ALL4TEC

TRAIN POSITION

Véronique Gontier
V2

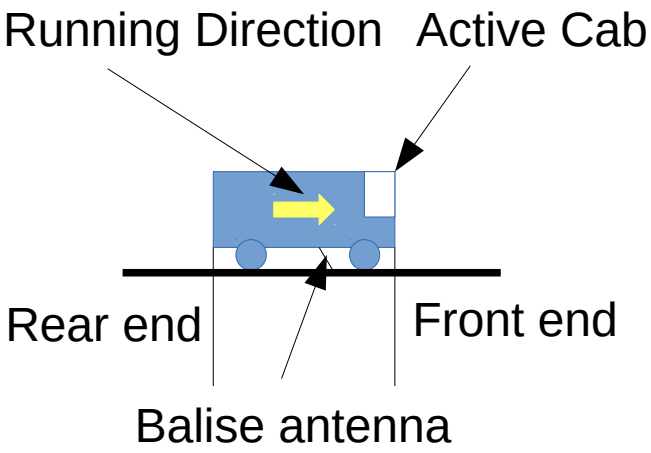
TRAIN POSITION INFORMATION

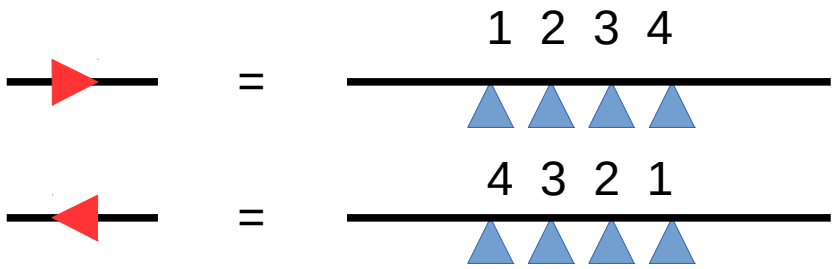
The Train Position information defines the position of the train front in relation to a balise group, which is called LRBG (the Last Relevant Balise Group). It includes:

* The estimated train front end position, defined by the estimated distance between the LRBG and the front end of the train
* The train position confidence interval
* Directional train position information in reference to the balise group orientation of the LRBG, regarding:
    - the position of the train front end (normal or reverse side of the LRBG)
    - the train orientation
    - the train running direction
* A list of LRBGs, which may alternatively be used by trackside for referencing location dependent information

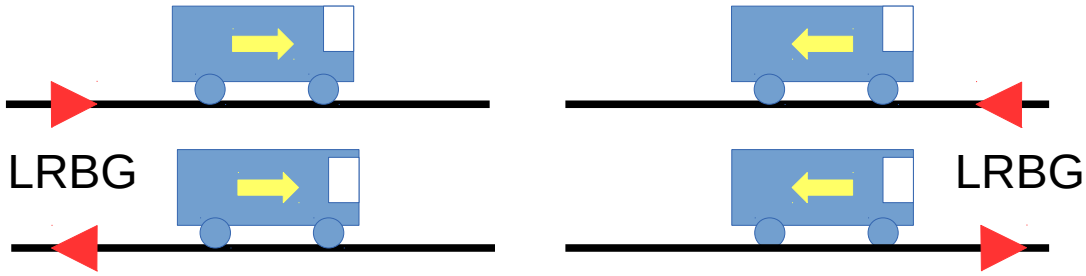
(SRS.3.6.1.3)

DIRECTIONAL TRAIN POSITION INFORMATION (1/2)



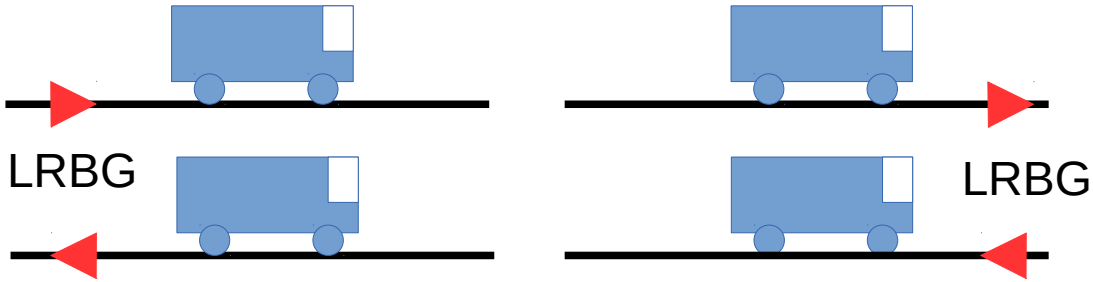


BG orientation



Running Direction = normal

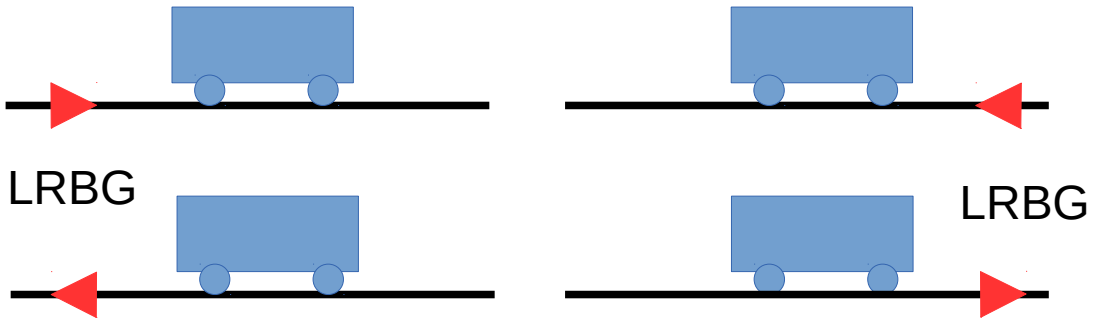
Running Direction = reverse



Train Orientation = normal

Train Orientation = reverse

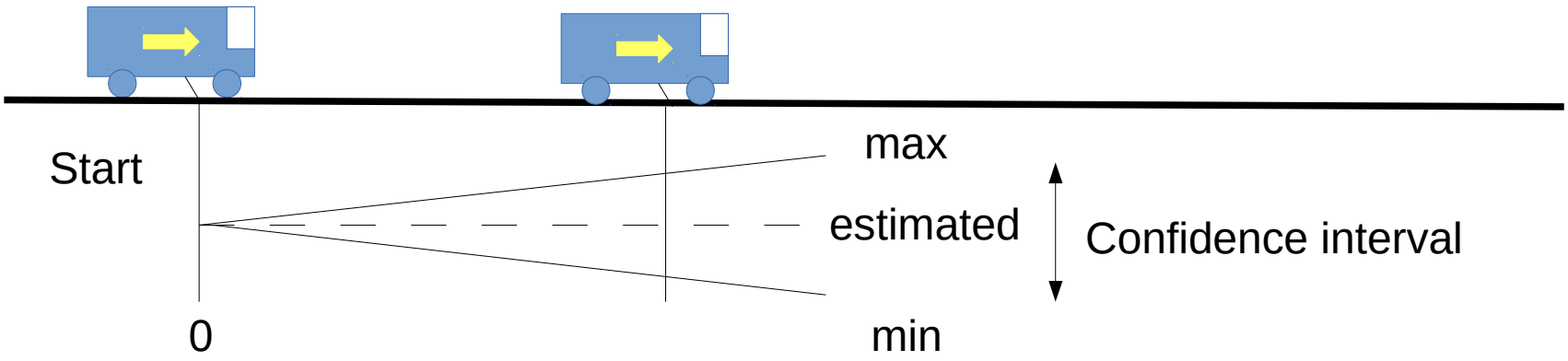
DIRECTIONAL TRAIN POSITION INFORMATION (2/2)



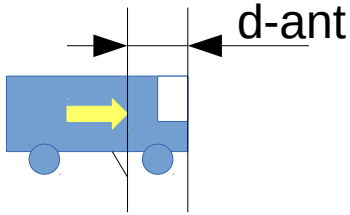
Train position = normal

Train position = reverse

ODOMETRY DEFINITIONS (1/2)

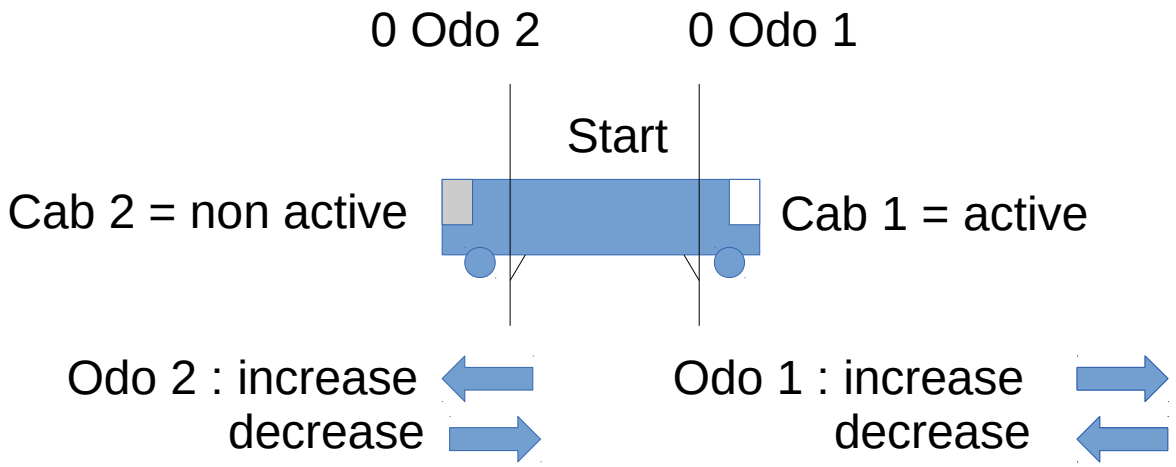


Max, estimated and min values are given by odometry
The confidence interval shall be < 5 %
Odometry calculates these values each 100ms (about)
N.B.: the confidence interval always increases as the train moves, forward OR backward



d-ant = distance between the front end and the balise antenna (about 3m)

ODOMETRY DEFINITIONS (2/2)



Generally, a train has two OBU and two odometries, one for each cab

Only one cab is active but the two odometries always work : one increases and the other decreases. So, if the active cab changes, the location is preserved and the reference (0 odo) automatically changes

USE OF DIRECTION ODOMETRY

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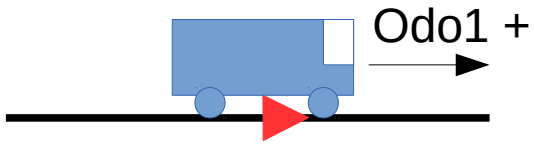
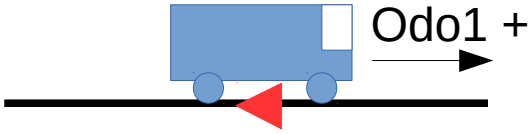
Odometry is used to calculate train orientation as the train pass over a new LRBG



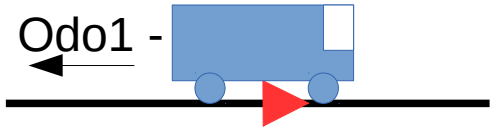
Running Direction = normal

Train Orientation = normal



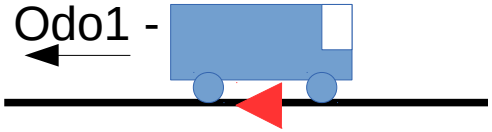
Running Direction = reverse

Train Orientation = reverse



Running Direction = reverse

Train Orientation = normal

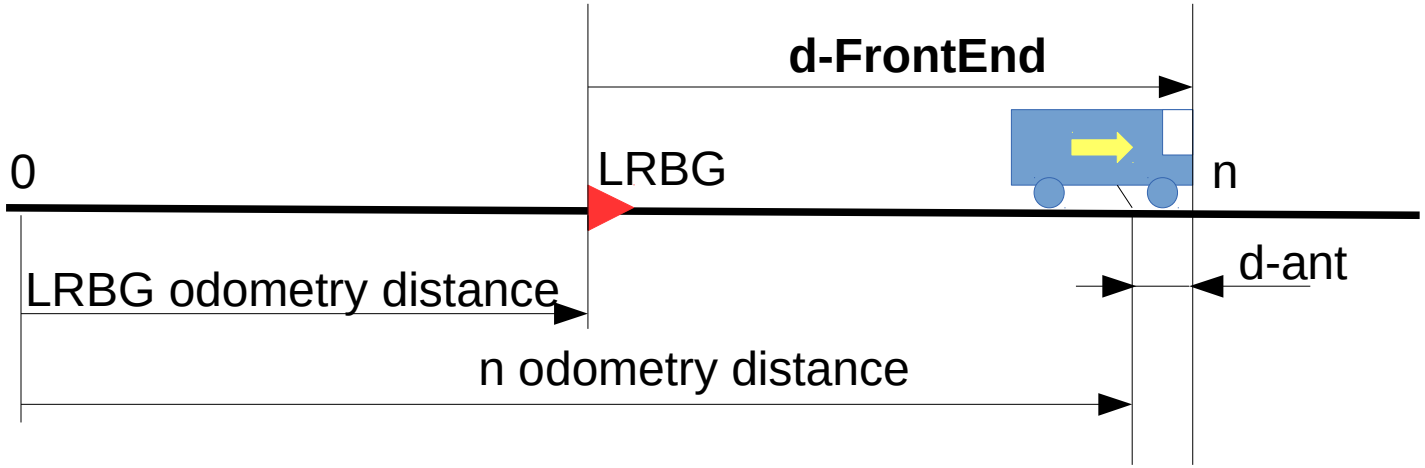


Running Direction = normal

Train Orientation = reverse

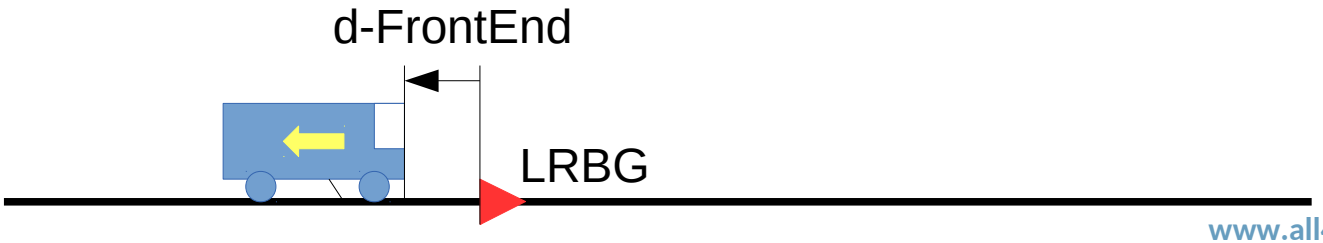
SIMPLIFIED LOCALISATION

To localize a train,two data are needed:
- LRBG (Last Relevant Balise Group), whose localisation is known
- d-FrontEnd: distance between the train front end and the LRBG
  This value is calculated with odometry information



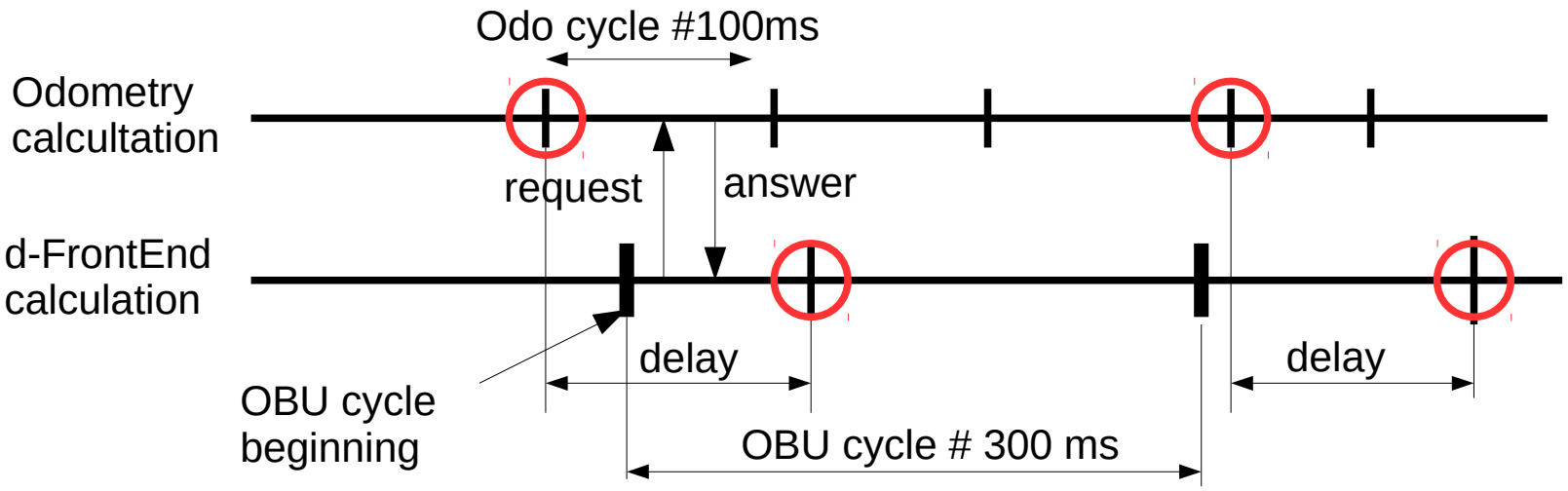
d-FrontEnd = n odometry distance – LRBG odometry distance + d-ant

NB : if the train goes backward, this value can be negative



TIME CYCLE CORRECTION

The OBU cycle is about 300ms and the odometry one is about 100ms
A timer distributes the same time to the OBU, the odometry and balise antenna system together
At its cycle beginning, the OBU asks odometry a set of refreshed data to calculate the FrontEnd position, and the odometry replies with a time-stamped information
So, the calculation has to take into account the distance traveled by the train during the delay between both the last odometry information time stamp and the Calculation time stamp itself

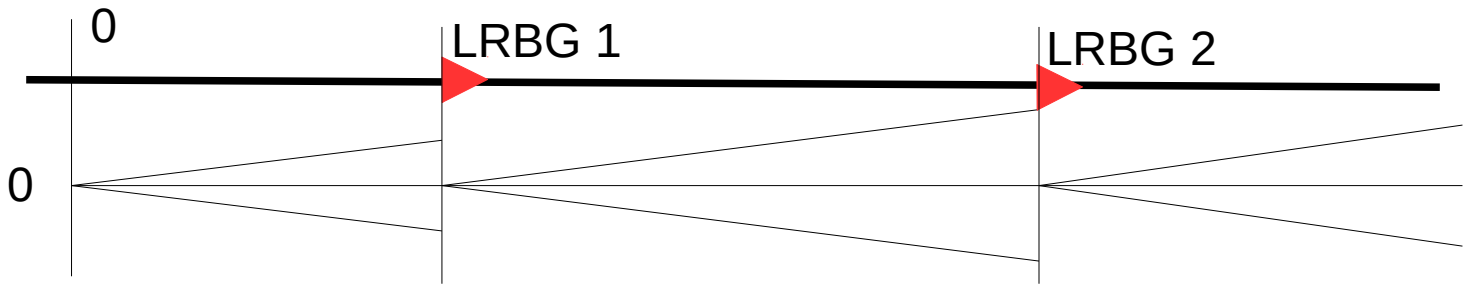


Estimated d-frontend = estimated n odometry distance – LRBG odometry distance + d-ant + (delay x current train speed)

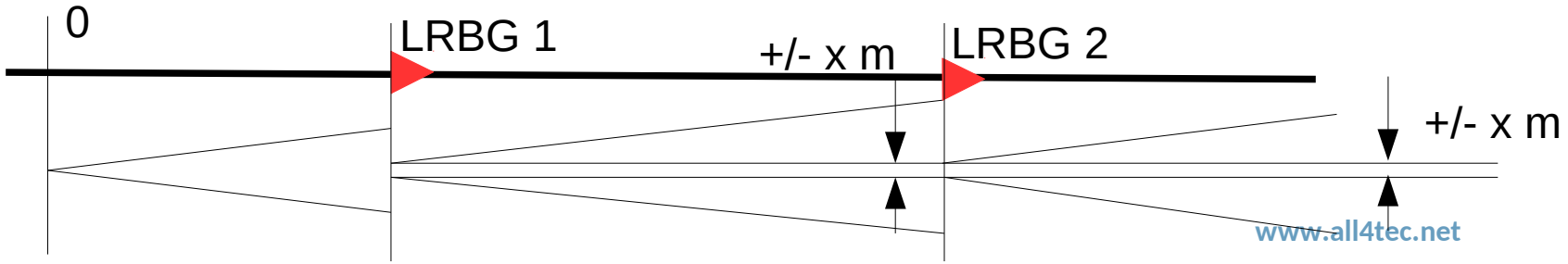
NB : at 350 km/h, the distance traveled by the train during a time cycle (300ms) is about 30m. So the corrective values are not insignificant

CONFIDENCE INTERVAL (1/1)

As the train passes over a new LRBG, the confidence interval can be reset, because the distances are reset

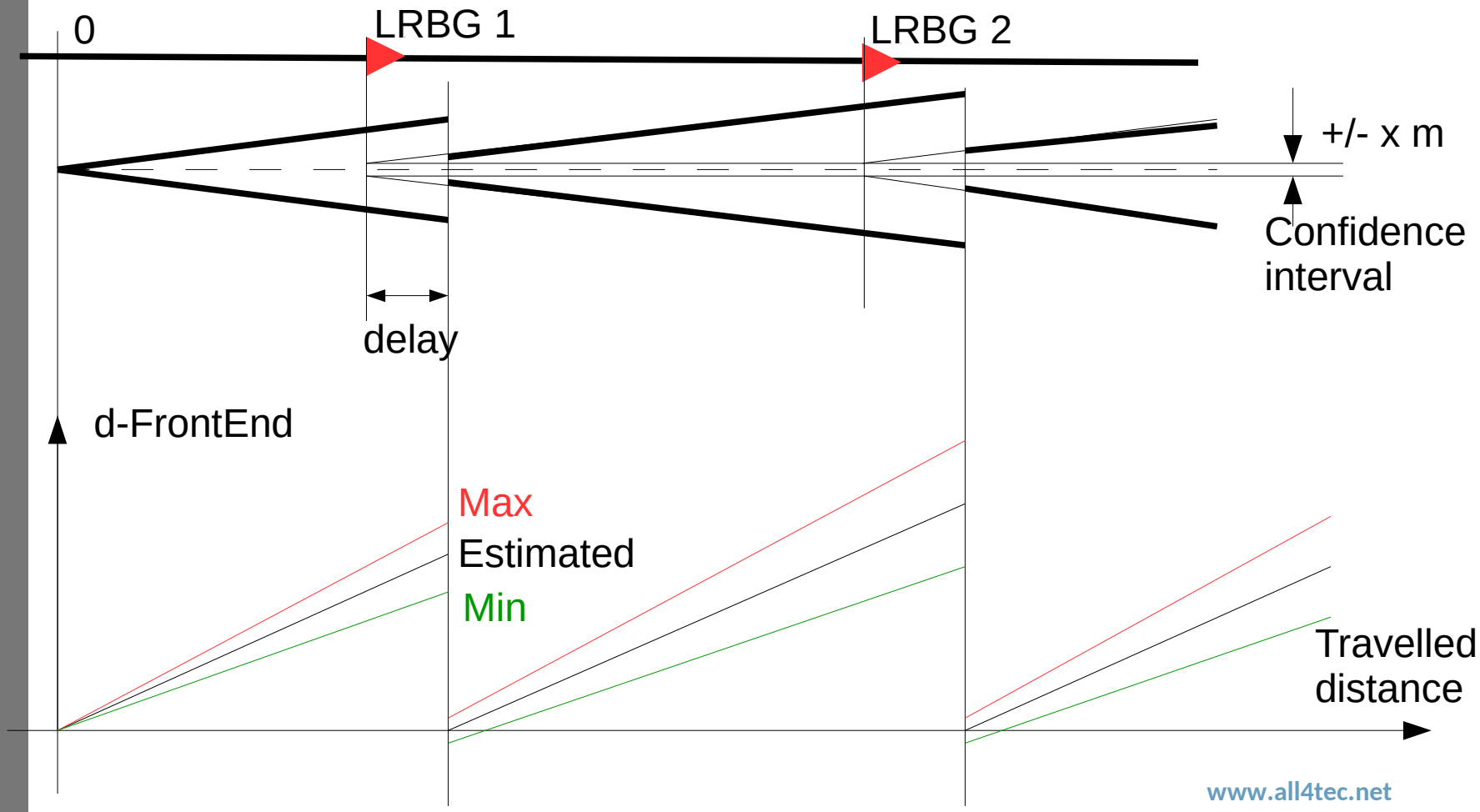


So, as the LRBG changes, the OBU shall inform the odometry and this one shall reset the confidence interval
But this reset can not be 0 because there always remain some uncertainties:
- uncertainty of physical balise position
- uncertainty of antenna measurement
- (delay between antenna detection and consideration by OBU) x train speed
The sum of these uncertainties shall be < +/- x m. x is given by Q_LOCACC or a national value



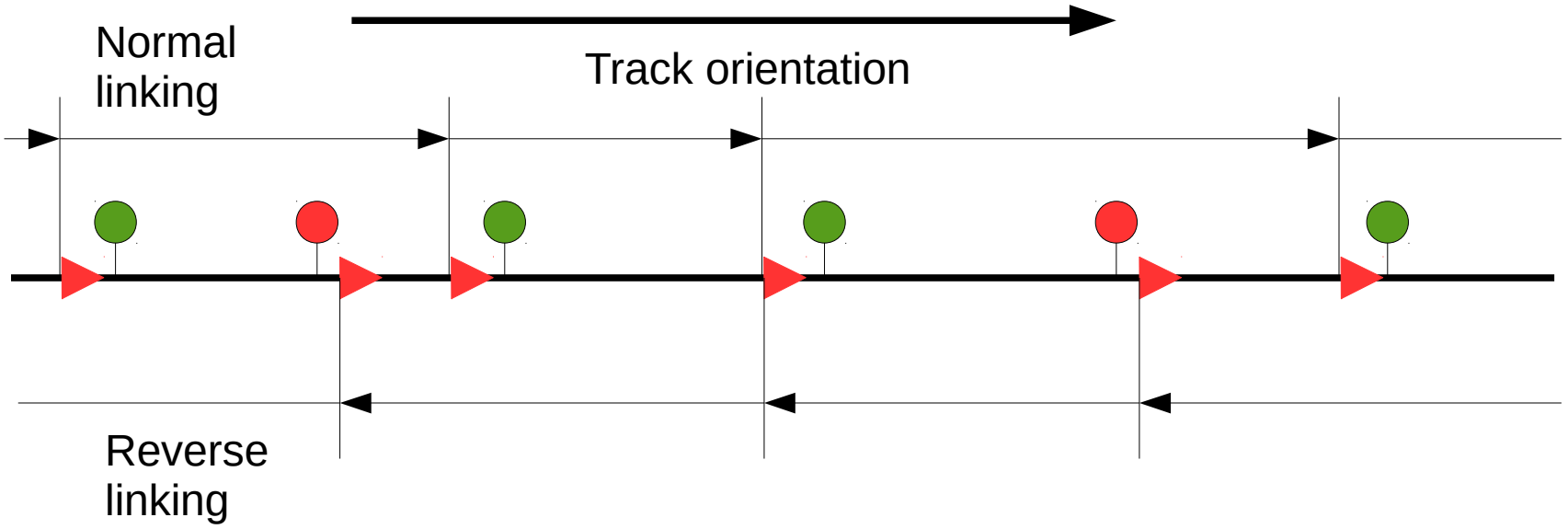
CONFIDENCE INTERVAL (2/2)

Last correction :
The delay between the LRBG pass over and the reset of the odometry values by OBU shall be taken into account

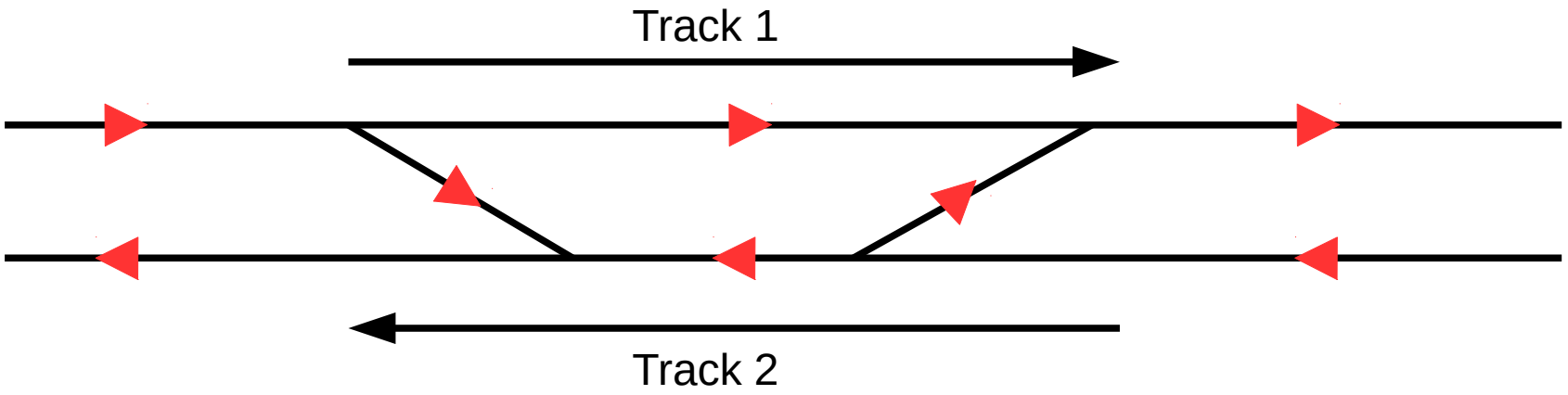


BALISE GROUP ORIENTATION

Balise groups are always oriented in the track normal direction
In one track there are both two linked systems: normal and reverse
A BG can be used for normal and reverse linking



BALISE GROUP ORIENTATION

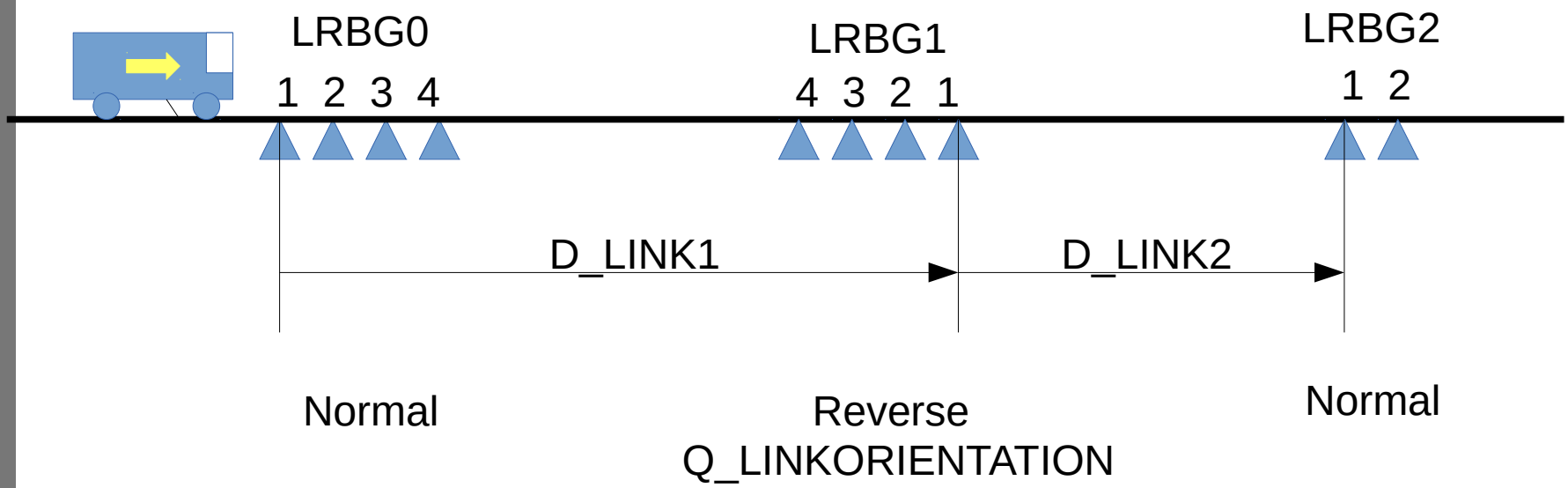


In front of a point, the system needs a switchable balise to give the appropriate linking, according to the point position

N.B. It is also possible to put the two linkings in a non switchable balise: the train opens an acquisition window for each linking but only one is present and can be read

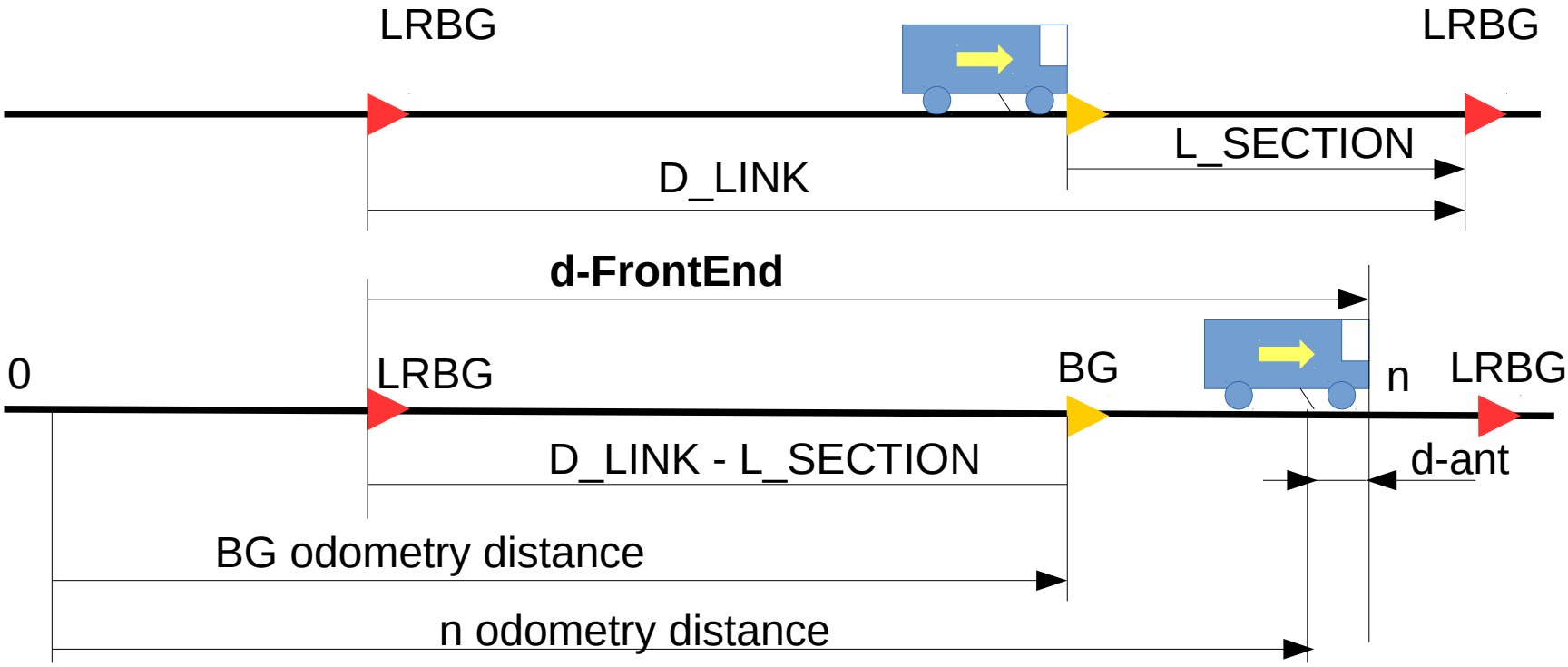
LINKING

If linking is used, the next LRBG is announced by the previous one, in a packet 5
The transmitted linked BG table contains information for the next 3 or 4 BG:
- D_LINK: distance between linked BG (balise n°1)
- NID_BG: BG Number
- Q_LINKORIENTATION: BG orientation (seen from the current LRBG)
- Q_LINKREACTION: what shall the train do if it does not find the BG
- Q_LOCACC: accuracy of the balise location



PACKET 16 REPOSITIONING (1/2)

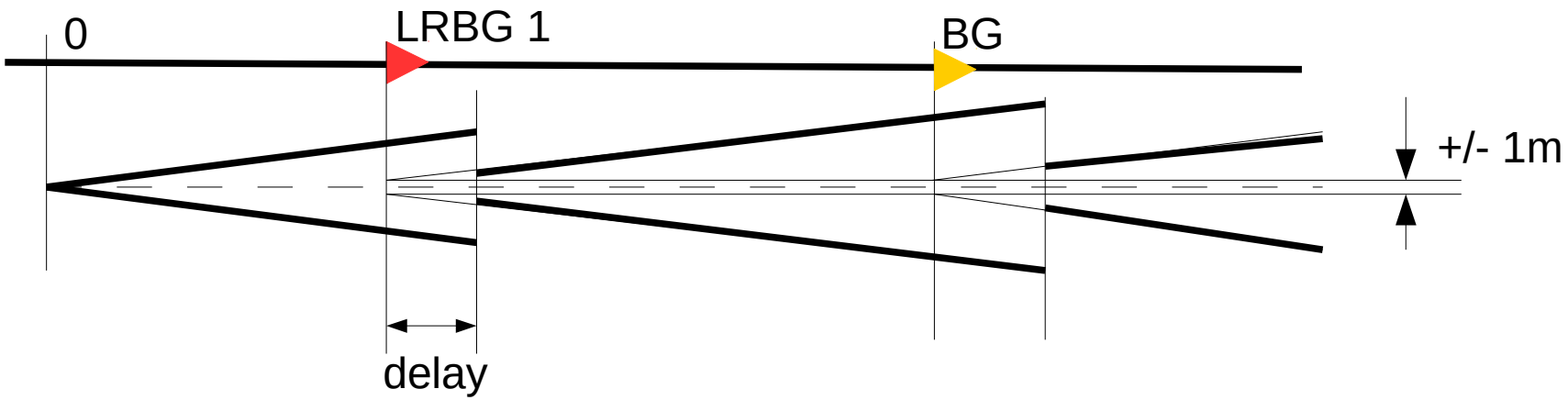
If the system needs a good location accuracy (to enter a new domain for example), it is possible to command a repositioning with a « normal » BG
A packet 16 gives the L_SECTION, e.g. the distance between the next linked BG and the current BG



d-FrontEnd = n odometry distance – BG odometry distance
+ d-ant + (D_LINK - L_SECTION)

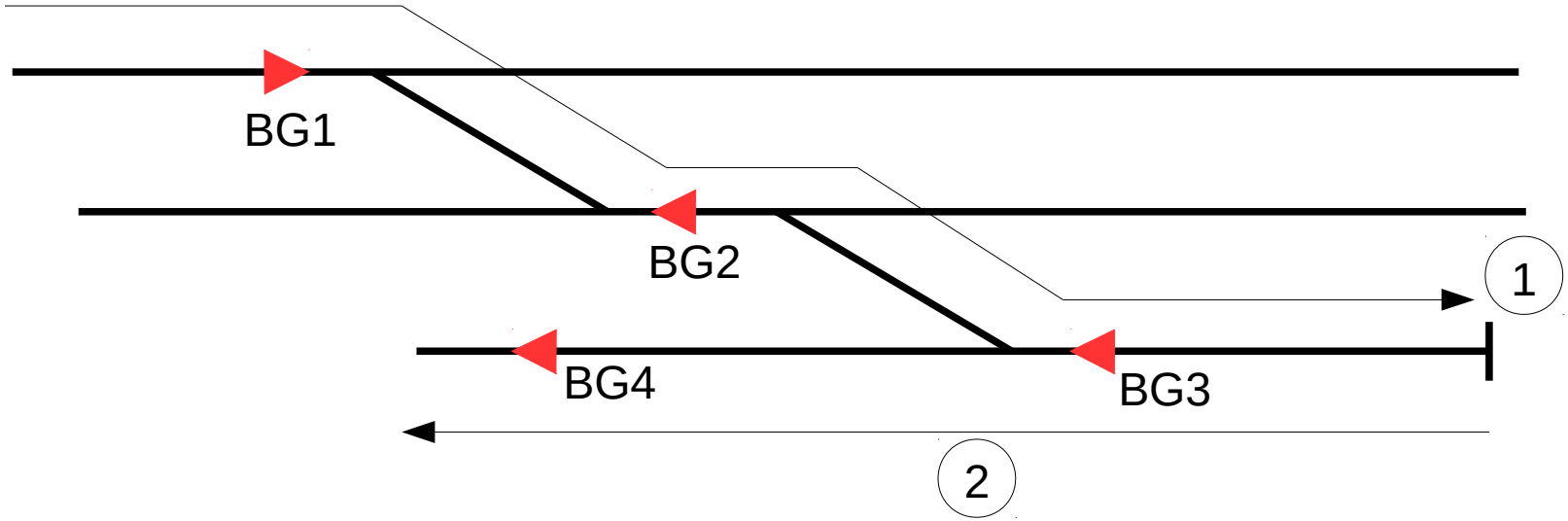
PACKET 16 REPOSITIONING (2/2)

Accuracy value can be reset at repositioning place in the same way a LRBG place



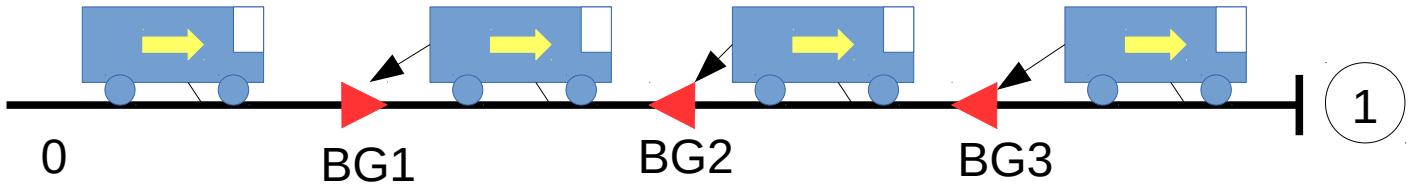
TRAIN ORIENTATION CALCULATION

Manoeuvre example 1

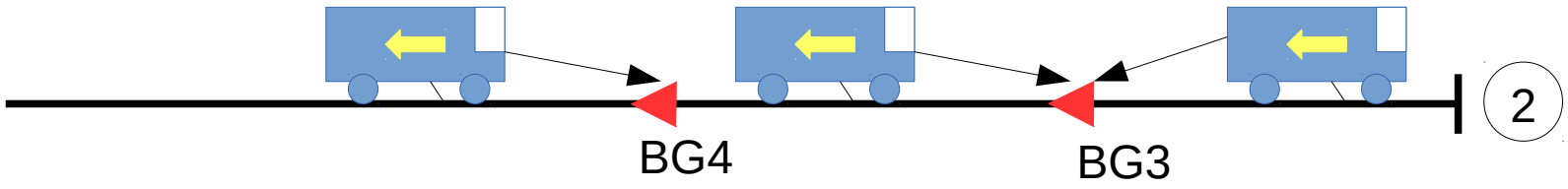


At the end of (1) The train can a) go backward
or
b) change cab

Manoeuvre example 1 a) go backward

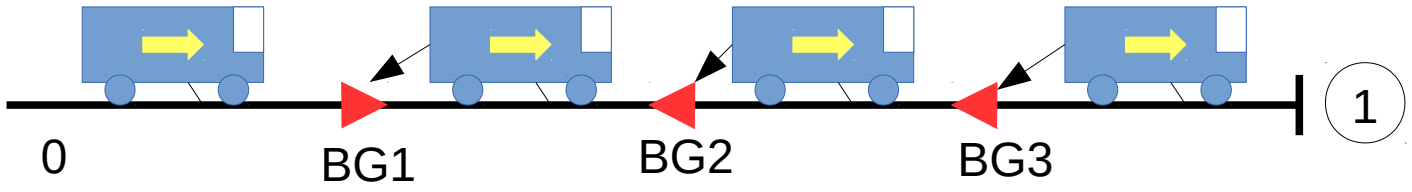


Running dir.	UnK	N	R	R
Train orient.	UnK	N	R	R
Train position (/ LRBG)	UnK	N	R	R

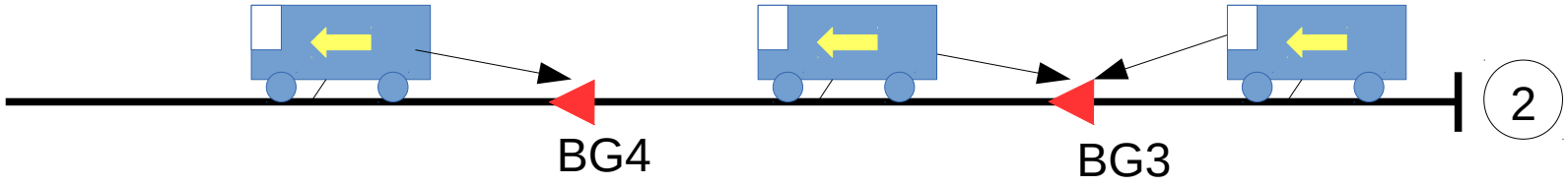


Running dir.	N	N	N
Train orient.	R	R	R
Train position (/ LRBG)	N	N	R

Manoeuvre example 1 b) change cab

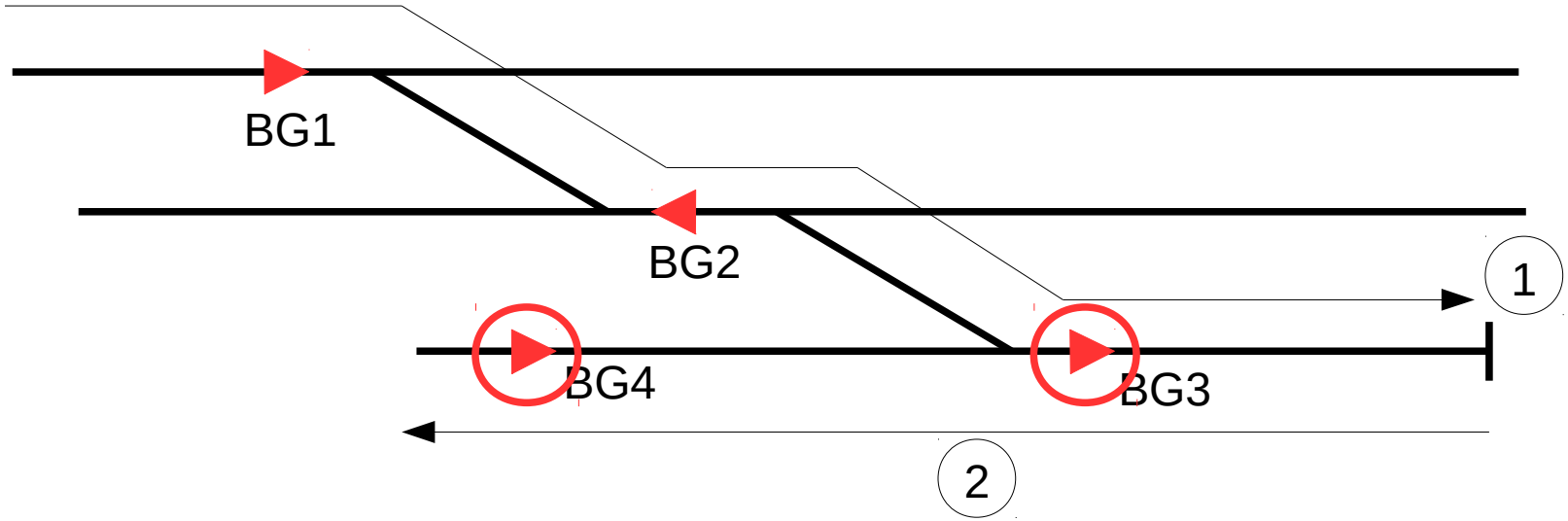


Running dir.	UnK	N	R	R
Train orient.	UnK	N	R	R
Train position (/ LRBG)	UnK	N	R	R



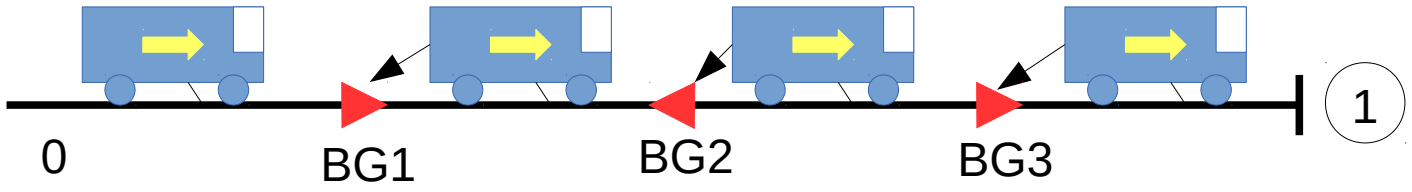
Running dir.	N	N	N
Train orient.	N	N	N
Train position (/ LRBG)	N	N	R

Manoeuvre example 2

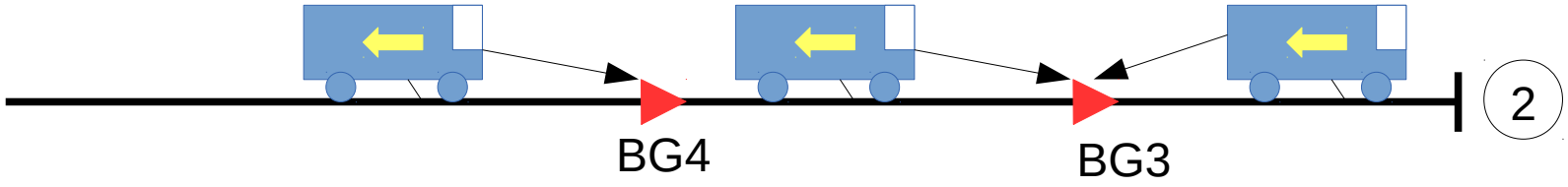


At the end of (1) The train can a) go backward
or
b) change cab

Manoeuvre example 2 a) go backward

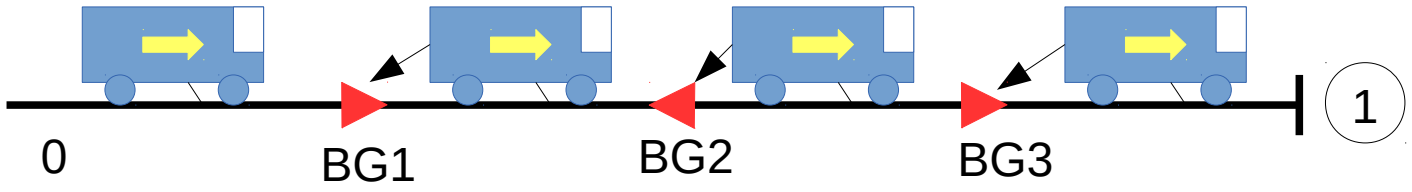


Running dir.	UnK	N	R	N
Train orient.	UnK	N	R	N
Train position (/ LRBG)	UnK	N	R	N

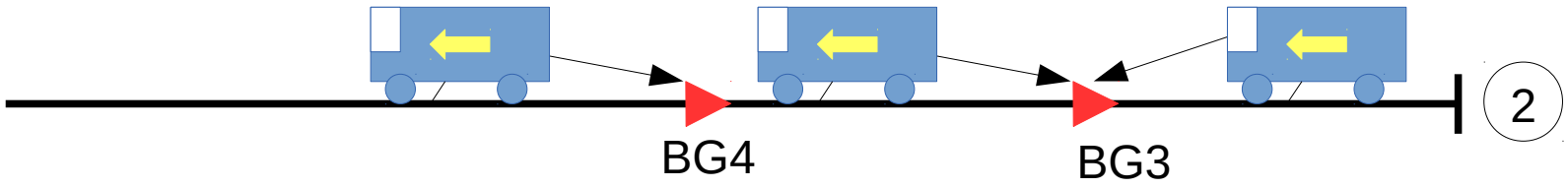


Running dir.	R	R	R
Train orient.	N	N	N
Train position (/ LRBG)	R	R	N

Manoeuvre example 2 b) change cab



Running dir.	UnK	N	R	N
Train orient.	UnK	N	R	N
Train position (/ LRBG)	UnK	N	R	N



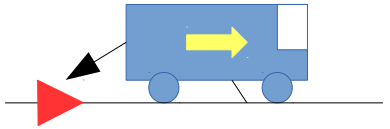
Running dir.	R	R	R
Train orient.	R	R	R
Train position (/ LRBG)	R	R	N

Orientation rules 1

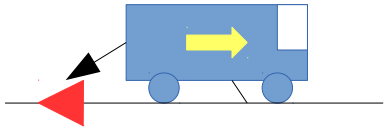
A. As far as the train does not pass over an oriented balise group (= more than 1 balise), running direction, train orientation and train position related to LRBG are unknowned

B. As the train goes ahead and passes over an oriented balise group used as LRBG:

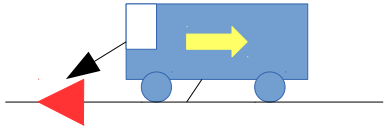
- if LRBG orientation = train orientation AND train runs forward then Running direction = N
  Train orientation = N / Train position = N



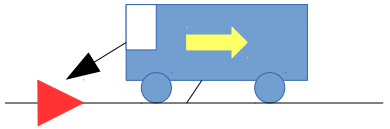
- if LRBG orientation >< train orientation AND train runs forward then running direction = R
  Train orientation = R / Train position = R



- if LRBG orientation = train orientation AND train runs backward then running direction = R
  Train orientation = N / Train position = R

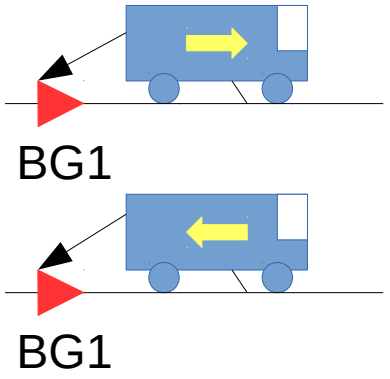


- if LRBG orientation >< train orientation AND train runs backward then running direction = N
  Train orientation = R / Train position = N

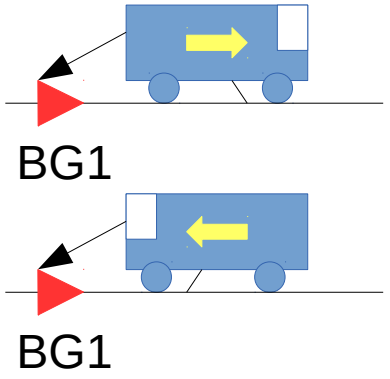


Orientation rules 2

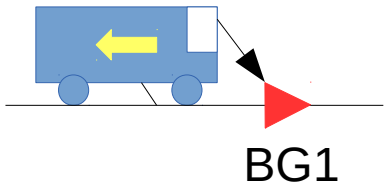
C. If the driver changes the direction selector (=odometry direction changes):
- LRBG does not change
- running direction changes
- train orientation does not change
- train position does not change



D. If the driver changes cab:
- LRBG does not change
- running direction changes
- train orientation changes
- train position does not change



E. If the train runs backward and passes over the LRBG,
- LRBG does not change
- running direction does not change
- train orientation does not change
- train position changes



Orientation calculation inputs / outputs

ALL4TEC

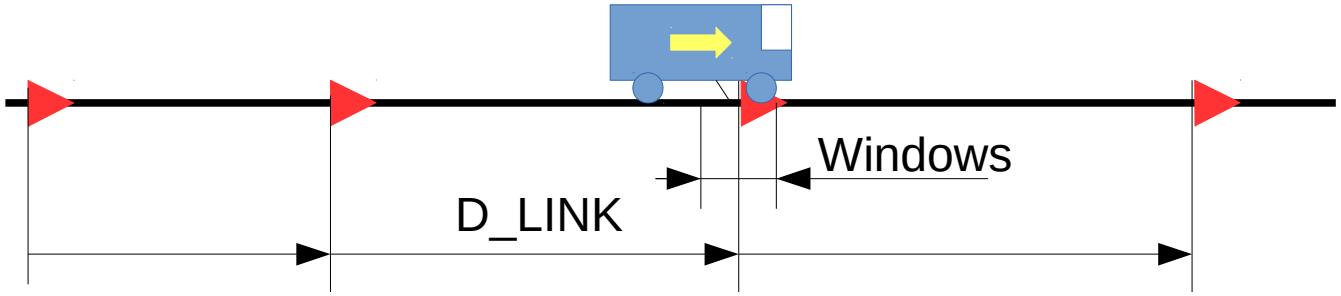
Inputs:
- LRBG Id
- LRBG orientation underneath the train
- active cab
- odometry direction

Outputs:
- train running direction / LRBG
- train direction / LRBG
- train position / LRBG
- LRBG Id

TRACK EVENTS POSITION CALCULATION

LINKING AND LINKED (1/6)

A linking packet defines the distance D_LINK between balise groups
This data is only used to open an acquisition windows and manage the train reaction if no BG is read inside this windows
But ERTMS can work without linking.

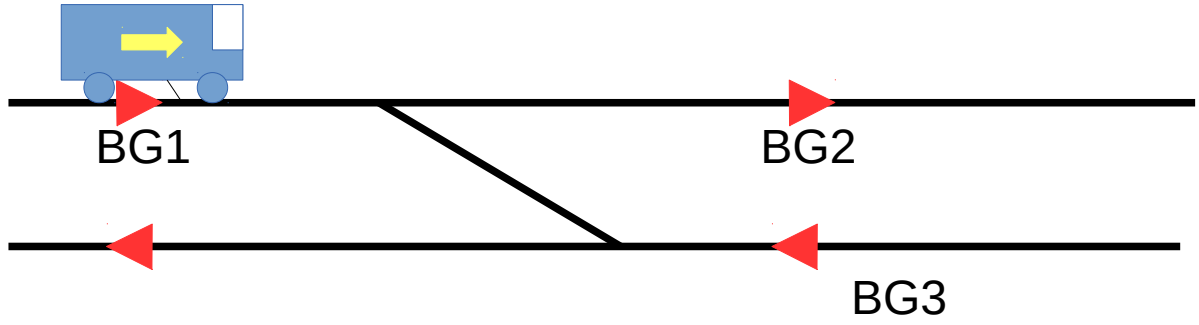


A linked balise group gives speed control information (at least MA, SSP and gradiant) to the train
This information is essential for ERTMS
Only a linked balise group can be used as LRBG

But a linked balised group can be out of linking

LINKING AND LINKED (2/6)

Example of linked BG out of linking



The train reads BG1 and this one gives it a linking packet to BG2
But there is a breakdown on track 1 : train has to stop in front of the point (or even go backward) and run on track 2. Then, it reads BG3 instead of BG2
BG3 is a linked balise group and gives the train a complete reverse MA
It can be used as LRBG but it is out of linking.

LINKING AND LINKED (3/6)

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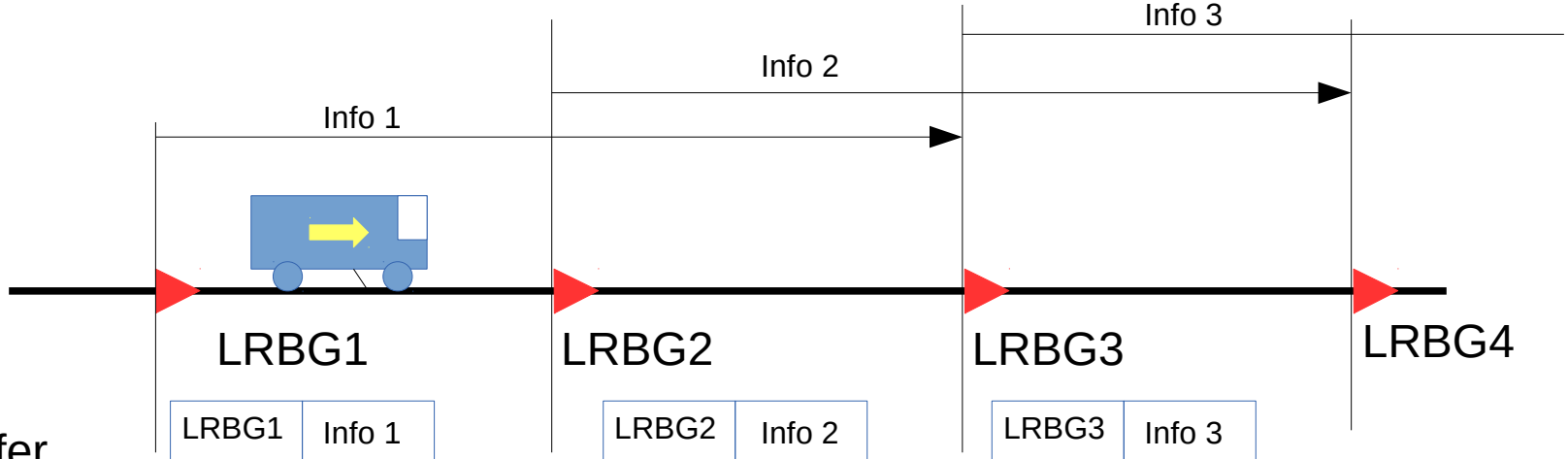
Speed control information management

As the train passed over a linked balise group, it takes this BG as LRBG and speed control information are reset with the new data recieved from this BG
Old speed control information (and their old LRBG) shall be memorized as far as the train rear end did not pass over the new LRBG
In real life, speed control information are stored in a turning buffer and this requirement is always satisfied.



Buffer

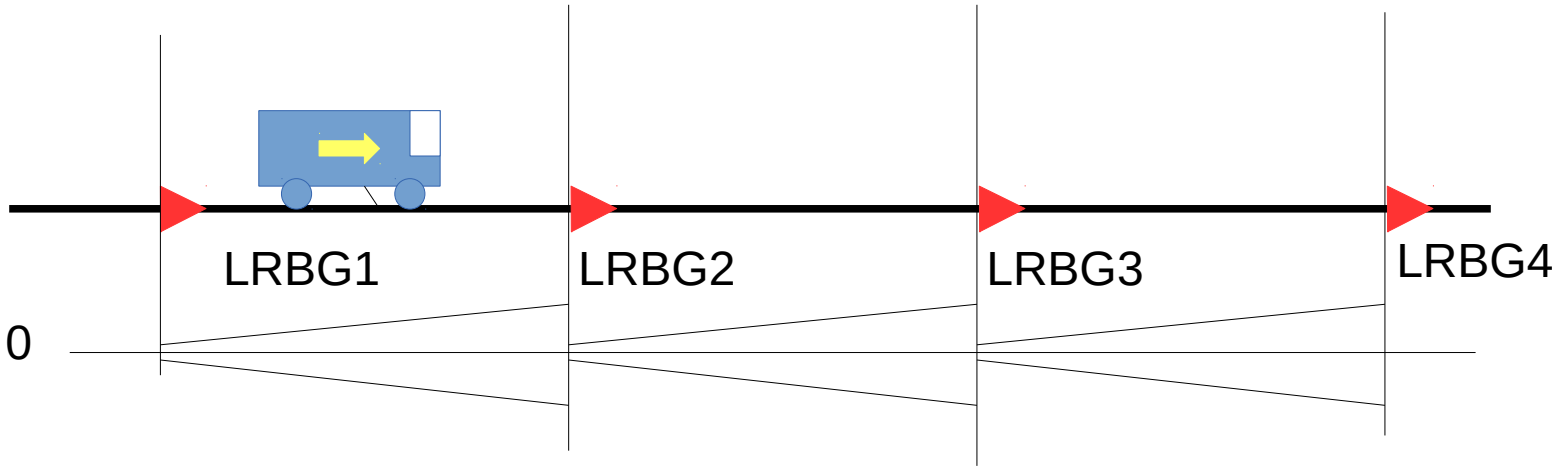
LRBG1	Info 1

LRBG2	Info 2
LRBG1	Info 1

LRBG3	Info 3
LRBG2	Info 2

LINKING AND LINKED (4/6)

As the train passes over a linked balise group – and as this one becomes LRBG - the confidence interval is also reset (with its inaccuracy)

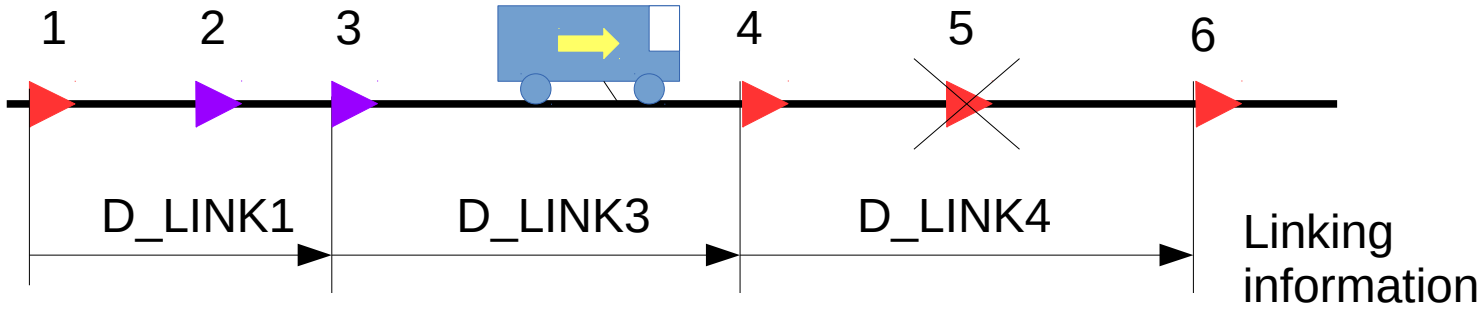


LINKING AND LINKED (5/6)

ALL4TEC

If linking is used

- Non linked BG = additional data information BG
- Linked BG = LRBG



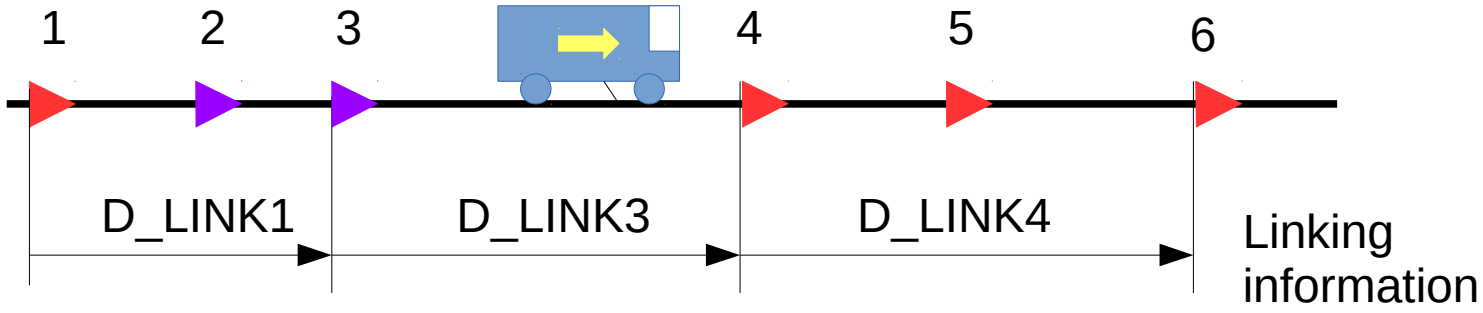
1 : LRBG, train checks position
2 : train stores additional information
3 : train checks position and stores additional information if position is OK
4 : LRBG, train checks position
5 : ignored BG

LINKING AND LINKED (6/6)

ALL4TEC

If linking is not used

- Non linked BG = additional data information BG
- Linked BG = LRBG

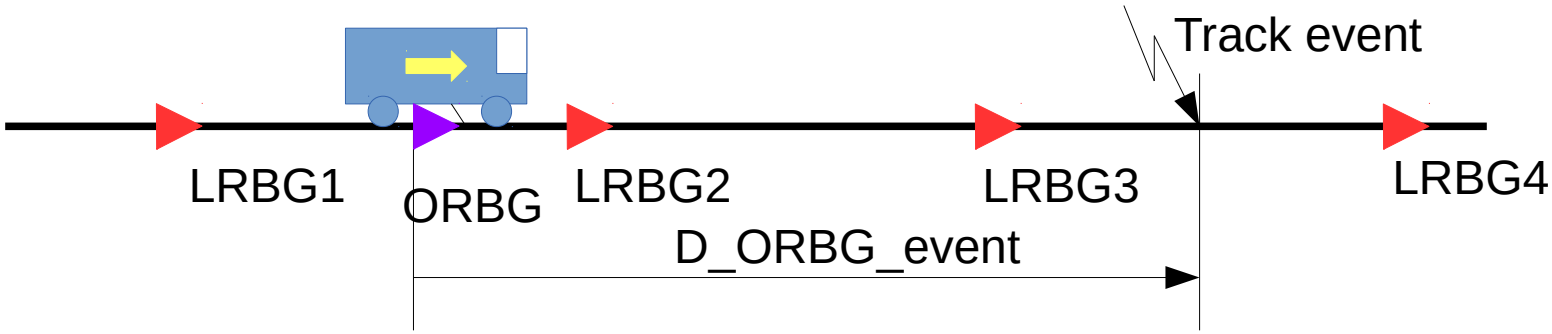


1 : LRBG, train does not checks position
2 : train stores additional information
3 : train stores additional information
4 : LRBG, train does not checks position
5 : LRBG, train does not checks position

TRACK EVENTS

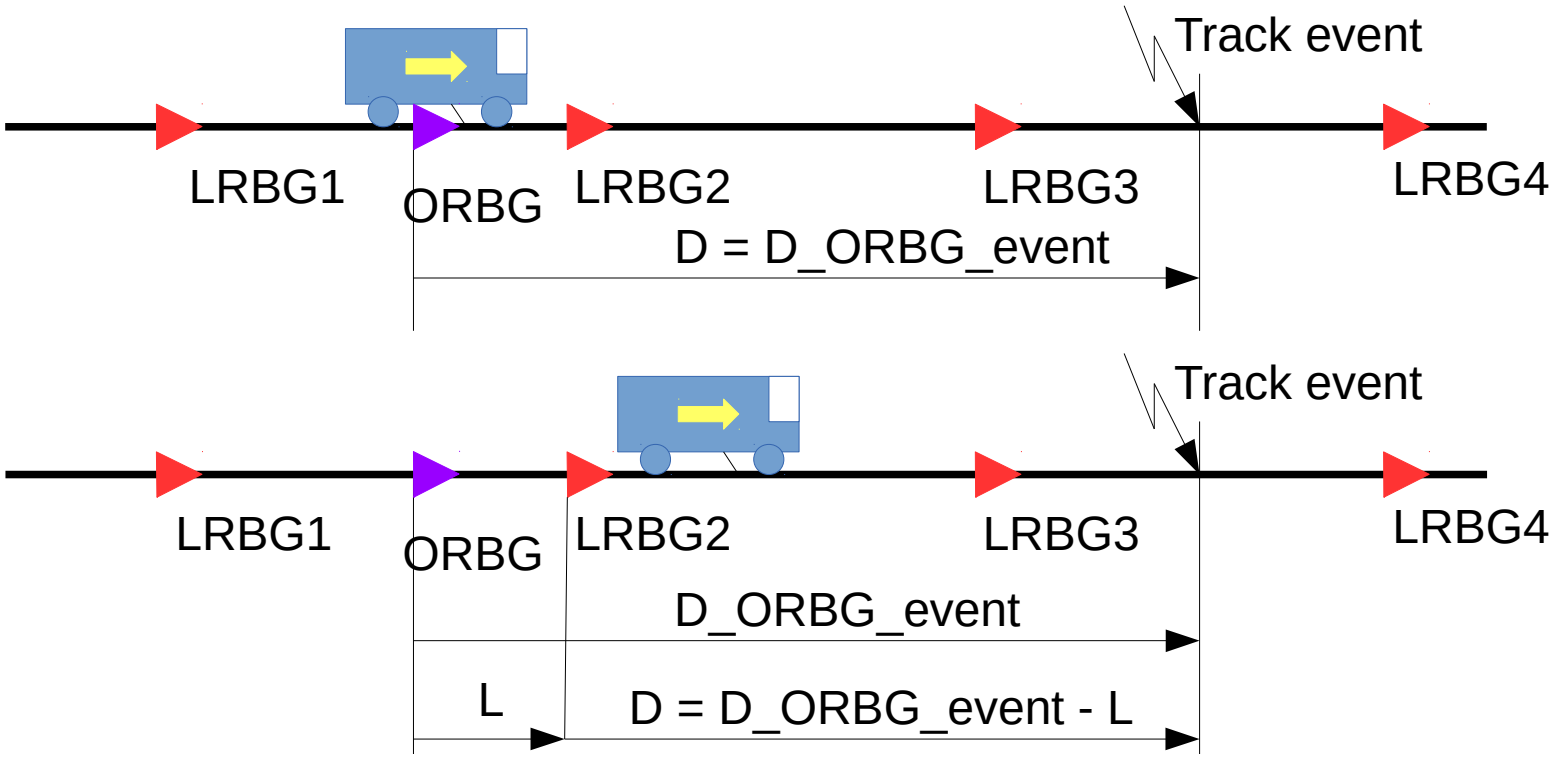
Track events (out of Speed control information given by linked balise groups) could be transmitted:
- by Balise Group
- by Radio (level 2/3 only)

These events are always regarding to a balise group (original reference Balise group - ORBG)
This balise group can be linked or not. For example, TSR (Temporary Speed Reduction) are often given by non linked balise groups



Track events distance

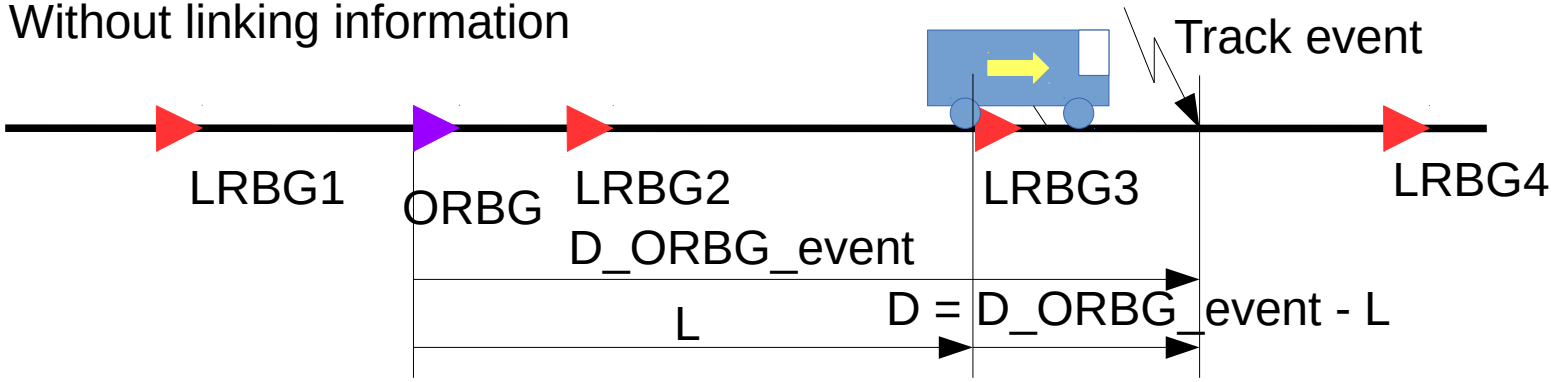
If the track event is not repeated inside the next BG, the OBU shall memorize and update the information as the LRBG is changing.



L = odometry measurement between both ORBG and LRBG2

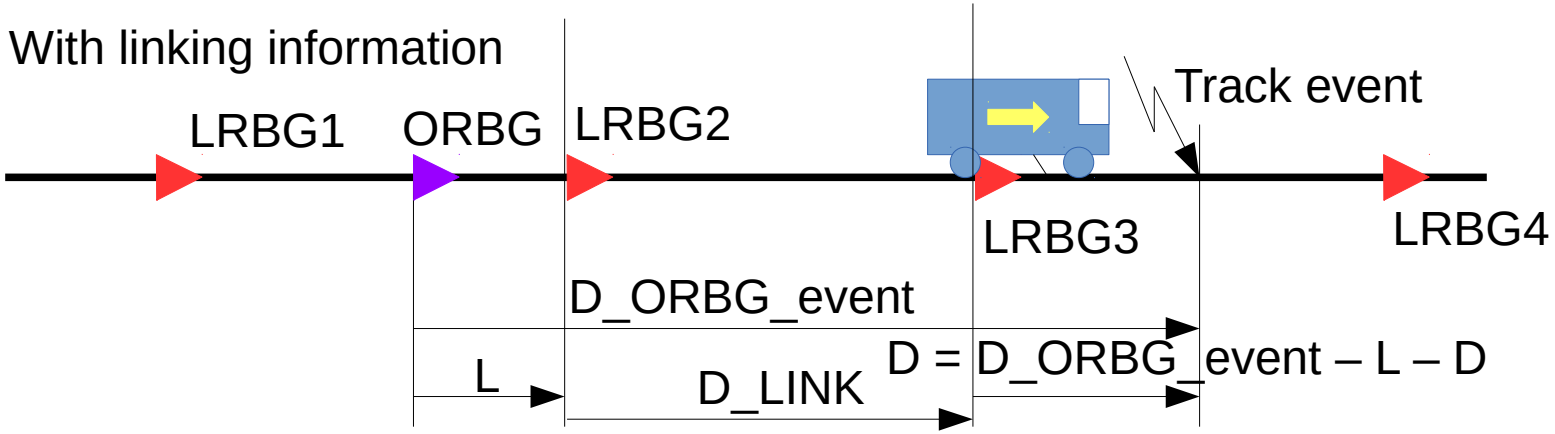
Track events distance

Without linking information



L = odometry measurement between both ORBG and LRBG3

With linking information



L = odometry measurement between both ORBG and LRBG2
D_LINK = linking distance between LRBG2 and LRBG3

Track events distance

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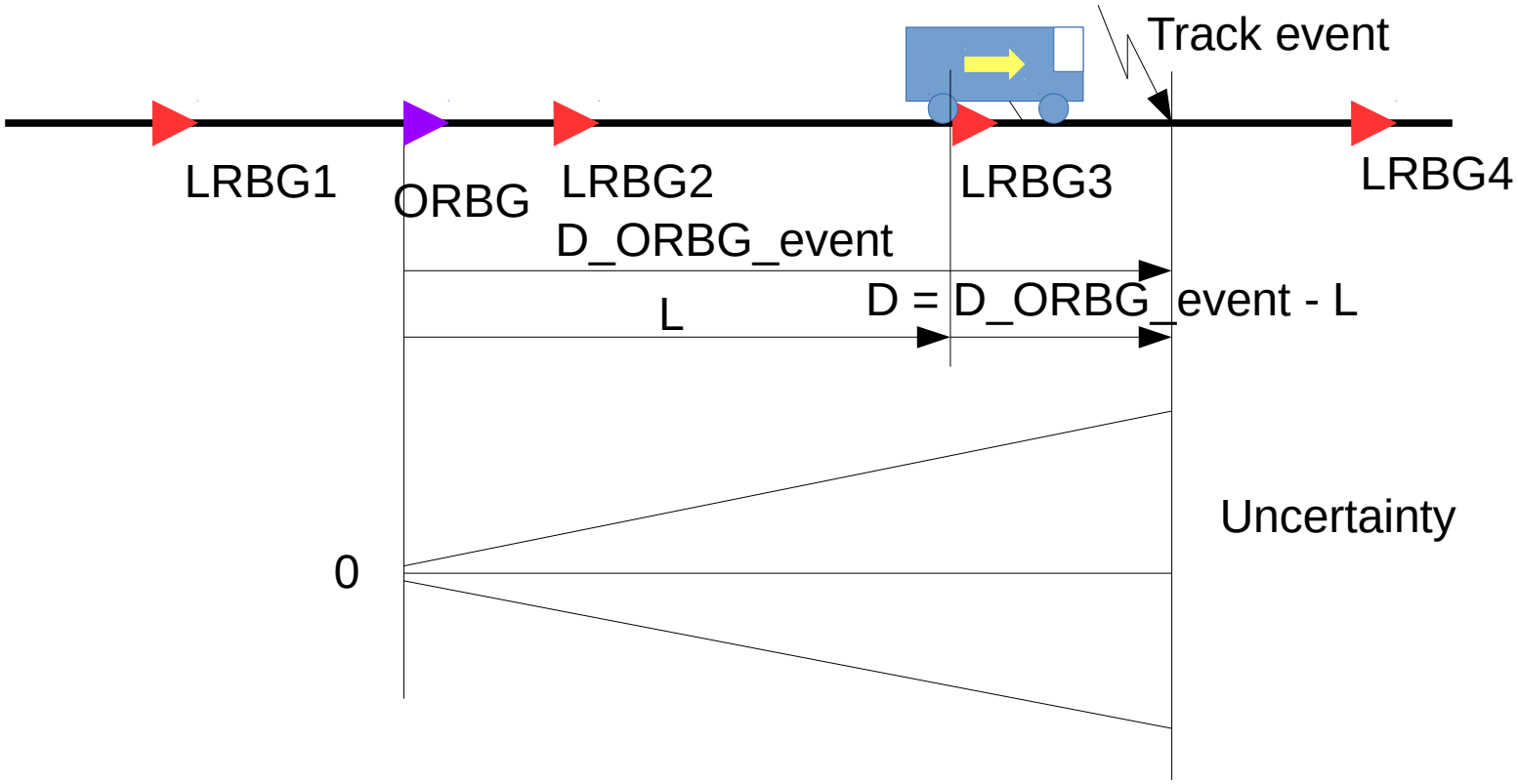
Odometry uncertainty without linking information



Track events distance