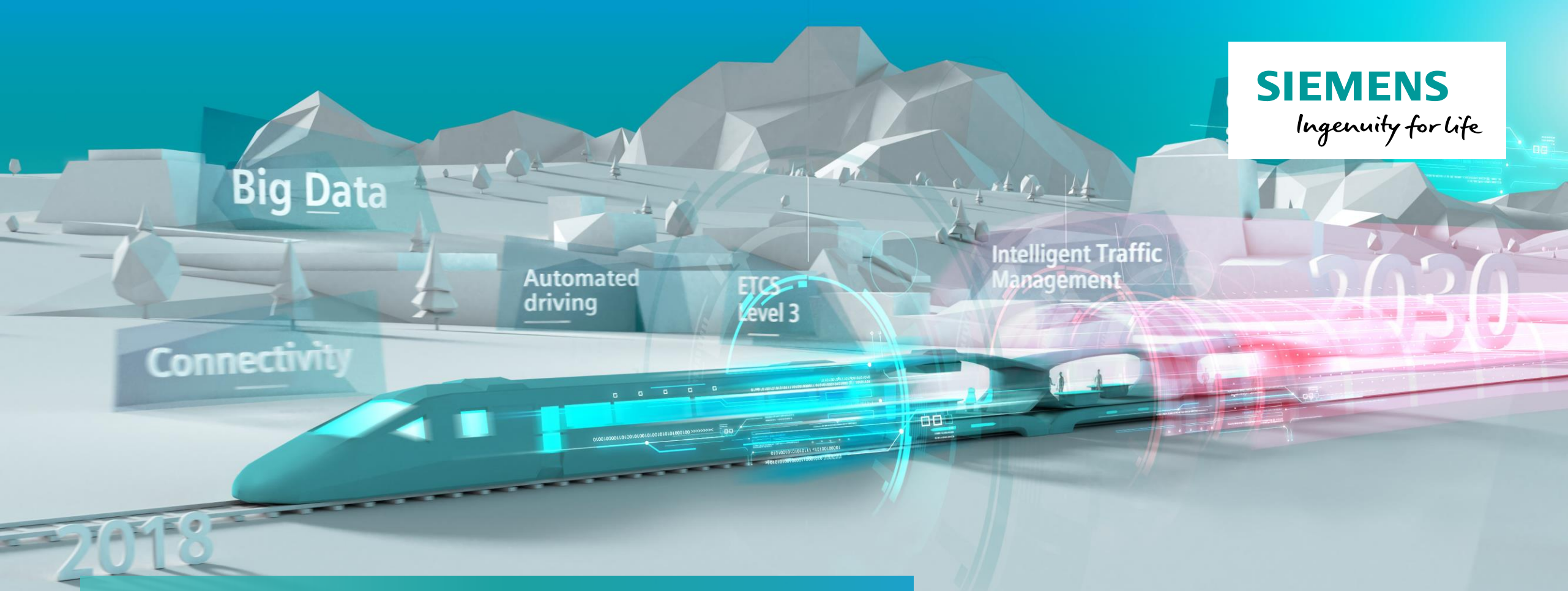


SIEMENS
Ingenuity for life

ETCS Level 3

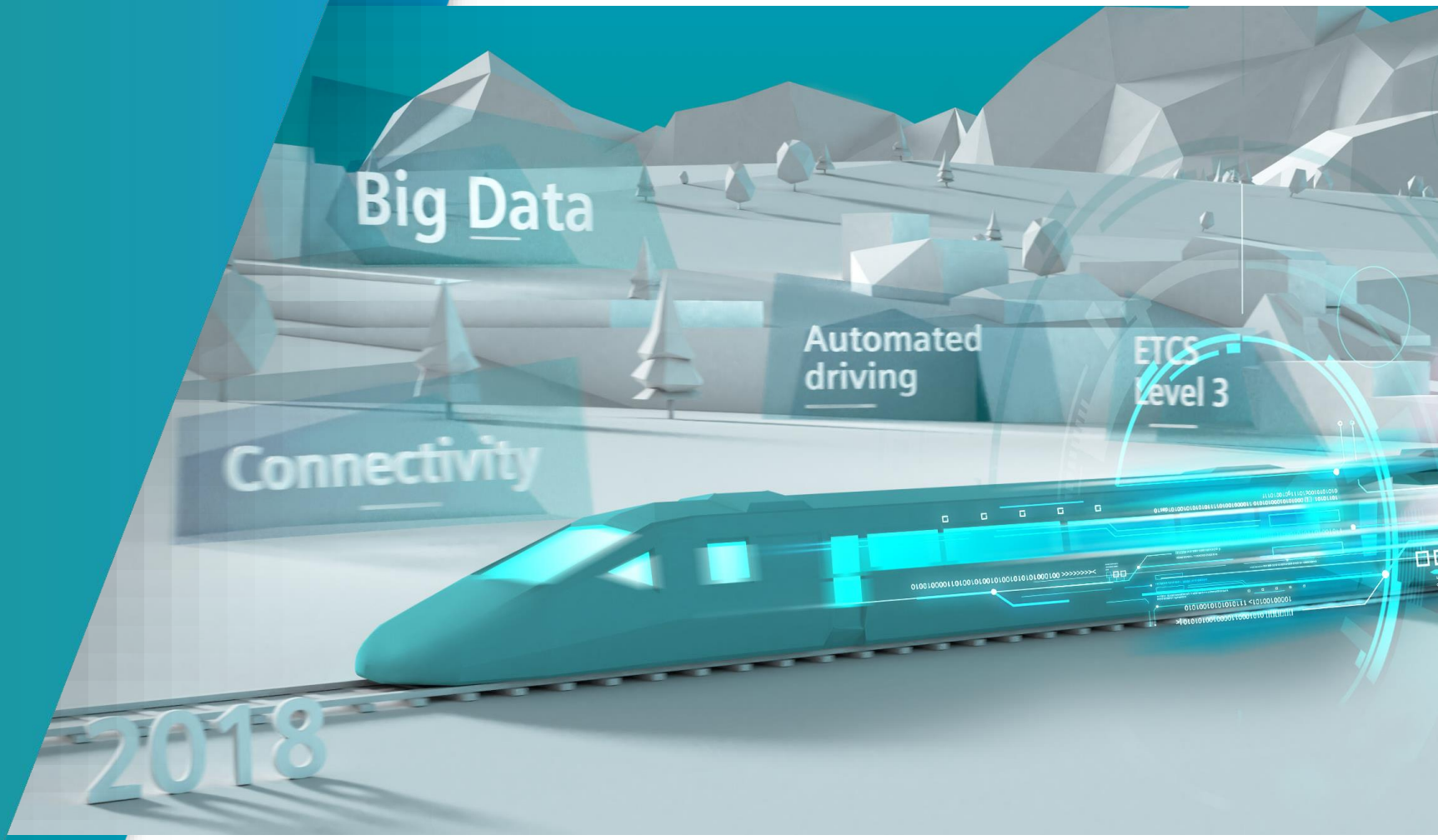
SIEMENS
Ingenuity for life

1. Strategy and benefits
2. Migration, implementation and blockers
3. Ideas on open challenges

SIEMENS
Ingenuity for life

ETCS Level 3

Strategy and Benefits



Strategy and Benefits
ETCS Level 3

SIEMENS
Ingenuity for life

Cost benefits

- Less trackside equipment
- Less trackside work – improved work safety
- Simplified interlocking functions
- Improved track utilization
- Significant energy savings with DAS and ATO

But

- Efforts for storing operational situations: “state of the railway”
- Challenge to reach full interoperability in an international context
- Challenges for introduction into an existing network (migration)

Strategy and Benefits
ETCS Level 3

SIEMENS
Ingenuity for life

High-density mainlines

- Capacity increase
- High availability
- Interoperability
- Improved cost/performance ratio
- High safety/security requirements

Low-density secondary lines

- Low CAPEX

  and OPEX …

  cost, cost, cost

Freight

- Reduced costs of operation
- Higher degree of automation
- Autonomous driving

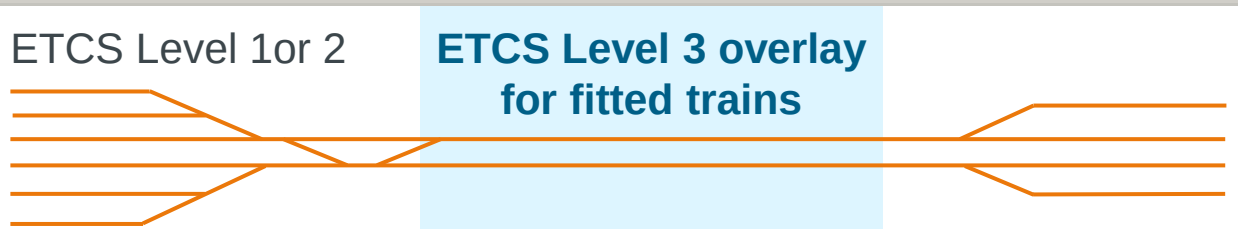
Mining

- High availability
- DTO/UTO
- Pit-to-port: integrated solutions
- Precise stopping
- Robustness

Strategy and Benefits
ETCS Level 3

SIEMENS
Ingenuity for life

Capacity @ high availability

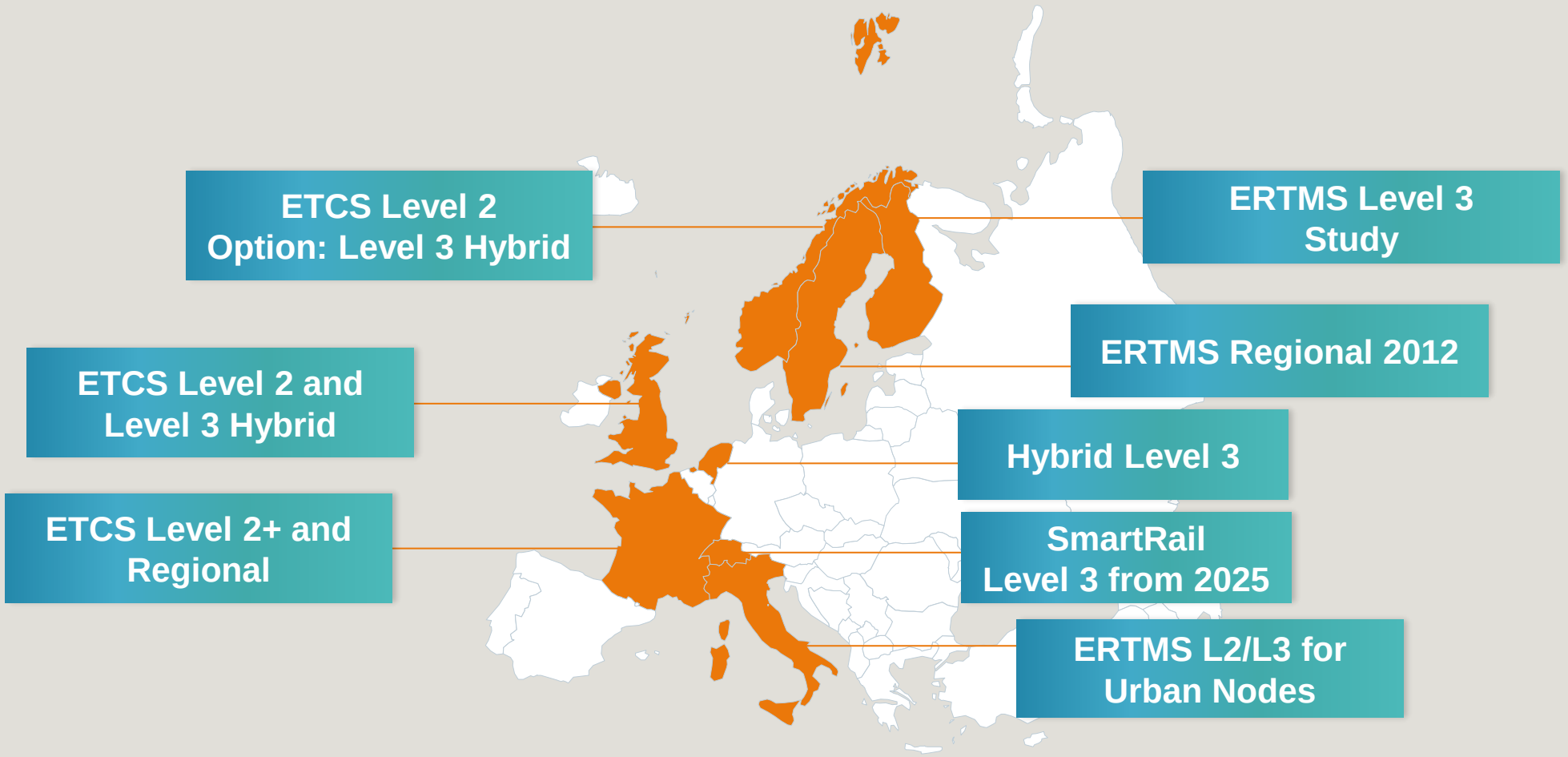


Reduced total cost of ownership

Goal: Towards a high-capacity and highly available ETCS-Level-3-only railway

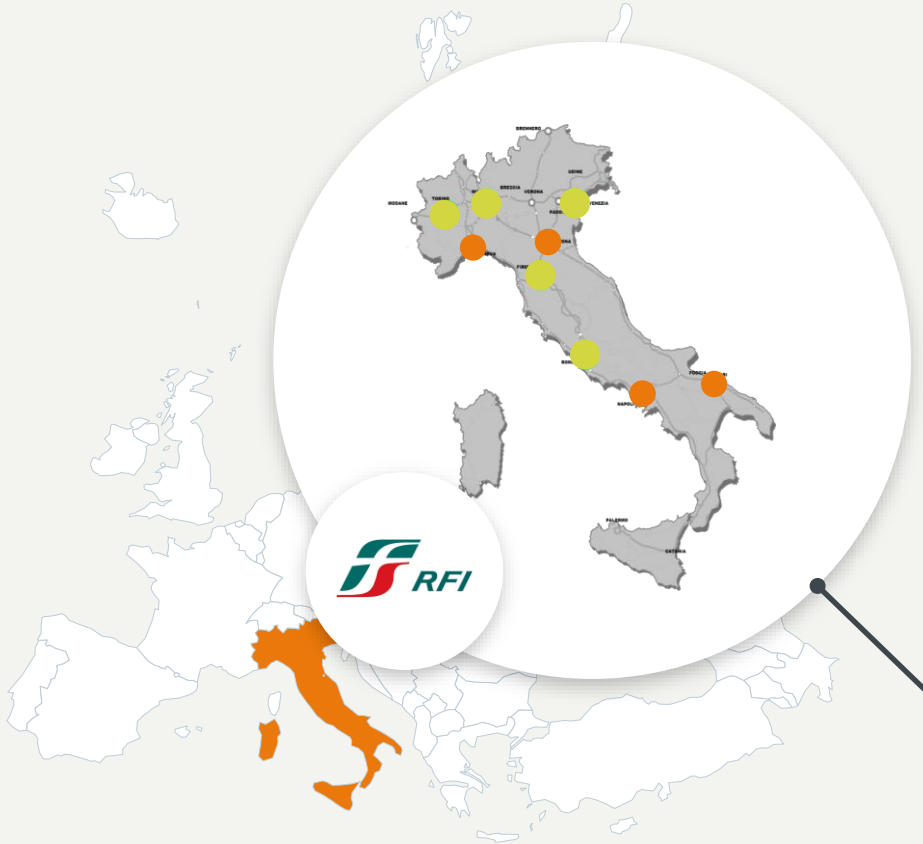
There are several Railways in Europe considering ETCS Level 3

SIEMENS
Ingenuity for life

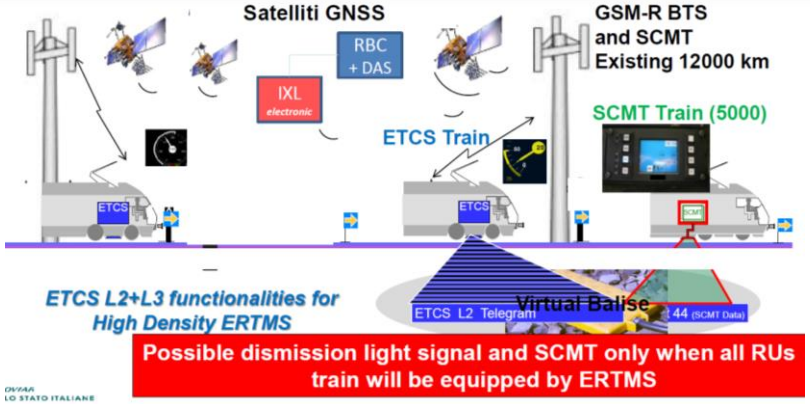


Italy: ETCS L3 for „Urban Nodes“
Implied by Future Developments

SIEMENS
Ingenuity for life



ERTMS Migration with an initial overlapping of SCMT:
TEN-T Corridors, HD Urban Nodes and Regional Lines



ERTMS HD Urban Nodes (km)

Source: NR

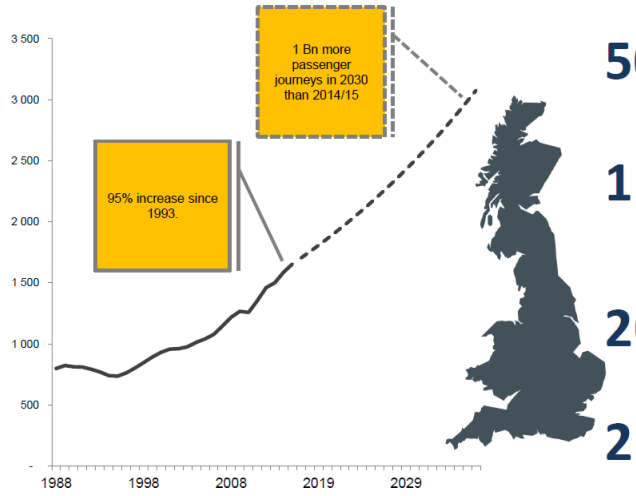
United Kingdom: High Capacity ATP System

A keystone to cope with the huge Challenges Railway is facing in the UK

SIEMENS
Digital Railway mobility for life

Why do we need to change in the UK?

Digital Railway



50% Of Europe's congested infrastructure

1bn Extra passenger journeys predicted in next 2 decades

200% Peak time overcrowding on our busiest routes

2nd Most intensively used railway in Europe

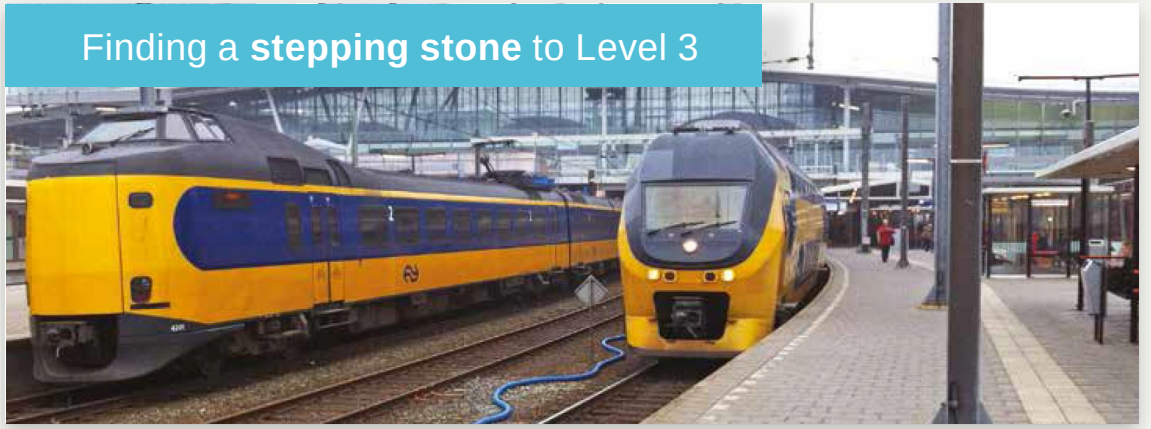
Source: NR

The Netherlands: ETCS Level 3 Hybrid

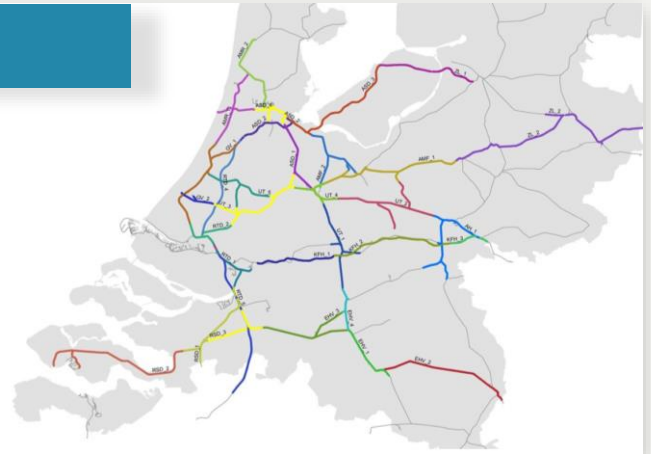
A pragmatic approach towards a High Capacity Railway

SIEMENS
Ingenuity for life

Finding a **stepping stone** to Level 3



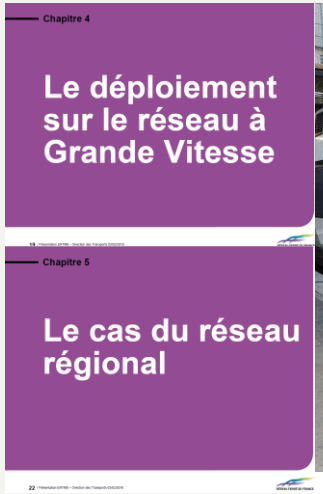
Resulting RBC areas



Source: ProRail, Railway Gazette

France: Already in 2010 SNCF considered ETCS Level 3 like approaches for High Speed Lines and to reduce Costs on Regional Lines

SIEMENS
Ingenuity for life



Source: SNCF

Strategy and Benefits
ETCS Level 3

SIEMENS
Ingenuity for life

Next steps

- Automatic train operation (ATO)
- Moving block
- IP radio
- Train integrity
- Satellite positioning

Future developments

- Station/platform functions
- Automatic train regulation
- Autonomous driving in depots and on open track

Strategy and Benefits
ETCS Level 3

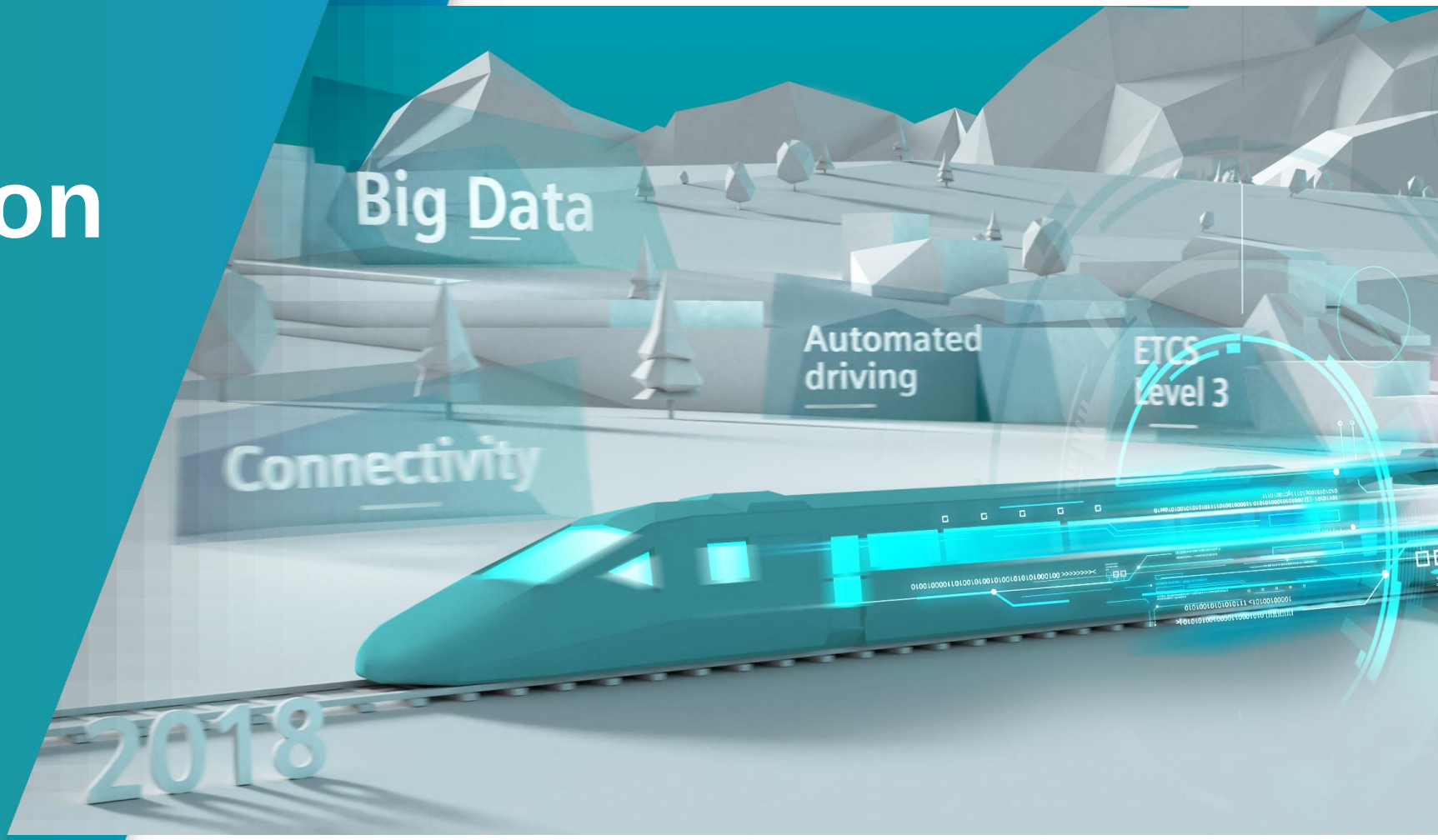
SIEMENS
Ingenuity for life

Conclusion

- ETCS Level 3 is a step change
- ETCS Level 3 provides significant benefits to the rail sector
- Interoperability will become an even bigger challenge
- Consensus on operational rules is a key for success
- All next steps require more cooperation within the sector

SIEMENS
Ingenuity for life

Migration, Implementation & Blockers



Migration, Implementation & Blockers

SIEMENS
Ingenuity for life

Migration

- Complex landscape
- Many start and end-states
- Variety between and within countries

Implementation

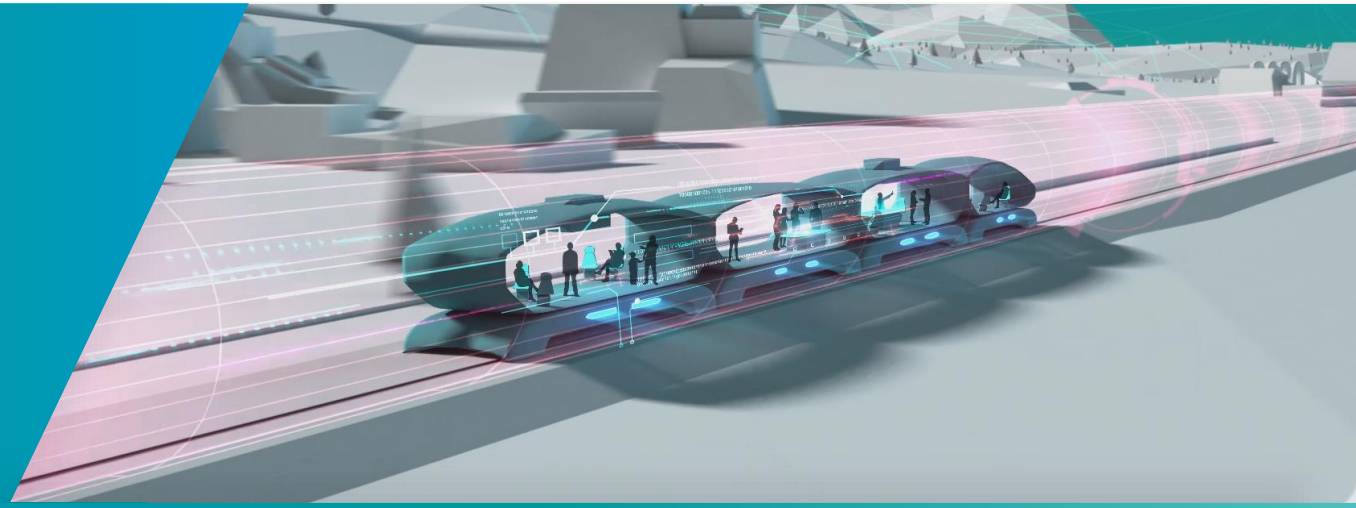
- Dealing with the Migration Steps
- Getting the railway from start to end-state(s)
- Dealing with the challenges & blockers

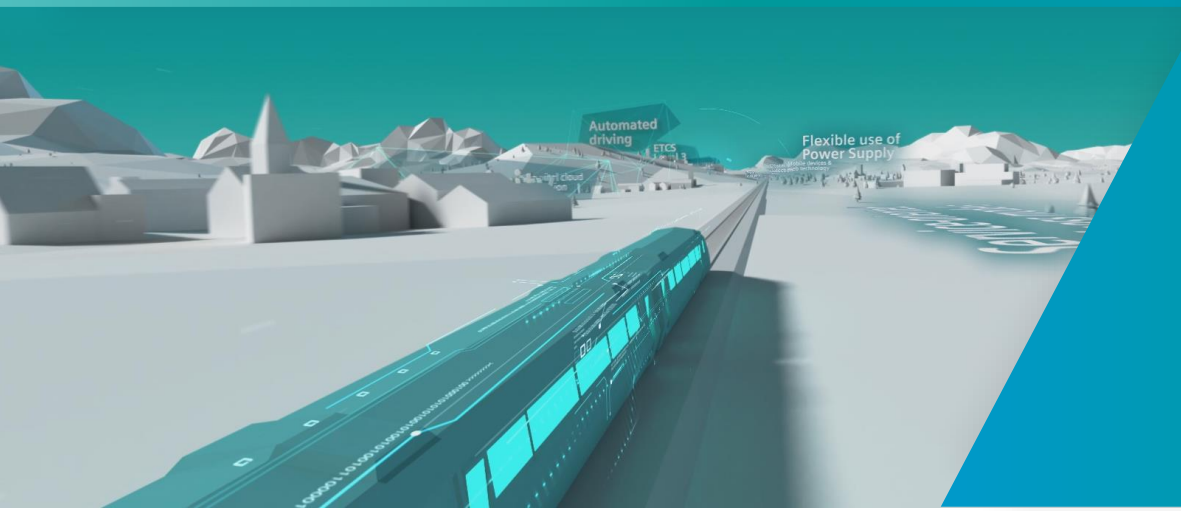
Migration, Implementation & Blockers

SIEMENS
Ingenuity for life

1. Migration paths

- Complexity and variety
- Which are plausible/ likely?
- Technology starting points?



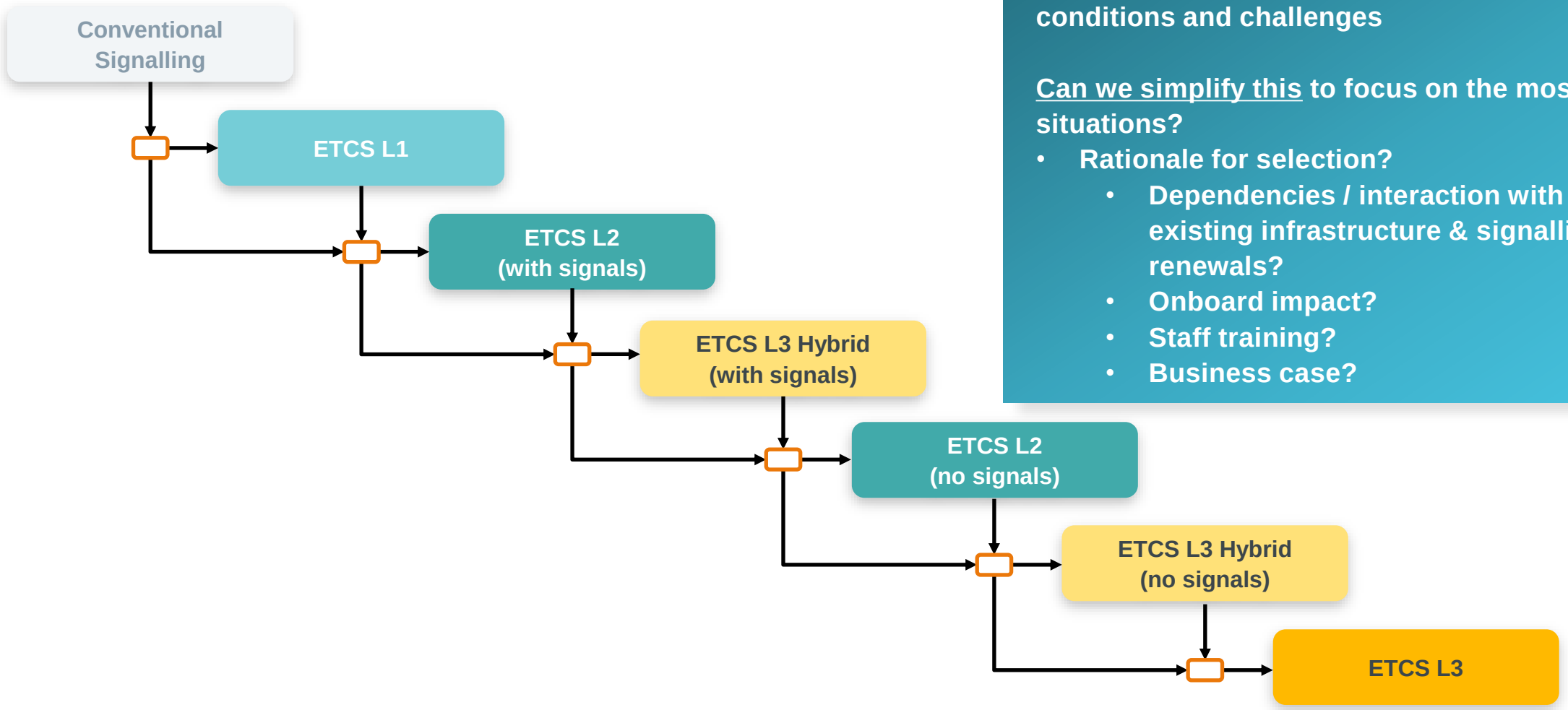


2. Implementation of Migration Paths

- How can migration be achieved in practice?
- What are the challenges and solutions?

Migration Paths to L3

SIEMENS
Ingenuity for life



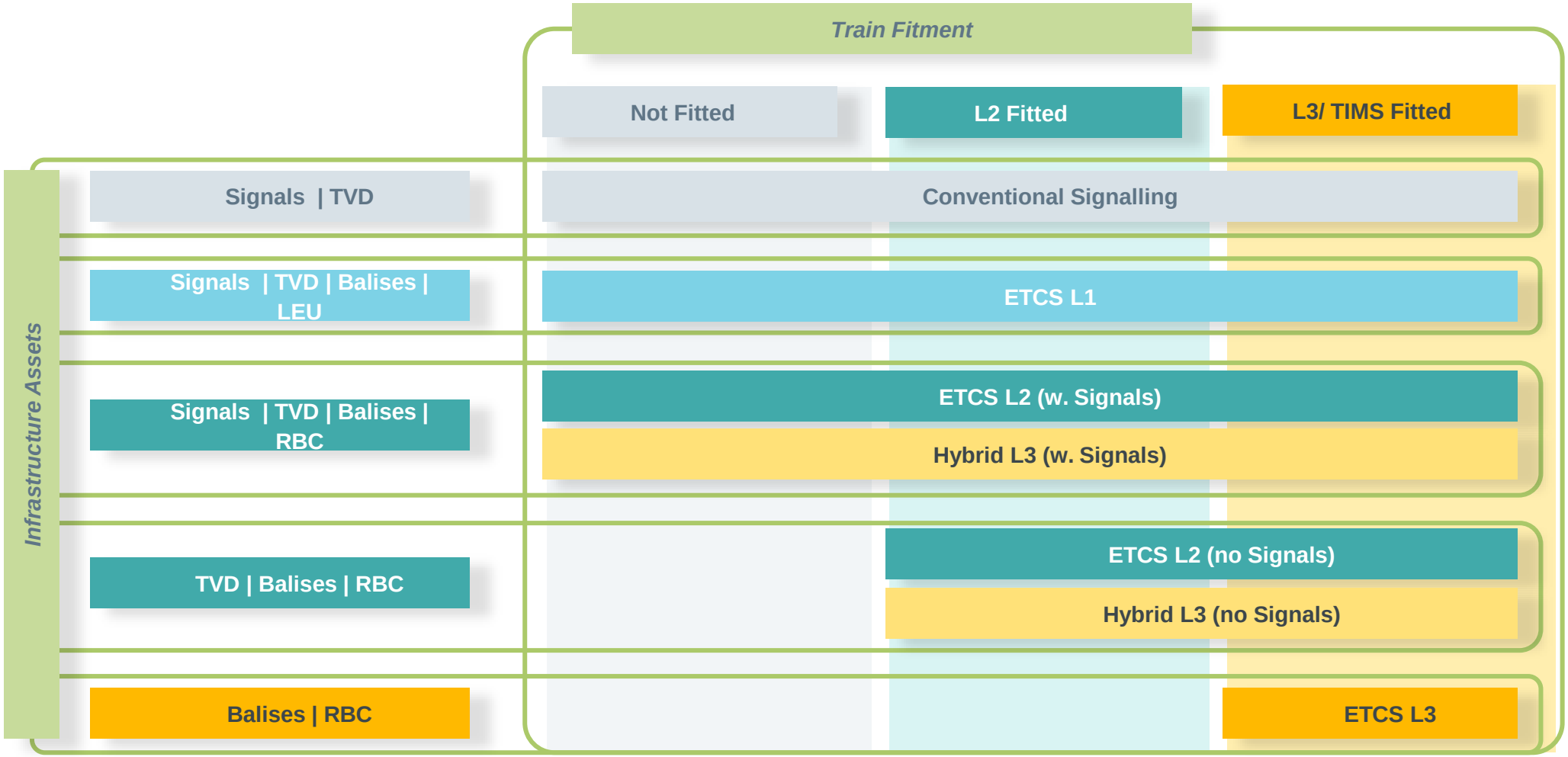
21 possible steps to L3 - each with its own conditions and challenges

Can we simplify this to focus on the most likely situations?

- **Rationale for selection?**
  - **Dependencies / interaction with existing infrastructure & signalling renewals?**
  - **Onboard impact?**
  - **Staff training?**
  - **Business case?**

ETCS Migration Matrix

SIEMENS
Ingenuity for life



Level 3 Implementation - Methods

SIEMENS
Ingenuity for life

Implementing optimal migration

- Probable stages/ phases within each migration step
- Key considerations / what really matters?
- How to achieve?
    - Minimise disruption or ‘Big Bang’?
    - Train fitment
    - Trackside fitment – overlay
    - Phased infrastructure upgrades
    - Phased operations changes
    - Integration and Test

Implementation Challenges

- What difficulties are presented at each step?
- How might these be addressed or avoided?
    - Unique migration technologies/ solutions
    - Operational methods

Addressing Migration Challenges

SIEMENS
Ingenuity for life

Avoid mixed fleet operation with day / night separation

- Level 3 during day with fitted trains
- Level 2 during night with a unfitted fleet

Onboard Unit is kept in Level 2 – but with Level 3 operation

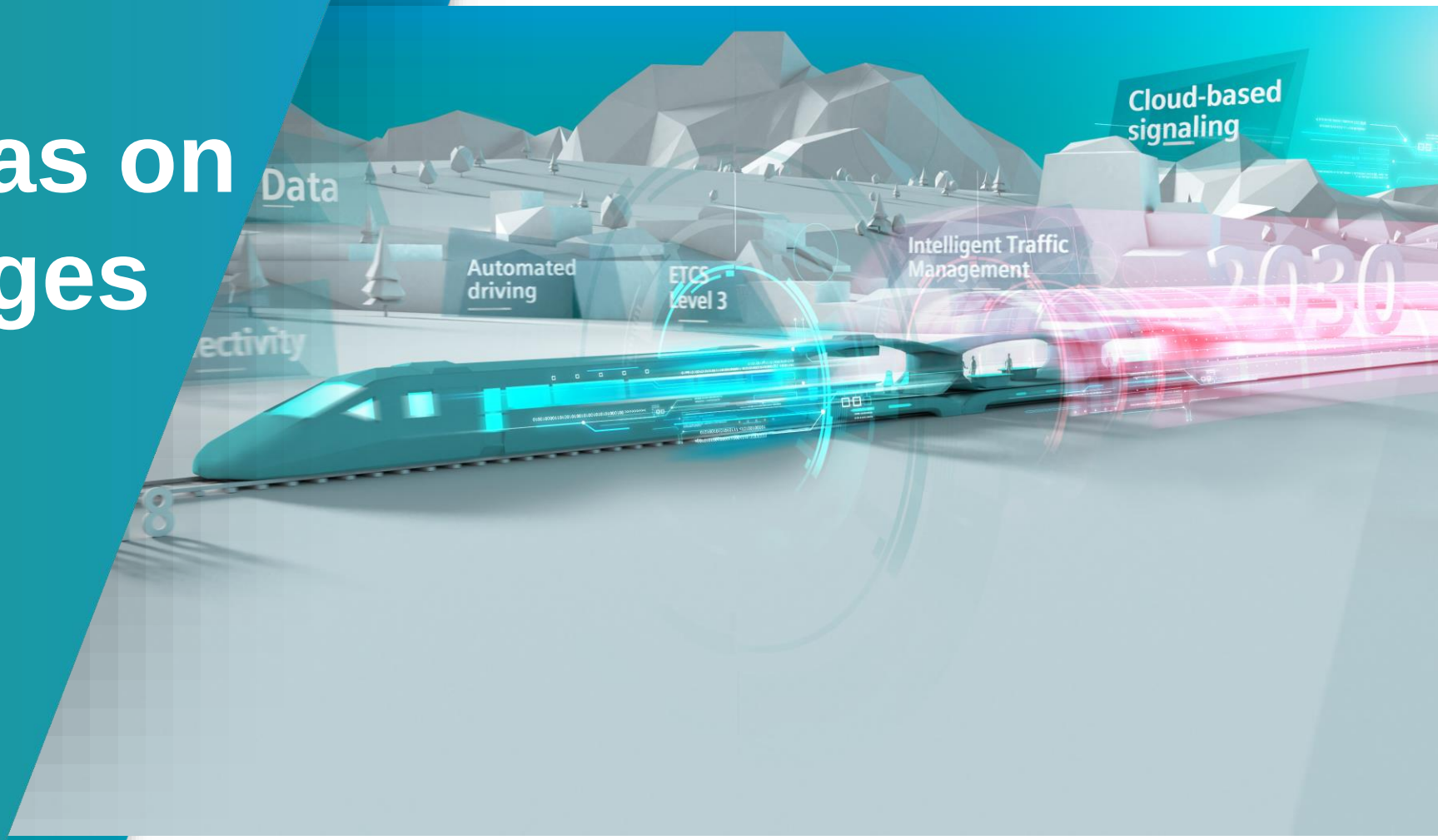
- closing the gap until all specifications are ready
- ETCS Trackside to evaluate if a train is L3 ready

Shadow Mode implementation

- Install the whole system in parallel with existing and run in the background / switch in & out for test

SIEMENS
Ingenuity for life

ETCS L3 - Ideas on Open Challenges



Content
ETCS L3 Open challenges

SIEMENS
Ingenuity for life

// Definitions of ETCS L3

// Introduction to 4 System types

// Assumptions for L3 operation

// Safety analysis on L3

// Accuracy of Train Length

ETCS Level 3 Definitions
according to specs and a baseline conclusion

SIEMENS
Ingenuity for life

Subset - 023

“ A level of ERTMS/ETCS that uses radio to pass movement authorities to the train. **Level 3 uses train reported position and integrity** to determine if it is safe to issue the movement authority. ”

Subset - 026

“ Train position and train integrity supervision are performed by the trackside radio block centre in co-operation with the train (which sends position reports and train integrity information). ”

Functional Requirements Specification v5.0 (Baseline 2 only)

“ Same as level 2 except that train integrity is provided by onboard and therefore **trackside train detection is optional**. ”

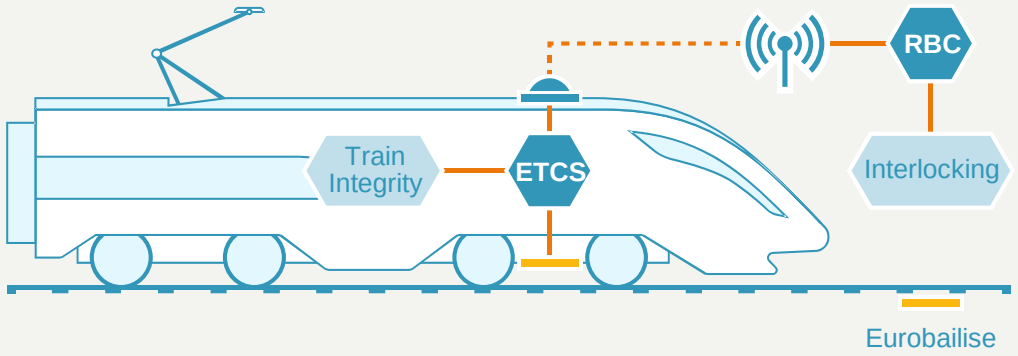
The Baseline:

ETCS Level 3 uses train reported position and integrity and by this is not dependent on trackside vacancy detection.

ETCS Level 3
Four Main principles

SIEMENS
Ingenuity for life

Core Building Blocks



Core Building Blocks of ETCS L3 are:

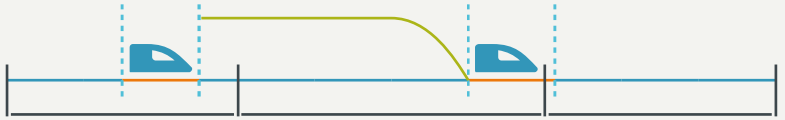
- ETCS On-Board unit enhanced by Train Integrity
- Interlocking and RBC at trackside
- Eurobalise

Main system principles

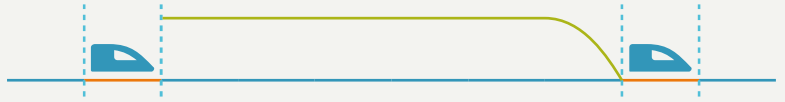
1. Virtual Block with TVD (following *unfitted* train)

2. Virtual Block *w/o* TVD (following fitted train)

3. Moving Block with TVD

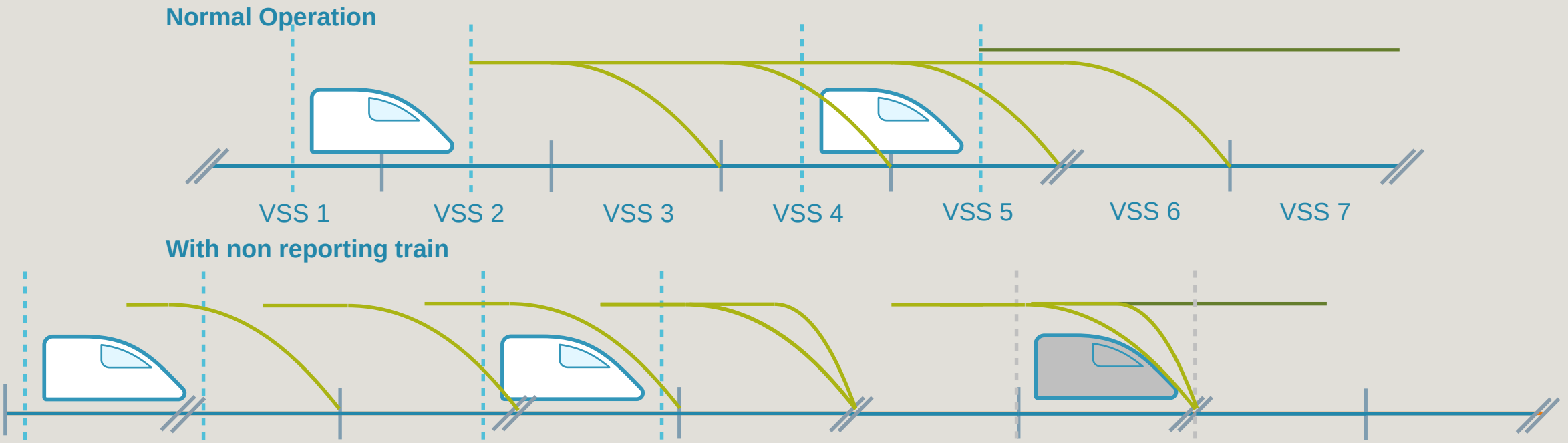


4. Moving Block *w/o* TVD



System Type 1
Virtual Block with TVD (= Hybrid L3)

SIEMENS
Ingenuity for life

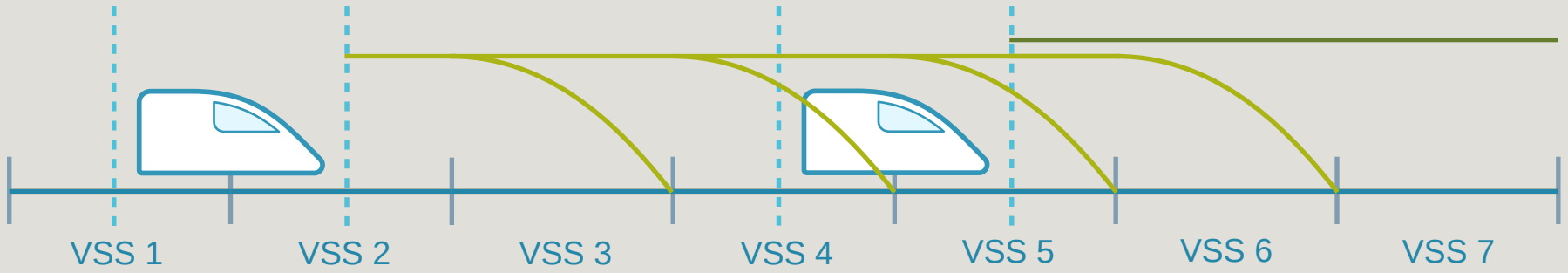


Two sources of train position information:

- The ETCS position report (incl. train integrity info)
- Track Vacancy Detection.

- Trackside must decide how to combine/prioritize the TVD and virtual block information.
- For trains reporting integrity info, the MA calculation for following train is based on virtual blocks.
- For trains NOT reporting integrity info, the underlying TVD info can be used for MA calculation.

System Type 2
Virtual Block without TVD



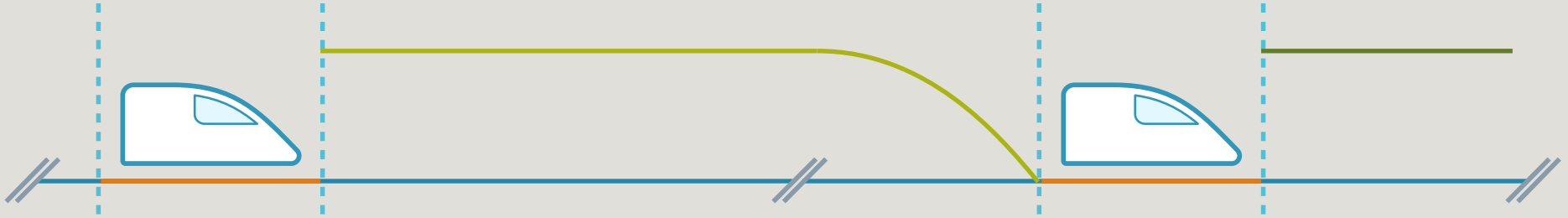
One source of train position information:

- The ETCS position report (including train integrity information)
- Trackside is divided into fixed virtual blocks.
- The blocks are occupied/cleared based on info in the position report.

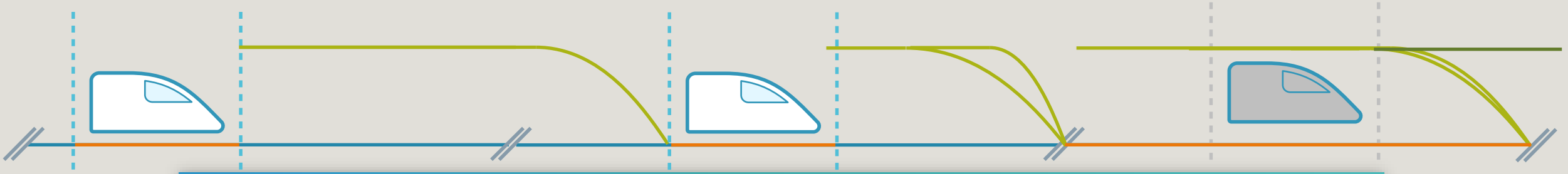
System Type 3
Moving Block with TVD

SIEMENS
Ingenuity for life

Normal Operation



With non reporting train



For trains NOT reporting integrity info, the fixed block of the underlying TVD can be used for MA calculation.

System Type 4
Moving Block without TVD

SIEMENS
Ingenuity for life

One source of train position information:

- the ETCS position report (including train integrity information)
- The reserved block moves with the train.

Assumptions & Preconditions
ETCS Level 3

SIEMENS
Ingenuity for life

- All trains - also non-ETCS-equipped - are known by ETCS trackside
- On-Board and trackside always try to communicate inside L3 areas
- ETCS On-Board is in charge to transmit Train Data, Train Integrity and Train Length as safety relevant information
- RBC calculates MA of train and secures the route in collaboration with Interlocking
- Cold Movement Detection essential on-board provision
- Accurate Train Length and Train Integrity Info to determine End of Train
- Other systems (e.g. ATO) can be attached and/or integrated
- No trackside signals nor track vacancy detection required

Safety Analysis on Level 3
shall provide framework for solution development

SIEMENS
Ingenuity for life

Solutions on train integrity can be derived accordingly

- Current specs miss a safety analysis for ETCS Level 3
- Focus on difference between Level 2 and 3
- Check suitability of mission profile of L1/L2
- Apportionment of THRs to equipment
- FMEA based on operational scenarios and/or user requirements

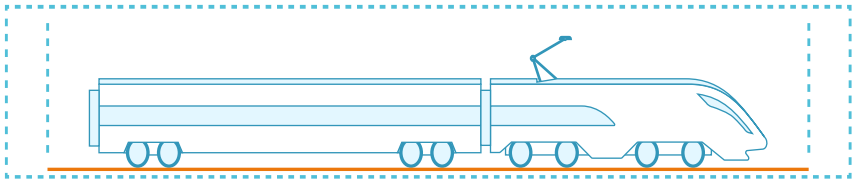
Benefits
of accurate Train Length

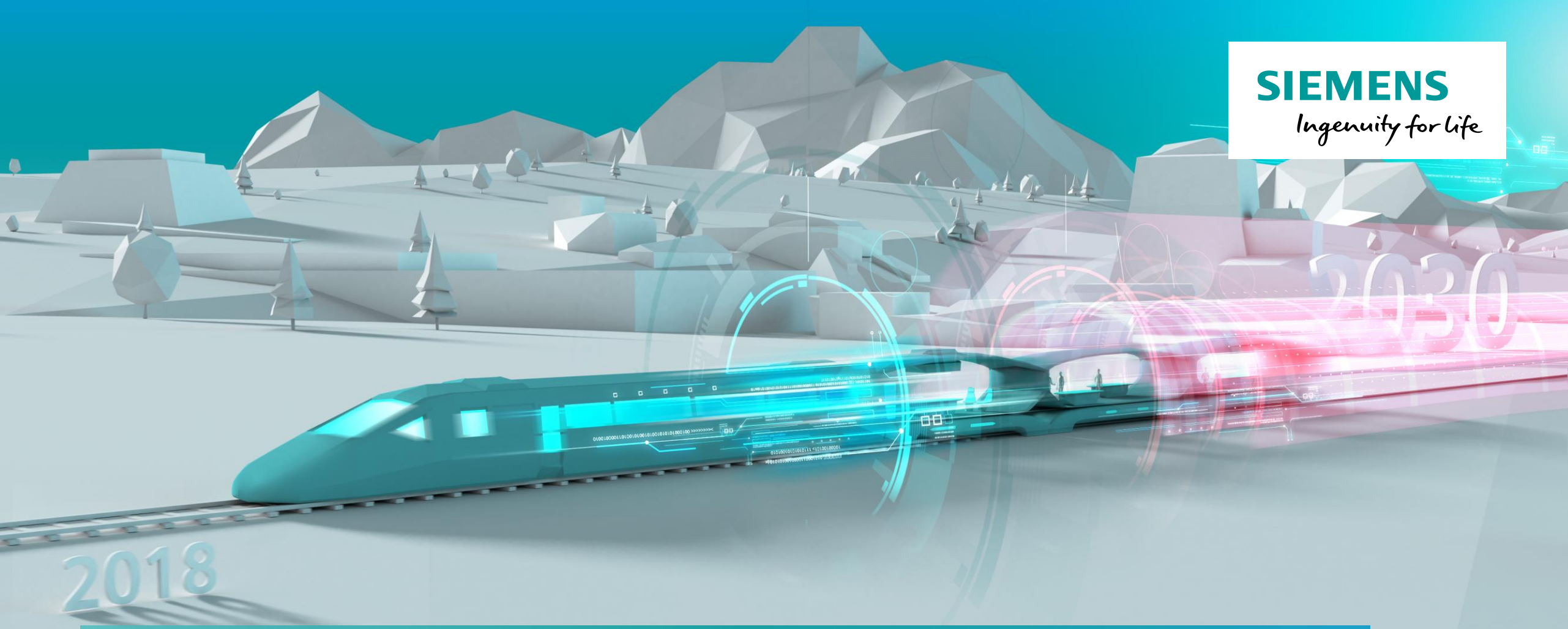
SIEMENS
Ingenuity for life

With an accurate train length information, these challenges can be covered:

- The validation process during Start of Mission becomes easier
- The obstacle definition after End of Mission can be minimized
- The intentional Joining and Splitting can be better automized

The next specs shall specify the accuracy level of L_TRAIN





We turn your vision into reality.