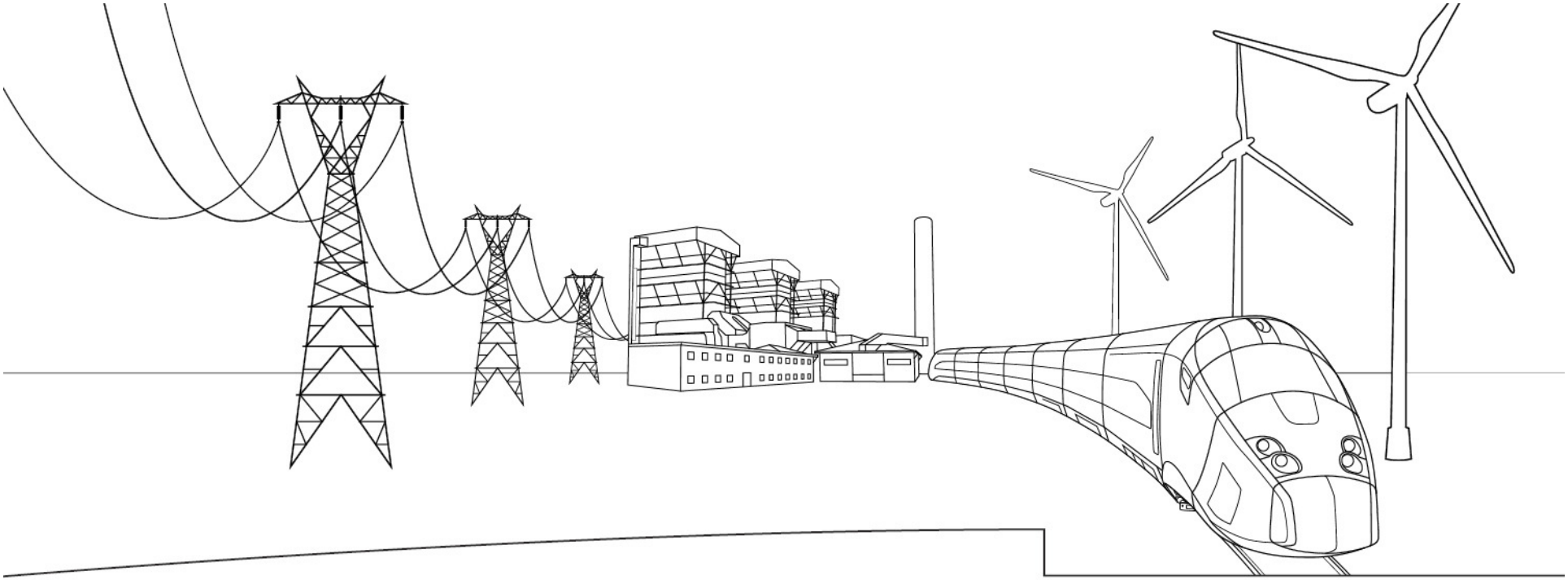


APS-Electric Road System
Conductive Solution Demonstrator
February-2015

ALSTOM
Shaping the future

APS-ERS CERV 201502091

Alstom Transport

A WORLDWIDE LOCAL COMPANY

- 90 sites
- 60 countries
- 28,300 employees.

ALSTOM

Alstom Transport activities

- Trams, metros, trains.
- Services.
- Signalling.
- Infrastructure and systems.

- N°1 in high-speed & very-high-speed trains.
- N°2 in urban transport (metros & tramways).

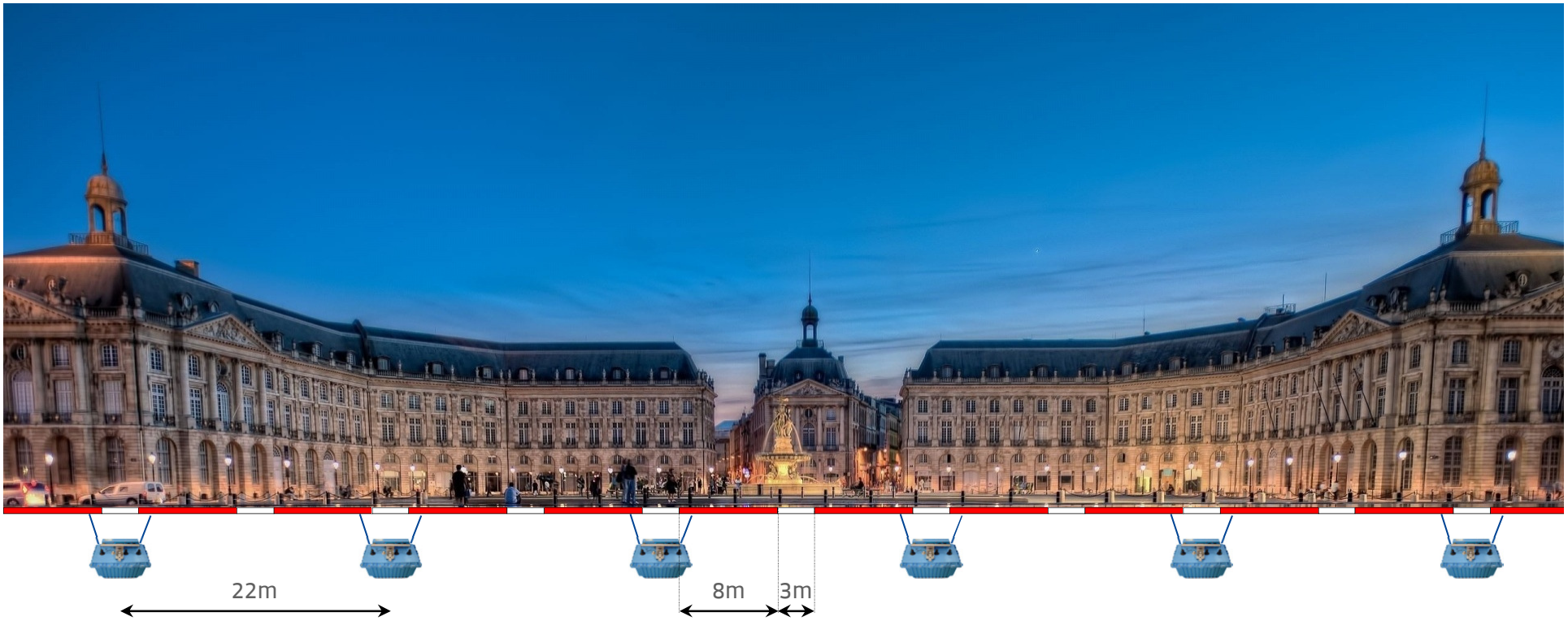
Design of Ottawa Citadis Spirit (United States)

ALSTOM

Alstom: No. 1 in catenaryless solutions for tramways thanks to APS (ground-level feeding system), since 2003

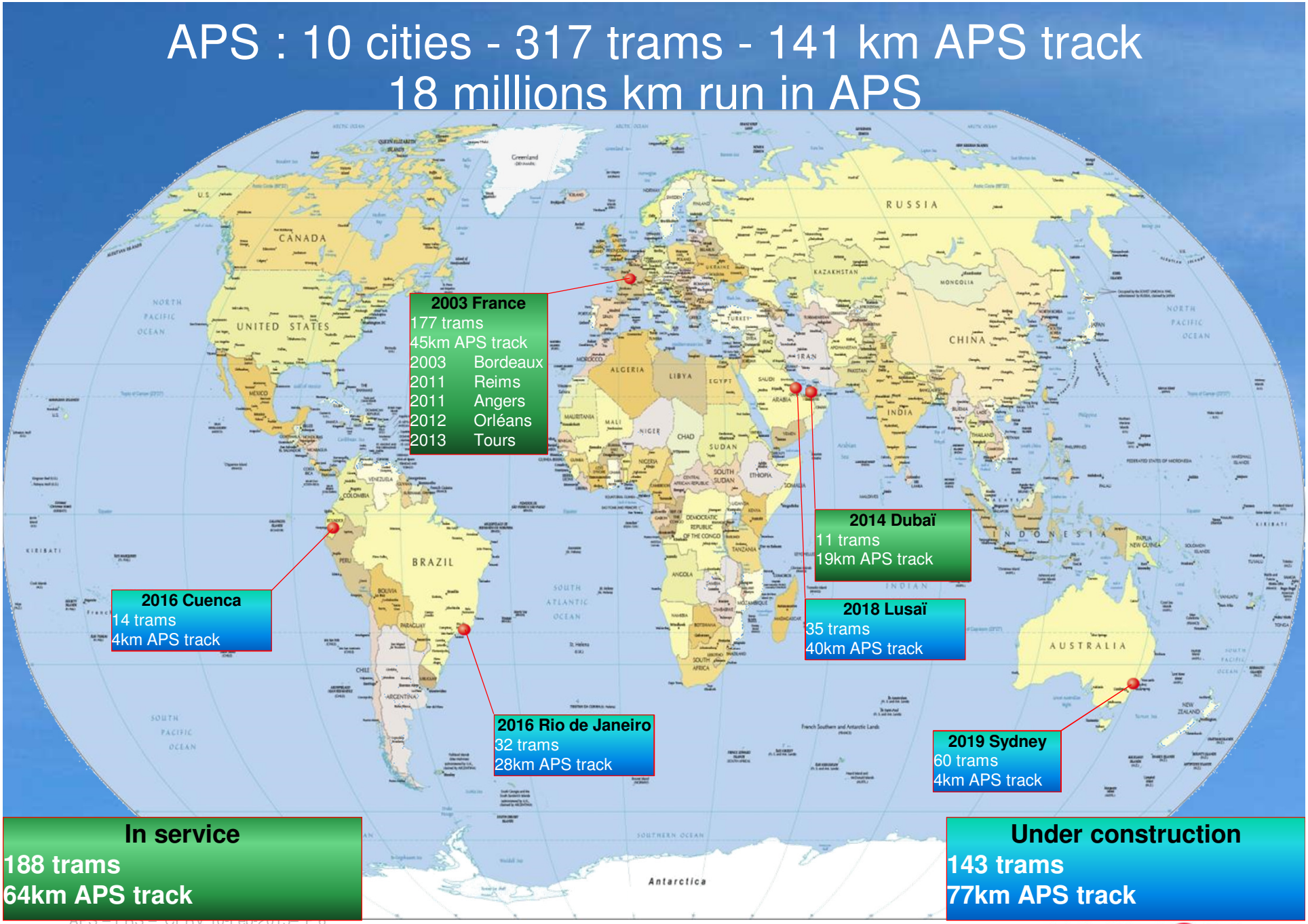
ALSTOM

APS Basic Principle

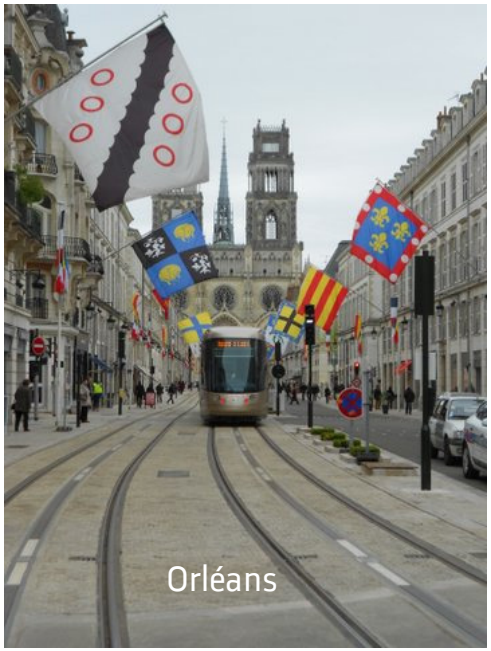


- ✓ Period : 11m / Conductive Segment 8m / Neutral zone : 3m
- ✓ Each power box drives 2 segments, a power box every 22m
- ✓ Tramways are 30 or 40m long, covering every live segments
- ✓ After tram passage, the segment is connected to the rail voltage

APS : 10 cities - 317 trams - 141 km APS track
18 millions km run in APS



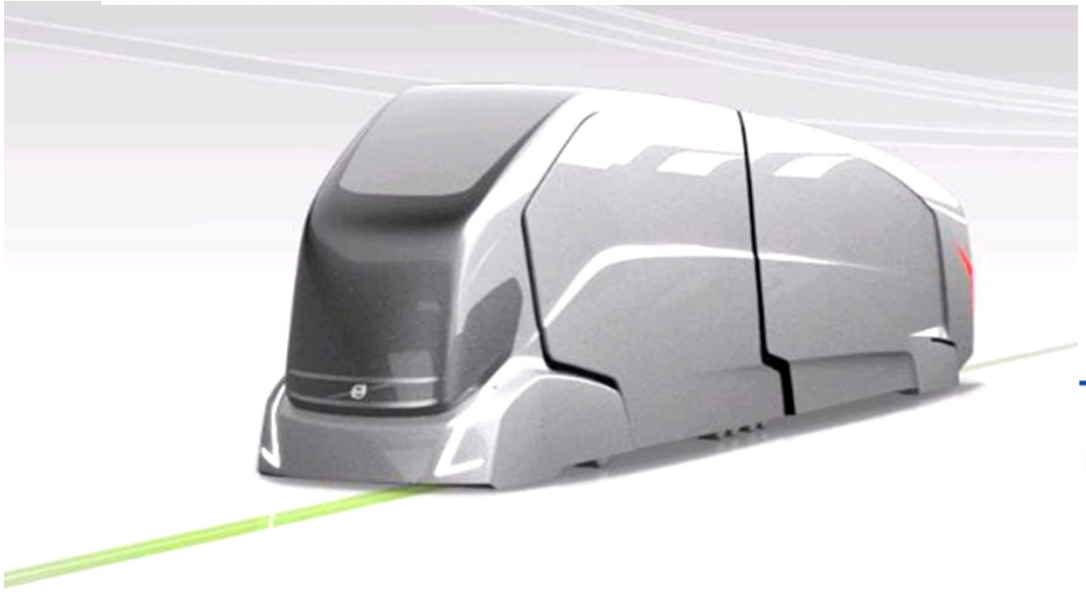
Catenaryless tramways projects using APS



ALSTOM

Slide-in Electric Road System

- In 2012, in the context of an ERS solution evaluation initiated by the Swedish Energy Agency, Volvo Truck trusted Alstom as a partner for the adaptation of the APS system to the road. A demonstrator of conductive solution for slide-in application has been implemented and evaluated on Volvo Test track in Sweden.



Swedish Energy Agency

FFI
FORDONSSTRATEGISK FORSKNING OCH INNOVATION

VOLVO
ALSTOM
SCANIA
TRAFIKVERKET
VATTENFALL
LUNDS UNIVERSITET
KTH
Svenska Elvägar AB
CHALMERS

ALSTOM

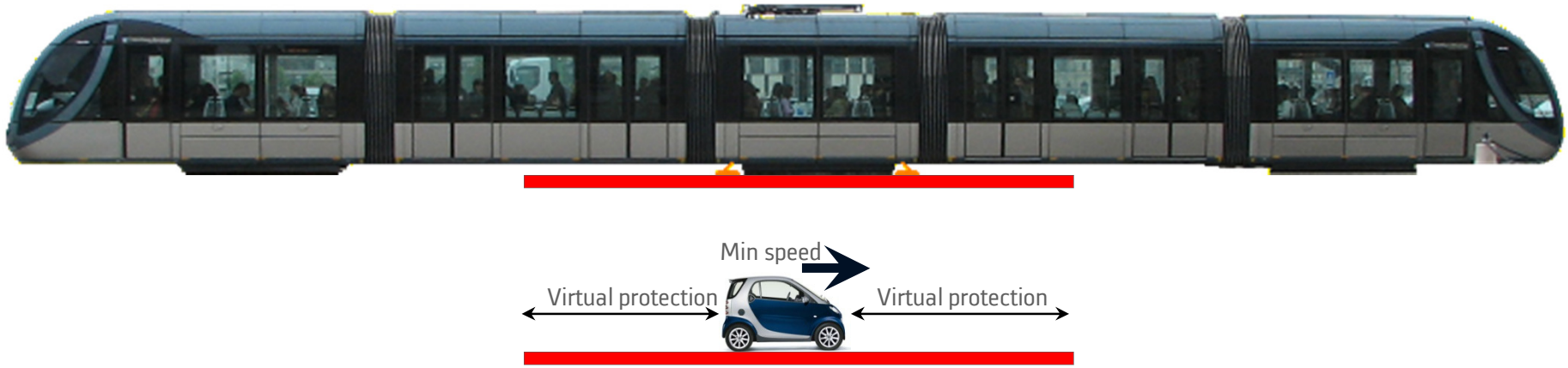
APS / ERS Traffic and required power differences

Tramway	Road
1 tramway every 3 minutes	1 car every 3 seconds
2 tracks	Several tracks
Power 0,5MW / km	Power 2 to 10MW / km
Max power per segment : 1MW	Max required power per segment : 130kW
The return circuit via the running rails	Rubber tires

ALSTOM

APS / ERS Safety difference

short vehicles cannot cover the segments



The length of the vehicles is shorter and diversified, so the live polarity is applied to a virtual zone in the front of the vehicle and behind the vehicle only when the vehicle is detected at a minimum speed (60km/h).

ALSTOM

APS adaptation to ERS
Safety solution: Live segments not accessible

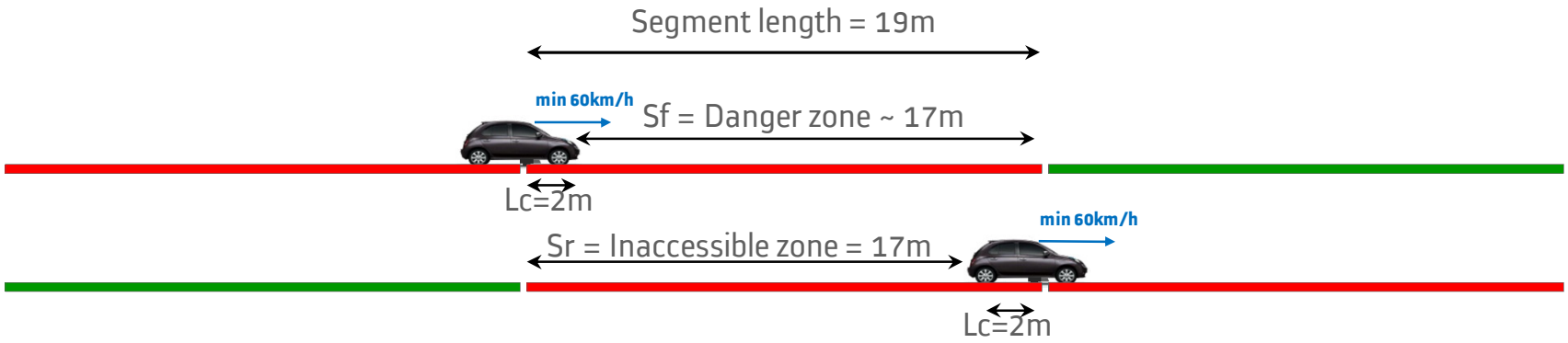
- The basic safety principle is based on a virtual moving zone in front of and behind the vehicle.
- The platform is energized in front of the vehicle and behind the vehicle only when the vehicle is detected at a minimum speed.

Assumptions :
- Min speed = 60km/h (17m/s)
- Human time to escape = 1sec
- Min Distance between collector shoe and front / rear : l = 2m

→ Sf = Sr ~ 17m

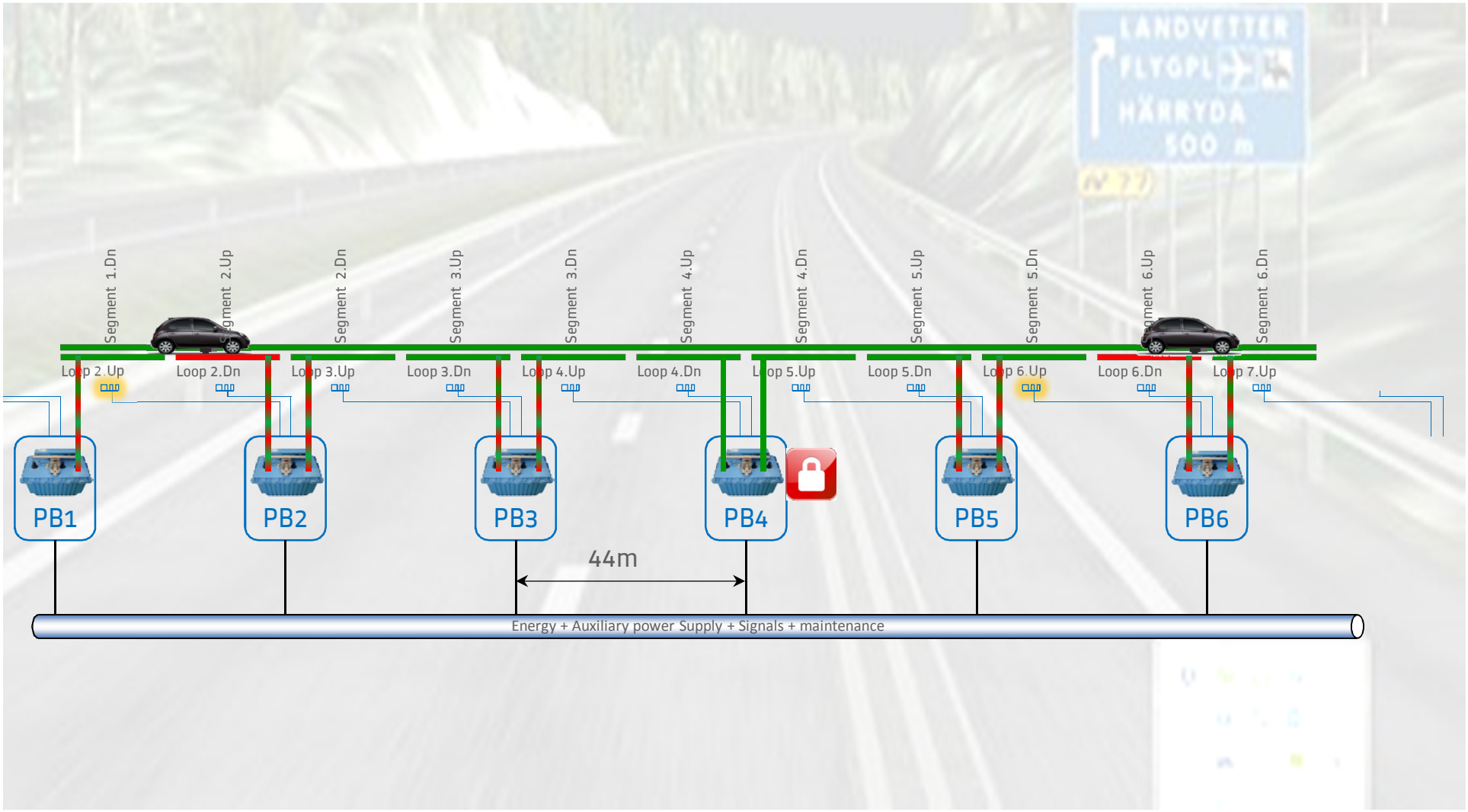
Result :

→ **Segment length = Sf + lc = 19m**



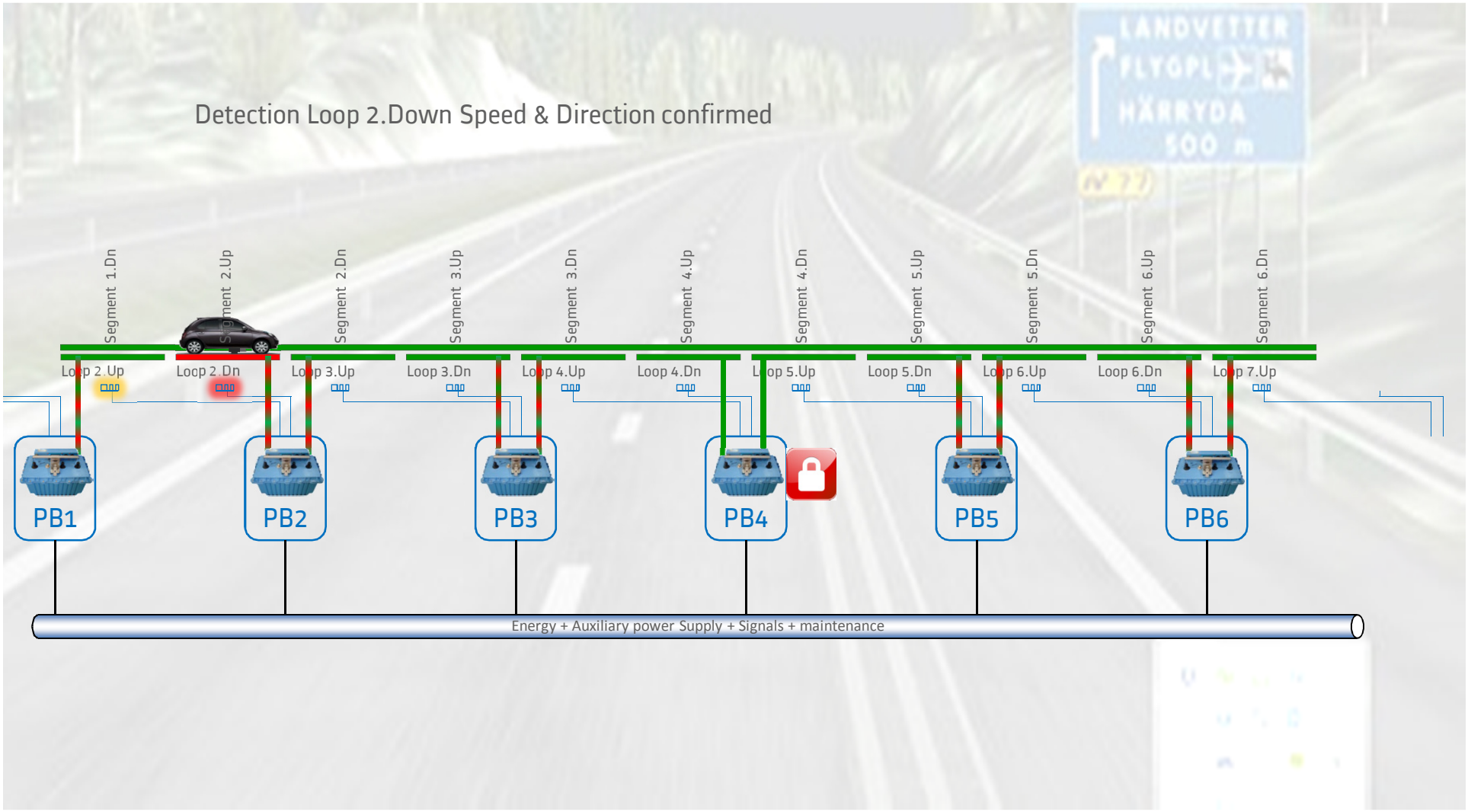
ALSTOM

Principle



ALSTOM

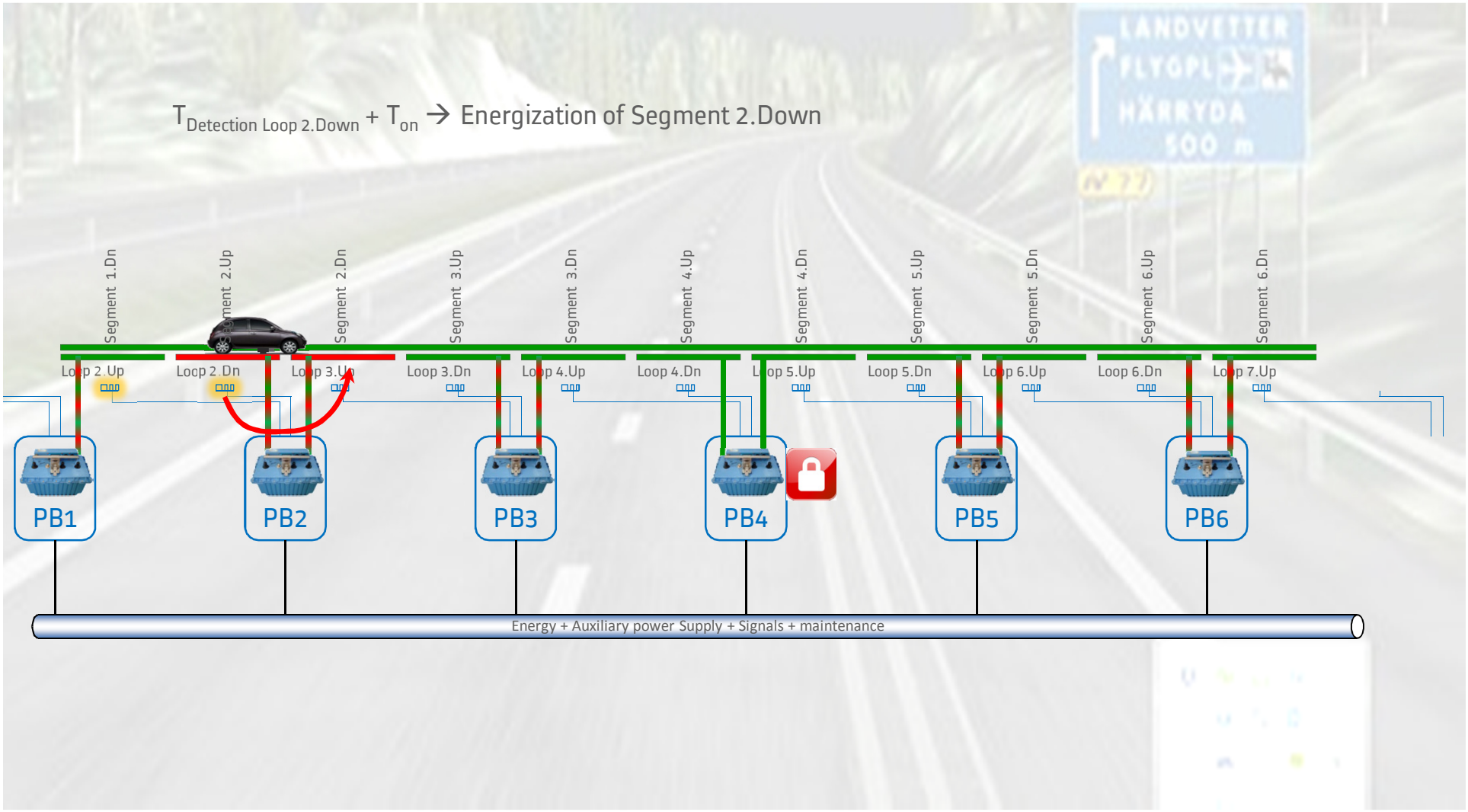
Principle



ALSTOM

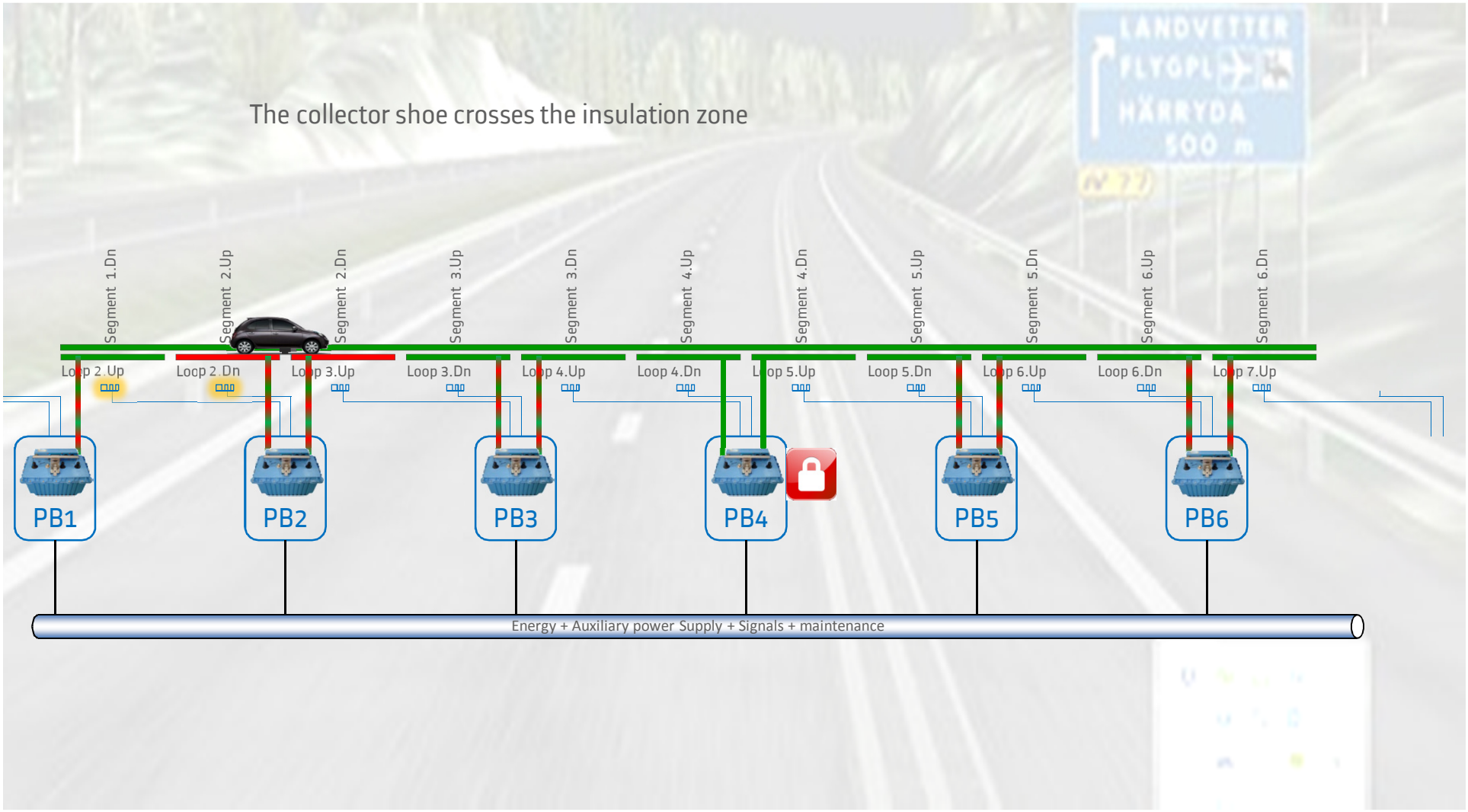
Principle

$T_{Detection\ Loop\ 2.Down} + T_{on} \rightarrow$ Energization of Segment 2.Down



ALSTOM

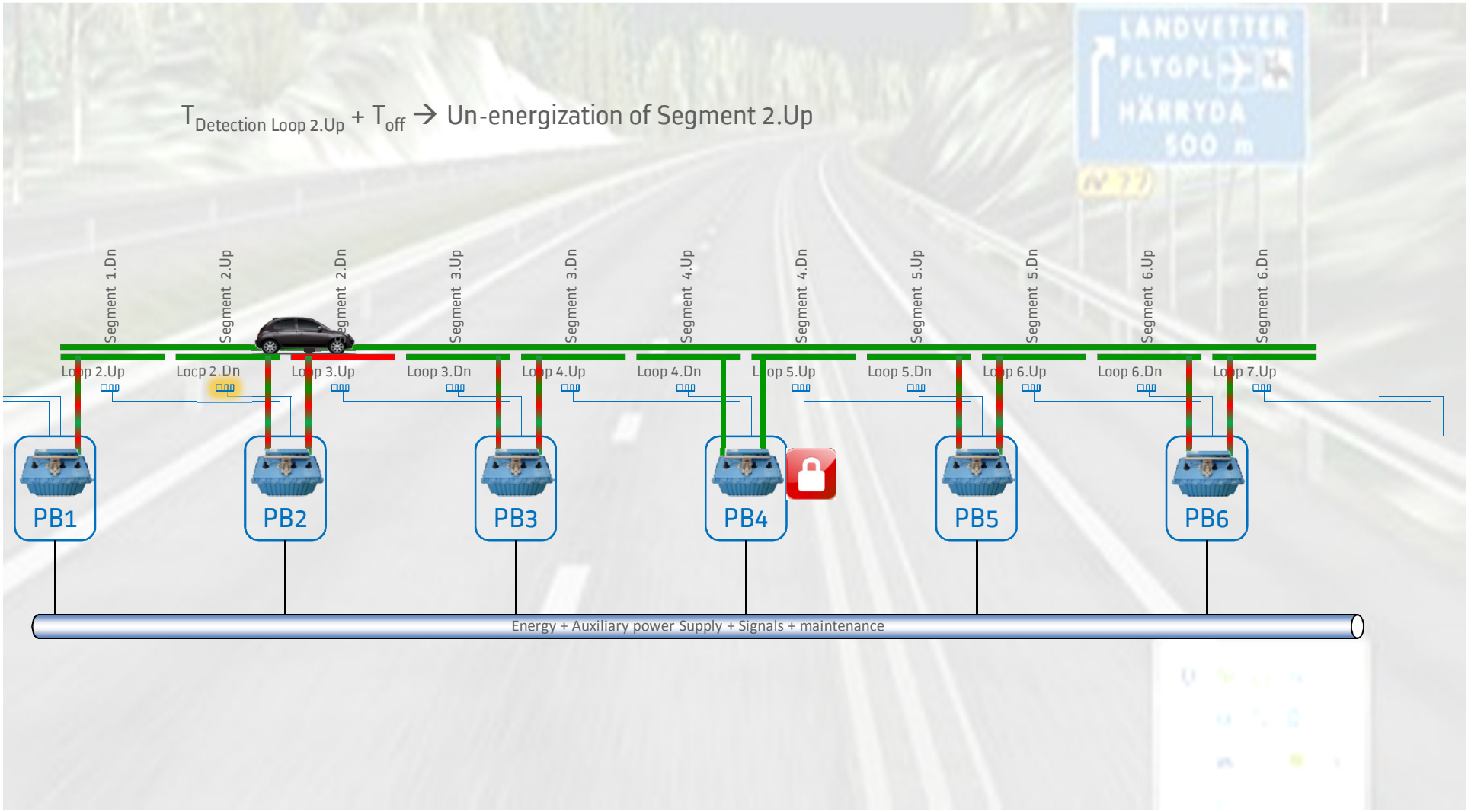
Principle



ALSTOM

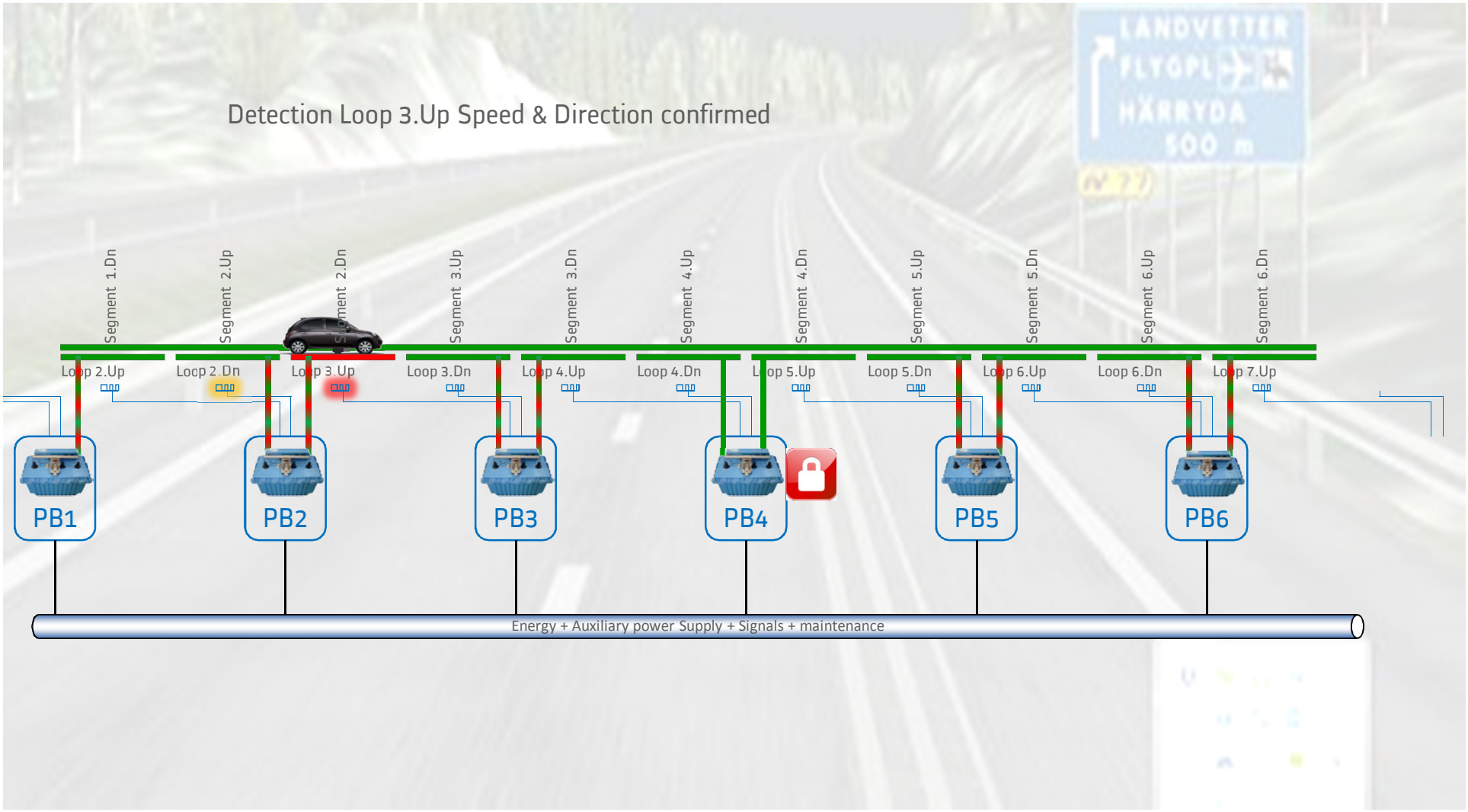
Principle

$T_{Detection\ Loop\ 2.Up} + T_{off}$ → Un-energization of Segment 2.Up



ALSTOM

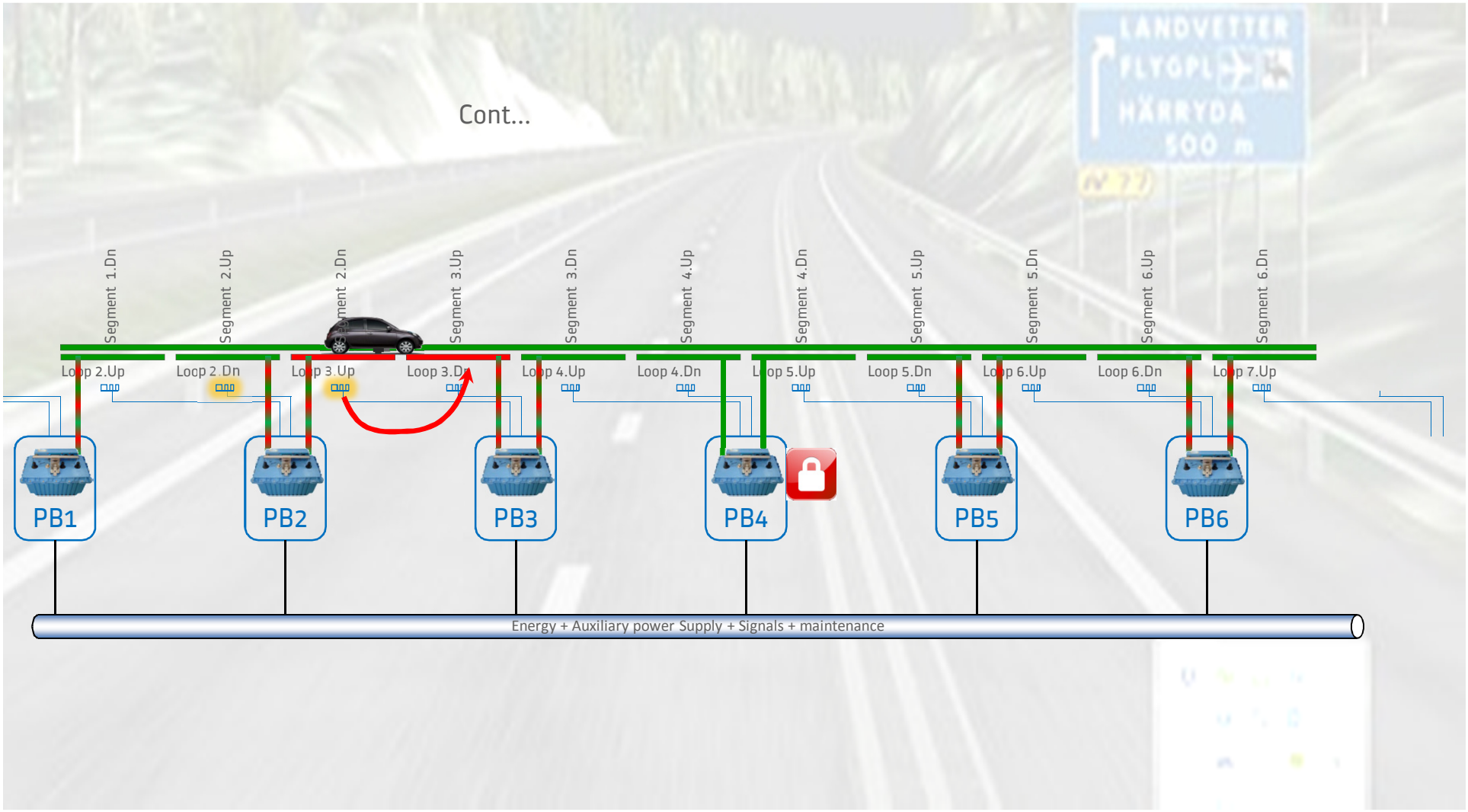
Principle



ALSTOM

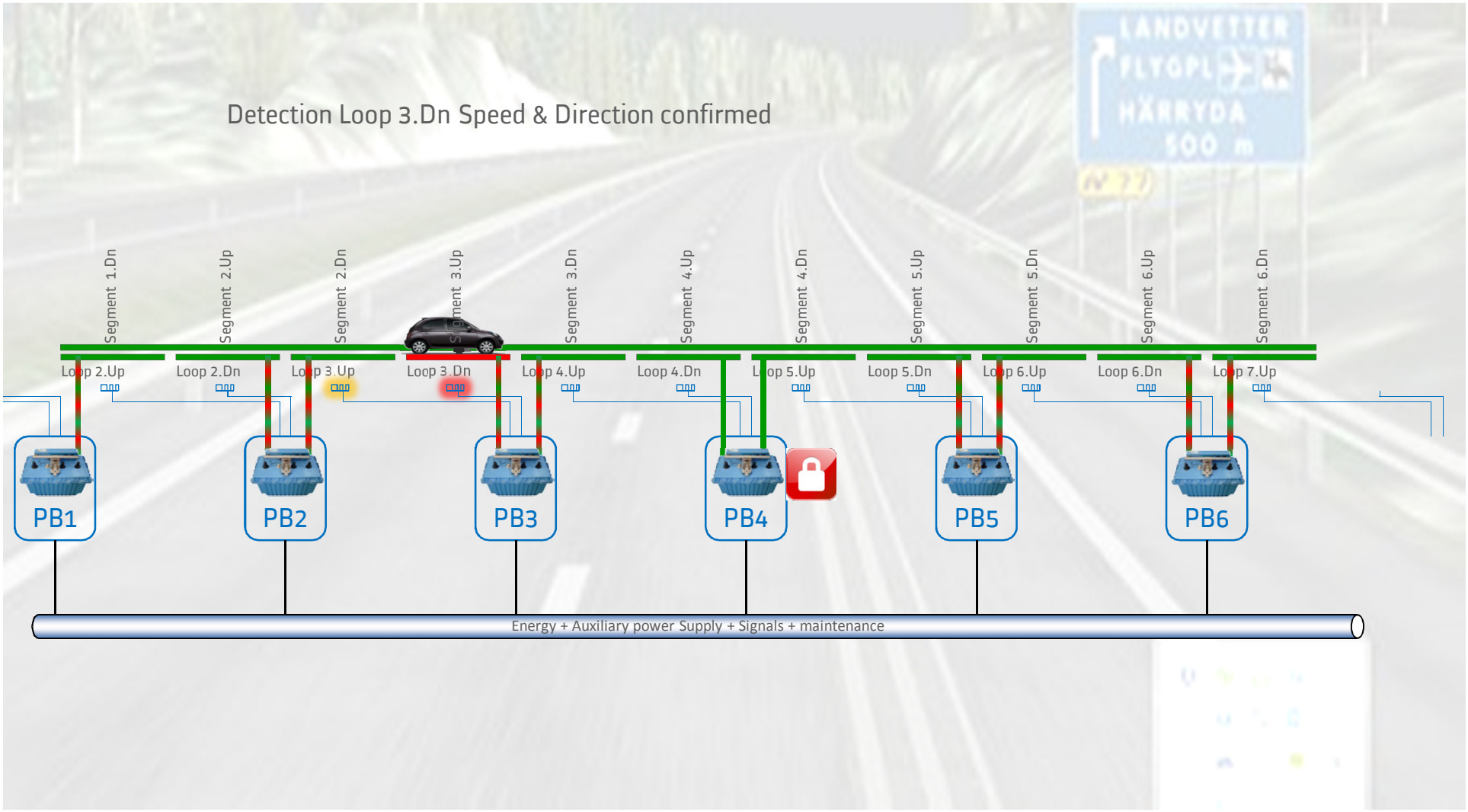
Principle

Cont...



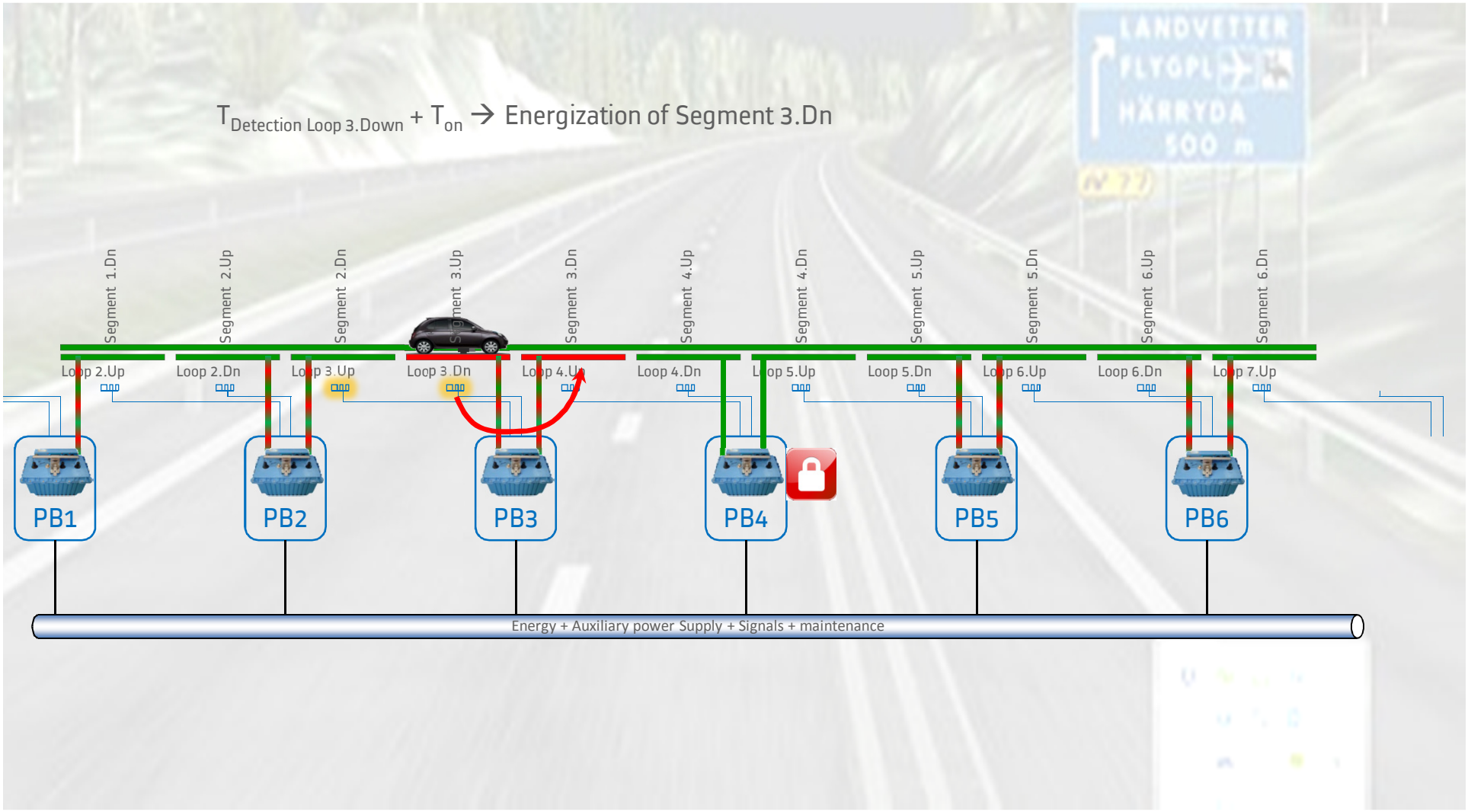
ALSTOM

Principle



ALSTOM

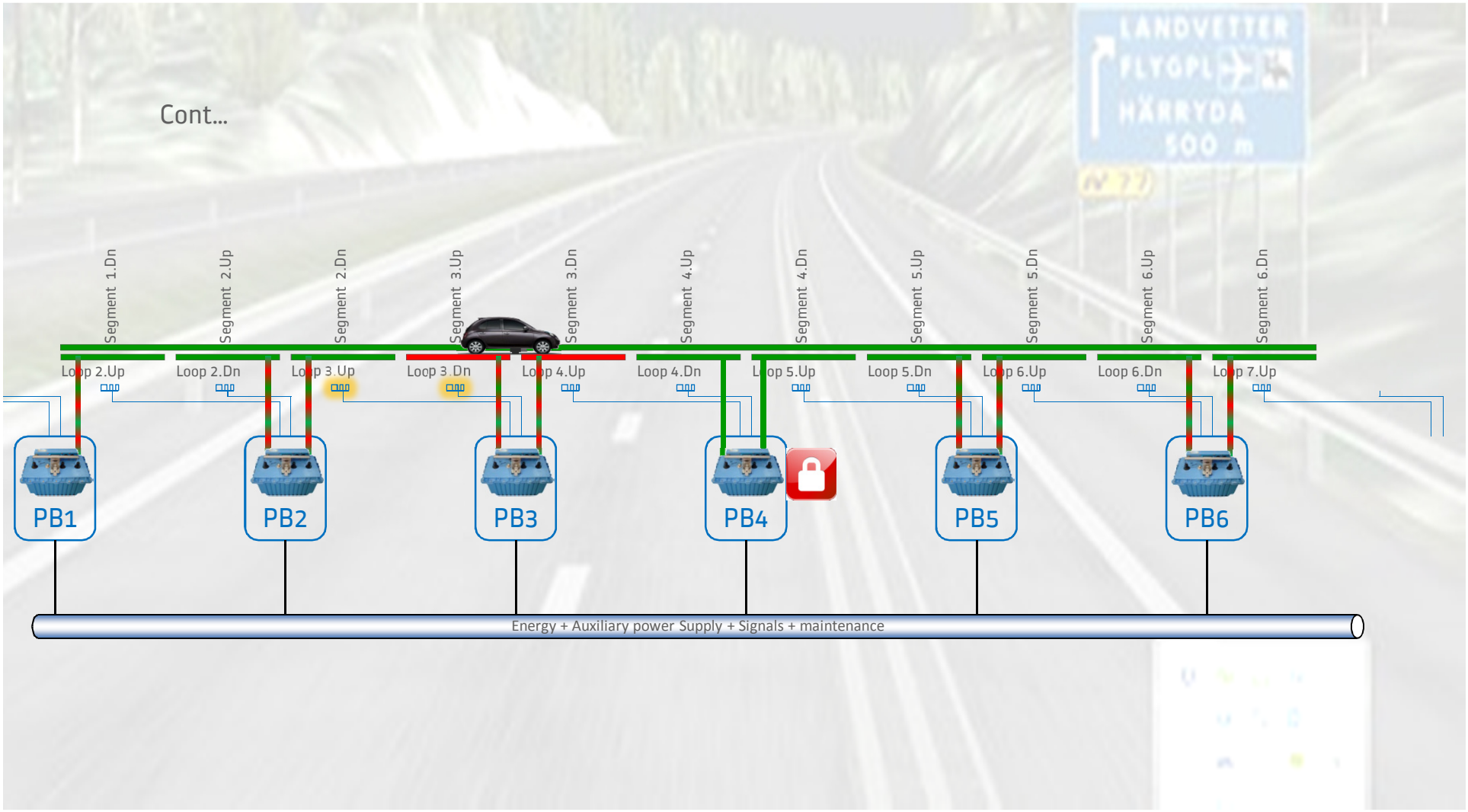
Principle



ALSTOM

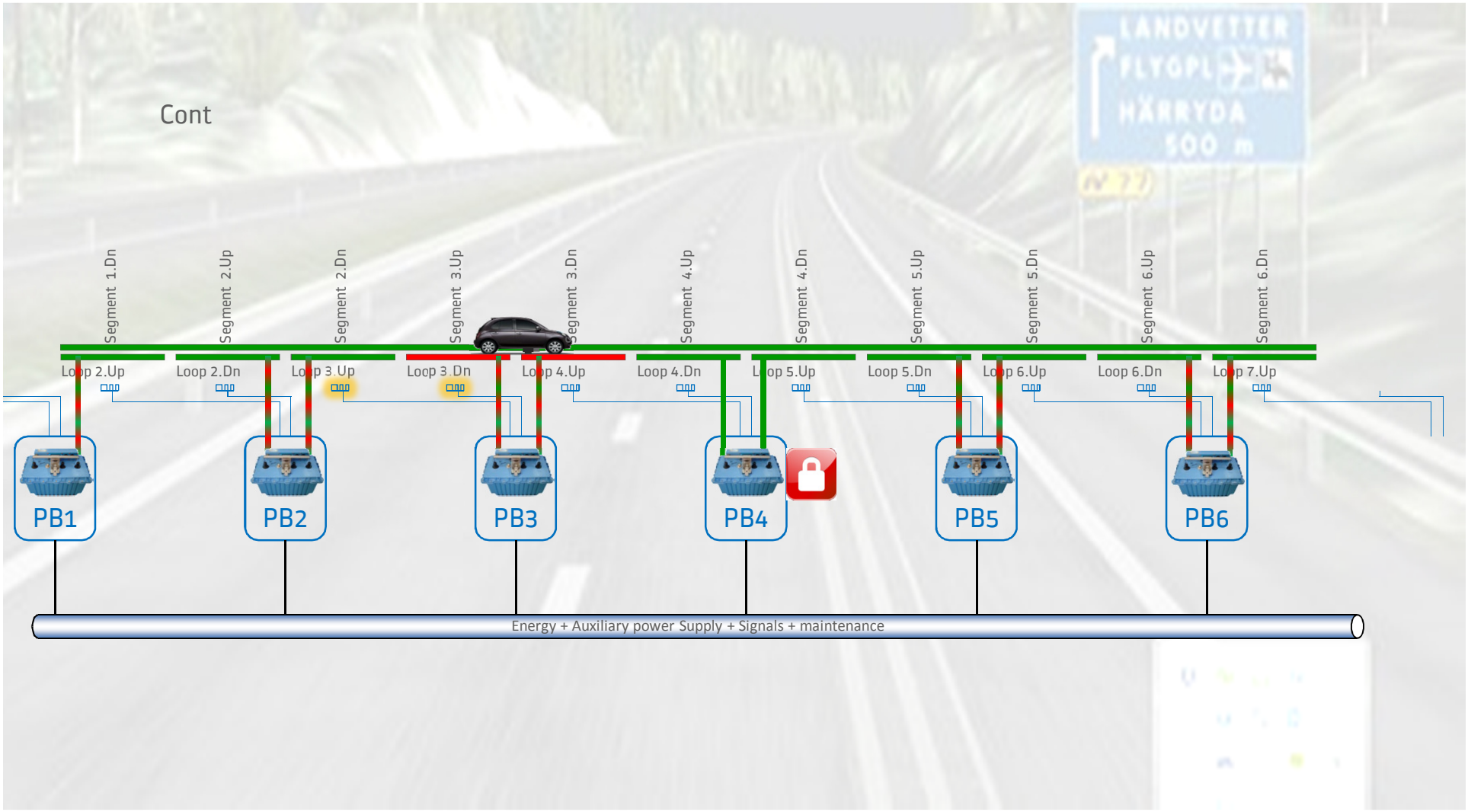
Principle

Cont...



ALSTOM

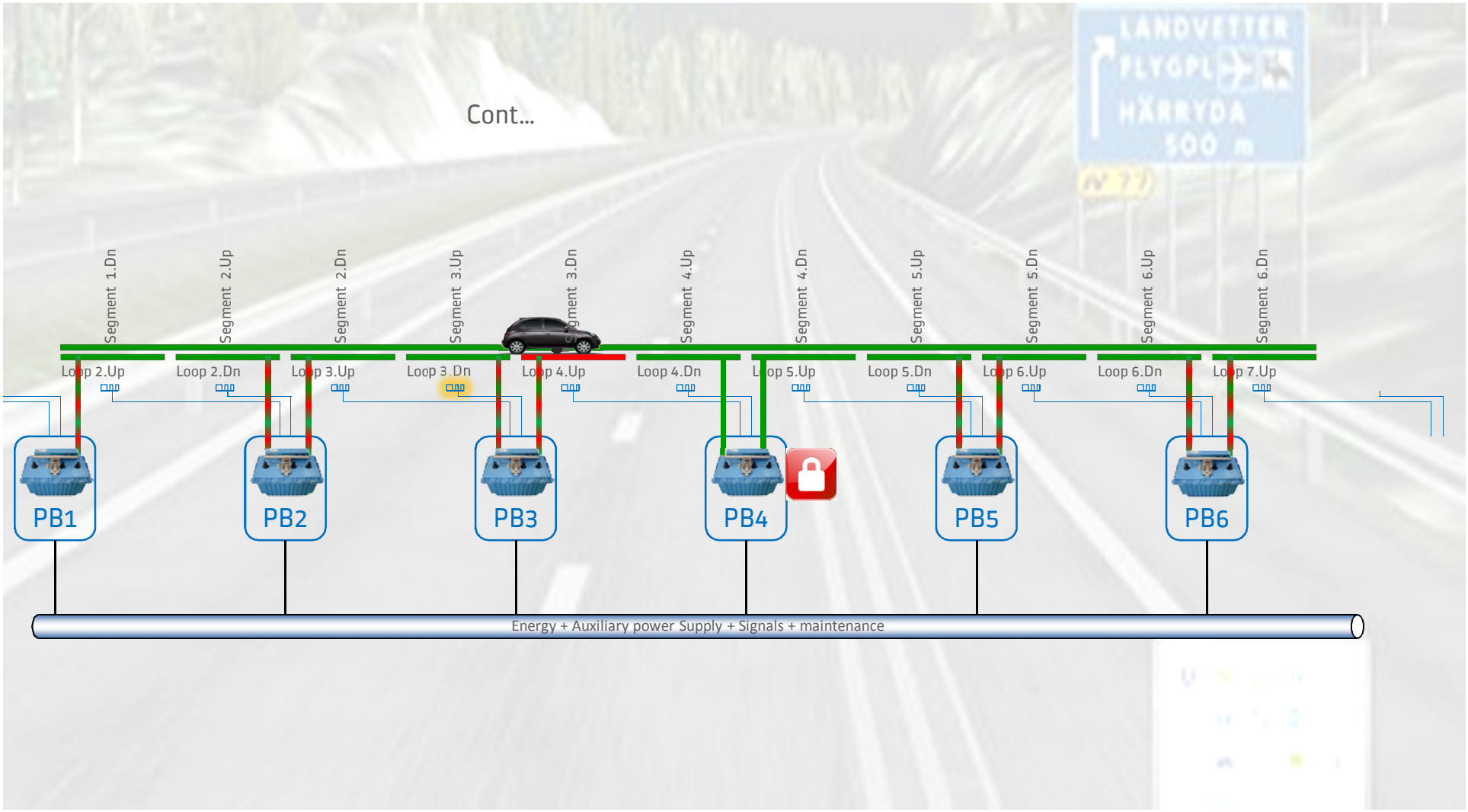
Principle



ALSTOM

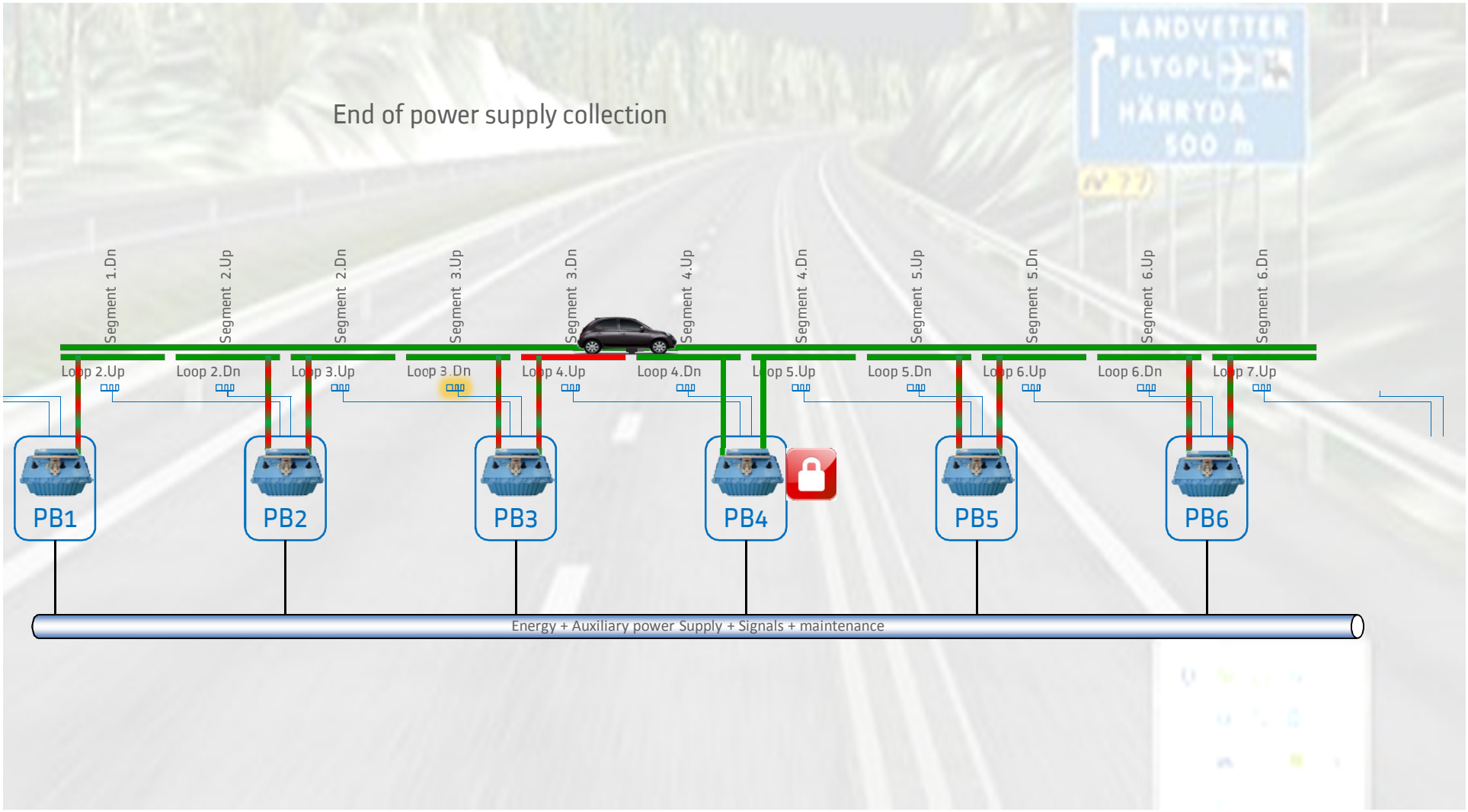
Principle

Cont...



ALSTOM

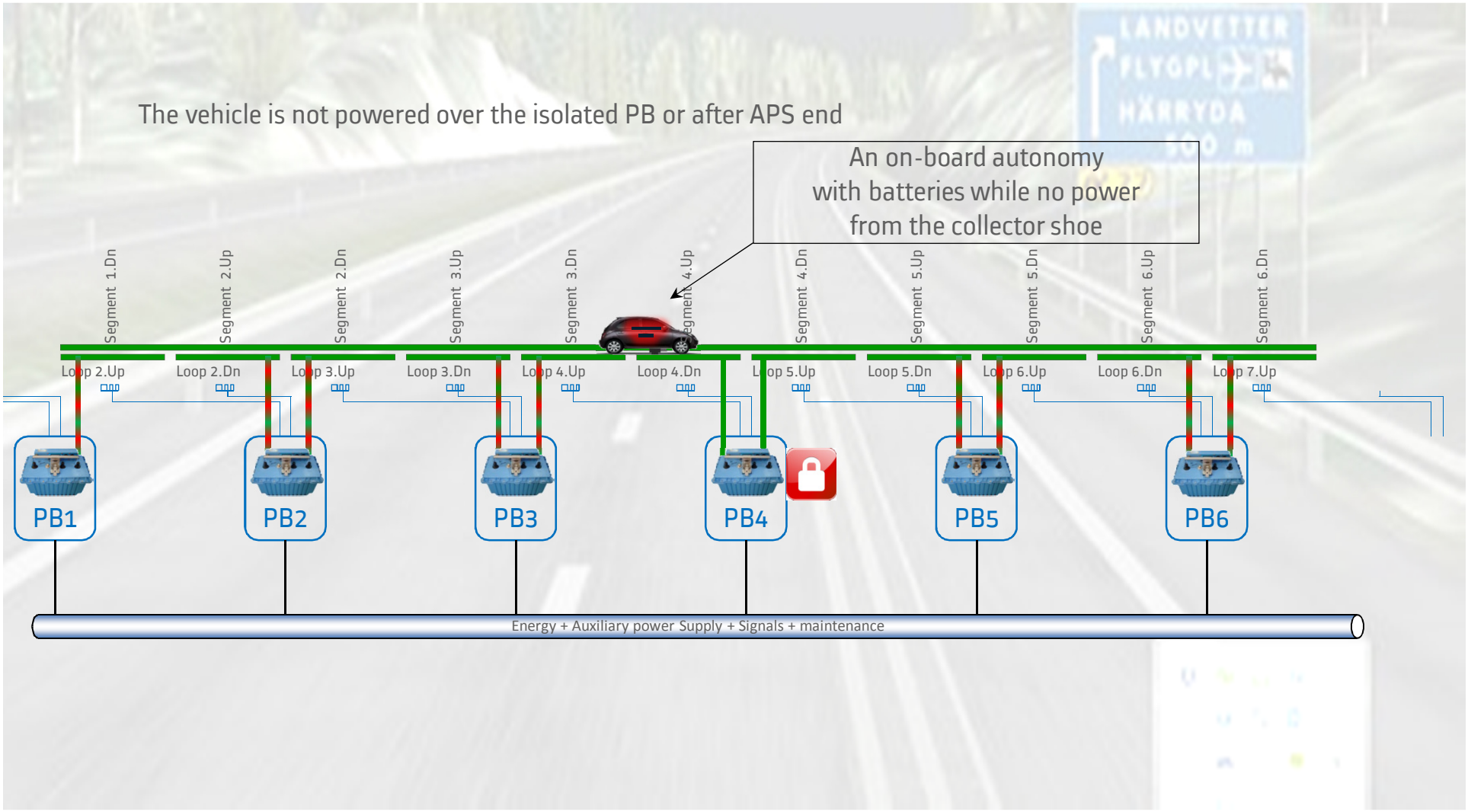
Principle



ALSTOM

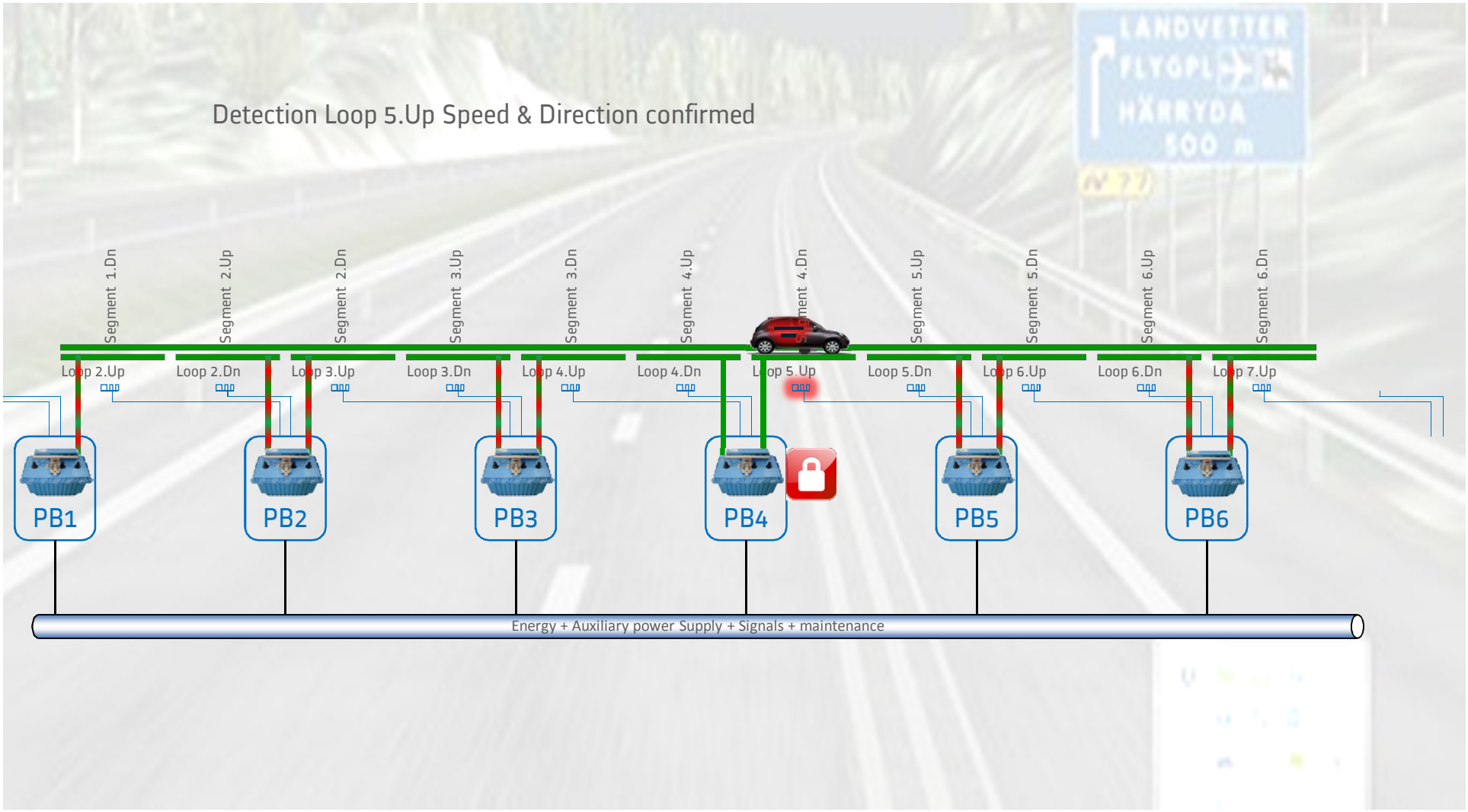
Principle

The vehicle is not powered over the isolated PB or after APS end



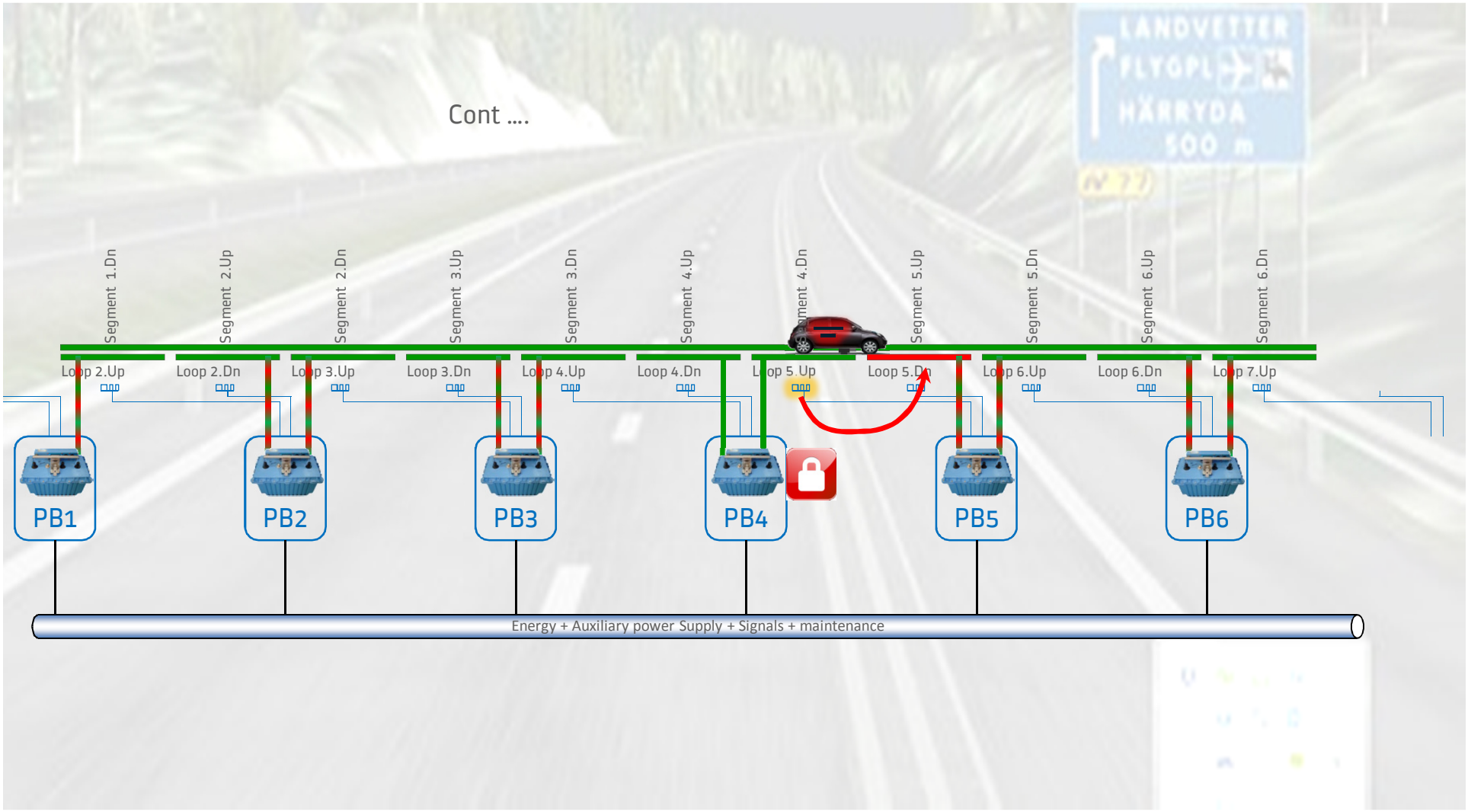
ALSTOM

Principle



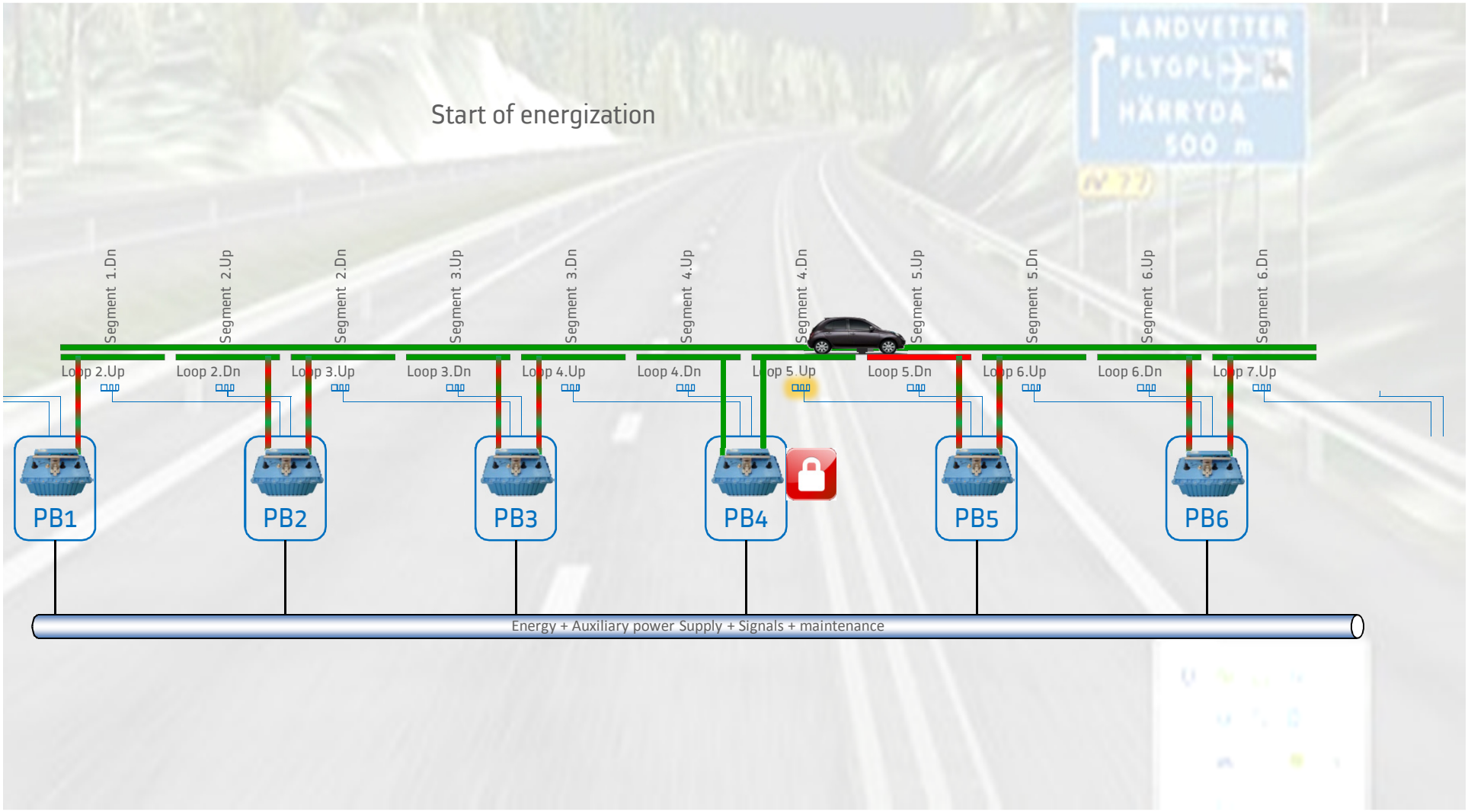
Principle

Cont ….



ALSTOM

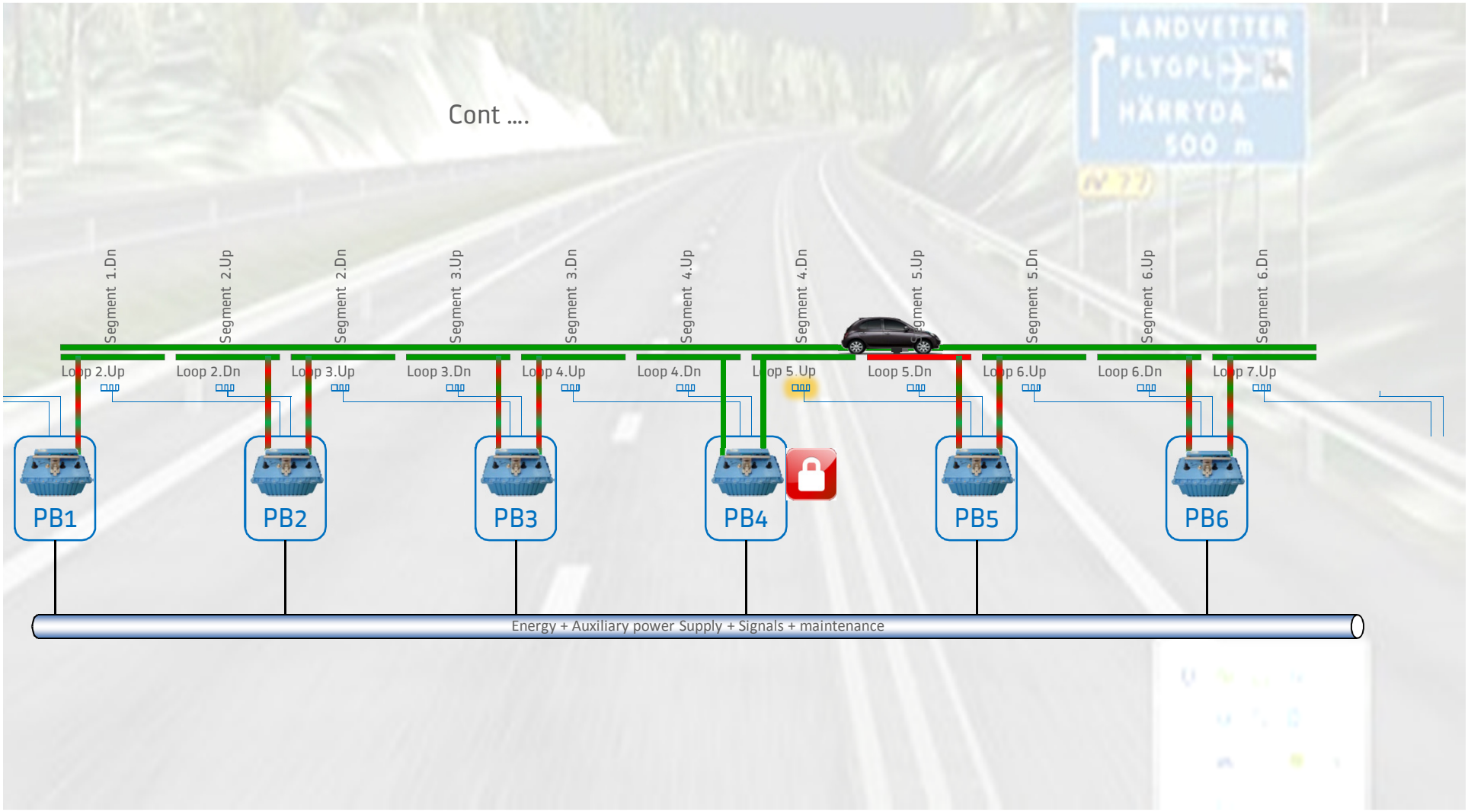
Principle



ALSTOM

Principle

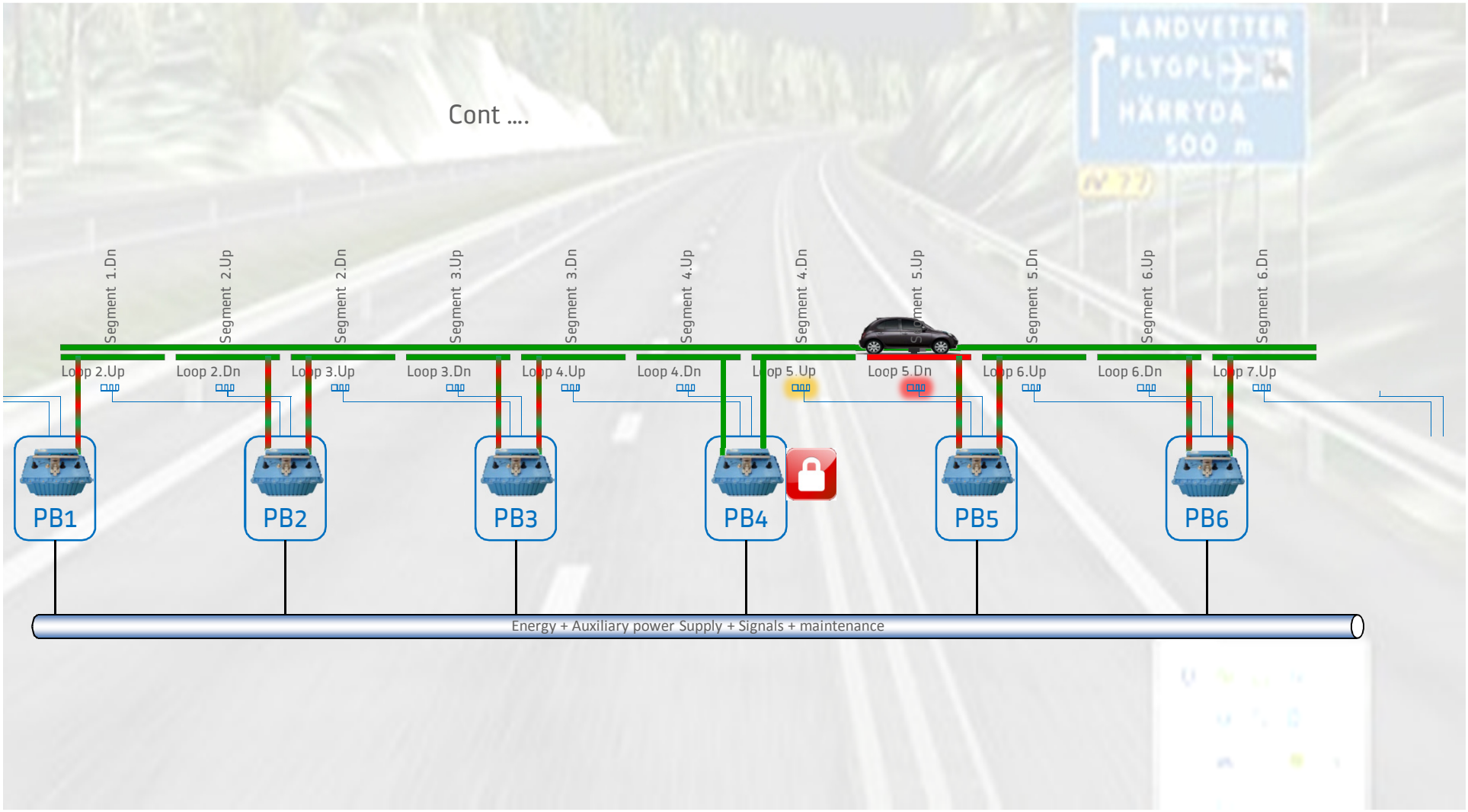
Cont ….



ALSTOM

Principle

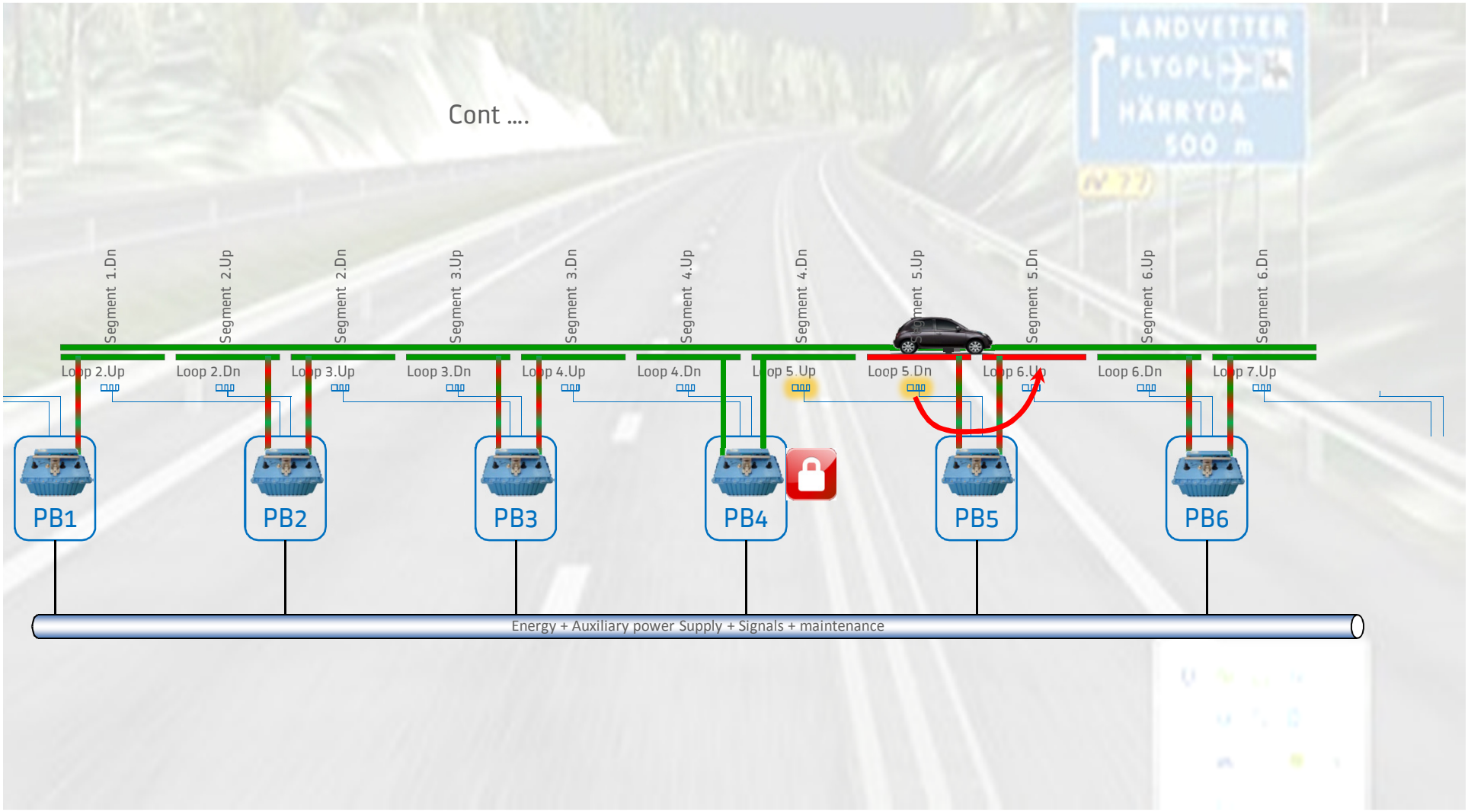
Cont ….



ALSTOM

Principle

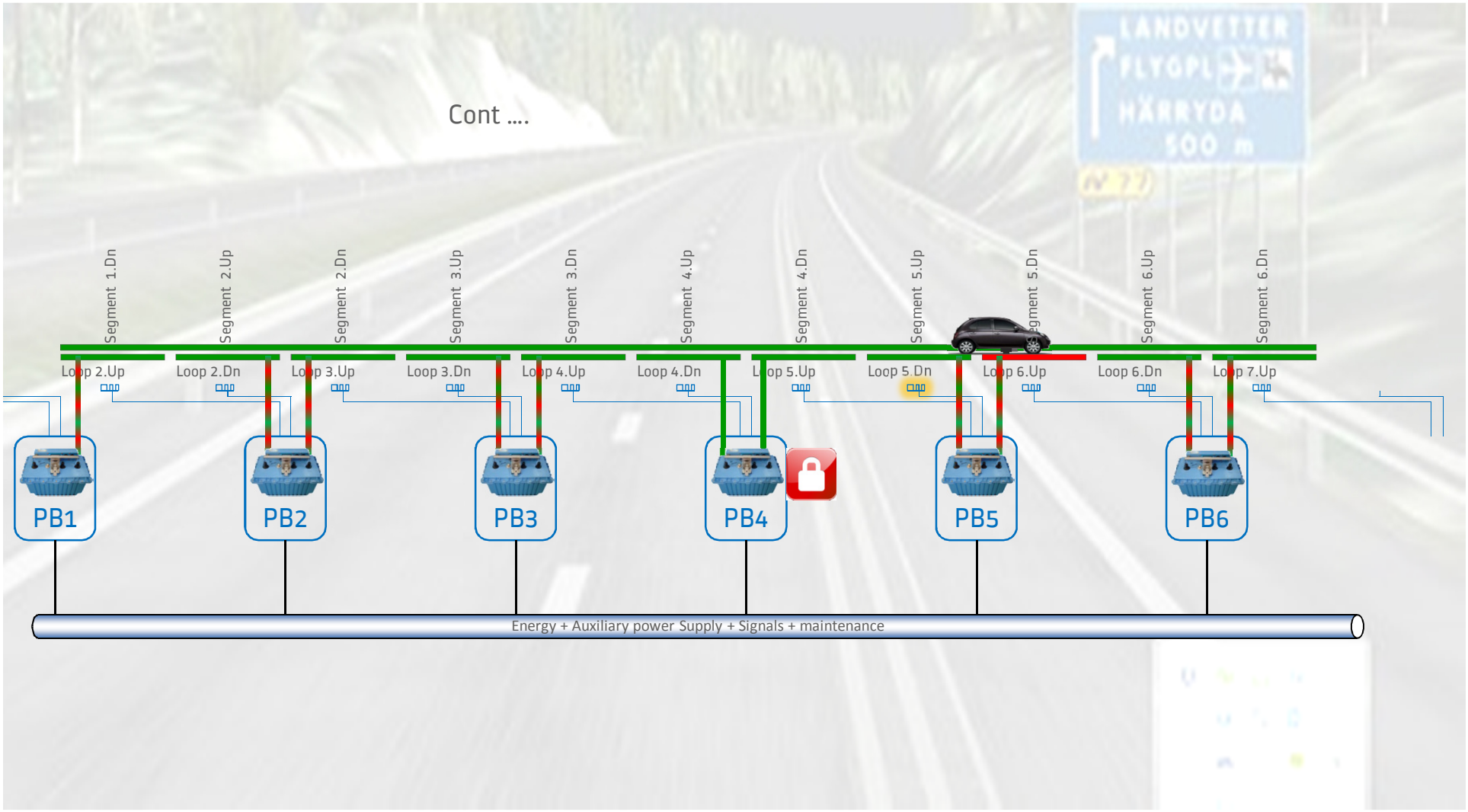
Cont ….



ALSTOM

Principle

Cont ….

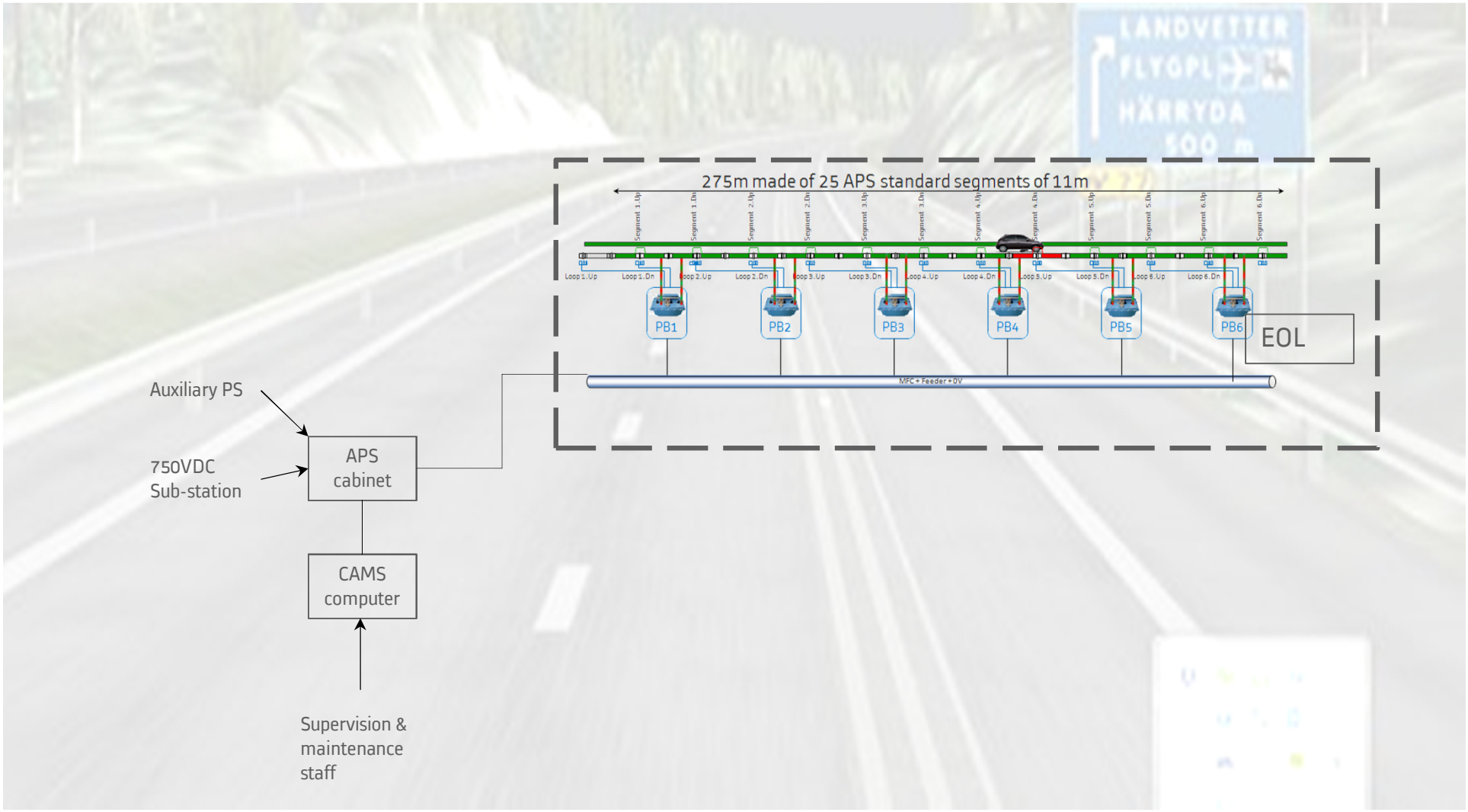


ALSTOM

APS / ERS Slide-in evaluation – Göteborg (Sweden)

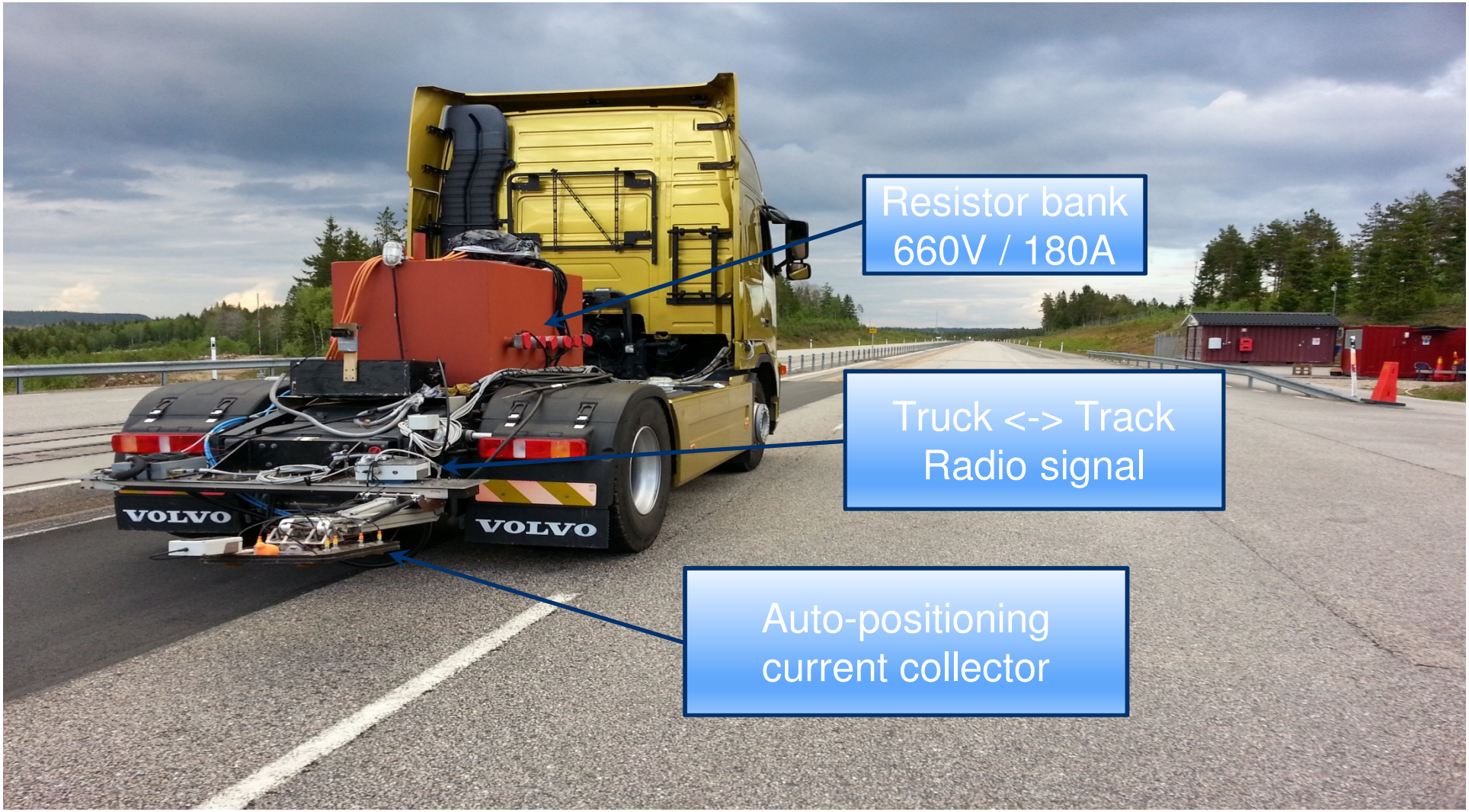
ALSTOM

APS-ERS Demonstrator Power supply architecture



ALSTOM

APS-ERS Demonstrator : The vehicle is developed by Volvo truck.



ALSTOM

ERS-APS Conductive slide-in solution evaluation Phase 1
7km run in may 2013 with transfer of energy up to 126kW

Current collection test	Result
126kWatts 180Amps 690VDC transfer	✓
7km of continuous power transfer	✓
Rainy conditions	✓
Short circuits tests	✓

Re-use of existing items from APS

Existing architecture

Existing Power Boxes

Existing Safety Short-circuitor and supervision in sub-station

Existing Infrastructure

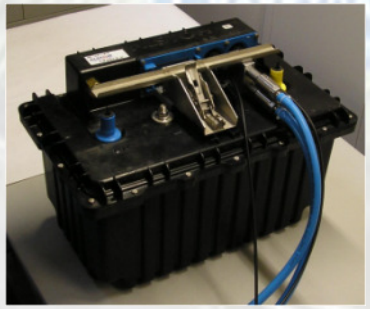
ALSTOM

ERS-APS Conductive slide-in solution evaluation Phase 2
20km run in Oct 2014 with transfer of energy up to 126kW

Adaptation of APS to ERS

New third rail beam adapted for road

Static switches Power box



Adherence improvement
Engraved conductive bars

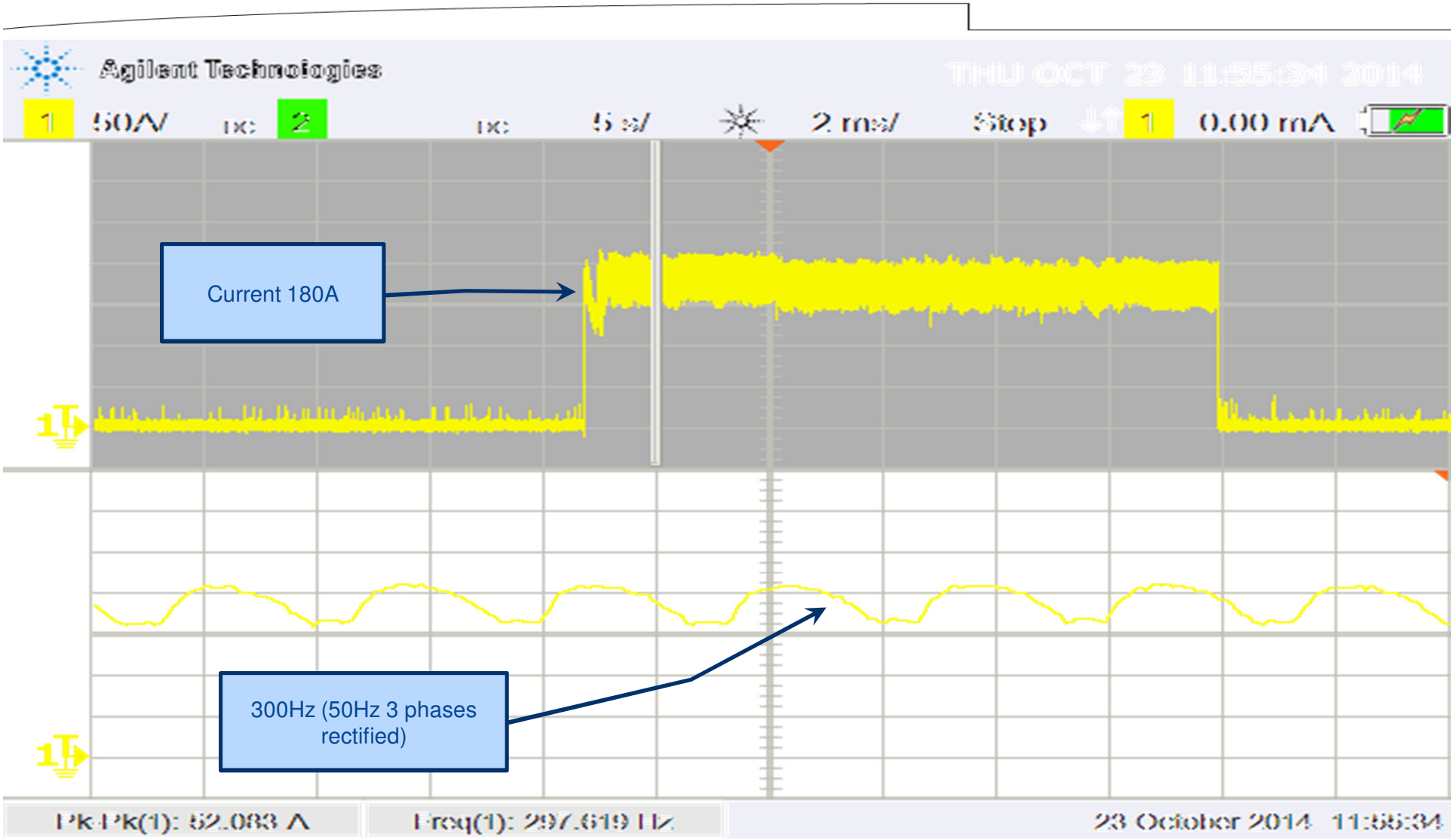
	Tramway	ERS
Nb vehicles per day	200	20 000
Nb switchings per 5 years	365 000	36 500 000

ALSTOM

Infrastructure with engraving in order to improve the road adherence.

ALSTOM

Current measured at the substation level

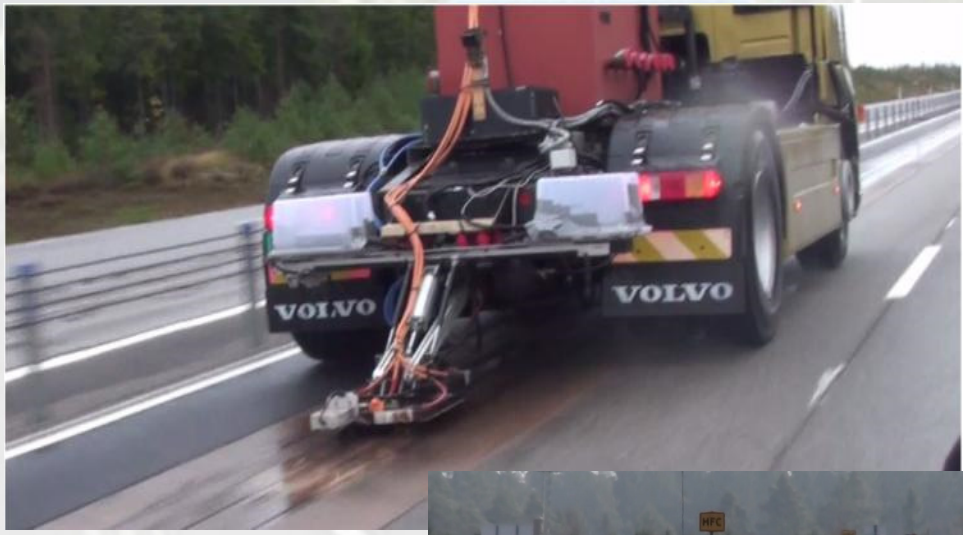


ALSTOM

Phase 2 Test conditions and results

Tests in October 2014

Current collection test	Result
126kWatts 180Amps 690VDC transfer	✓
Truck speed more than 80km/h	✓
20km of continuous power transfer	✓
Rainy conditions	✓
Short circuits tests	✓
Track adherence tests	✓



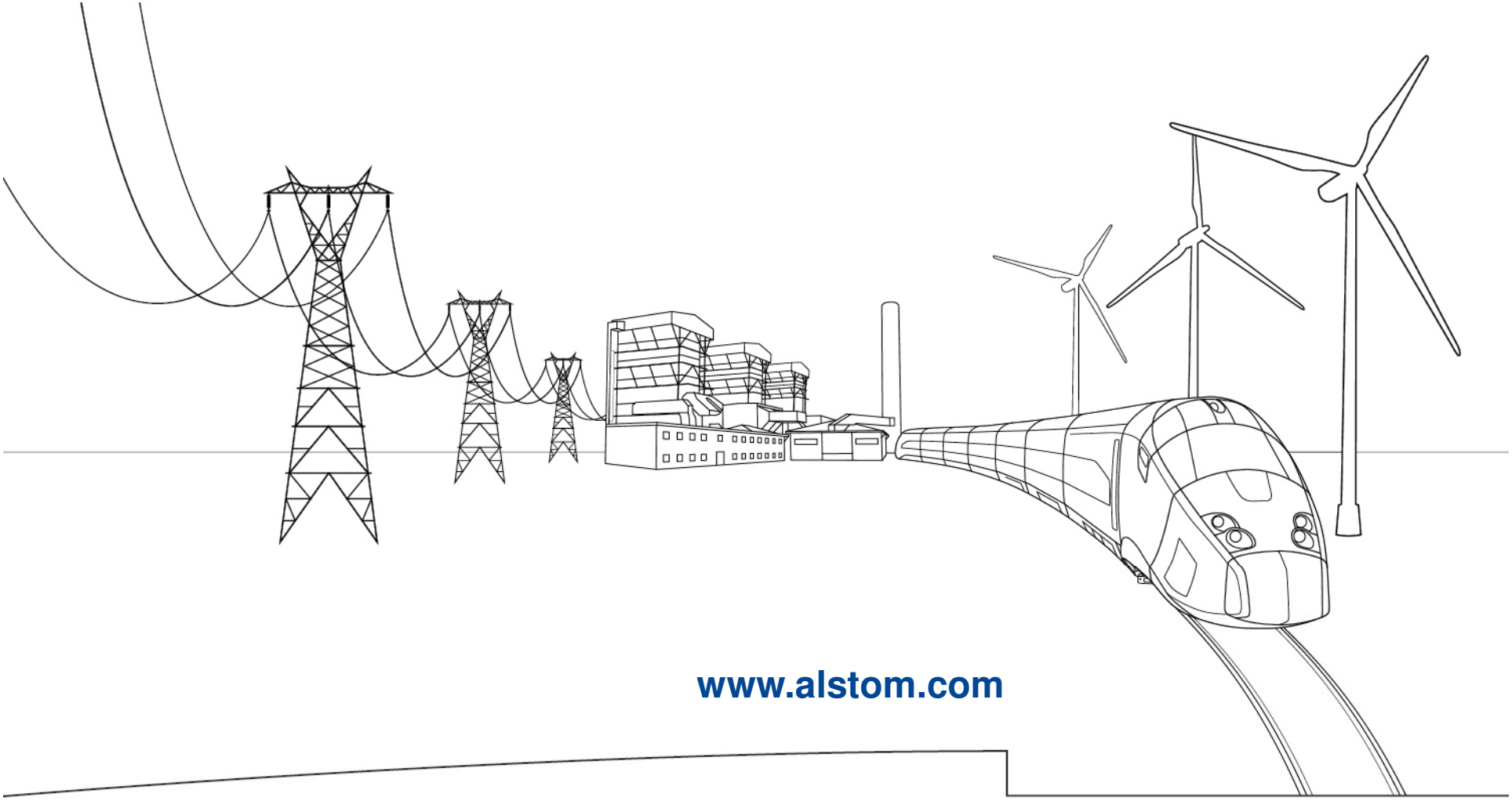
ALSTOM

APS-ERS Conductive solution Test-track Video

ALSTOM

Today, APS technology meets ERS Slide-in requirements

ALSTOM



www.alstom.com

ALSTOM

Shaping the future