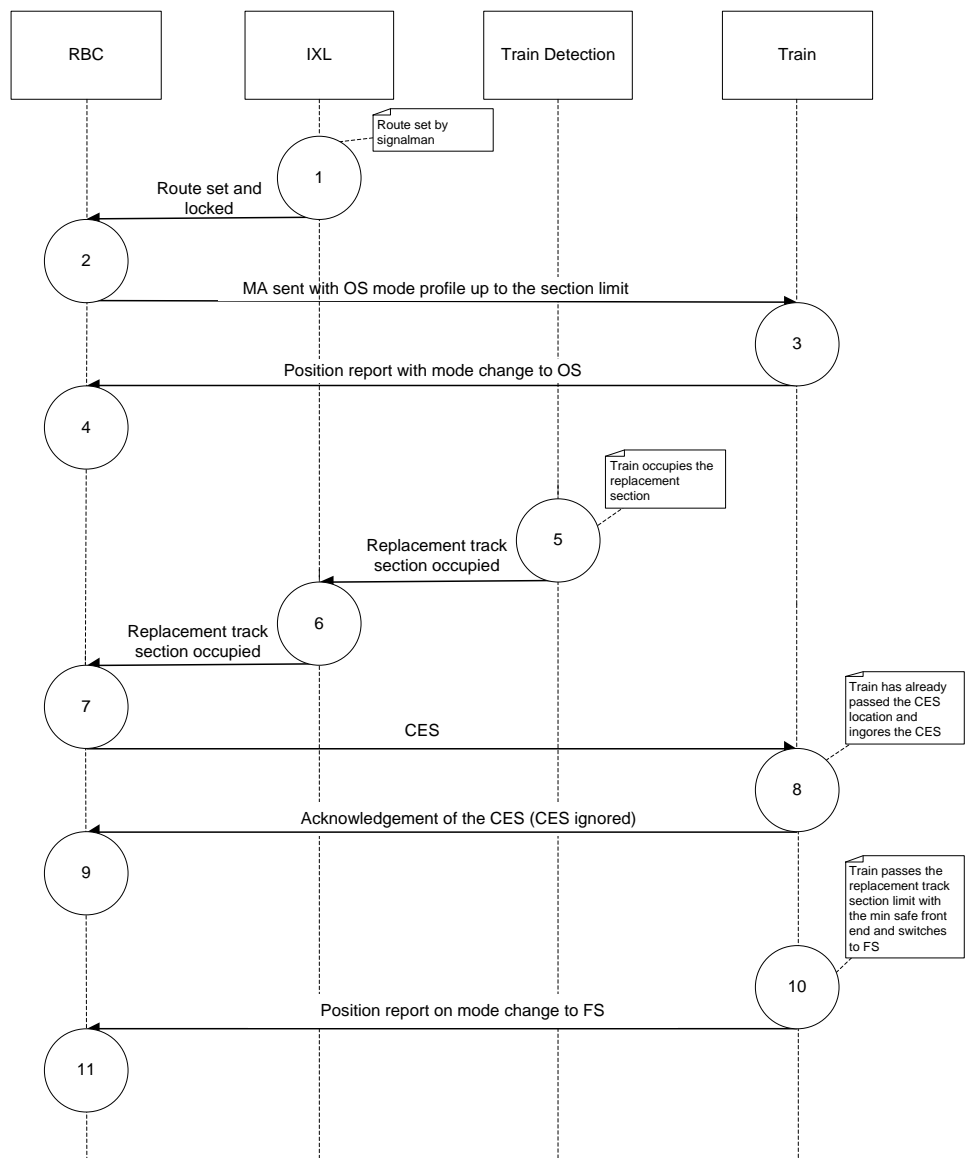


Figure 11: ATAF Interaction diagram using CES method

4.1.3.2 Description of the ATAF using CES method interaction diagram:
 Initial state: The train is either at a stand or approaching the marker board. The train has a valid position, is oriented in the correct direction, and this has been reported to the RBC.

- 1) The onward route from the marker board has been set and locked by the interlocking. This route status is sent to the RBC.
- 2) With the route set and locked, and the train reporting a valid position, the RBC transmits a movement authority including an OS mode profile to the train. The OS mode profile covers track for which the train occupation is unknown, normally until the replacement section in advance of the marker board.
- 3) The movement authority is received by the ETCS on-board, then the driver acknowledges immediate entry into OS mode, proceeds and passes the marker board.
- 4) The ETCS on-board sends a position report to the RBC with the mode change to OS.
- 5) The train occupies the replacement track section and train detection equipment informs the interlocking.
- 6) The interlocking informs the RBC of the replacement track section occupancy.
- 7) The RBC sends a CES to the ETCS on-board.
- 8) The ETCS on-board receives the CES and evaluates the position, then informs the RBC that the CES is ignored.
- 9) The RBC receives the acknowledgment of the CES.
- 10) The train passes the end of the OS mode profile (the track section limit) with the min safe front end and switches to FS mode. A position report with the mode change is sent to the RBC.
- 11) The RBC is informed about the mode change to FS mode.

4.1.3.2.1 Note: The event 11) can occur before event 7). For example, if the confidence interval of the odometer is small and the delays of the track section occupation triggering the CES are relatively large. In this situation the RBC does not need to send the CES because when the train reports being in FS mode the RBC knows that the train has already passed the CES stop location with its min safe front end and therefore the CES would be ignored.

4.2 Safety considerations for ATAF using CES message

4.2.1.1 For the CES stop location, either the reported train position confidence interval is used, or a pre-defined confidence interval based on the considered performance requirements.

4.2.1.2 To avoid that the train trips itself the CES stop location is shifted from the section limit location where the following distances should be taken into account:

- The error in detection of the balise group (this is included in SUBSET-041 [2] clause 5.3.1.1)
- Train position confidence interval (SUBSET-026 [1] clause 3.6.4)
 - Depending on the considered performance requirements (e.g. SUBSET-041 [2] clause 5.3.1.1)

- The distance of the last relevant balise group assuming the estimate train position when the max safe front end is at the replacement section limit.
- Location accuracy:
 - Q_LOCACC used in linking (project specific)
 - Q_NVLOCACC used without linking information (project specific)
- Minimal distance between first axle and front end of the train (project specific)
- The distance travelled by the train between passing the track section limit and evaluating CES stop location with the min safe front in the train. This distance depends on:
 - The speed of the train (project specific, typically between 0 km/h and the OS speed including possible overspeed due to the speed margins)
 - The delay until the RBC sends the CES message after the train occupies the replacement section (i.e. time to detect replacement track section occupation, time required to inform the RBC, time required for the RBC to process the information and generate the CES message, this is project specific).
 - The transmission delay for sending the CES to the train (project specific)
 - The processing delay for evaluating the CES message (<1sec according to SUBSET-041 [2])

4.2.1.3 The used CES stop location depends on the project specific considerations and is a balance between the safety (CES is ignored while another train in advance occupied the section) and the operational considerations (see Figure 12 for a visual representation of these considerations).

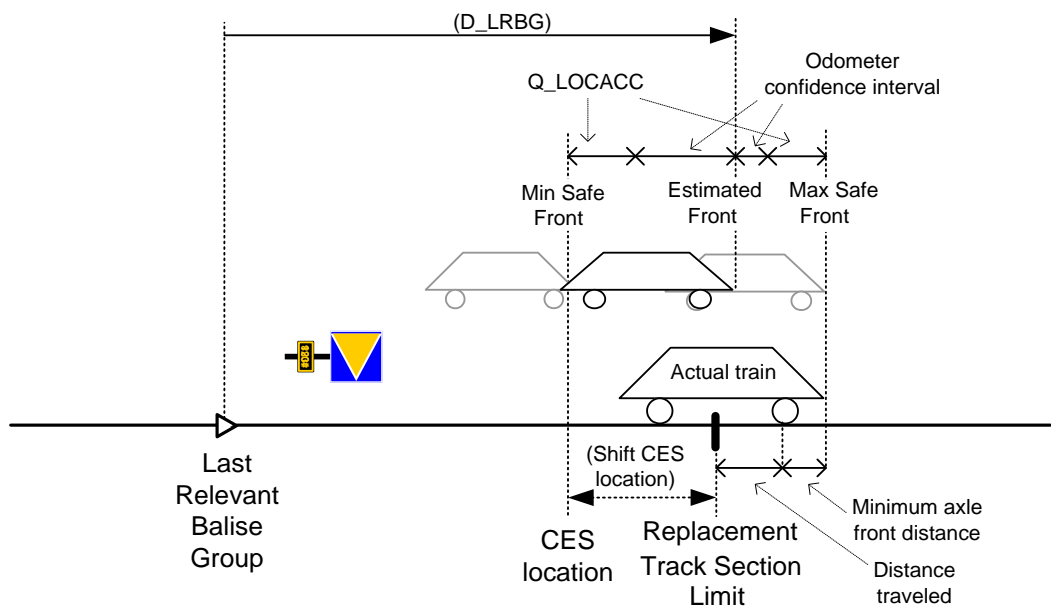


Figure 12: Considerations for ATAF using CES method

- 4.2.1.4 A train with a position confidence interval outside the considered odometry performance requirements could be tripped if the train speed is such that the train min safe front end is still in rear of the CES stop location when the CES is received on-board. This trip is however the consequence of an on-board failure and cannot be attributed to the ATAF function.
- 4.2.1.5 The risk of a train being tripped by the CES is inversely proportional to shift of the CES stop location from the track section. The larger this distance, the lower is the chance on a trip on the CES. Conversely, the safety of the function is proportional the shift of the CES stop location. The closer the CES stop location is to the track section, the smaller the risk that the wrongly assigned MA of a following train is not shortened.

5. Automatic TAF using a distance guaranteed as free

5.1 Principles for Automatic TAF using a distance guaranteed as free

5.1.1 Principles

5.1.1.1 The main characteristic of this procedure is to define the distance for which it can be considered that there is no train in rear of the next track section limit. The use of this functionality is possible for the transition to FS from the modes: SB, SR, OS and PT.

5.1.1.2 The main principle is that if a train reports its position within this distance, the RBC will be able to send a FS MA if all the conditions are fulfilled for the route after the signal.

5.1.2 Benefit of this method

5.1.2.1 Drivers are consistently provided with the FS MA at a recognised location.

5.1.2.2 This solution enables the system to provide a FS MA during the SoM from SB mode allowing for the driver to start a mission with no transition to a mode that gives the responsibility of the train movement to the driver.

5.1.2.3 This functionality can be applied for the train in any mode in which a transition to FS could be necessary in level 2.

5.1.3 Interaction diagram

5.1.3.1 The interaction diagram for ATAF using a distance guaranteed as free can be seen in Figure 13 below.

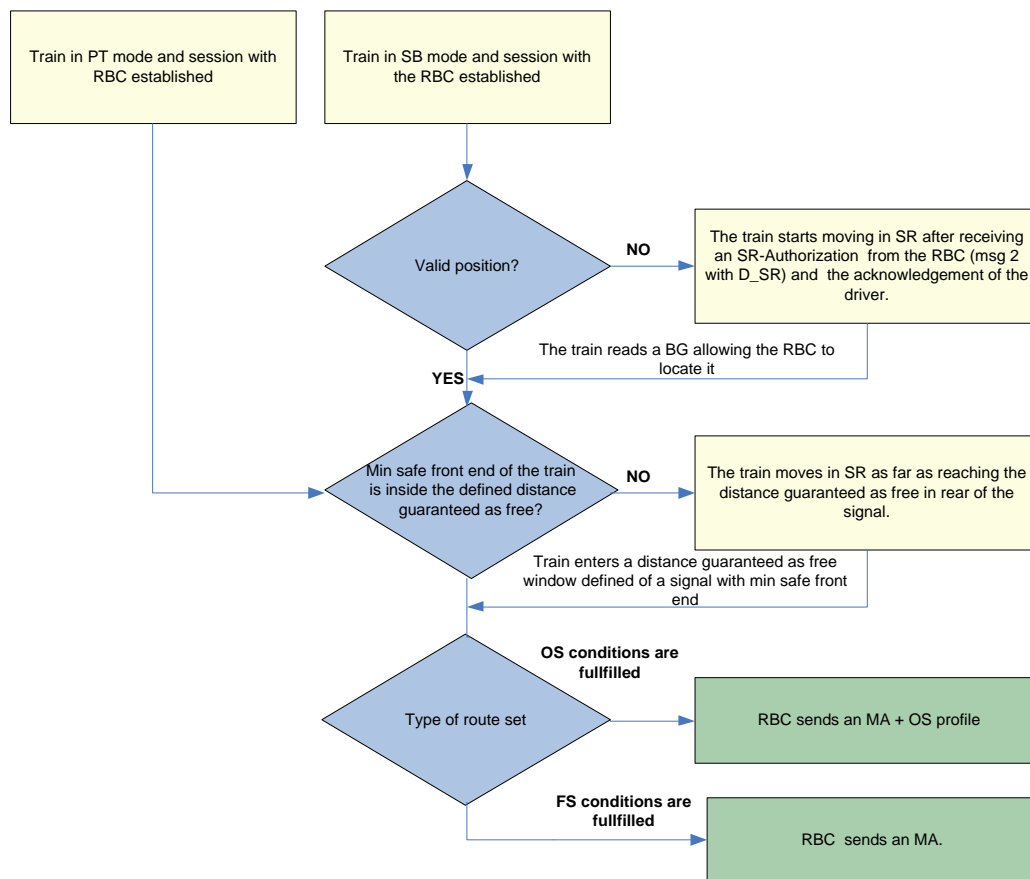


Figure 13: Interaction diagram of ATAF using a distance guaranteed as free

5.1.3.1.1 Note: It is possible that while at standstill in rear of the signal or approaching the area, the signal aspect or the route setting change. In this situation the RBC should update the information sent to the train according to the diagram. For example, the train at standstill in rear of a signal in SR mode, if the route is set and the conditions for FS are fulfilled, the RBC could send an MA to the train.

5.1.3.1.2 Note: If the route is not set, the driver will be able to move the train in SR mode as far as it is possible operationally taking into account the distance given by the variable D_SR, or the override procedure.

5.2 Implementation of Automatic TAF with distance guaranteed as free

5.2.1.1 The use of this functionality is possible for the transition to FS from the modes: SB, SR, OS and PT. The RBC will be able to send an FS MA if all the conditions are fulfilled for the route after the signal.

5.2.1.2 Figure 14 below gives a visual representation of the references for the implementation of ATAF with distance guaranteed as free.

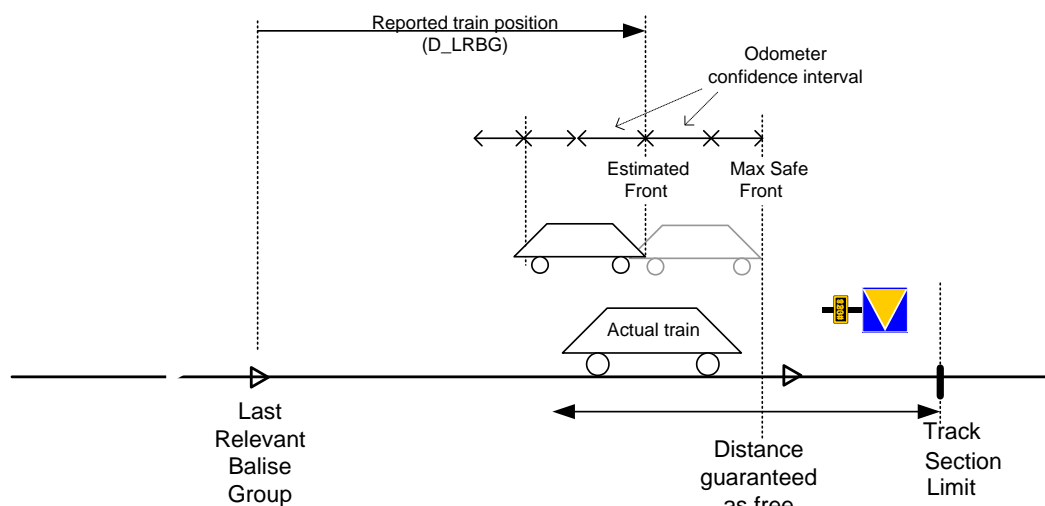


Figure 14: References for ATAF with distance guaranteed as free

- 5.2.1.3 The RBC will send FS MA if the following conditions are fulfilled:
- The reported train position and directional train location information are valid.
 - The reported minimum safe front end of the train is closer to the track section limit than a defined distance.
 - The route protected by the signal is set proceed and the conditions are fulfilled for an FS route.
- 5.2.1.4 If the conditions are fulfilled for an OS route, the MA will be sent together with a mode profile for OS.
- 5.2.1.5 In all other cases, the train will not make a transition to FS/OS mode as no MA will be sent from RBC.
- 5.2.1.6 The definition of the distance guaranteed as free will have to take into account:
- The length of the smallest train considered in the line.
 - To successfully obtain an MA implementing this functionality, the RBC has to receive a position report from the train for its minimum safe front end to be within the defined distance before the train reaches the next track section, or within a short delay after this section is occupied.
- 5.2.1.7 To achieve a position report within the distance guaranteed as free, the position report parameters are defined. The trackside will at least request the train to send a position report when its max safe front end is at the next track section limit (with variable D_LOC) and cyclically (T_CYCLOC), taking into account the speed (i.e. maximum speed of the modes in which the train can be approaching this area with a need to update the MA) and the length of the distance guaranteed as free.
- 5.3 Safety considerations for Automatic TAF using a distance guaranteed as free**

- 5.3.1.1 The distance guaranteed as free has to be defined for each line by the infrastructure manager. It should be based on the length of the smallest train in operation on this line and project specific safety analysis.
- 5.3.1.2 If the resulting distance needed to achieve an acceptable rate of success for the functionality is too long, additional mitigation measures are required. This functionality can be combined with some other ATAF functionality methods.
- 5.3.1.2.1 Note: This combination of the method can be performed with both of the ATAF as described in sections 3 and 4. For the combination with the ATAF using a position report, refer to section 3.3. For the combination with the ATAF using CES message, the transition to FS will be performed in rear of the optical signal within the distance guaranteed as free. Therefore, the protection of the CES message will be achieved with the train already in FS mode.

Appendix A Interaction diagram Automatic TAF Pre-check alternative with CES

A.1.1.1 Figure 15 below depicts the scenario for the pre-check ATAF with a CES for a train with MA with an OS mode profile. In the scenario the train passes the marker board and occupies the track section in advance.

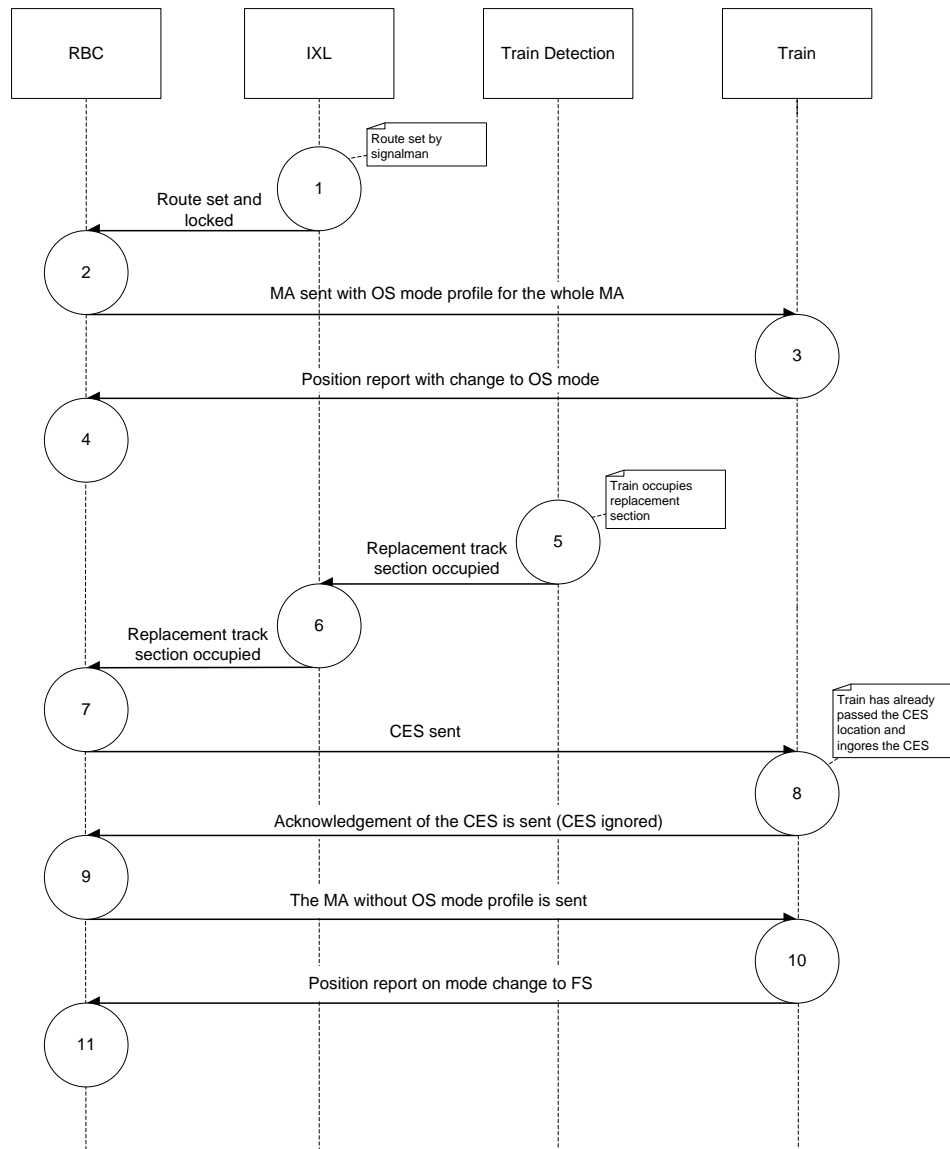


Figure 15: Interaction diagram of pre-check ATAF using CES

A.1.1.2 Description of the pre-check ATAF using CES interaction diagram:

Initial state: the train is either at a stand or approaching the marker board. The train has a valid position, is oriented in the correct direction, and this has been reported to the RBC.

- 1) The onward route from the marker board has been set and locked by the interlocking. This route status is sent to the RBC.

- 2) With the route set and locked, and the train reporting a valid position, the RBC transmits a movement authority including an OS mode profile to the train. The OS mode profile covers the whole MA.
- 3) The movement authority is received by the ETCS on-board, and the driver acknowledges immediate entry into OS mode, proceeds and passes the marker board.
- 4) The ETCS on-board sends a position report with the mode change to OS to the RBC.
- 5) The train occupies the replacement track section and local train detection equipment informs the interlocking.
- 6) The interlocking informs the RBC of the replacement track section occupancy.
- 7) The RBC sends a CES to the ETCS on-board.
- 8) The ETCS on-board receives the CES, evaluates the position and informs the RBC that the CES is ignored.
- 9) The RBC receives the acknowledgement of the ignored CES and sends a (FS) MA without OS mode profile to the ETCS on-board.
- 10) The ETCS on-board receives the MA, switches to Full Supervision and a position report with the mode change to FS is sent to the RBC.
- 11) The RBC is informed about the mode change to FS.

Appendix B ATAF using smart axle counters

B.1 Principles

- B.1.1.1 Axle counters or interlocking using axle counters can provide more information than just “TTD occupied” or “TTD free” which can be used in the RBC to implement ATAF function. Among the interesting information, the IXL could transmit the number of axles in a given TTD section to the RBC.
- B.1.1.2 The ATAF function aims at guaranteeing that there is no “non communicating” vehicle between the concerned train and the end of the TTD section to transmit an FS MA to the train.
- B.1.1.3 As soon as the train data are validated and the session is established with the RBC, the on-board transmits the “validated train data” to the RBC. The number of axles of the vehicle in which the EVC is installed is also transmitted in the “validated train data” and cannot be modified by the driver (N_AXLE, see definition in SUBSET-026 [1] clause 7.5.1.79.1).
- B.1.1.4 By comparing the number of axles in a given TTD section reported by the IXL and the number of axles reported by the on-board, the RBC can determine that there is no other vehicle in the TTD section and can transmit and FS MA from the front end of the train to the end of the TTD section. If the numbers of axles don't match, or if the train has no valid position, the RBC won't issue an FS MA.

B.2 Benefits of this method

- B.2.1.1 The FS MA can be transmitted as soon as the train has a valid position, and the RBC has acknowledged the validated train data.

B.3 Drawbacks of this method

- B.3.1.1 This method can only be used for trains which report N_AXLE different from 1023 (special value meaning “unknown”). It is a complementary method to others.
- B.3.1.2 As N_AXLE is the number of axles in the trainset or locomotive in which is installed the EVC, this method does not work for hauled trains (loco + coaches or wagons) and multiple units of trainsets: if the value N_AXLE is different from the number of axles reported by the interlocking, the RBC won't issue an FS MA.
- B.3.1.3 This method was never fully analysed nor implemented by any of the EUG members; it is then hard to identify problems which could emerge from such a concept. It requires further analysis at system level (involving also IXL and axle counters) to understand if such a method can achieve a satisfying level of performance and safety.