

ERTMS: a means to an end

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ERTMS: a means to an end

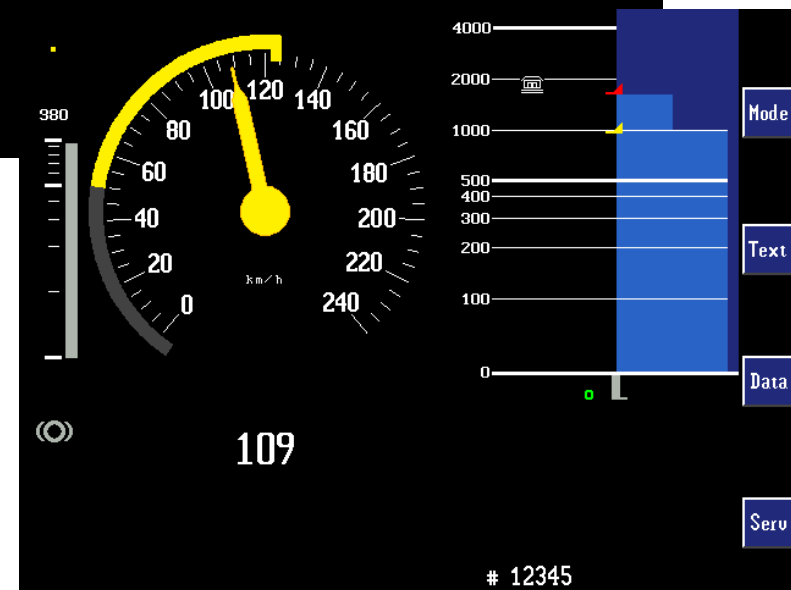
Capacity consumption and traffic management

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Outline

ERTMS: a means to an end

- Introduction
- ERTMS Level 2
- Capacity consumption
- ERTMS: more than a safety system
- Speed advice/command
- Intelligent traffic management
- DAS/ATO with TMS
- Developments elsewhere
- Conclusions

Introduction

ERTMS: European Rail Traffic Management System

ERTMS has three components

- **ETCS**: European Train Control System
 - ☐ Signalling and automatic train protection/control
 - **GSM-R**
 - ☐ Mobile communication between 'track' and train
 - **ETML**: European Traffic Management Layer
 - ☐ Not developed yet!
-
- ERTMS has three main levels depending on
 - ☐ Data transmission
 - ☐ Track-free detection

Introduction

ERTMS Level 2

- Reasons to implement ERTMS Level 2 include
 - ☐ Interoperability
 - ☐ Improved safety
 - ☐ Replacement of legacy systems at the end of their life-time
 - ☐ Improved capacity and speed
 - ☐ Two-way communication between train and track

ETCS

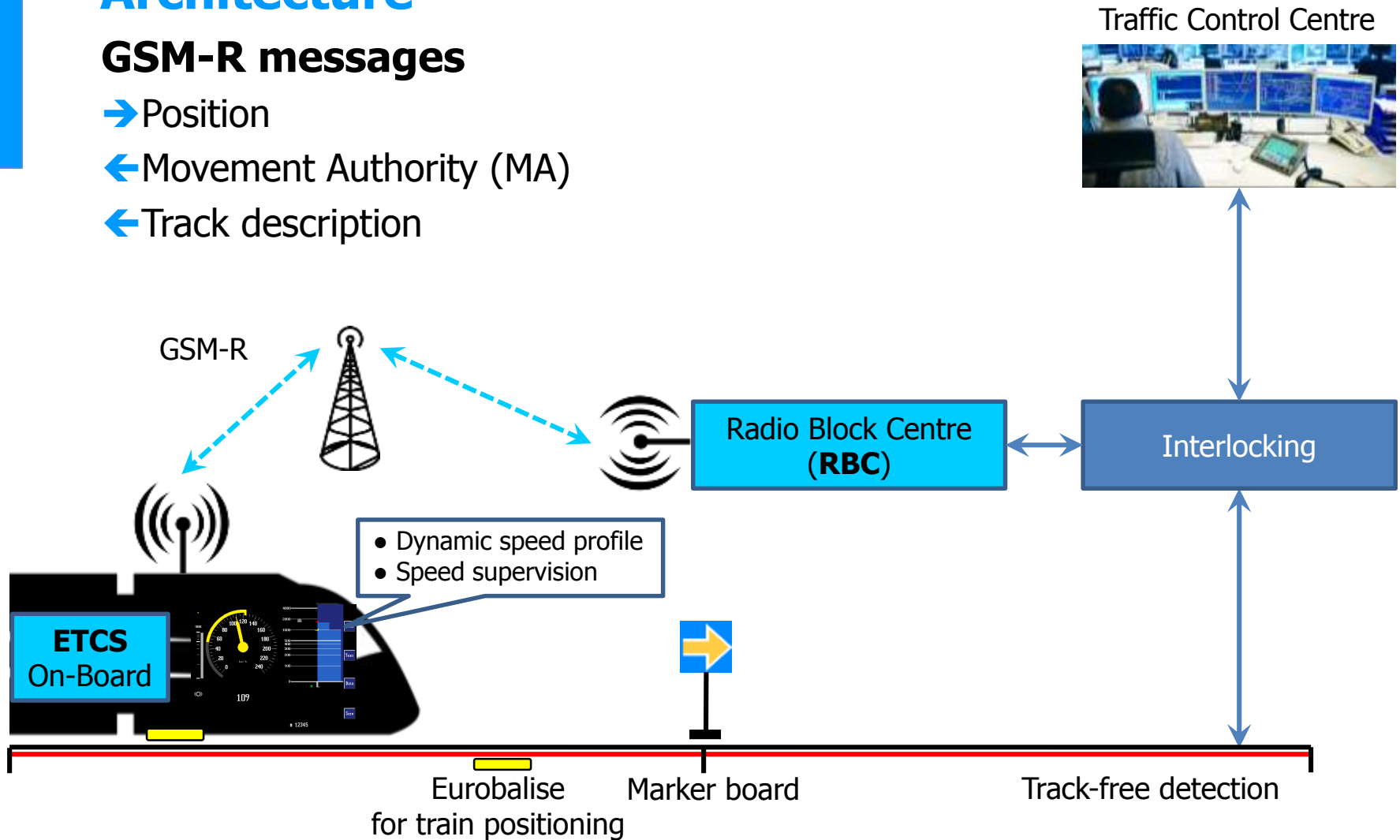
- Specification for state-of-the-art cab signalling and ATP with
 - ☐ **Movement authority** (permission to proceed) and corresponding **track description** transmitted to train and displayed in the cabine
 - ☐ **Dynamic speed profile** computation in train
 - ☐ **Ceiling speed and braking curve supervision** in train

ERTMS Level 2

Architecture

GSM-R messages

- Position
- ← Movement Authority (MA)
- ← Track description

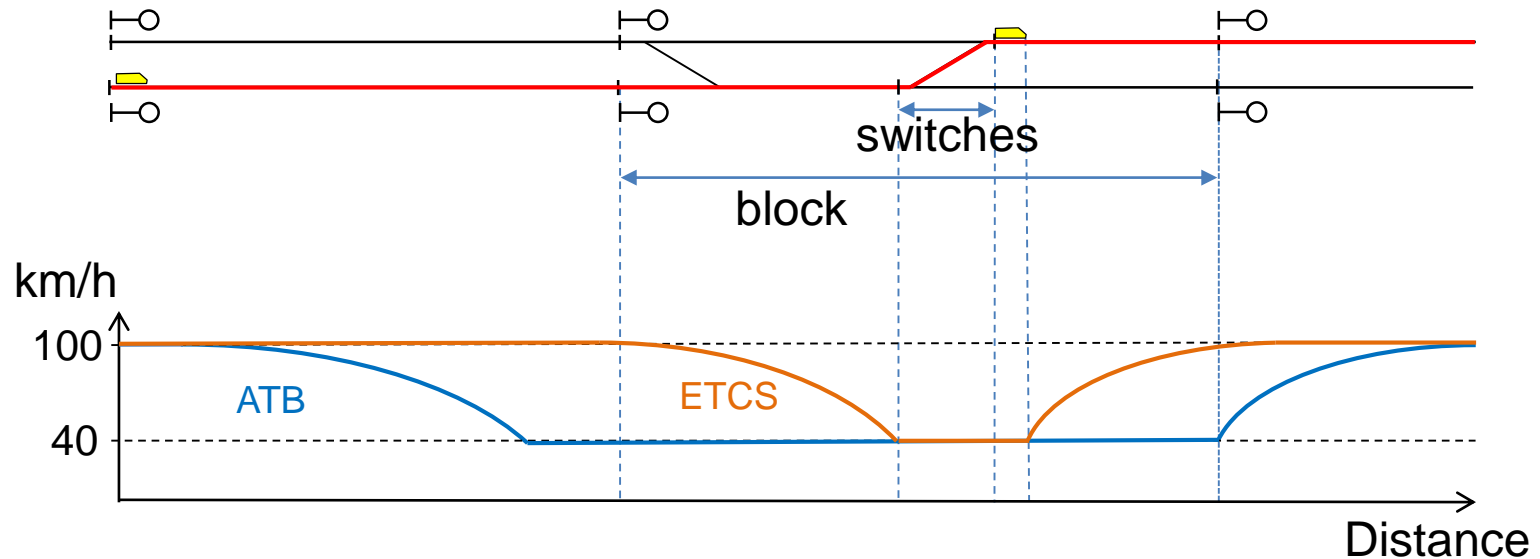


Capacity consumption

Operational characteristics ERTMS Level 2

Shorter running times and separation distance

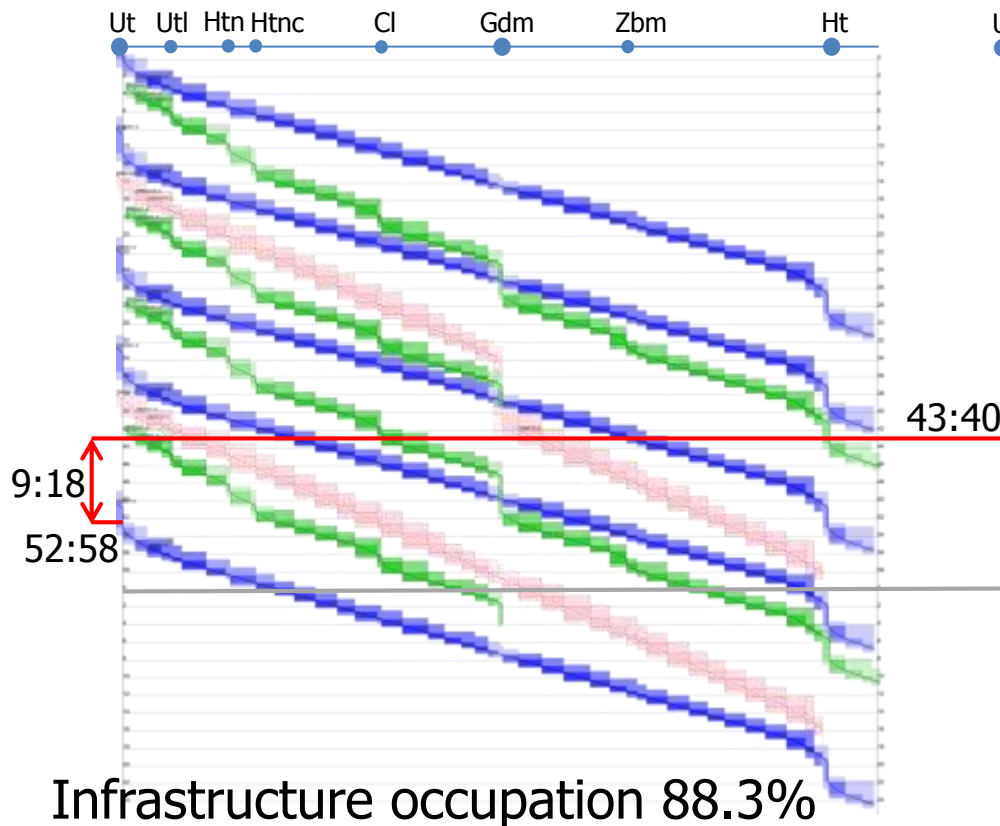
- By dynamic speed profile and braking curve supervision
 - ❑ **Train-dependent:** braking not earlier than needed for specific train
 - ❑ **Block-independent:** start braking independent of block boundaries
 - ❑ **Route-dependent:** dynamic speed profile for specific route
 - ❑ **Speed-dependent:** shorter braking distances at lower speeds



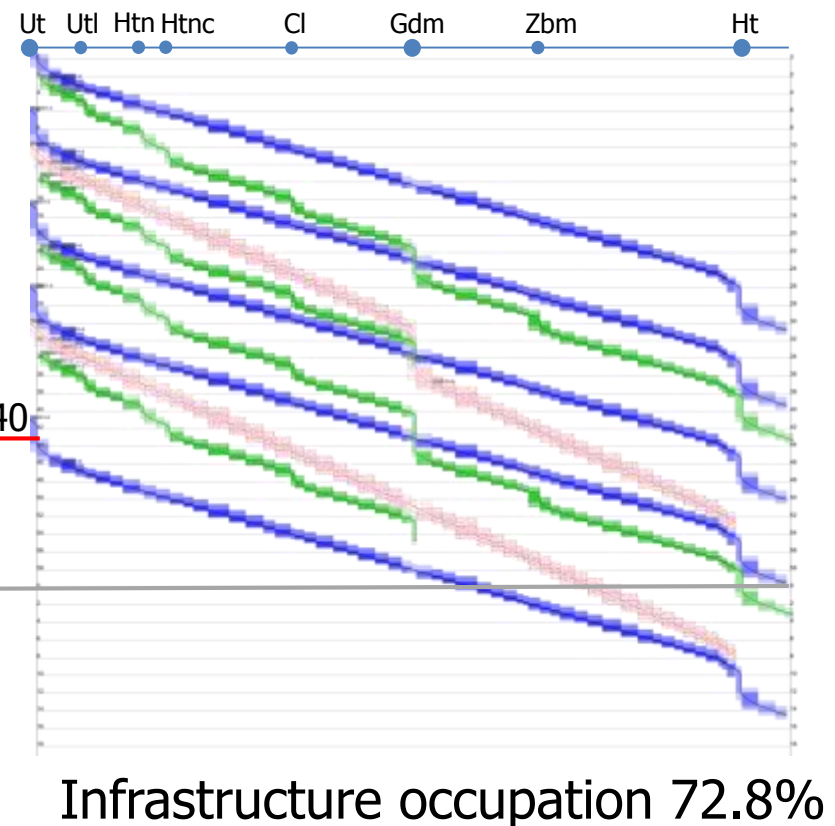
Capacity consumption

Case Utrecht-Den Bosch: infrastructure occupation

Current signalling (NS54/ATB)



ETCS L2 with blocks ~700 m

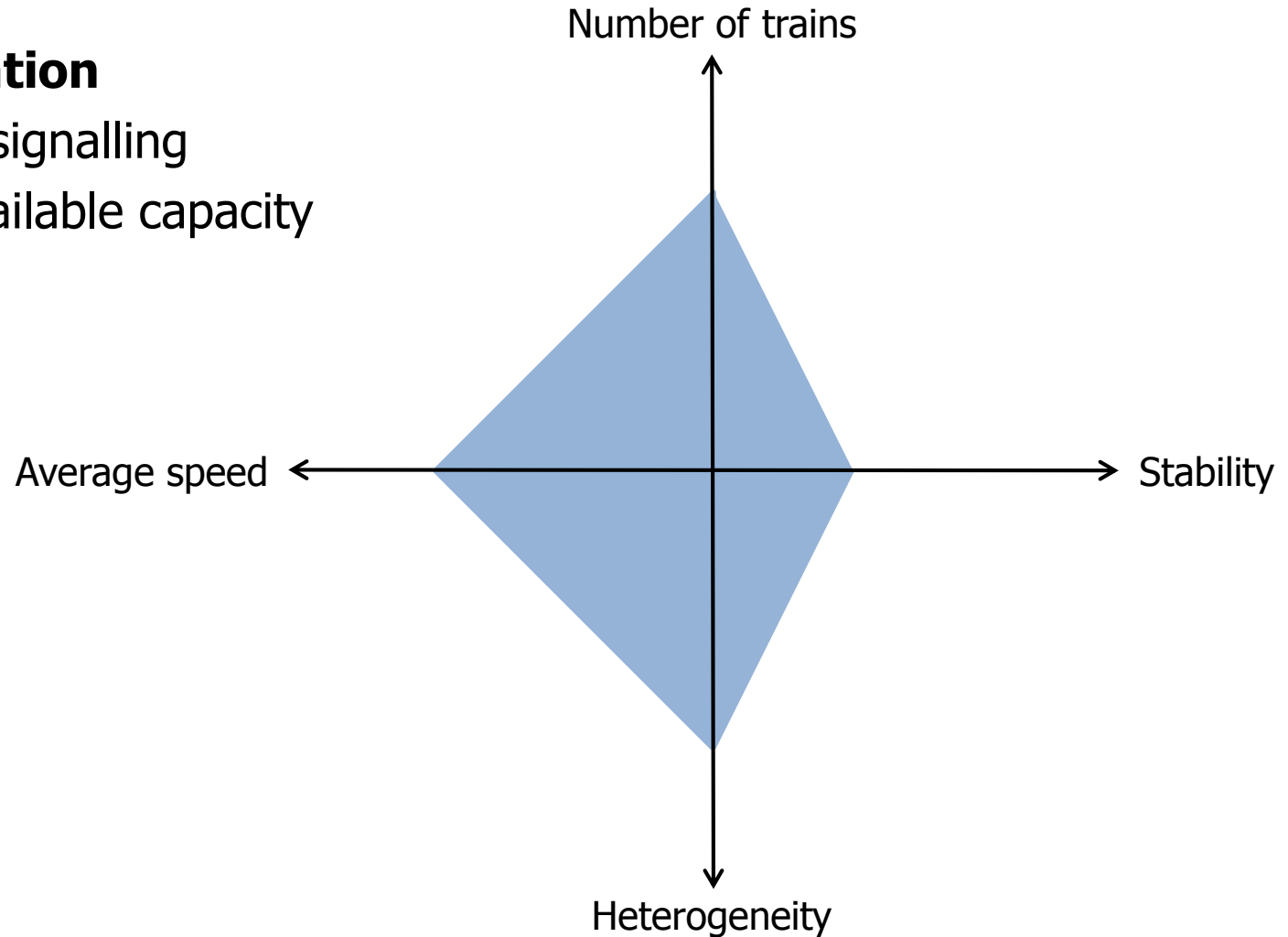


Capacity consumption

Capacity balance

Base situation

- Existing signalling
- Area: available capacity

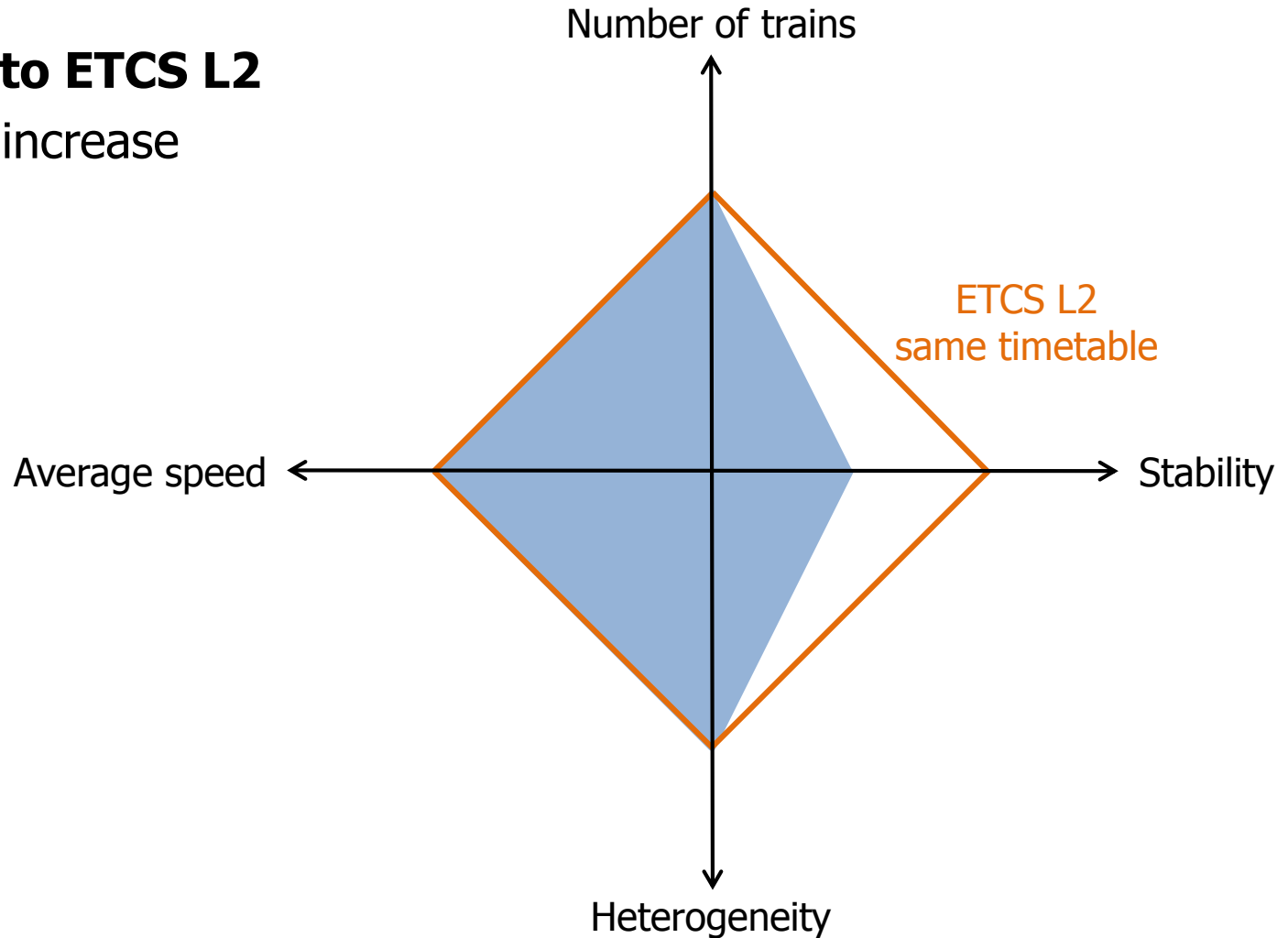


Capacity consumption

Capacity balance change under ETCS L2

Migration to ETCS L2

- Capacity increase

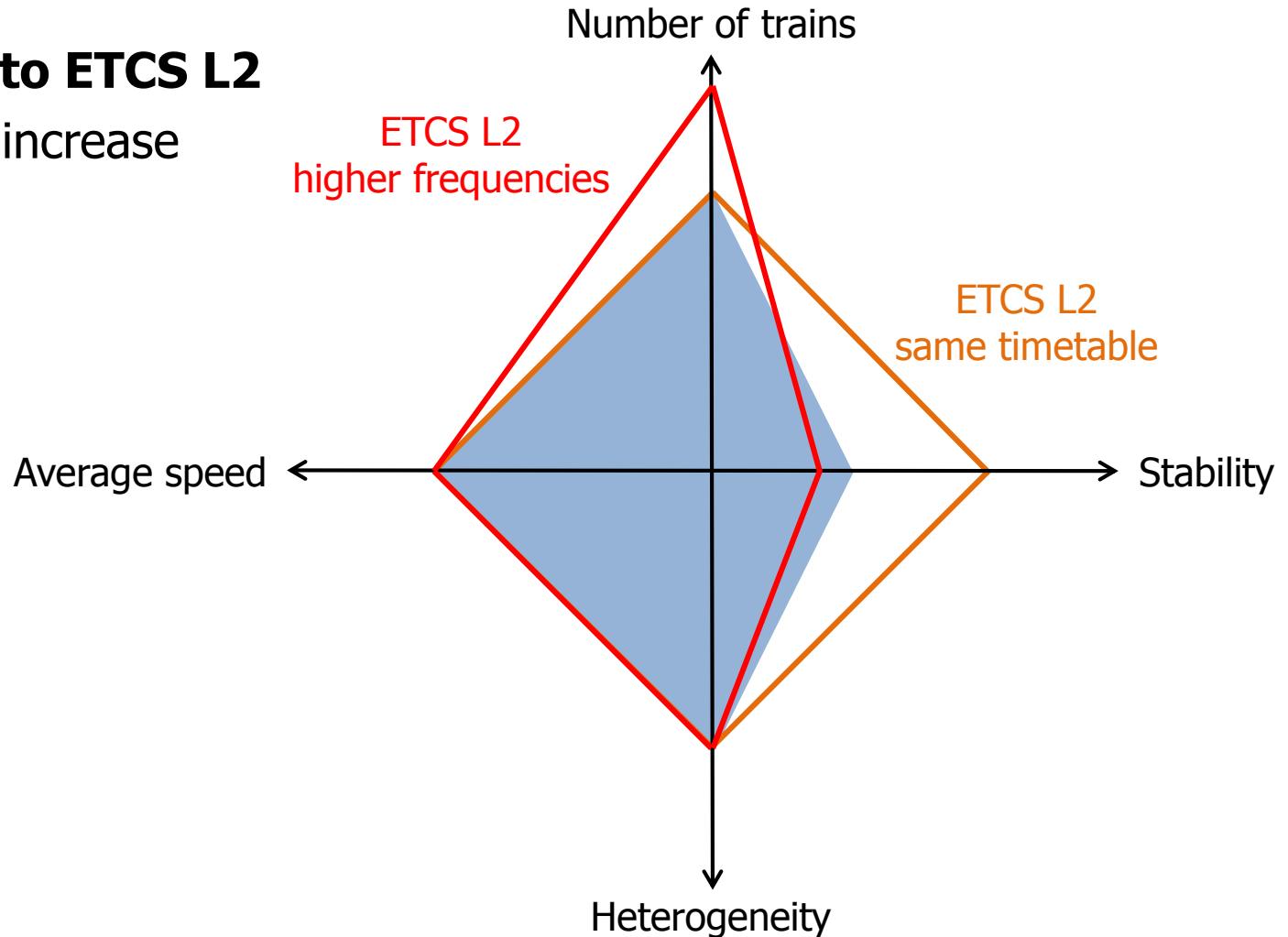


Capacity consumption

Capacity balance change under ETCS L2

Migration to ETCS L2

- Capacity increase

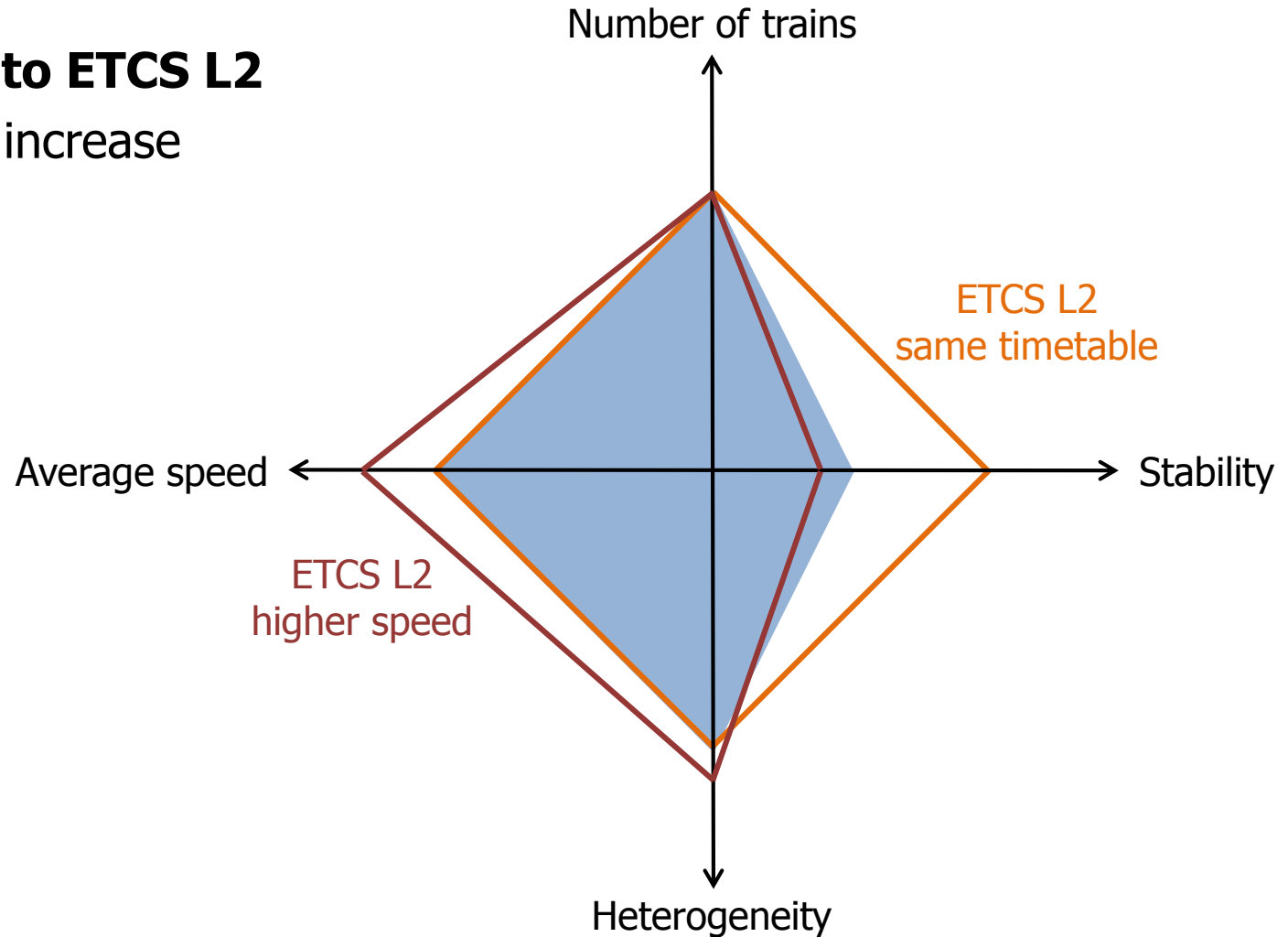


Capacity consumption

Capacity balance change under ETCS L2

Migration to ETCS L2

- Capacity increase

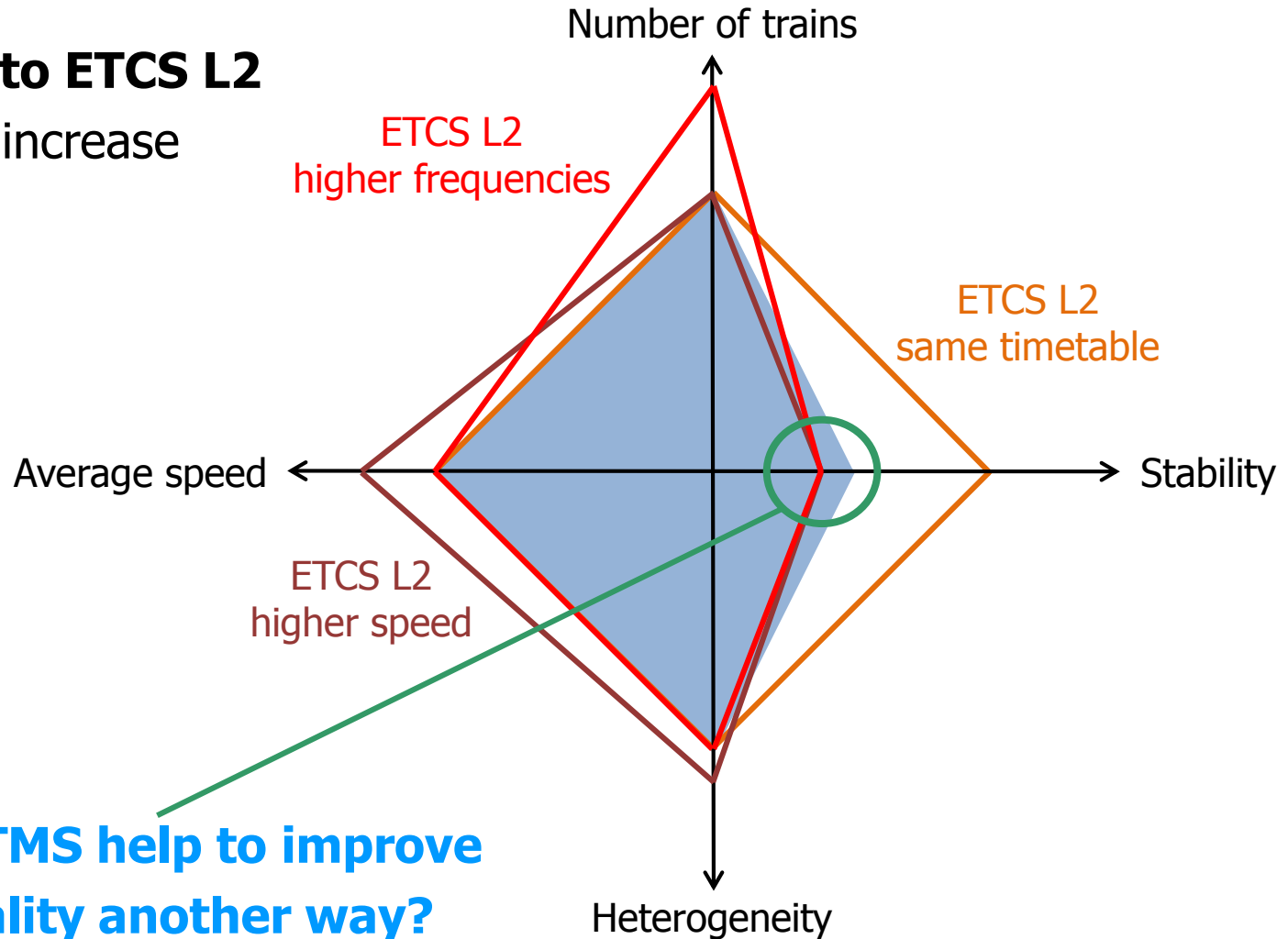


Capacity consumption

Capacity balance change under ETCS L2

Migration to ETCS L2

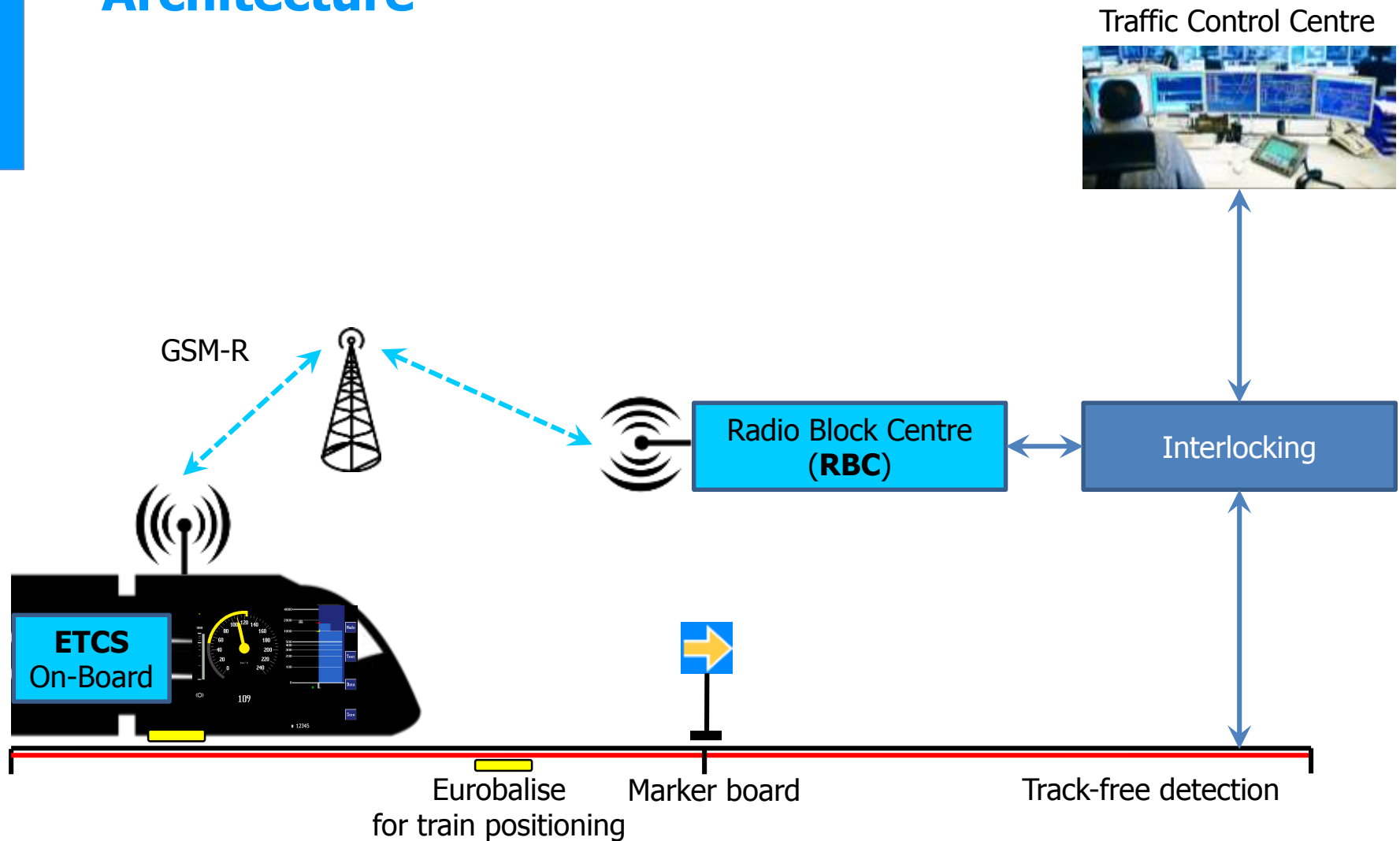
- Capacity increase



- Can ERTMS help to improve punctuality another way?

ERTMS: more than a safety system

Architecture

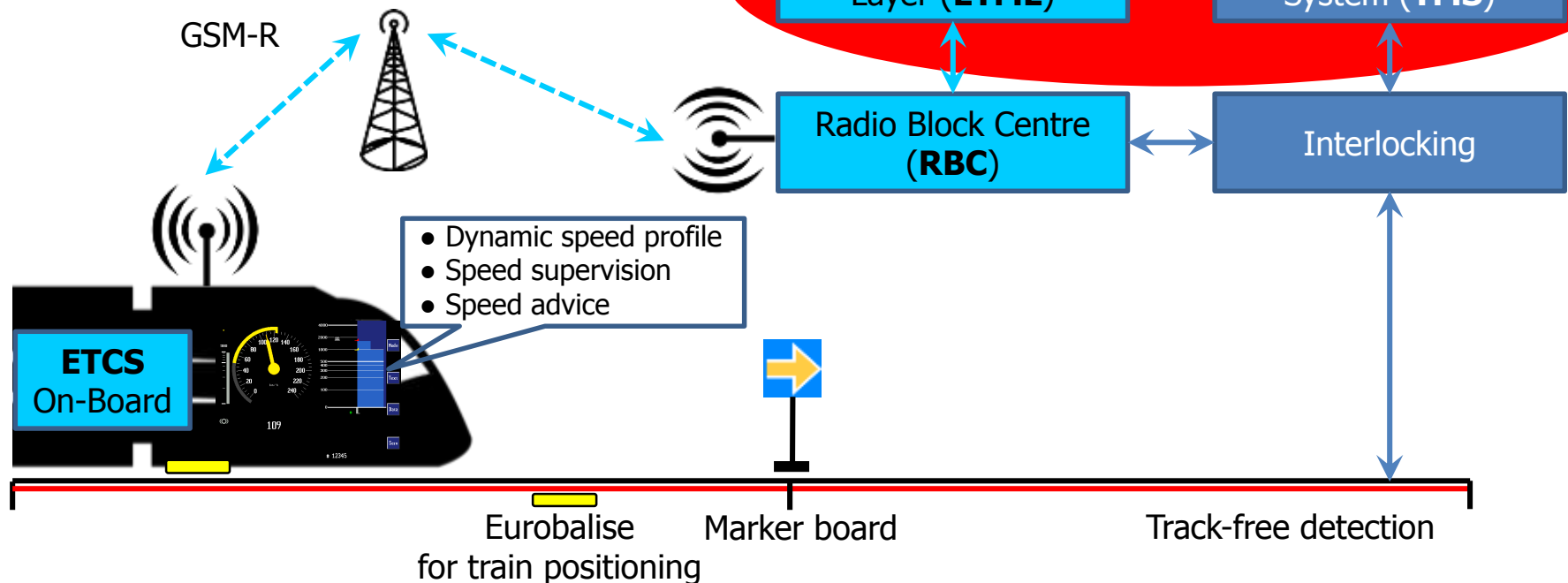


ERTMS: more than a safety system

Architecture with traffic management

GSM-R messages

- Position & Speed
- ← Movement Authority (MA)
- ← Track description
- ← Timetable & Speed advice



ERTMS: more than a safety system

Traffic management and train control...

- ETCS as ATP system just gives upper bounds on speed
- However, two-way communication between train and RBC/TCC also allow advice on optimal speed
 - ❑ Accurate positioning of trains by GSM-R (position, time, speed)
 - ❑ Possibility to communicate speed advice or new targets through GSM-R

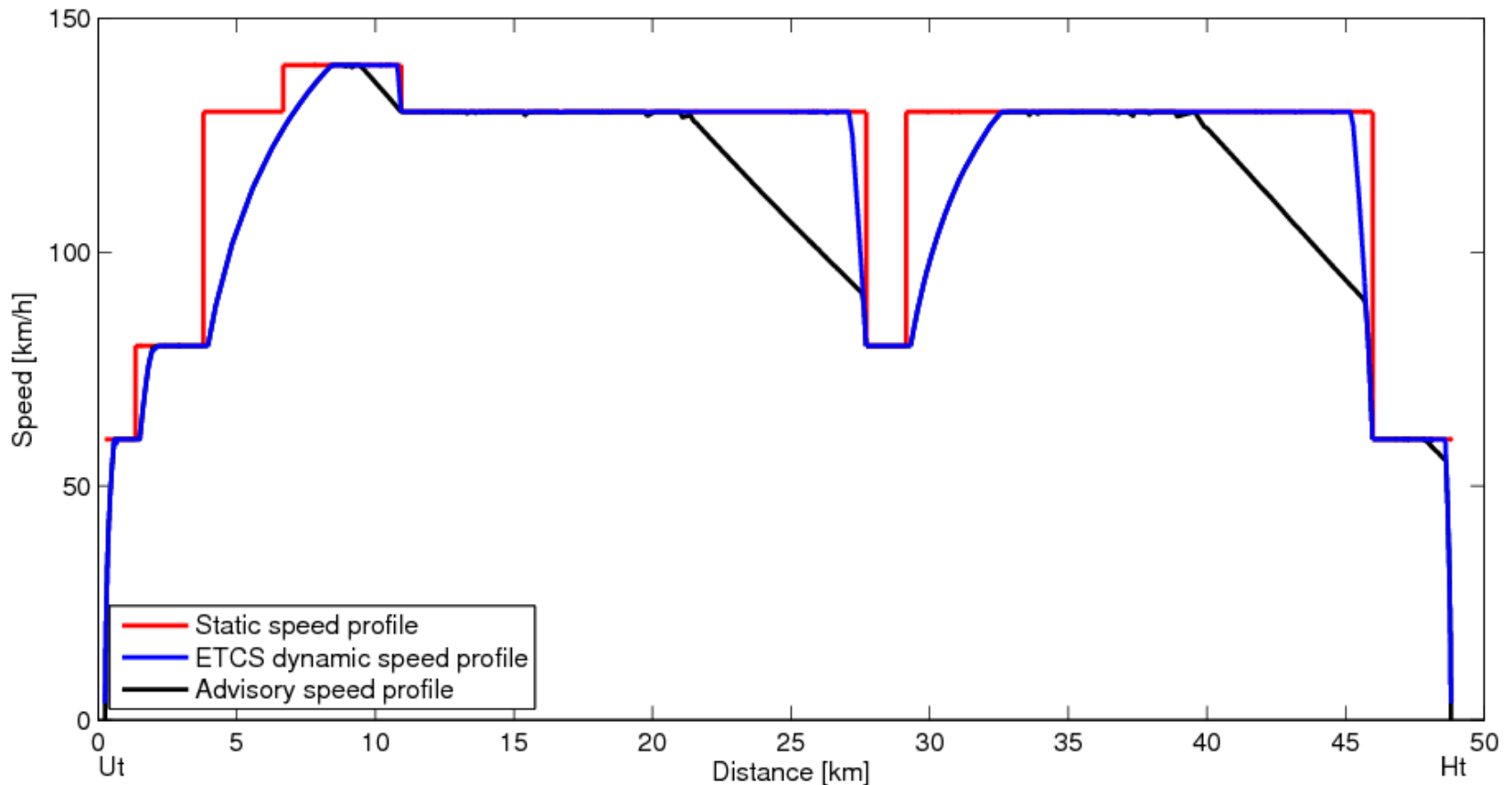
Possibilities

- **DAS**: Driver Advisory System
 - ❑ Energy-efficient driving advice based on up-to-date timetable
- **DAS/TMS**: DAS connected with Traffic Management System
 - ❑ TMS implements centralized conflict detection and resolution (CDR)
 - ❑ Optimal driving advice based on conflict-free target times or envelopes
- **ATO**: Automatic Train Operation (with TMS)
 - ❑ (Semi-)automatic train operation based on optimal speed profile

Train speed advice/command

DAS/ATO

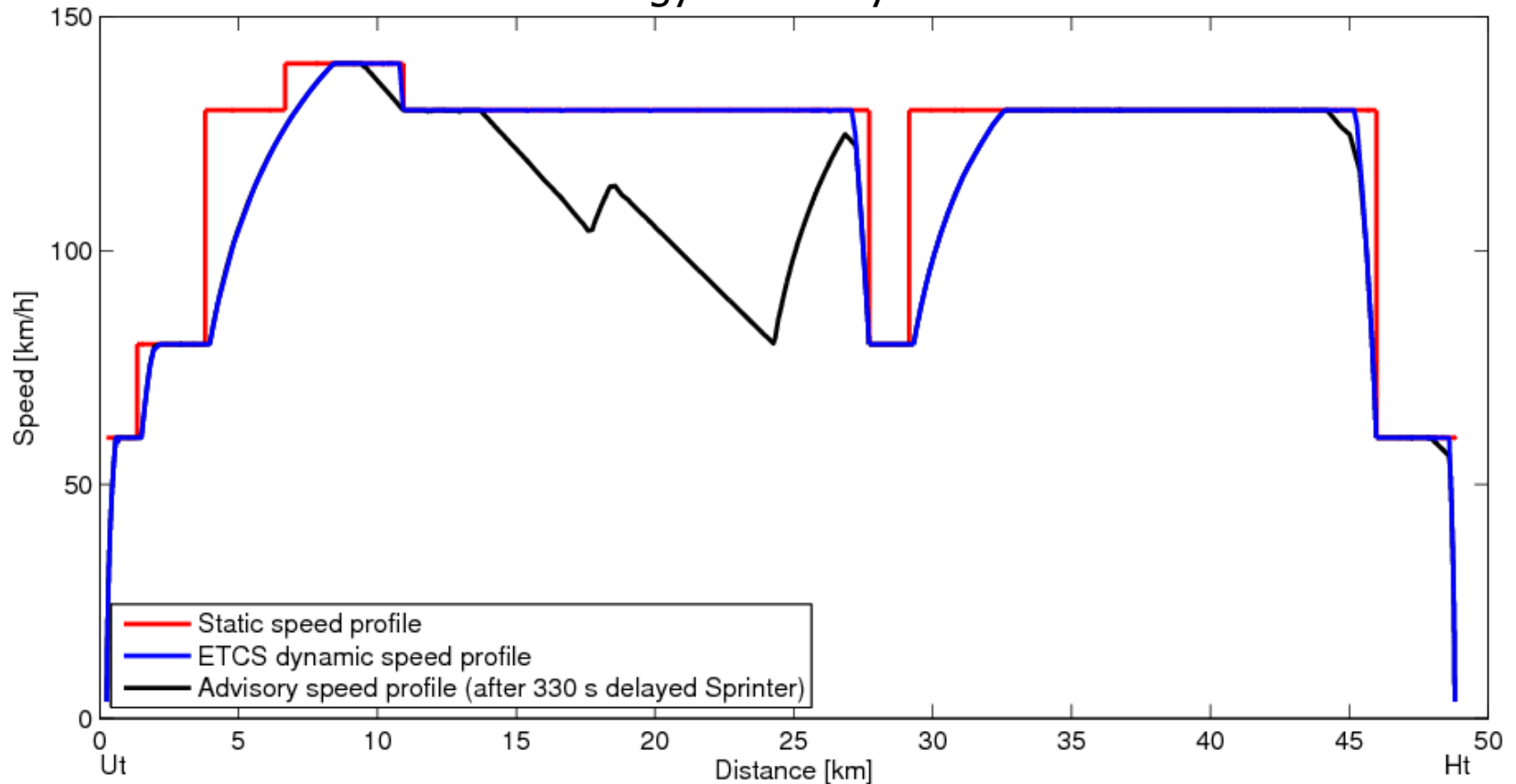
- Optimal speed profile: energy-efficient driving



Train speed advice/command

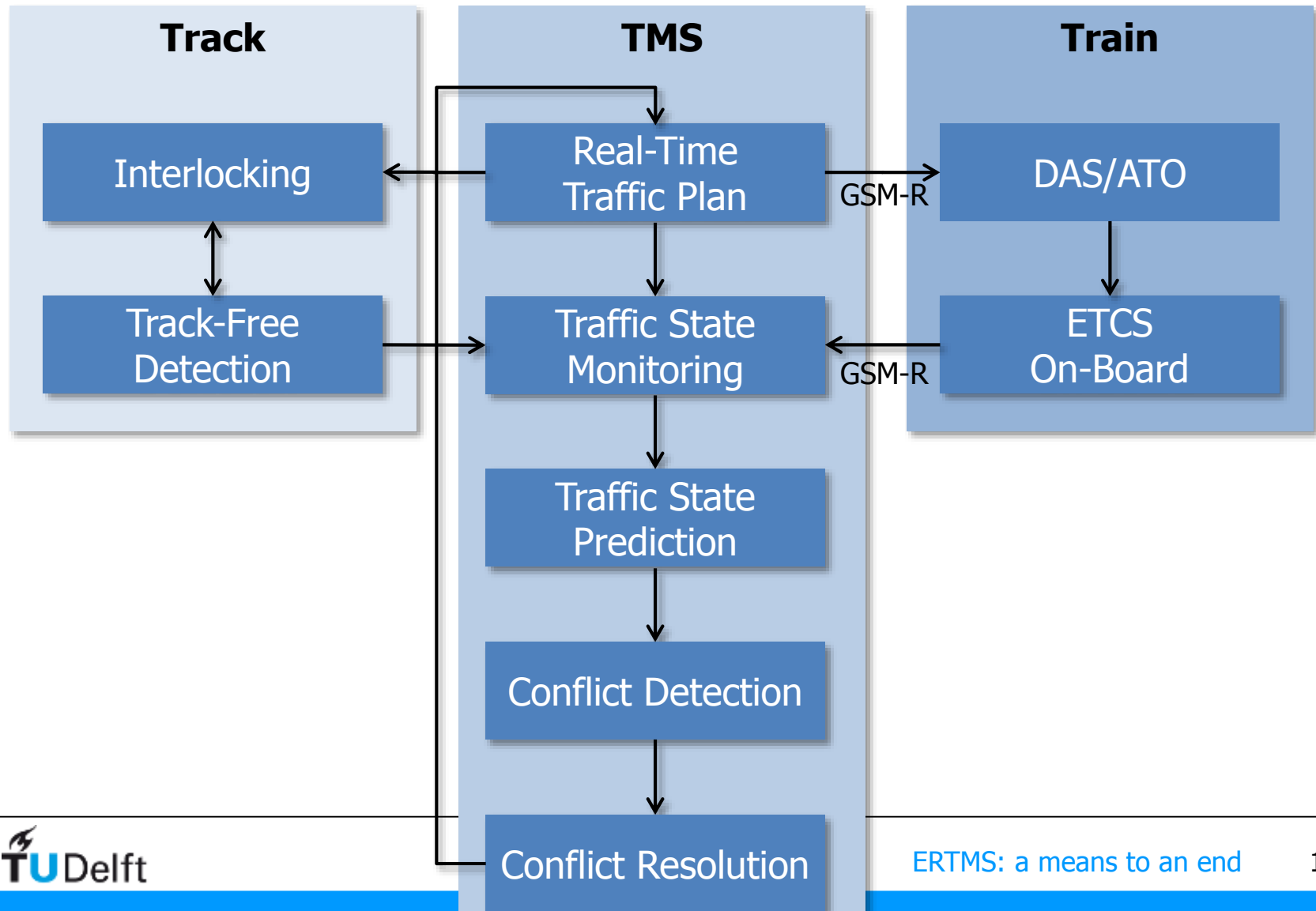
DAS/ATO with TMS

- Optimal speed profile following delayed previous train
 - Trade-off between energy-efficiency and on-time arrival



Intelligent Traffic Management

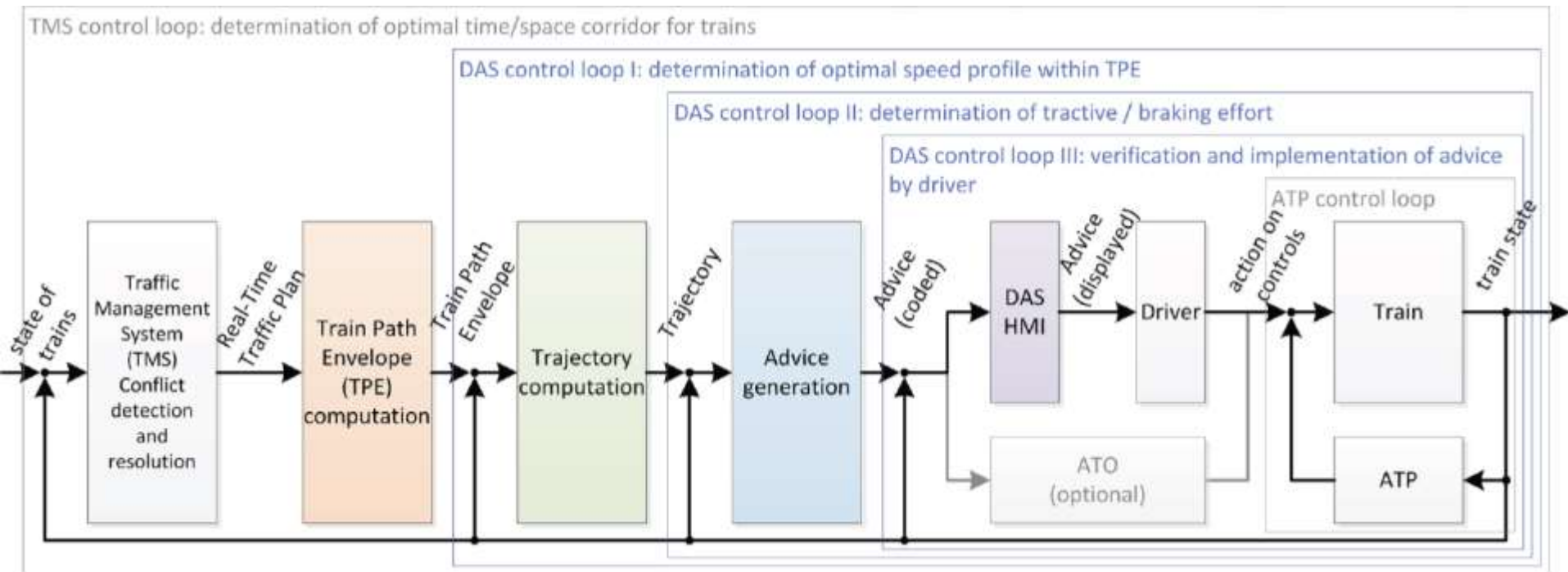
With DAS/ATO



DAS/ATO with TMS

Centrally guided train operation

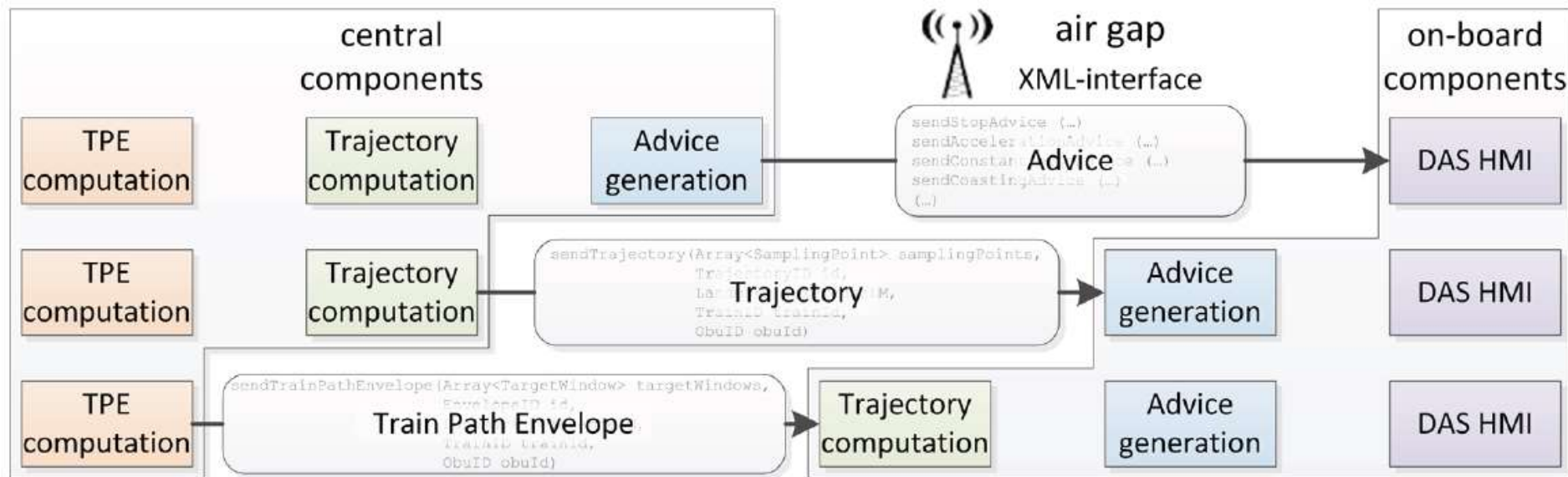
- Closed-loop between traffic management and train control



DAS/ATO with TMS

Architecture options

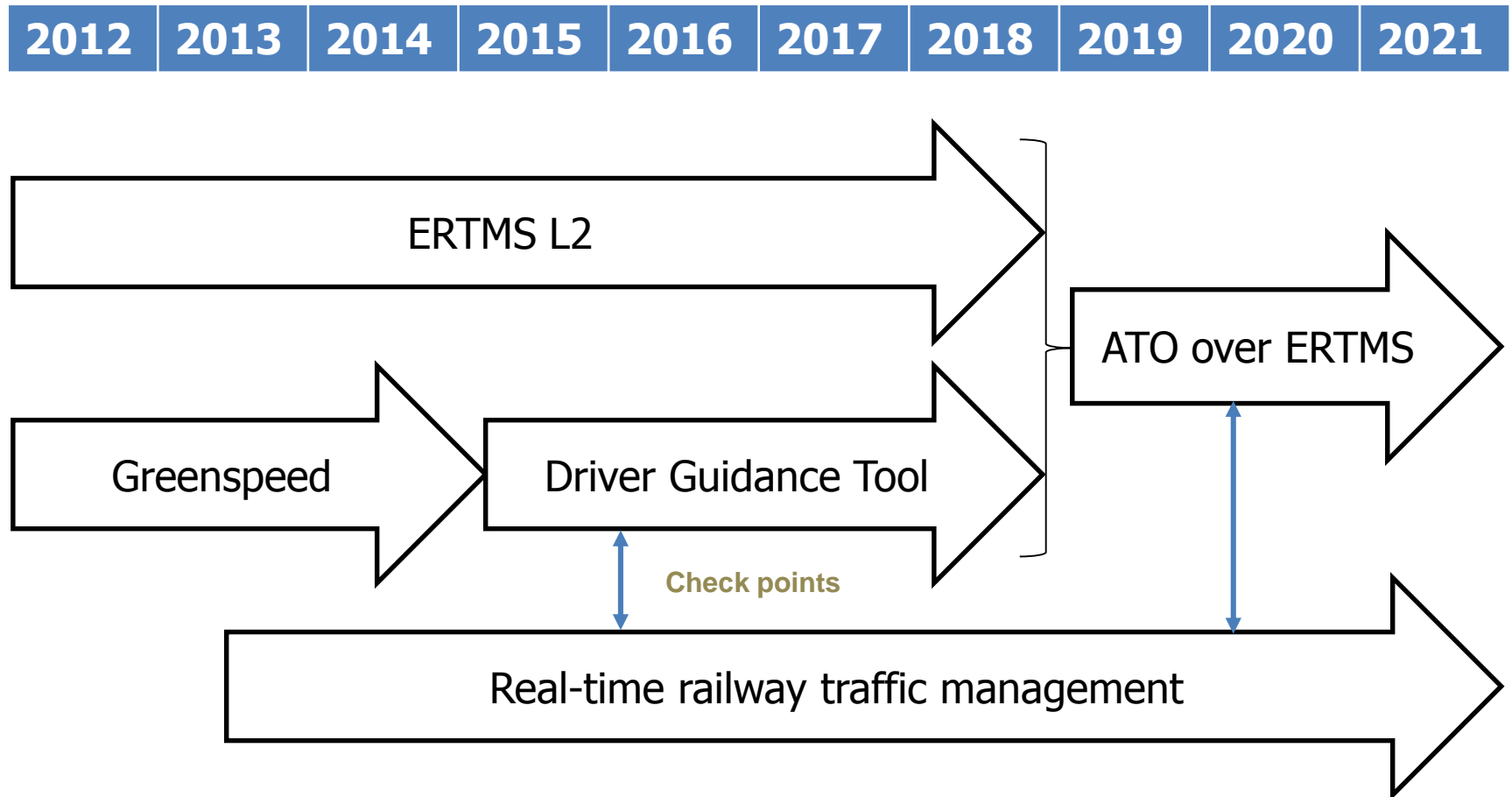
- DAS-C (Central): Trajectory and advice computed centrally
- DAS-I (Intermediate): Trajectory computed centrally, advice on-board
- DAS-O (On-board): Trajectory and advice computed on-board



- Standardized messages already developed for each option

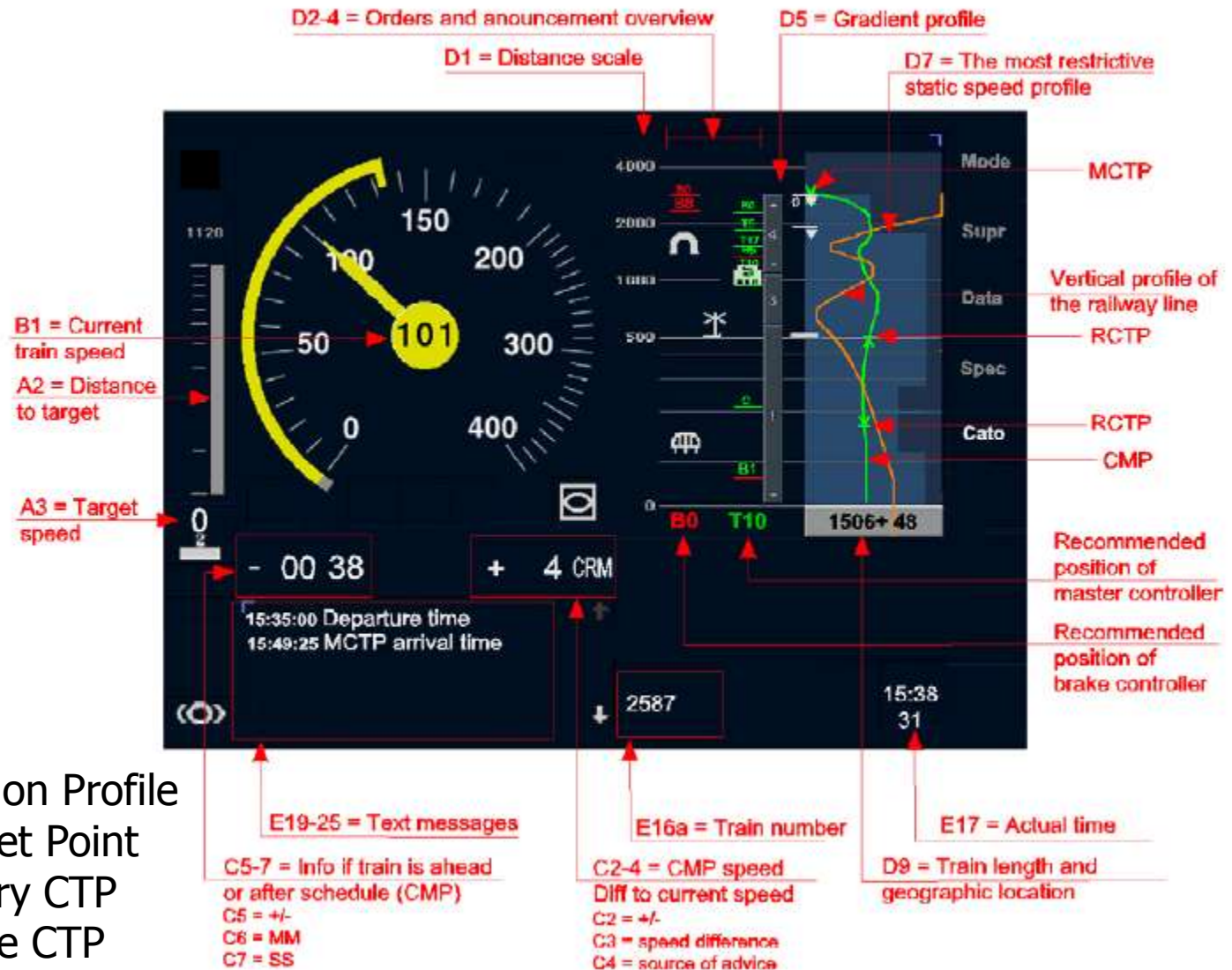
Developments elsewhere: Denmark

ERTMS migration plan Denmark



Developments elsewhere: Sweden

CATO over ERTMS (proposal)



Conclusions

ERTMS: a means to an end

- ERTMS is more than a safety system (cab signalling and ATP)
- DAS or ATO over ETCS improves capacity consumption, punctuality, and energy savings
 - ☐ Even more in connection to TMS
- ERTMS specification in preparation for ATO over ETCS
 - ☐ DAS and ATO communication based on ETCS
 - ☐ DAS and ATO are not safety related
 - ☐ ETCS DMI planning screen may be used
- ERTMS will generate a systems jump in innovations
 - ☐ ERTMS as an advanced traffic and train control system
 - ☐ This is needed to manage high-frequent heterogeneous train traffic
 - ☐ Lots of research still needed
 - ☐ Don't wait until ETCS has been implemented (as a safety system)