openETCS “Determine Train Location” Procedure

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# openETCS “Determine Train Location” Procedure

## references

UNISIG Subset\_026 version\_3.3.0

Chapter 3.6 : Location Principles, Train Position and Train Orientation

## object

This document specifies how the position of a train is determined on a one-dimensional track. The intension is not to repeat the contents as specified in Subset 026, chapter 3.6, but to reduce the complexity of the train position calculation to an algorithm not more complex than the problem itself.

Therefore, the following are the essentials of train position calculation.

# Basic Inaccuracy Calculations

## Addition of independent Tolerance Values

is a triple of a nominal value with a minus tolerance (negative) and a plus tolerance (positive) so that

.

The addition of 2 such values leads to

.

For the addition of more values in general:

This equation in a different notation

... which means that the tolerances of the sum equals the sum of the tolerances.

This applies only, if each of the values has its own tolerances independent from each other.

## Subtraction of Tolerance Values

The substraction of 2 tolerance affected values leads to

The minimum and maximum tolerance limits are generated by the suitable combination of min/max of values 1 and 2:

## Distances between linked Elements (BaliseGroups, ...)

The rules of chapter 2.1 and 2.2 refer to distances between elements along the track in general.

But for distances between linked elements, there is an important difference: Linked elements like balises are – as specified in Subset 026-3.6 – thought to be positioned on an absolutely correct nominal position with a known min/max accuracy around the nominal position.

Therefore, the tolerances of 2 and more linking distances between balises must not be summed up as calculated in chapter 2.1. Instead, only the positioning inaccuracies of the first and the last balise group in a chain of linking distances is relevant for distance calculation:

This equation is also suitable, if the LRBGONB changes between linked balise groups, and balise groups distances have to be recalculated as references to the new LRBGONB .

# Sources of Location Inaccuracies

Location inaccuracies are caused by a couple of sources. Since this document relates on the determination of the train position from the train perspective, only those causes that can be seen on the train are of relevance.

As stated in chapt. 2.3, it has to be differentiated between inaccuracies caused by independent effects and “linked” inaccuracies.

## Sources of independent Inaccuracies

The effects of inaccuracy – as understood here – are independent if they are not correlated or related to each other, so that the rules from chapter 2.1 apply.

Such independent sources and effects are

* Odometry
* Distance between train front end and balise antenna
* Distance between train front and rear end
* Inaccuracy of balise group center detection on the train
* Time delays between the occurrence of an event and its recognition by the OBU
* Time measurement inaccuracies on the train

For example, the location determination accuracy of unlinked balise groups is affected by these causes.

## Location Inaccuracies between Linked Elements

The locations of linked elements are determined by calculating the distances to linked reference balise groups according to chapter 2.3.

This refers to all distances between linked elements without any linking hole in between like

* Distances between linked balise groups
* Distances between linked continuous and non-continuous profile data

# Determination of the Train Location

The goal of this chapter is to design a procedure for determining the train location; it bases upon Subset 026, Chapter 3.6, but exceeds it with a practical approach.

## The OBU Coordinate System

As a measure for train location, the OBU makes up its own the one-dimensional coordinate system. It is private and only known by the OBU.

The origin of the OBU coordinate system can be chosen arbitrarily; to set it at system start up is a suitable choice.

The orientation of the coordinate system equals to the actual train orientation.

The train starts at location 0 at system start up.

The OBU coordinate system is preserved as long as the train is in operation; a reset of the coordinate system is permitted only when the OBU is restarted or all location and position information can be deleted.

## Location of Track Elements

All track elements – linked as well as unlinked – are mapped to their appropriate location on the OBU coordinate system.

The location of these track elements on the OBU coordinate system is determined as follows:

* After system start, there typically is no linking information available. The location of the first balise group is then determined mainly by the odometry and the effects of chapter 3.1.
* The location of unlinked elements (s. 3.1) or as long as no linking information is available is calculated with the rules of 2.1 and 2.2.
* The location of linked elements with no linking holes in between is calculated via the addition of differences according to 2.3 in relation to the appropriate reference balise group.   
  The location of the first linked (reference) balise group results cannot be determined by linking distances and therefore has to assigned according to 2.1 and 2.2.
* When the new location information is received from track that affects known track elements, their location at the OBU coordinate system has to be recalculated. To provide this, the originally information received from track should be stored as properties of the track elements.

In summary, all track elements are mapped to their location with the appropriate tolerances on the OBU coordinate system.

## Train Position = Location of the Train

The actual position of the train on the OBU coordinate system has to be calculated with the same methods as characterized in 4.2.

* It is a combination of summing up unlinked distances according to 2.1 and linked distances according to 2.3.
* The position of the train directly above a linked balise group is set to the location of this balise group plus the applicable inaccuracies from 3.1. In this case,
  + The train “jumps” to the location of the balise group.
  + The odometry is normalized with the balise group location (see Subset 026-3.6, fig. 13a).
* The normalization of the odometry with the balise group location means practically
  + To store the odometry value with its inaccuracies at the position of the balise group,
  + To compensate the distance and accuracy data received from the odometry during the following train movements with the stored odometry values.

## Train Position Reporting to the RBC

The train has to send position reports to the RBC regularly. These position reports inform the RBC about the actual train position, i. E. the actual distance of the train to the actual last relevant balise group LRBGONB.

With the OBU coordinate system the distance is quite simple:  
By subtracting the location of the LRBGONB from the actual train position by applying the rules of 2.2.