STRC

Swiss Transport Research Conference

Exchanging Ideas for Transport

17–19 May 2017, Monte Verità

Towards Automatic Train Operation (ATO) for long distance services:

State-of-the-art and challenges

Some definitions concerning the level of automation (GoA: Grade of Automation)

GoA0: Everything is managed by the driver. No supervision (by ex. Tramway)

GoA1: Everything is managed by the driver. Partial or Full supervision
(ATP: Automatic Train Protection)
Sometimes: speed cruise control devices

GoA2: Driver is in the cab but normally doesn't drive between stops. Full supervision
(ATO/SATO or ATO/STO: Semi-Automatic Train Operation)

GoA3: No Driver. Full Supervision
A staff member watch the door closure and could sometimes move slowly the train in degraded operating conditions
(ATO/DTO: Automatic Train Operation / Driverless Train Operation)

GoA4: No Driver. Full Supervision
No staff
(ATO/UTO: Automatic Train Operation / Unattended Train Operation)

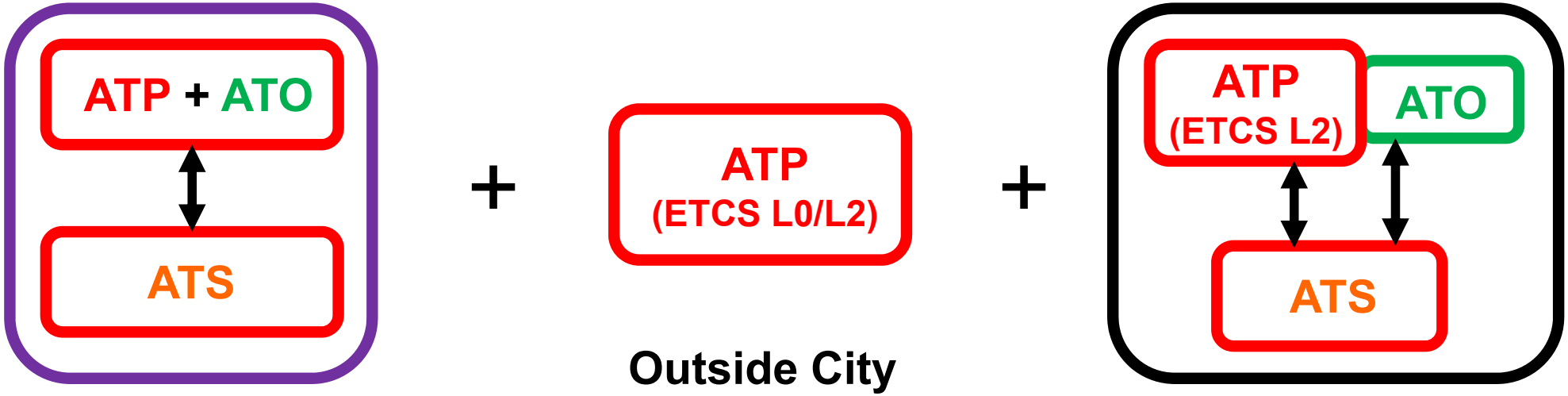
CBTC: Communication Based Train Control

ATS: Automatic Train Supervision System

ATP: Automatic Train Protection System

ATO: Automatic Train Operation System

TMS: Traffic Management System



CBTC

Inside City
Proprietary solution

Outside City
ETCS_L0
(Proprietary solution)
ETCS_L2
(European solution)

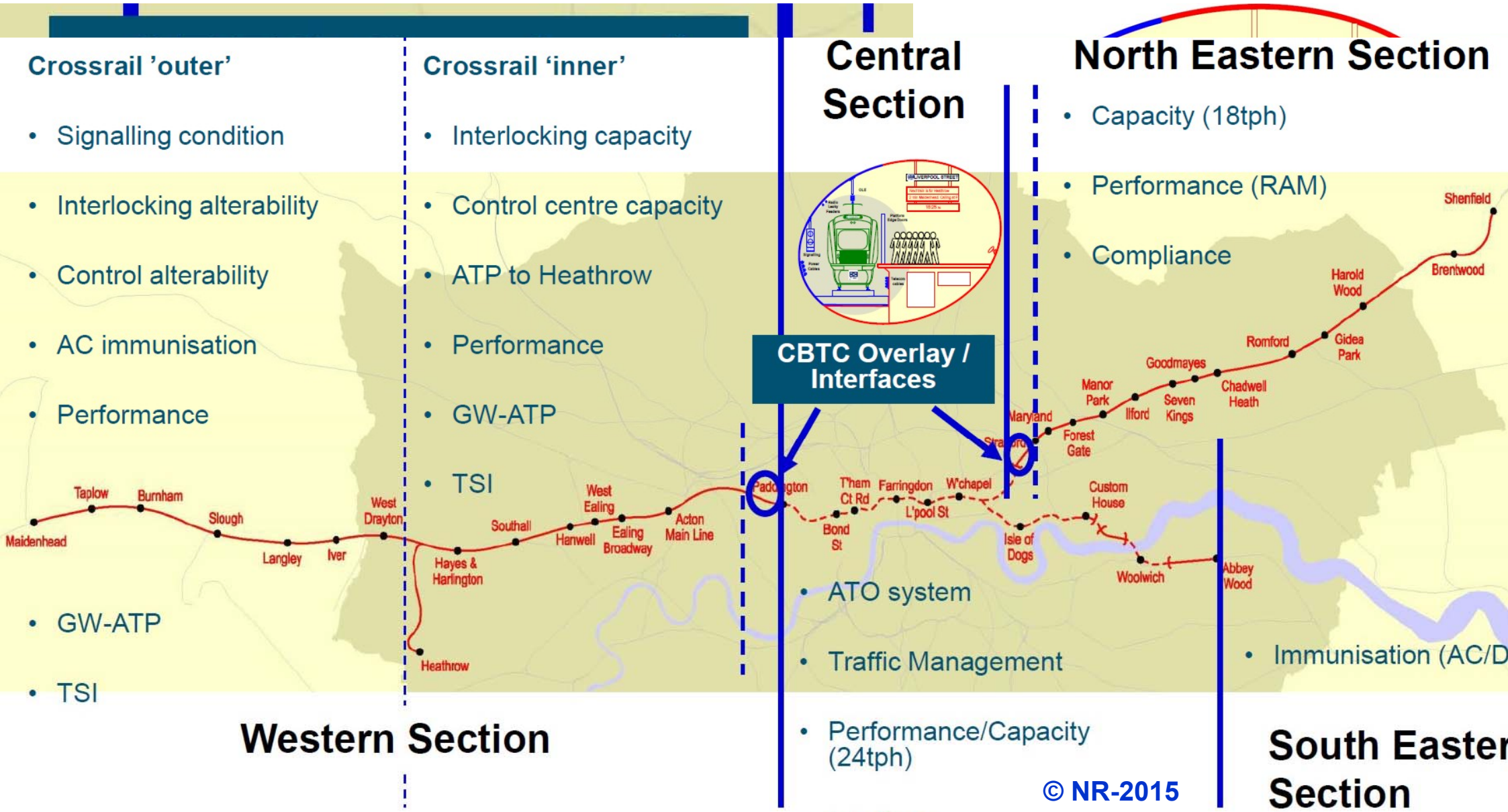
Inside City
European solution

Crossrail ***Thameslink***

Main Goal: **Capacity increase** in the city central section where **bottlenecks** are **at station entries**

Dual system (for ex. Crossrail project: ETCS_L2 - **CBTC** - ETCS_L0)

ETCS Only (for ex. Thameslink project: ETCS_L2 +ETCS_L0/1/2)


Crossrail 'outer'
• Signalling condition
• Interlocking alterability
• Control alterability
• AC immunisation
• Performance
• GW-ATP
• TSI
Crossrail 'inner'
• Interlocking capacity
• Control centre capacity
• ATP to Heathrow
• Performance
• GW-ATP
• TSI
Central Section
CBTC Overlay / Interfaces
• ATO system
• Traffic Management
• Performance/Capacity (24tph)
• Interfaces
North Eastern Section
• Capacity (18tph)
• Performance (RAM)
• Compliance
• Immunisation (AC/D
Western Section
South Easter Section
Maidenhead
Taplow
Burnham
Slough
Langley
Iver
West Drayton
Hayes & Harlington
Heathrow
Southall
Hanwell
West Ealing
Ealing Broadway
Acton Main Line
Paddington
T'ham Ct Rd
Farringdon
W'chapel
L'pool St
Bond St
Isle of Dogs
Custom House
Woolwich
Abbey Wood
Maryland
Forest Gate
Manor Park
Ilford
Seven Kings
Goodmayes
Chadwell Heath
Romford
Gidea Park
Harold Wood
Brentwood
Shenfield
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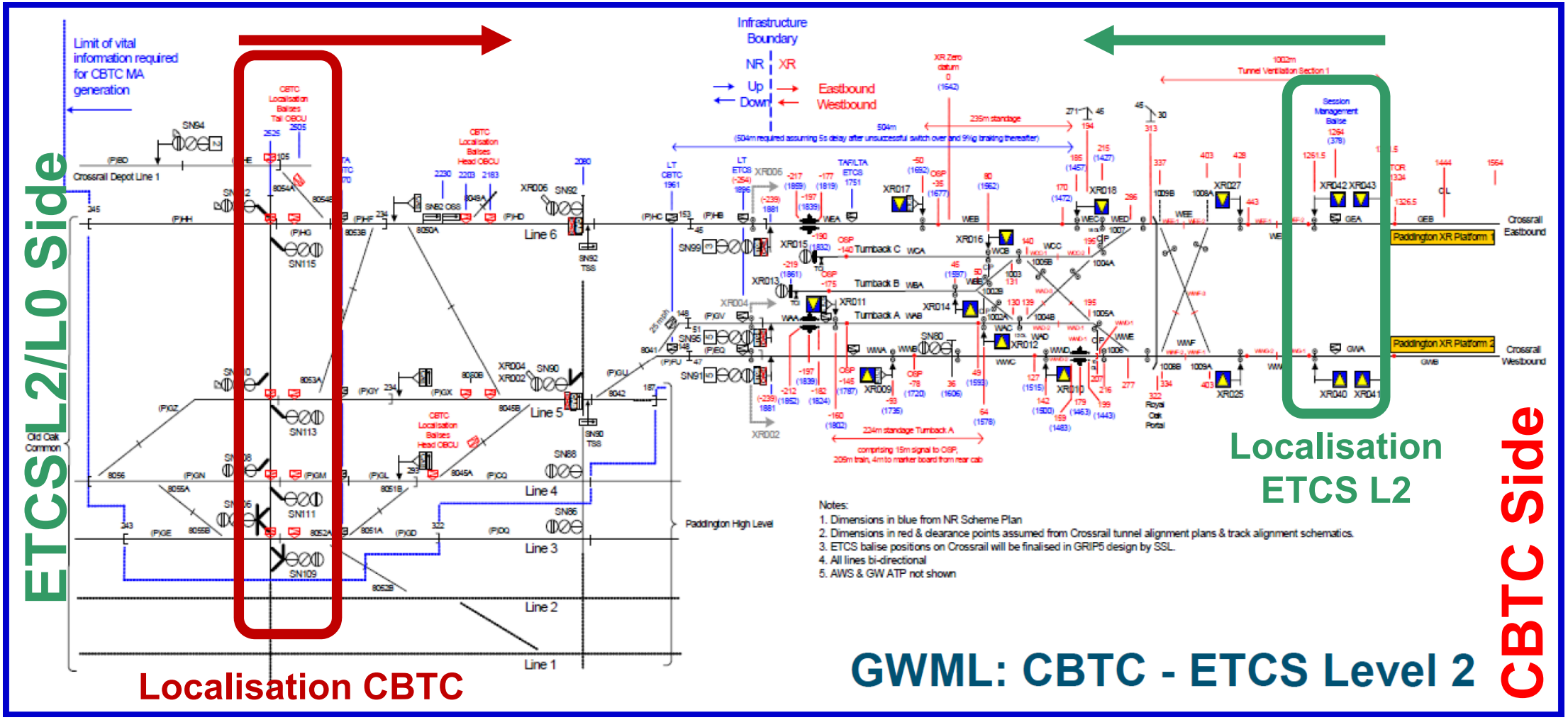
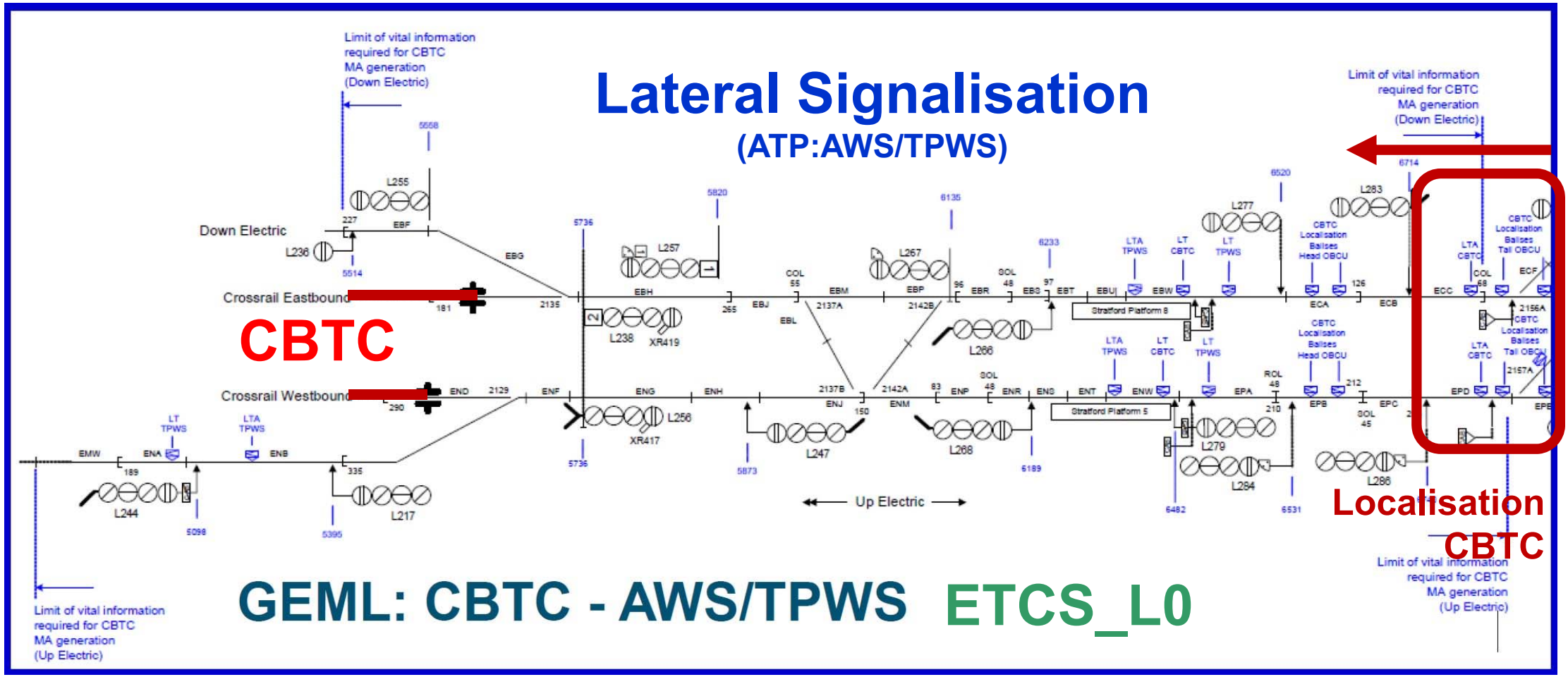
CROSSRAIL



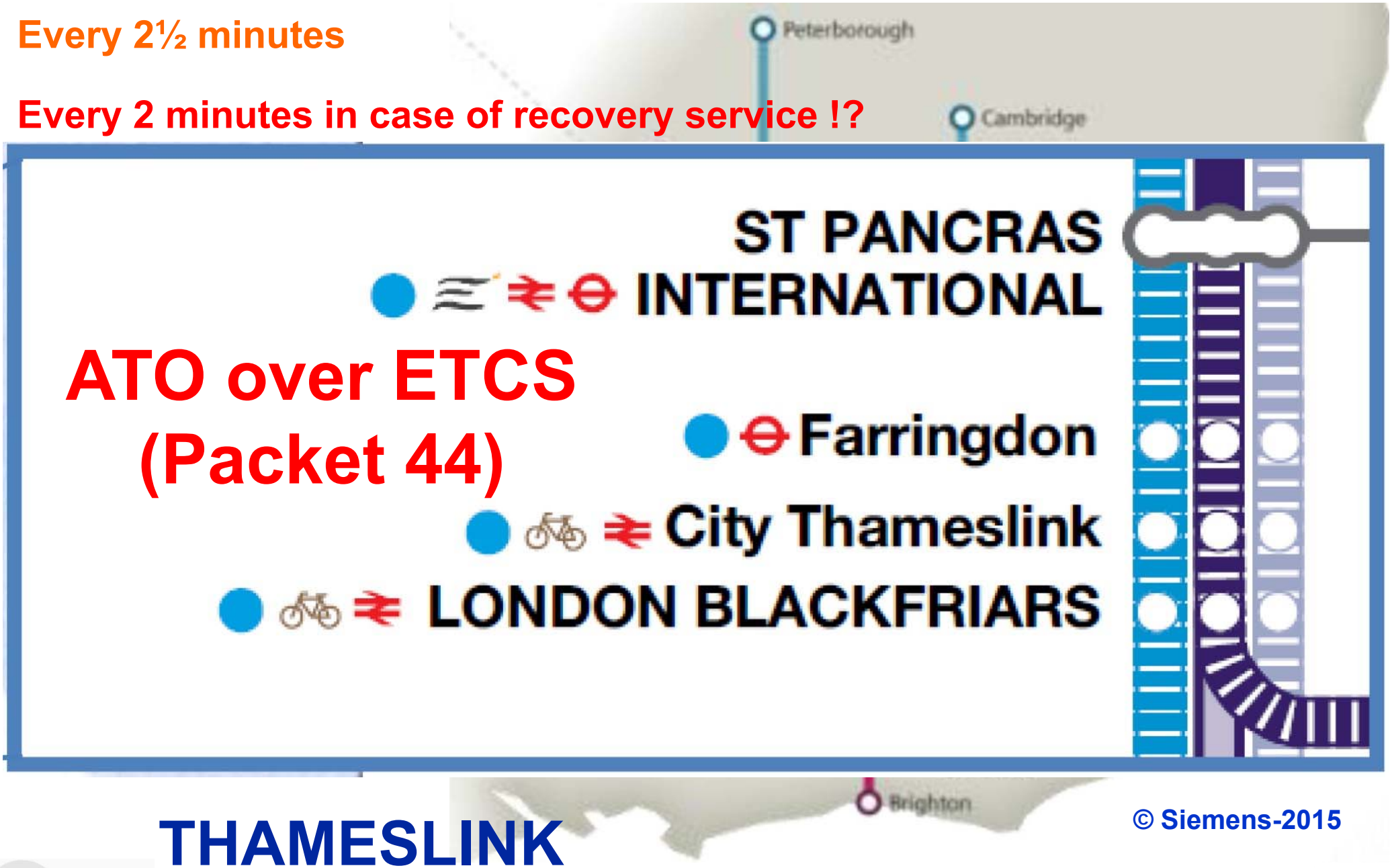
CROSSRAIL



CROSSRAIL

Every 2½ minutes

Every 2 minutes in case of recovery service !?



THAMESLINK

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ETCS+ATO: Use of the multi-purpose ETCS Packet 44
Possible use with ETCS_L1 FS (with GSM-R) or ETCS_L2 FS

If the goal is to increase capacity in bottleneck then the use of **ETCS_L2** (shorter fixed block sections than with ETCS_L1) is efficient

Siemens/Alstom/Invensys/NR: *ATO with ETCS Data Flows and Data Packets (2011):*
- Segment Profile: Real time update of infrastructure data
- Journey Profile: Real time update of timing points
(timing point main types: departure/passing/arrival)

*In 2011, a timing point is **only***
*a three-dimensional entity: type, location and time **(but not speed)***

THAMESLINK

Capacity with a CBTC system or with ETCS_L2 + ATO: Only slight differences

$D_{max/min}$: max/min distance between the safe rear end of a train and the NV_MAL of the following train
[hypothesis: Immediate and continue update of train locations. No specific Danger Point (DP)]

L: Section Length
CAM: Collision Avoidance Margin
RbM: Rollingback Margin
V_MAL: Vital Movement Authority Limit
NV_MAL: Non-Vital Movement Authority Limit

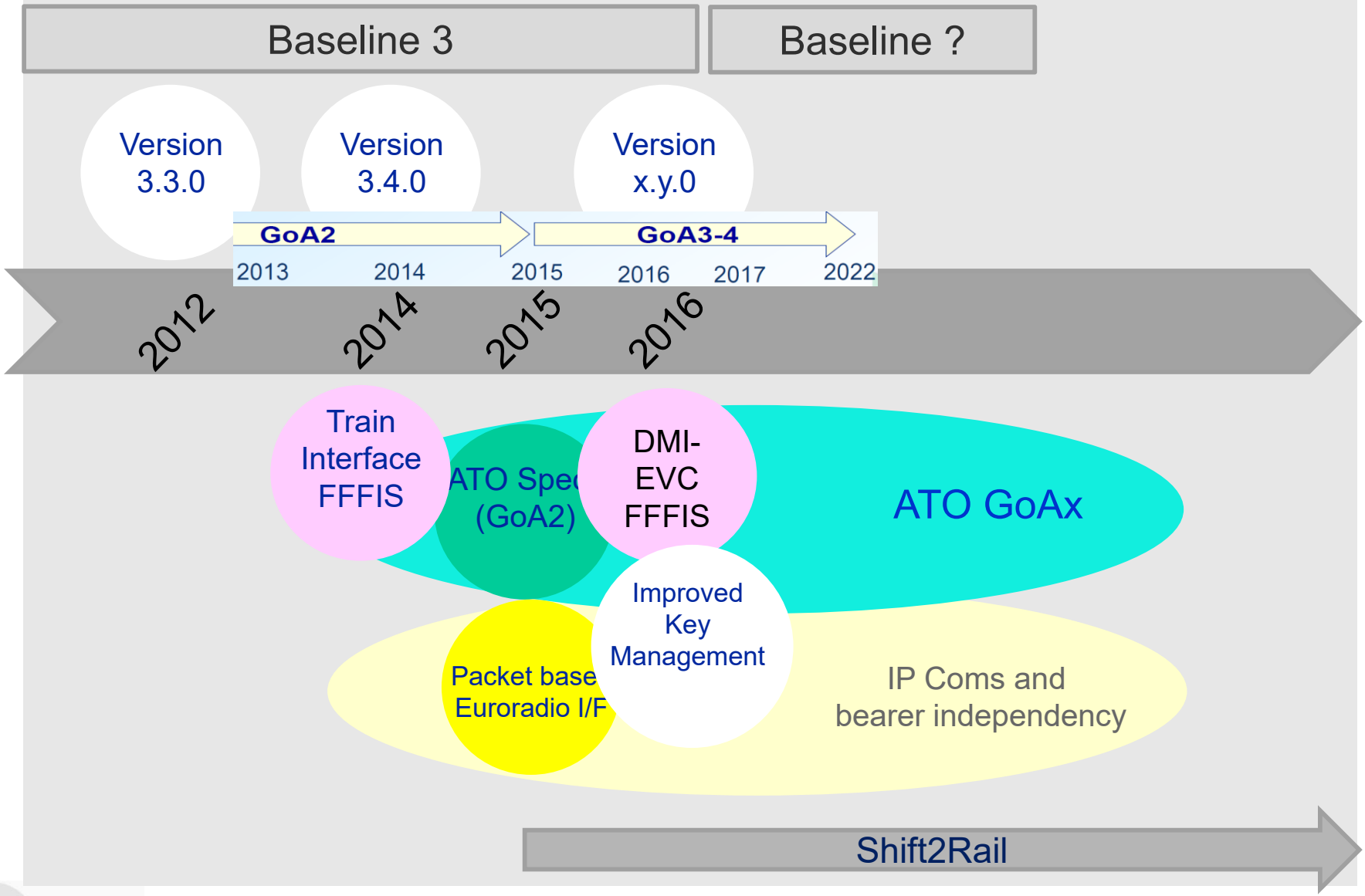
Examples	CBTC Strategy V_MAL / NV_MAL	D_{min}	D_{max}
Paris M14	Fixed / Fixed	CAM+RbM	L+CAM+RbM
Paris M1	Moving / Fixed	CAM+RbM	L
Lyon Ligne D	Moving / Moving	CAM+RbM	CAM+RbM

State-of-The-Art Summary:

System/Project Name	Inside City	Outside City	Remark
Cruise speed keeper	GoA_1	GoA_1	Long distance / HSL
Cruise speed controller	---	GoA_1	Freight(TripOptimizer) / HSL
Crossrail	GoA_4-CBTC	GoA_1	Outside City: ETCS_L0/L2
Thameslink (2018)	GoA_4-ETCS	GoA_1	Outside City: ETCS_L0

System/Project Name	ATO and TMS	Goal
Long distance passenger service	Not connected	Driving comfort / Punctuality
TripOptimizer (Freight)	Connected or not	Energy saving
Crossrail	Connected in city center	Bottleneck capacity
Thameslink (2018)	Connected in city center	Bottleneck capacity

Mastering and planning the ERTMS/ETCS Long-Term Evolution



ERA – 2016:

GoA2 in 2018/2019

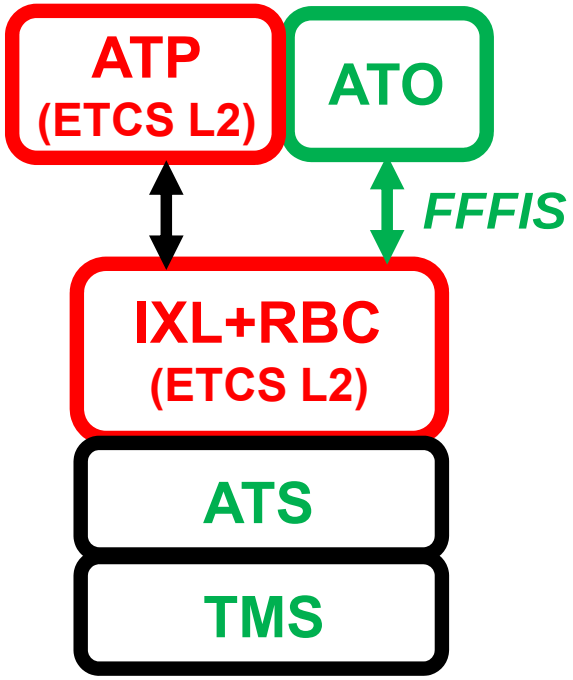
GoA3: long term

*Challenge GoA2_**A**: **How to keep self-motivated and skilled drivers ?***

- To spend more time in driving simulators

*Challenge GoA2_**B**: **ETCS-ATO Interface standardization***

*- To develop Form Fit Function Interface Specifications (**FFFIS**)*



*Challenge GoA2_**C**: **ETCS-ATO Improvement***

- To add speed in the timing point features

ETCS-GoA_2: let's go !

*Challenge GoA3/4_**A: Supervision of the train working order***

- To add more sensors and to correlate their results

*Challenge GoA3/4_**B: Cross-check of outside aspects of trains***

- To film and analyse train videos

- To develop trackside more sophisticated and more numerous devices in the context of the global Wayside Train Monitoring System (WTMS)

*Challenge GoA3/4_**C: Obstacle on the track visually detected***

- To film and analyse in real time train video looking ahead

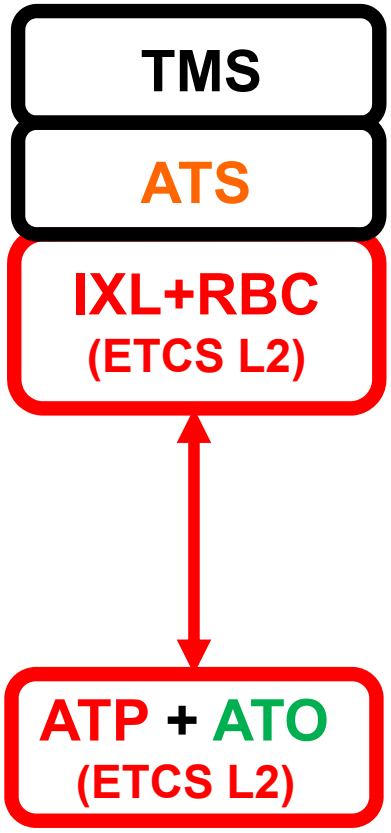
*Challenge GoA4_**D: Running "On Sight" (OS), under "Staff Responsibility" (SR) or "Shunting" (SH) modes***

- To film and analyse in real time train video looking ahead

- To use a telecontrol system

To resume

GoA2 over ETCS: let's go !



GoA4 over ETCS: for tomorrow !

Thank you for your attention

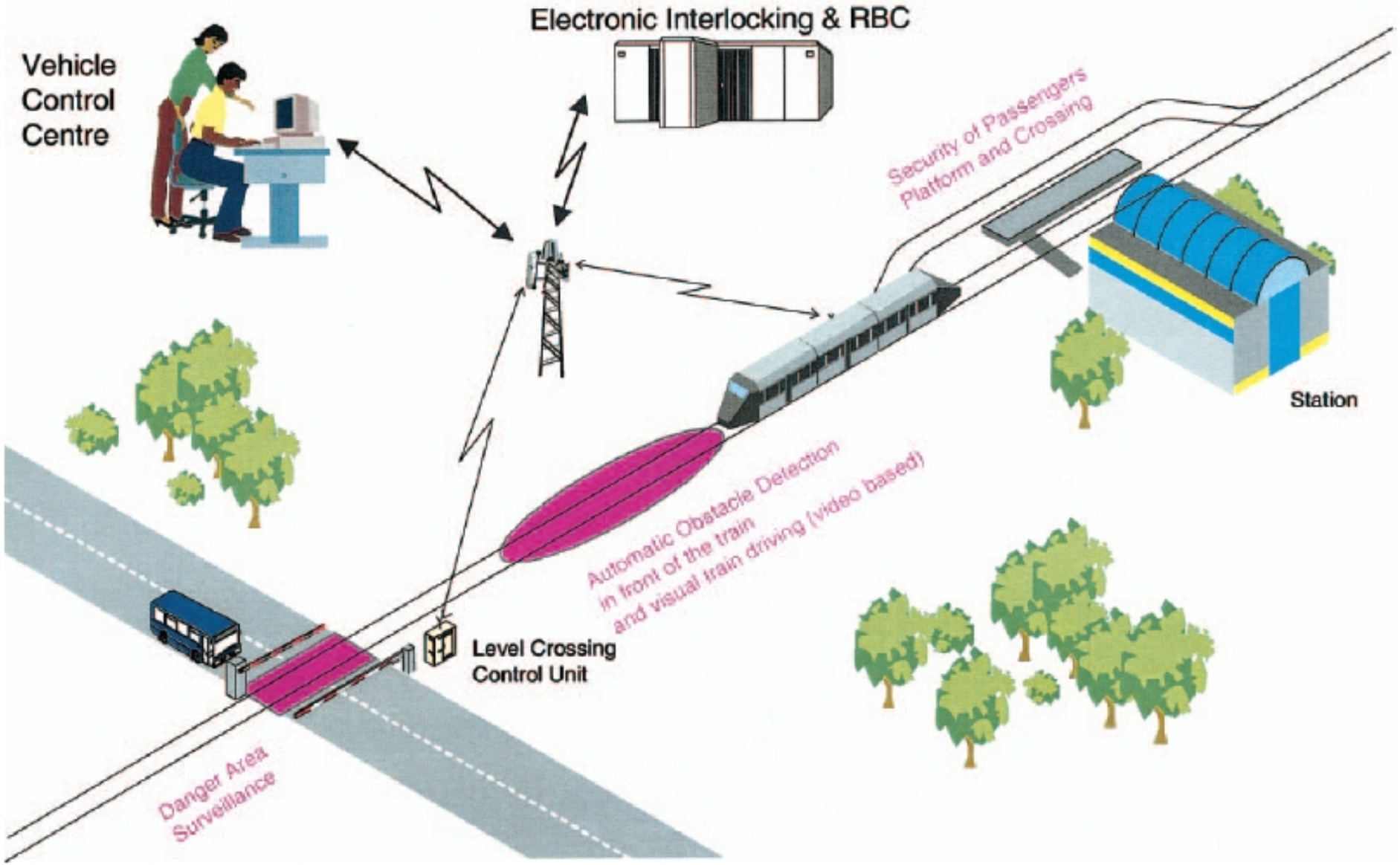
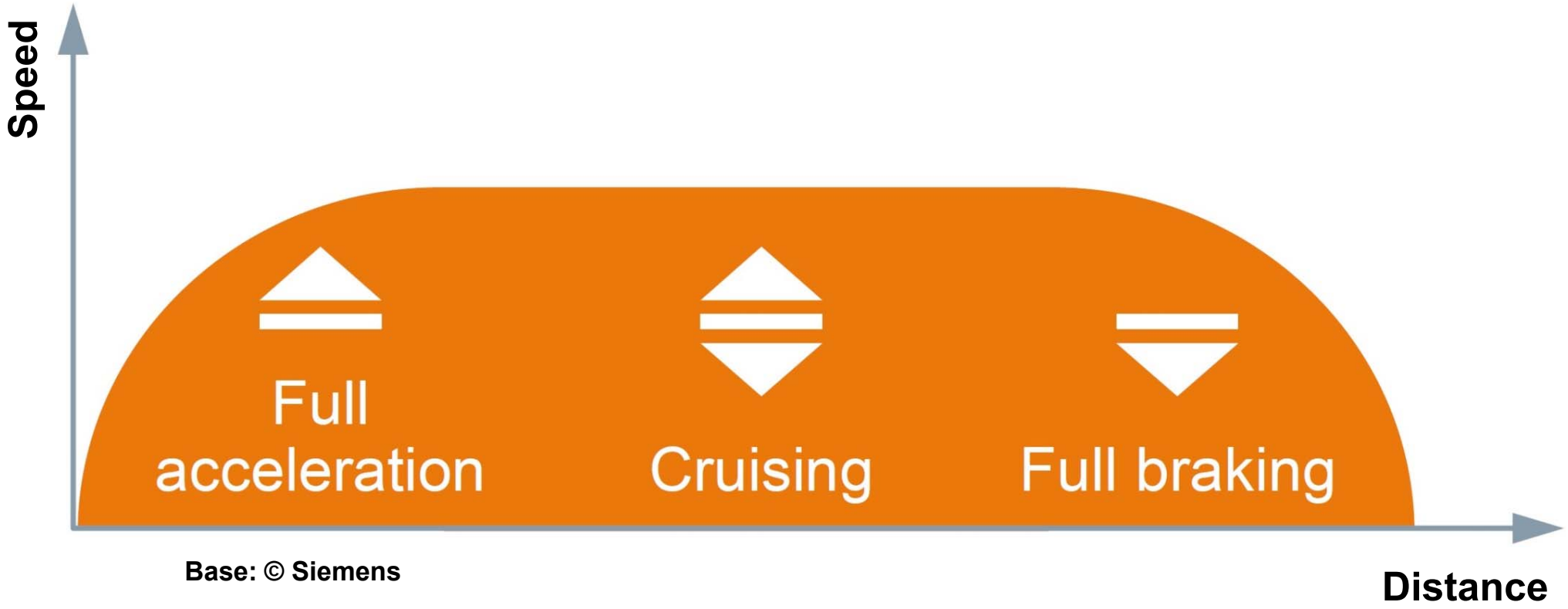


Fig. 7: Components for automated rail traffic ("KOMPAS" research project)

Capacity with a CBTC system or with ETCS_L2 + ATO: <u>Only slight differences</u>



Base: © Siemens

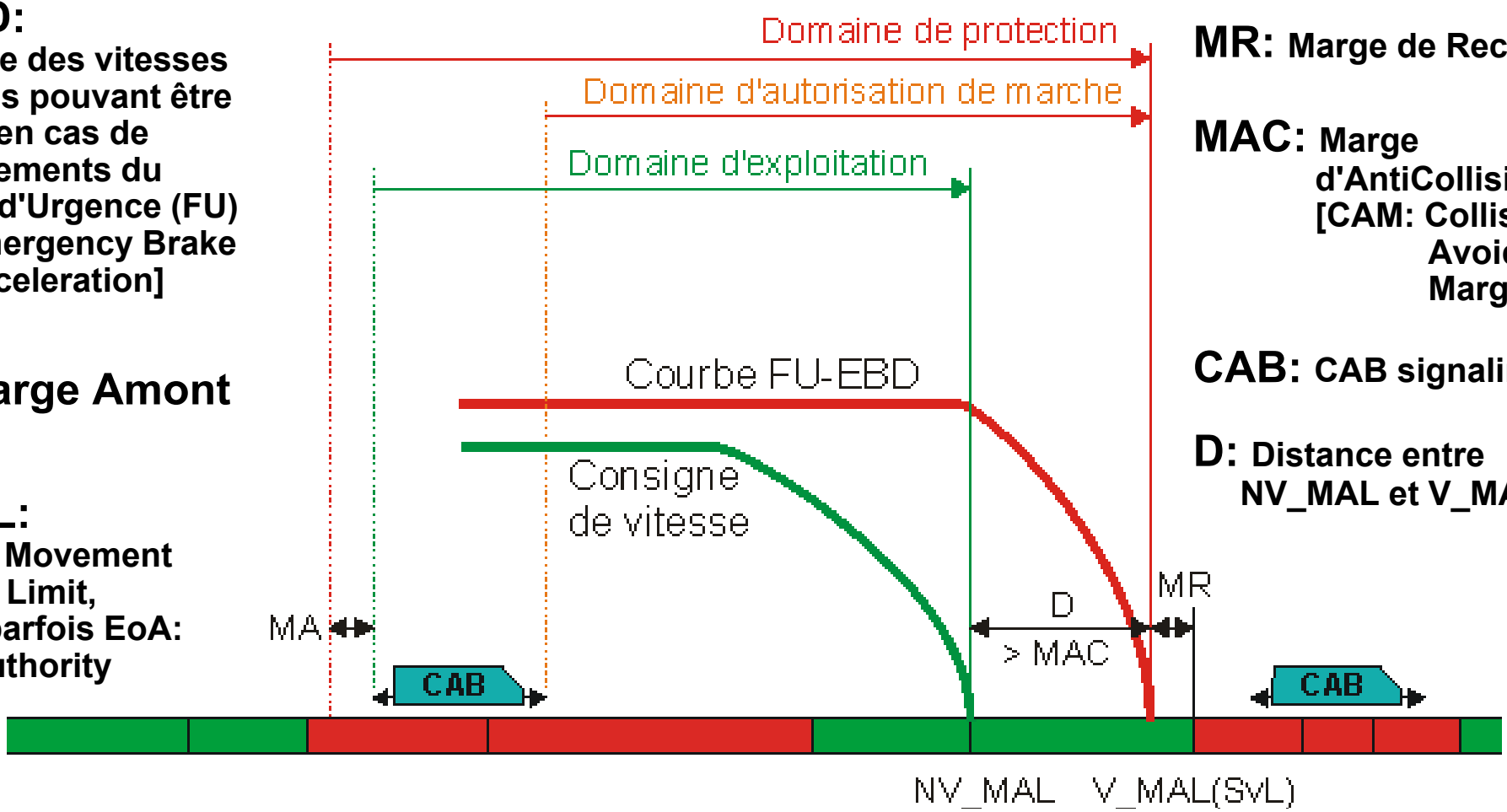
Time-minimum train run
(very simplified)

Les domaines avec cantons virtuels fixes purs et canton tampon

FU-EBD:
Enveloppe des vitesses maximales pouvant être atteintes en cas de déclenchements du Freinage d'Urgence (FU) [EBD: Emergency Brake Deceleration]

MA: Marge Amont

NV-MAL:
Non-Vital Movement Authority Limit, appelée parfois EoA: End of Authority



MR: Marge de Recul

MAC: Marge d'AntiCollision [CAM: Collision Avoidance Margin]

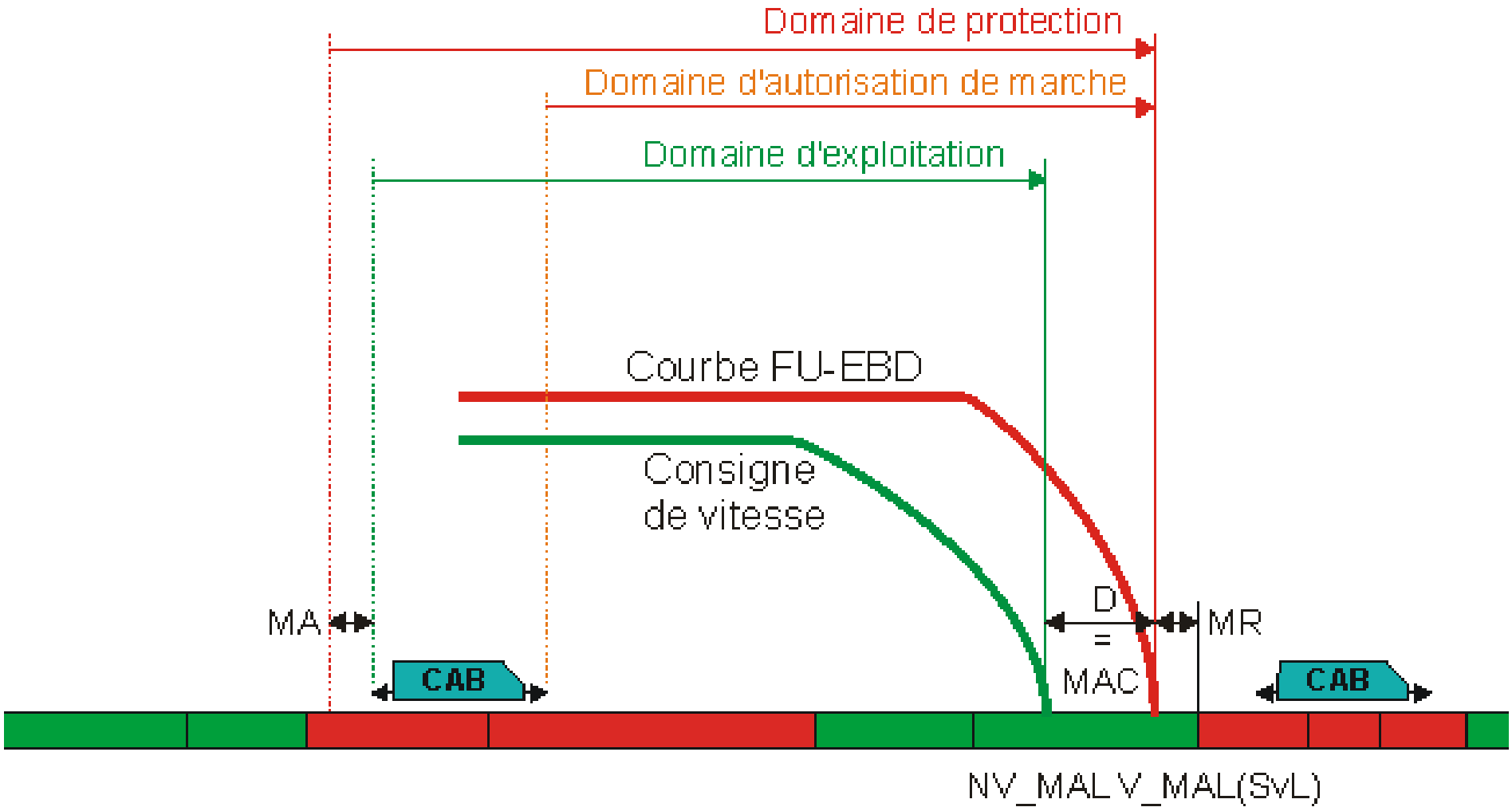
CAB: CAB signaling

D: Distance entre NV_MAL et V_MAL

V-MAL: Vital Movement Authority Limit, appelée parfois SvL (Supervised Location)

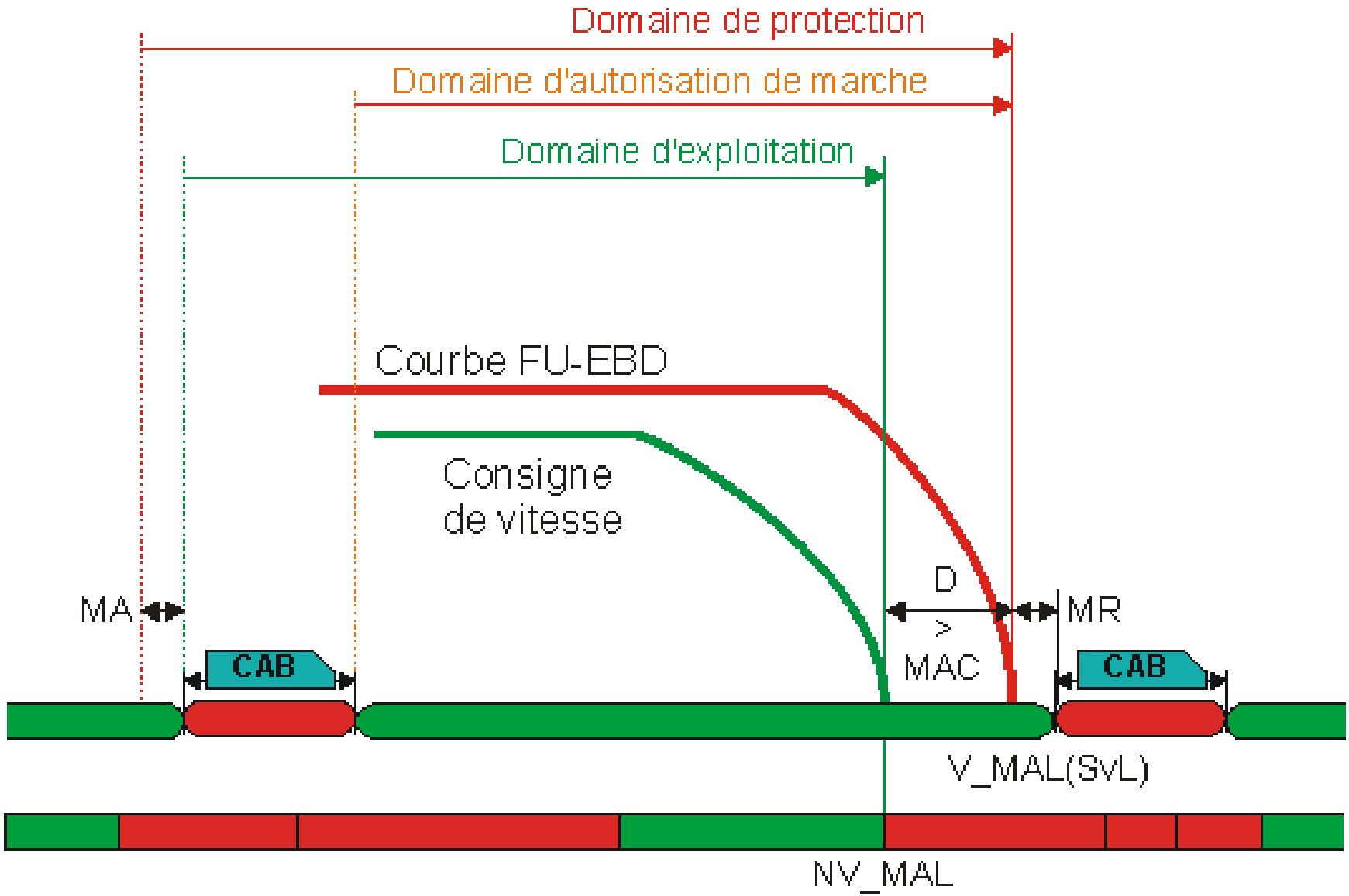
Déplacements simultanés de FU-EBD et Consigne par libération de cantons virtuels fixes

Les domaines avec cantons virtuels fixes purs sans canton tampon



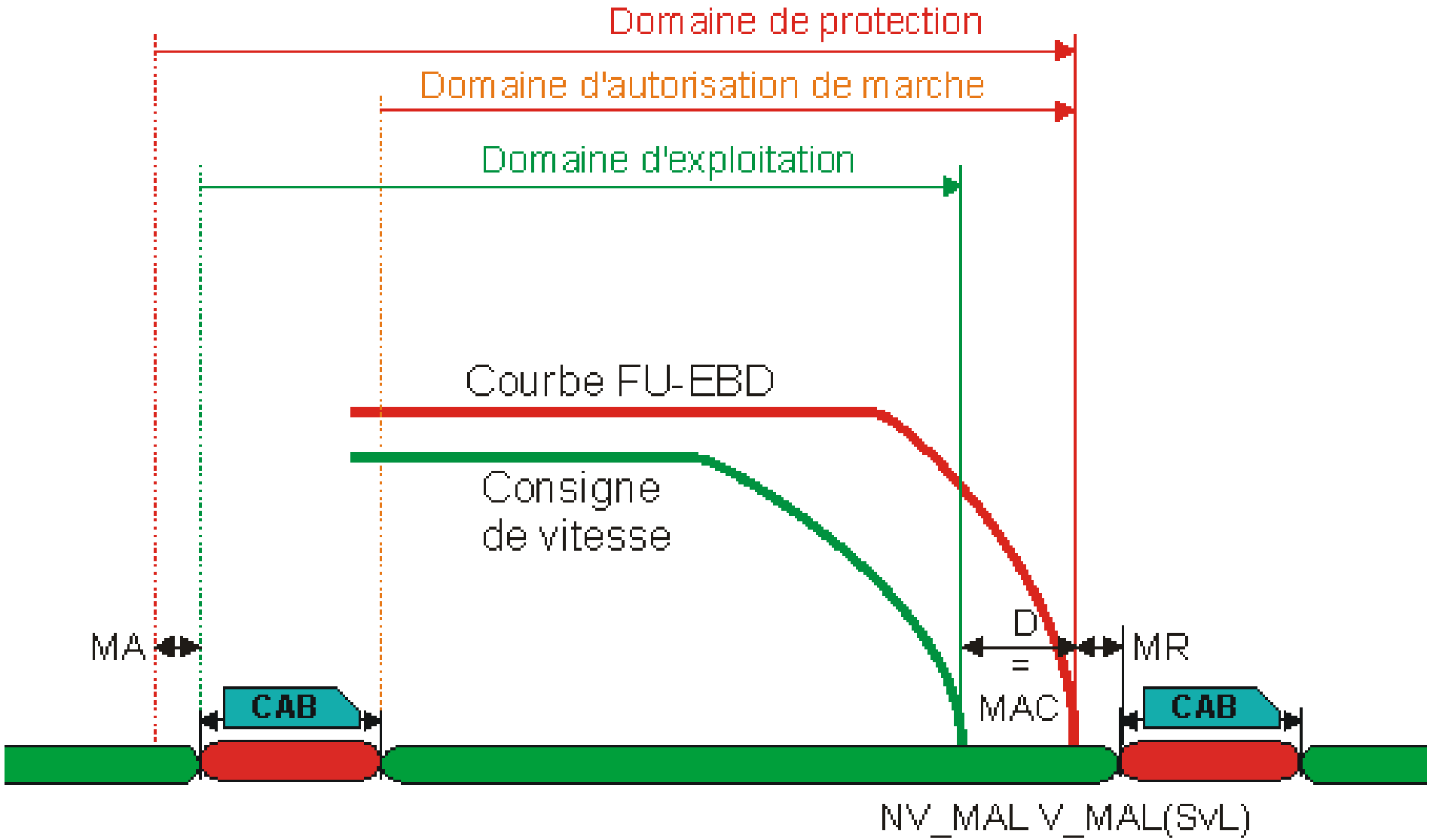
Déplacements simultanés de FU-EBD et Consigne par libération de cantons virtuels fixes (translations par sauts) [p.ex. Paris – Ligne M_14]

Les domaines avec cantons virtuels dynamiques et fixes (mixtes)



Déplacement continu de FU-EBD et par libération de cantons virtuels fixes pour Consigne [p.ex. Paris – Ligne M_1, Barcelona – Ligne M_9]

Les domaines avec cantons virtuels dynamiques



Déplacements continus de FU-EBD et Consigne [p.ex. Lyon – Ligne D]