ERJU SYSTEM PILLAR

Operational Vision CMS_TMS Part

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1 Document purpose and target group

This document was decided by the System Pillar Steerting Group in 2022.

This document sketches a compressed operational picture of the CCS and TMS/CM future. It is written for all readers. Technical background is not needed. A basic operational knowledge is being expected.

This vision is intended to be the starting point for the top-down discussion about the operational concept. It defines general directions and the ambitions for the future CCS and TMS/CM target systems as a discussion basis. It shall set the frame for more detailed discussions in the System Pillar, structured along the operational process areas.

Since the vision is touching several fundamental issues, a purely document-driven review process is not recommended. A collaborative discussion process, that will be initiated in the next step, will analyse this vision and the harmonisation process more in detail.

This operational vision was influenced (besides CBO, common business objectives) by the analysis of several future operational concepts or approaches of Shift2Rail (e.g., ATO, Moving Block,LinX4Rail), existing concept from initiatives (e.g., EULYNX, RCA, OCORA), ongoing enhancement discussions for the TSI CCS 2022 (e.g. for enhanced shunting and better support for ETCS Level 3 operations) and large railway programs (Target190 in NetworkRail, Digitale Schiene Deutschland in Deutsche Bahn, smartrail4.0 and succeeding projects in SBB, Hybrid Level 3 Concept). This document summarizes the major operational ideas behind them.

This document contains only considerations for CCS and TMS/CM.

Operational concepts touch all conceptual levels – from strategic to practical issues.

2 Purpose and structure of this operational vision document

Figure 1 OpCon derivation process

The CBO are generic targets, that were derived from several analysis documents in the sector for example in LinX4Rail, ERRAC, OCORA or RCA. In this document the CBO are translated into a compressed vision for CCS and TMS/CM from the operational perspective.

The operational concept describes three different conceptual areas (see also ISO 15288):

- CONOPS: Concept of operations,
  - Characteristics and requirements from business view
  - Major inter-company interactions on business level
  - Legal concepts and constraints
  - Shared sector and company structures (templates or standard services)
- CONUSE: Concept how to use the system
  - Concept for the production processes
  - Parameters, constraints, and rules of system usage
- CONEMP: Concept of employment
  - Asset management processes (plan, build, run, maintain, change, disinvest)

3 CONOPS Vision for CCS and TM/CM

See corresponding chapter in Operational Vision CCS Part

4 CONUSE Vision for CCS and TM/CM

4.1 Traffic Management / Capacity Management

4.1.1 Planning and replanning

Basic functionality of Traffic management and Capacity Management (roof requirement for all TM/ CM capabilities)
Traffic Management and Capacity Management include together three functions: Planning, deviation management (for track-bound activities) and incident management (for non-track-bound activities in the case of disruptions or accidents).

CM/TM shall create an standardized operational plan
CM/TM means to create a long-term to short-term operational plan (production plan) that fulfils customer needs in an optimized way, to prepare and let execute the plan, and to predict and react on deviations and events with adapted planning or initiated interventions to solve production problems. The operational plan describes in very detail all types of track usage (train movements, stabling, construction sites, usage restriction areas, etc.).

The planing effort shall be reduced
This process includes a high work complexity, the interaction between several involved "planning and

operational partners" (several cross-border/cross-company IM, RU, maintenance departments / workshops/ depots, shunting yards, terminals, stations, non-railway planning partners etc.) and a large landscape of supervised production aspects like for example the involved train or asset health monitoring. Out of this, at present, large departments are needed to take care of the planning process and its cooperation. The duration of the cooperative planning process can delay solutions for the running production for a long time;

The quality of planning shall be increased to reduce resource consumption and increase reliability
The quality of the plans (resource consumption compared to the fulfilment of customer needs) depends on the limit of the affordable coordination between planning partners. Reduced plan quality leads to higher production resource consumption, capacity needs or planning reserves (infrastructure, but also resources like fleet, work forces, energy, etc.), less robustness and less predictability/reliability for the end-customers (passengers and shipping agents).

The planing process shall happen faster (response time)
The replanning process in the case of production deviations (called "disposition" today) takes too long and in every minute the negative impact of the deviation grows. The response time for long-range deviations on freight corridors can be many hours where freight trains are standing on tracks.

Vision for Traffic Management
The basic vision for Traffic Management is to reach a high, smart and flexible automation and cooperation levels for its long or short term simulation, planning, forecasting and coordination processes (cross-company, cross country) in a way that allows to work with an integrated and rolling high-quality plan in near-real-time, based on automated information exchange (based on forecasting) between all involved planning partners, that were mentioned above.

Digitalized short-term planning
The basic vision will also include a highly digitalized tactical short-term planning with the relevant cost-efficient approach to address risks and opportunities. This means concretely that for example automated replanning functions give operator advices or can directly find the best solutions in terms of cost optimisation and customer needs satisfaction. The intention is to find the optimal solution for (re)planning requests inside of the margins given by timetables, rolling stock reserves, etc.

High quality operational plan
The quality of the plan is increased by including all factors (like energy consumption) that are influencing the planning process into an integrated information basis, as described in Figure 2. Analytical processes, long-term planning, short-term deviation management and even near-real-time planning (like shunting, plan needed for automation) can be executed on the same high quality of data and (re)planning algorithms.

Shared operational plan
The plan is shared between all production partners, open at European level, to allow dynamic automation and optimisation processes on all sides and to reduce coordination effort.

"Connected" infrastructure
Concerning the infrastructure capacities "connected" to the normal infrastructure capacity used for stabling and train runs (like marshalling yards, harbours, terminals, etc.) the System Pillar processes and architecture will offer standard interaction processes for planning and deviation management. The more this is used in the market this will increase the completeness and reliability of the planning and will optimize the capacity usage.

RU planning processes
For the planning processes of RU the System Pillar processes and architecture will offer standard interaction processes and interfaces too. This will increase the grade of automation of the interaction between RU and IM, shorten the duration of deviations, and improve the process to find replanning solutions.

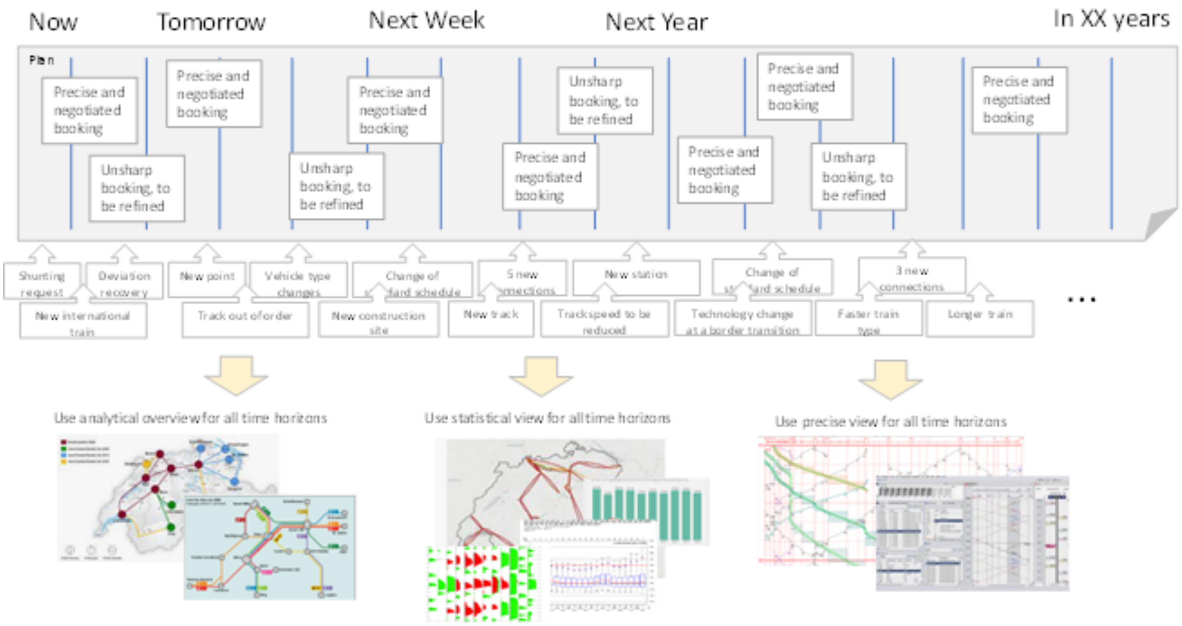


Figure 2 Integrated rolling plan as high-quality information platform for all processes

Integrated plan
This means an “one integrated plan” (infrastructure, booking/planning, etc.) for

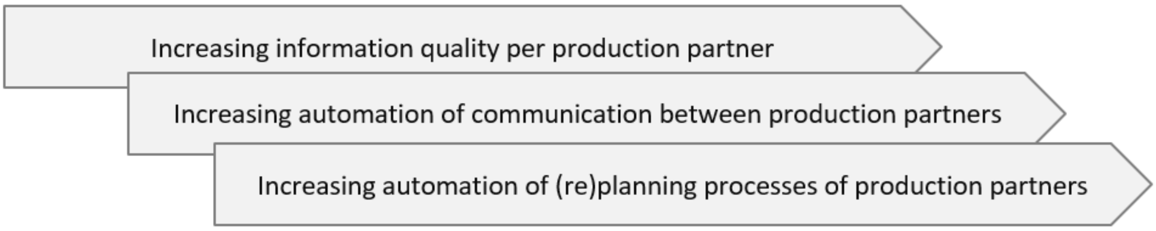
- Very-short-to-long term booking/planning (precise planning or capacity reservation/structuring)
- accessed by the same processes (consistent information transaction for all information)
- for the different use cases (different departments/companies in different planning situation)

Live re-planning
The automated planning and re-planning interaction between RU, IM, marshalling yards, stations, depots, terminals, clients, logistic value chain, (etc.) allow to react to production deviations and (re)planning requests in a live and optimized way.

Short-term customer alert
Short-term offers to customer requests and rapid alerts for the customers in the case of deviations or traffic congestions get possible.

Work-load reduction
A high work-load reduction for the planning resources, the reduction of some percent of the consumption of all production resources and much shorter duration for offers to customers and the solution for deviation problems can be achieved, which leads to smaller deviation impacts (higher punctuality) and optimized capacity usage.

Increase information quality of CM/TM to allow a higher automation (where econimcally viable)
The operational processes and the architecture shall support a market evolution that will happen in different areas in parallel (“TM Business2Business Evolution”, (“B2B”)):



CM/TM shall evolve to be a strong support for SERA
Implementing this basic vision creates several additional side effects. Based on such high -quality information several control processes can become more precise or assisted by smart self-learning digital assistants. Communication-based driver advisory systems and Automatic Train Operation systems can be tuned to take the precise traffic flow prognosis in the area into account. Synchronisation of train paths and traffic flows are embedded in the automated national cross-company/cross-country planning processes. The growing Business2Business traffic management network is the basis for the start of the SERA.

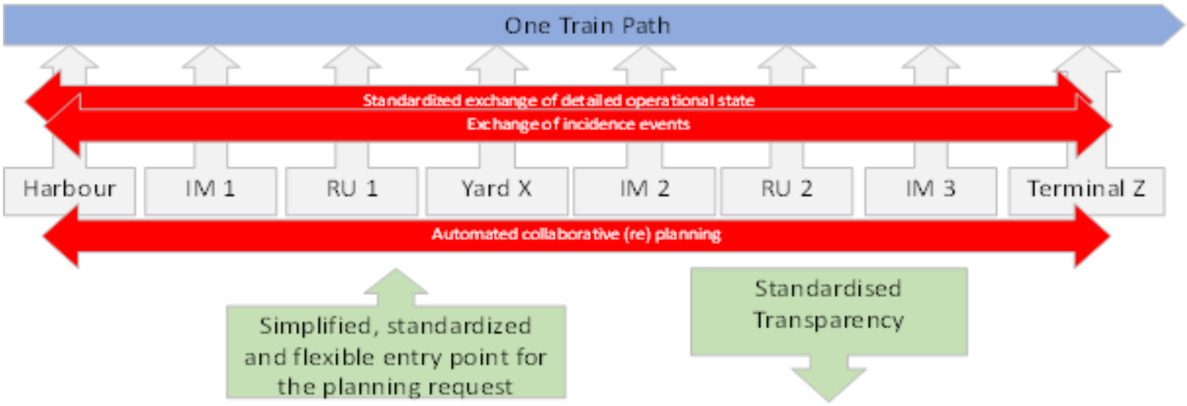


Figure 3: More and more automated B2B planning network cross-company and cross-country

A plan integrating all needed production factors and integrated communication with all planning partners is also the basis for a quantum-leap in the so called “conflict prognosis” and for the “ex-post analysis” for the optimisation of future planning processes.

Conflict prognosis and ex-post analysis
A precise conflict prognosis or ex-post analysis allows to detect problems earlier and understand them better, also for future avoidance.

Continuous improvement process
The integrated real-time communication and cooperation system allows to build a deviation management or feedback loops that are the basis for precise production interventions and a continuous improvement process.

Although it is assumed to reach a much higher automation level, there will be a natural limit where automation can become counterproductive, depending on the technological evolution.

Right level of automation
It is important to analyse all automated CCS and TM/CM systems concerning the right level of automation and integration of human and system interactions, as well as there will be legal and commercial constraints that make human decision steps necessary.

Enabling automation
The architecture shall offer (system/user) interfaces to *allow* a high grade of automation in the future evolution - but the implementation steps need to follow a European optimal balance, building upon national input but being addressed at national level or if needed at European level, that needs to be analysed in the System Pillar.

Coordination on European level
The need for a coordinating “organism” on European *operational* level needs to be analysed and discussed. The hypothesis is, that a business2business process of this size and complexity needs process coordination, and platform support.

4.1.2 Extended TM vision: Multi-modal open capacity management platform

The extended vision for TM planning is to implement large demand-and-satisfy intelligent interaction networks like this known from IoT or modern transport sharing applications, to achieve a high grade of Business2Business automation, real-time response to customer needs, maintainability, availability, performance, and cost reduction.

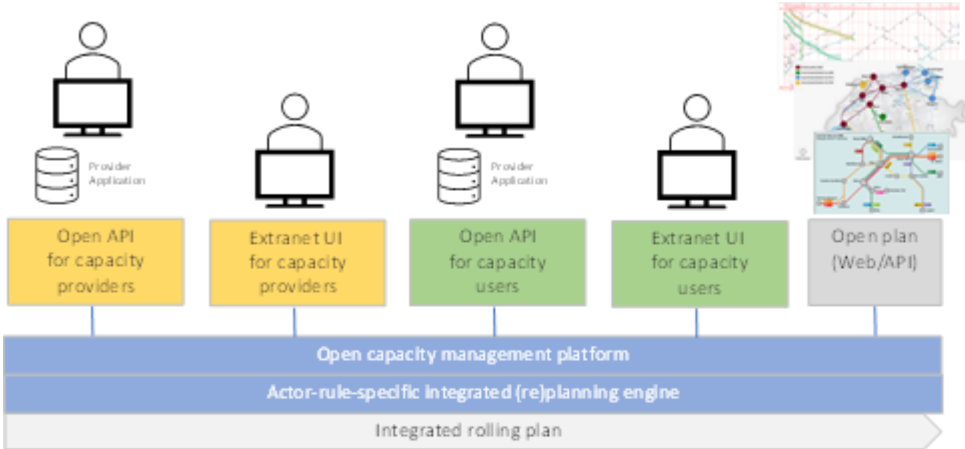


Figure 4: Vision - Open capacity management network (not the target solution, indictive example for illustration)

CM/TM shall offer an easy process and system integration for production partners (extended vision, open capacity mangement)
Every capacity offer (infrastructure, transport vehicles, production areas, etc.) is registered by its provider over “need to know” based platforms, “need to know” visible/accessible and can be requested as needed. Intelligent (AI based) automated broker and (re)planning systems answer to capacity demands of any type (track usage, freight transport, multi-modal passenger transport) based on automated cross-company processes.

The attractiveness of an open track/infrastructure capacity management platform does not only come from reduced local system and planning cost or faster, cheaper, and more precise (re)planning processes. As in all B2B applications over time two effects motivate capacity providers (IM, shunting yards, terminals, …) and track capacity users (RU, construction companies, …) to use the planning network / platform:

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  Capacity providers – being MS owned entities – shall aim for 24 / 7 capacity, relying on alternative capacity providers or solutions; they shall simplify the access of a preferably high number of capacity users to their offer
- Capacity users should be driving the ambition of the capacity targets, look for simplified access to a preferably large number of capacity providers; in fact, there should not be difference to them about the capacity provider used, unless different products are offered.
- The more “multi-modal” the open capacity management platform is working, the higher the quality of the virtual transport offer will be and the lower the coordination effort for single providers. Multi-modal means in terms of the working scope of the System Pillar to offer interaction standards (processes, interfaces) for efficient collaborative planning and deviation management to other transport systems.

The System Pillar can design the operational processes and architectural interfaces. The commercial implementation is - independent from this SP work - an evolution that will need, as all B2B concepts, the support by a formal framework and coordinating organizations. Participants will change their compatibility to such platforms over a long time and step by step. This process needs to be actively supported. Several commercial and legal aspects need to be managed.

Another important aspect of the extended TM vision is the innovation of planning methods and paradigms.

On demand planning, flexible transport timing, or Kanban-oriented (queued customers) transport management (extended vision)
Transport on spontaneous demand of the customer, flexible transport timing, or Kanban-oriented (queued customers) transport management shall be possible. Even “standard schedules” are extended and changed by the same mechanism and are mixed with the other planning methods.

4.1.3 Target picture for the Incident Management

CM/TM shall implement an high performance incidence management
Operational Incident Management (like for emergency cases, accidents, system failures, etc.) must sometimes handle a high complexity of often unstructured information between several different subjects and organisations (police, maintenance organisations, …). Information retrieval, field force coordination and the collaboration concerning the planning of interventions is sometimes overstraining the operation centres (which have to rely on local and national crisis rooms), especially when decision support for large incidents or international impacts is needed.
The target picture of incidence management is based on a high grade of digitally automated communication that allows electronic workflow management with high performance and precision.
The components of the target picture for incidence management are (depending on the severity of the incident, here for low severity):

- Automated pattern recognition detects in the digital operational state event patterns and starts an electronically managed workflow for the incidence management
- An integrated coordination process in the operation centre is connected automatically to the management processes of the field force, external, or for example emergency organisations.
- Incidence coordinators as assisted by smart self-learning digital assistants that help to reduce the complexity of the coordination process.
- Replan of the available capacity.

(Remark: The detailed process scope for the incident management standardization is an open point to be worked out in the system Pillar).

4.2 Traffic Control and Supervision

Traffic CS shall offer an optimized and automized basic functionality to control and report any type of track usage
The basic vision for Traffic Control and Supervision (Traffic CS) is that this control layer offers a very precise interface for the traffic management (e.g. detailed speeds, train characteristics, progress of processes). This preciseness allows to optimize all movements in relation to each other (capacity, speed, energy consumption), to reduce train ahead times, dwelling times, delay times, and unproductive waiting times of maintenance teams or construction sites. The operational state includes detailed information about all actors and systems in the production. The communication to all actors is digitized and because of this automatable.

ATO for normal and degraded modes
The second aspect of the basic operational vision is to highly automate Traffic CS (still allowing manual control) for normal and most of the degraded production situations, based on a scalable physical architecture and in collaboration with the Traffic Management process. Technical and operational interoperability - as needed for the SERA - is based on a simple compatibility management that supports an economic migration and mixed generations. Executing an operational plan coming from Traffic Management processes in short intervals in real-time shall be automated in all aspects, based on cooperation rules and procedures. This includes movement permissions for normal train movements, shunting, joining, splitting or other manoeuvres (supported by automated coupling), as well as granting possessions for construction sites, track access for maintenance teams, warning processes, or the change

of a point position that a maintenance team needs. The automation shall decrease effort and duration for operation and deployment, and increase reliability, safety, and precision/capacity.

Track user planning via Traffic Management process
All track user (vehicles, or field forces: e.g., track workers, operational services in the field, etc.) requests, needed actions, permissions, or asset changes are requested to and planned via the Traffic Management process in an optimized and integrated way. They can also be requested by field force applications or TM terminals in or near the train (e.g., to initiate remote controlled train movements), to allow a completely automated process. Non-track-bound track users or mobile objects (like a locatable construction site boundary marking device, or a localized person) are seamlessly integrated into to the safety supervision process like normal trains to achieve a complete safety supervision.

Safety assessment on run time
The Traffic Control process implements a “safety assessment on run time” method to assure flexible and scalable configurations, flexible and efficient migrations (deployment and evolvability), line access by heterogenous train types with different capabilities, asset changes on run-time, different asset capabilities, and degraded modes with still available production capacity and automation. The method shall follow the approach to assess dynamically and in real-time the available reliable information about configuration, track usage and asset conditions before allowing any change of status, movement, or new track usage.

Example:

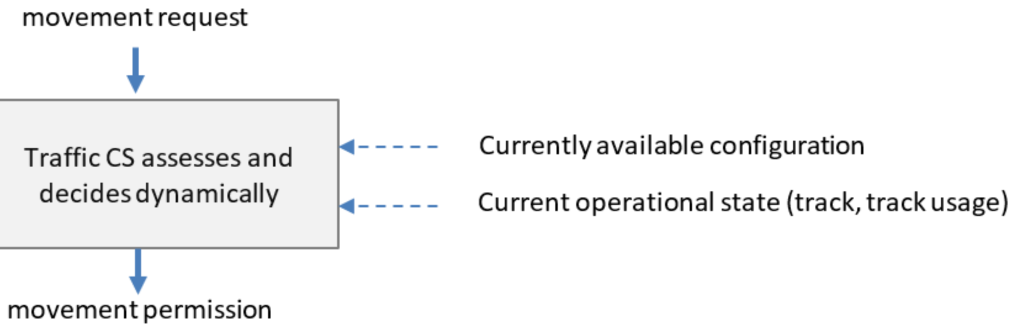

Figure 5 Example: Dynamic safety assessment on runtime

Automation in degraded modes and system intervention
One important improvement/requirement inside of this dynamic safety assessment is to allow some automation in degraded modes (if still possible) and to change infrastructures (or intervene into the system) under production in a safe way. Instead of working in an “on/off/verify/on” way, the Traffic CS shall assess on the basis of its available operational state information (assets, trains, etc.) what automation in degraded modes (“rich degraded modes”, e.g. automatic command for sweeping a defect point by moving on sight) or what system intervention (e.g. diagnosis test run in an component under production) is still safe. This increases availability and efficiency.

Continuous supervision of railway production
The safety, condition and availability supervision of the railway production is a continuous process for all types of track users (track-bound or non-track-bound) in the same way and includes static as well as configurable event pattern recognition for automatically triggering event-related mitigations or measures. All types of more and more available mobile, train-born, or fixed sensor information (also from outside of the CCS and TM/CM system) and data sources (like WIFI detection or mobile maintenance apps) are included dynamically into and combined in this supervision (like person counters for platforms or car detectors on crossings) to increase the reliability, robustness, availability, and precision of this supervision process.

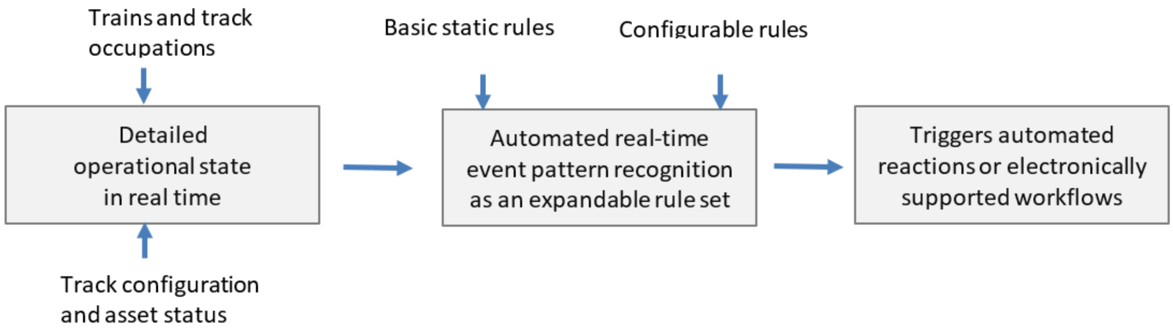

Figure 6 Comprehensive event pattern recognition for safety, availability, and asset conditions

Another important aspect of the improvement of the traffic control processes is the next evolution step for ETCS-based processes. The important next evolution step for ETCS is to tune the existing architecture to the performance and cost that it was designed for and like it is visible in some CBTC implementations (higher performance, less cost for trackside assets, simple deployment).

Improved ETCS performance
This includes for example precise braking and speed regime, complete supervision in all normal situations (like for shunting), fast and simple border transitions, fast change of direction, all types of movements (like propelling of yellow fleet trains) or fast start of mission.

Optimizing track capacity
The relevance of track occupancy information including safety margins shall be taken into account for optimizing track capacity.Traffic CS of today on mainline does not make the full use of the physical track capacity in this way. Diffuse operational states (e.g., track position of a starting train) are reported and control optimisations do not take train capabilities into account.

Stable and backwards compatible air gap interface
This does not mean to significantly change the interoperability-related specifications for the air gap interface as defined in the TSI CCS. Here only some dedicated extensions will be needed in future for automation, higher performance, less migration effort, and more scalability (e.g., driverless ATO GoA 4, support for enhanced onboard localisation, coexistence of ETCS system versions on a line (to a limited extend), supporting degraded modes on lines without trackside train detection, etc.).

5 CONEMP Vision for CCS and TM/CM

See corersponding chapter in Operational Vision CCS Part .