



3DEXPERIENCE®

Smart Mobility Operations

Agenda

- ▶ **The new segment «1.7 Mobility Services»**
- ▶ **Why this new segment?**
- ▶ **The new solution « Smart Mobility Operations »**
- ▶ **First focus on rail**
- ▶ **Beyond rail ?**

A new T&M Segment: 1.7 Mobility Services

Design, simulate, plan and schedule
attractive and robust transportation services
for safe, shared and sustainable mobility



Sub segments

Mobility Service Providers

Taxis, VTC, car sharing,...

Car Rental

Public Transport Operator

Metros, Tramways, Buses

Railway Companies

Passenger Train Operators

Transport Authorities

First focus

Agenda

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▶ First focus on rail

▶ Beyond rail ?

Our common challenge

How can we stay below a **2°C** rise in global temperatures?

Reduce carbon emissions to **0** by **2050**



Cities have clear sustainable mobility KPIs

...and regulate mobility of private cars



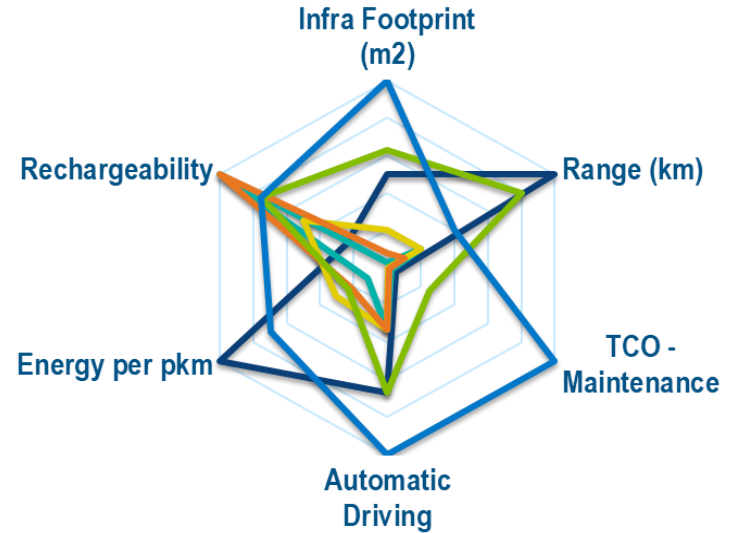
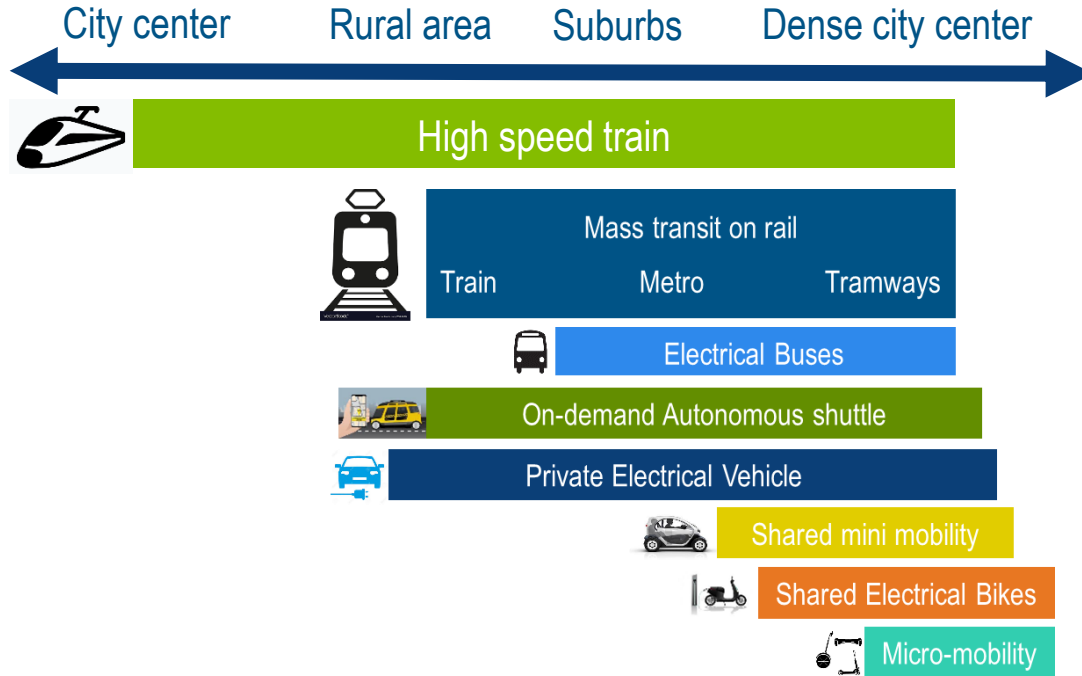
10 Healthy Street Indicators™



Source: Lucy Saunders

© 2020 Healthy Streets Ltd.

Our belief: Ecofriendly mobility is Multi-modal



Mobility Eco-system is evolving ...



Mobility as a Service

Why this segment ?

- ▶ **Mobility services replace car ownership**
- ▶ **Ongoing redefinition of the mobility service provider eco system / convergence:**
 - ▷ Public Transport extending their Multi-modal offer
 - ▷ OEM aiming to penetrate the market
 - ▷ GAFA/ Platform ...

4.3 MOBILITY AS A SERVICE MARKET, BY SERVICE TYPE

FIGURE 12 RIDE HAILING SEGMENT TO LEAD MARKET DURING FORECAST PERIOD

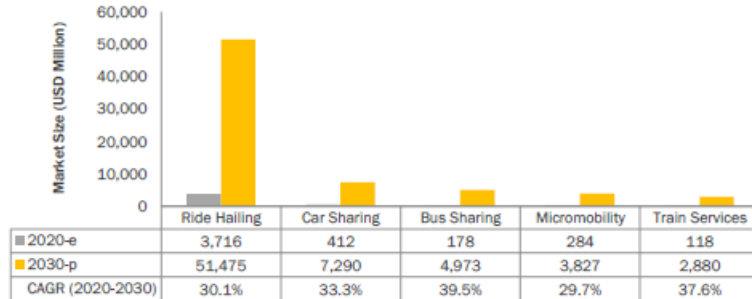
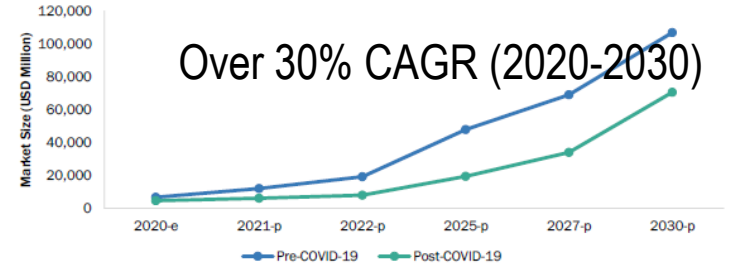


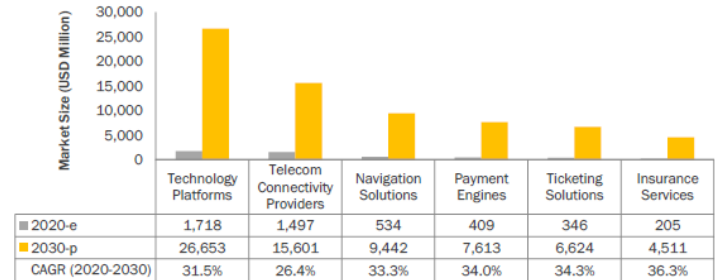
FIGURE 7 PRE- AND POST-COVID-19 SCENARIO: MOBILITY AS A SERVICE MARKET, 2020-2030 (USD MILLION)



e-estimated; p-projected

Source: Secondary Research, Expert Interviews, and MarketsandMarkets Analysis

FIGURE 11 TECHNOLOGY PLATFORM SOLUTIONS ESTIMATED TO DOMINATE MARKET DURING FORECAST PERIOD



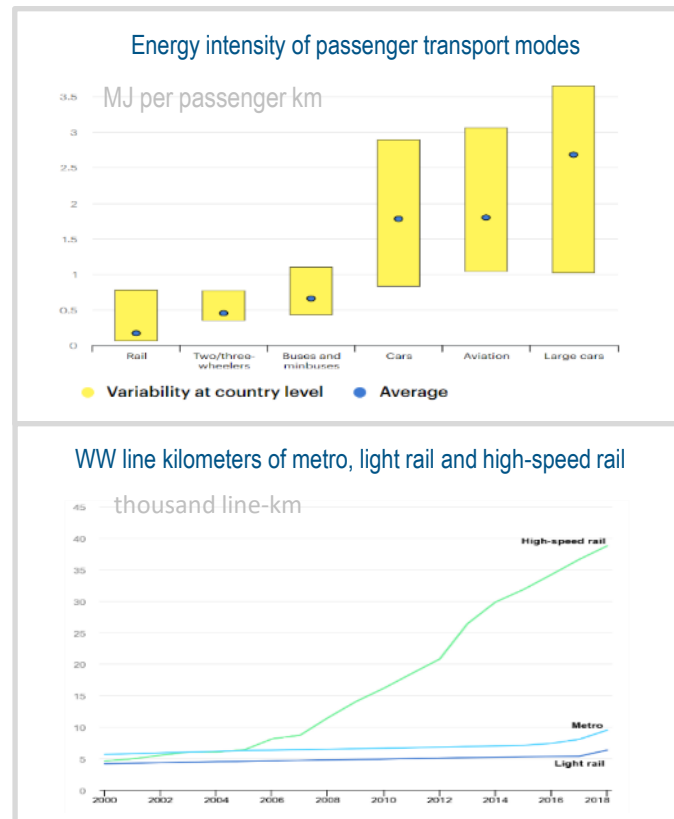
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Source: Expert Interviews and MarketsandMarkets Analysis

Increasing the Share of Rail

- ▶ Rail is one of the most energy-efficient transport modes
- ▶ Urban and high-speed rail infrastructure are expanding rapidly around the world
 - ▷ 90% of passenger rail activity is concentrated in China, the European Union, India, Japan and Russia
- ▶ **\$400 billion per year** planned to be invested in railway infrastructure worldwide

But rail share in mobility remains just below 10%



Rail at the Heart of Sustainable Mobility:

The example of Germany

"Germany, a car country, is becoming a railway republic"
"Without the train, Germany cannot achieve the climate goals"

Transport Minister, Andreas Scheuer

- ▶ **156 billion euros will be invested in the next 10 years** for construction and renovation of trains and routes
- ▶ Train traffic needs to increase to solve **Germany's climate and traffic policy deadlock**
- ▶ By 2030:
 - ▷ **Long-distance rail** transport should **double** to 260 million passengers/year
 - ▷ Commuter traffic – the number of commuters is expected to increase to **one billion per year**
 - ▷ Freight transport, trains will carry **70% more goods**

[Reference: Deutsche Bahn – das wird kein leichter Weg](#)

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- ▶ Beyond rail ?

What: Smart Mobility Operations

For mobility services with a **first focus on Railways and Train Operators (5 Processes)** and already many references

Operate



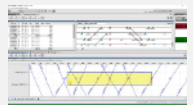
THALYS



avis budget group



Public Transport Scheduling



Rail Service Scheduling
Rail Fleet Scheduling
Rail Crew Scheduling

Public Transport Operations



Rail Service Operations
Rail Fleet Operations
Rail Crew Operations

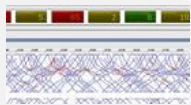
Mobility Service Operations



On-Demand Transport Planning & Optimization



Public Transport Planning



Rail Timetable Planning
Rail Fleet Planning
Rail Crew Planning

Mobility for people and business

Rolling Stock Maintenance Management



Maintenance data management
Asset Health Intelligence
Assets Maintenance Planning & Scheduling

Validate / Certify New Mobility Systems



Mobility Systems Virtual Testing

Design New Mobility Services



Mobility Systems Architecture



ALSTOM



Design

Legend

IPEs delivered in 21xFD05

IPE in nego 22x

Capabilities of our roles and software



What do Mobility Services Segment values the most?



ument_2020

01/18/2020

Confid

© Dassau



Increased competition between mobility services



**Population Dynamics
Increasing Urbanization
Urban sprawl**



**Sustainability of transport,
City livability**



Urban infrastructure saturation



Increasing demand for freight transport

**Business Drivers
WHY?**

**Business changes
WHAT?**

**Benefits &
KPIs**

Propose innovative and effective mobility services

Optimize Attractiveness of Service Timetables

Optimize Robustness and Stability of the Service Timetables

Timely communication on Services evolution to customers

Continuously optimize fleet and crew planning/allocation

Increase customer -citizen satisfaction

Decrease road congestion

Decrease time lost in transit and associated impact on GDP

Rail Network Usage Intensity (Revenue of the Infrastructure manager)

Load Factor (Margin of the operator)

Mobility Systems Architecture

Mobility Systems Virtual Testing

Rail Crew Planning

Rail Crew Scheduling

Rail Crew Scheduling

On-Demand Transport Planning & Optimization

Rail Timetable Planning

Rail Fleet Planning

Rail Fleet Scheduling

Rail Crew Operations

Rail Service Scheduling

Rail Service Operations

Rail Fleet Scheduling

Fleet Maintenance Optimization

Rail Fleet Operations

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Rail Attractiveness Depends on Operations Efficiency

Rail undertakings need to optimize their operations for



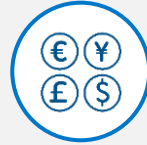
Excellent Service Quality

- Minimized delays
- Good information for travelers
- Vehicle in good conditions



Minimum Overall Transit Time

- Frequent services aligned with the demand
- Optimal connections (with other modes)



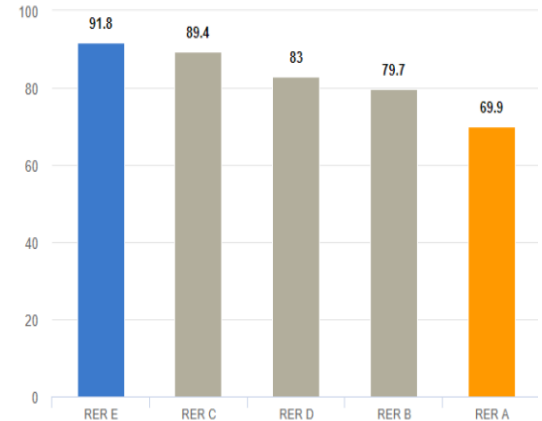
Controlled Cost

Key levers:

- ▶ Advanced train control systems and automatic operations
- ▶ Improved health of infrastructure and rolling stock assets through better maintenance
- ▶ Efficient rail operations, planning and optimization
- ▶ Mobility Services Integrated across all modalities and systems

30% of Paris Regional Trains on line A are late

Punctuality rate of Paris Regional Train line (October 2017)



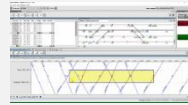
Source : SNCF Open data

Infographie LE FIGARO

Comprehensive Solutions for Smart Mobility Operations

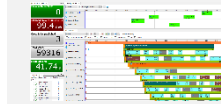
Operate

Public Transport Scheduling



Rail Service Scheduling
 Rail Fleet Scheduling
Rail Crew Scheduling

Public Transport Operations



Rail Service Operations
 Rail Fleet Operations
Rail Crew Operations

Public Transport Planning



Rail Timetable Planning
 Rail Fleet Planning
Rail Crew Planning

Rolling Stock Maintenance Management



Asset Health Intelligence
 Assets Maintenance Planning &
 Scheduling

*Mobility for people
 and business*

Validate / Certify New Mobility Systems



Mobility Systems Virtual Testing
 Software and hardware in the loop

Design New Mobility Services



Mobility Systems Architecture
 Evaluate & Communicate Mobility Concepts

Design

Legend

IPEs delivered in this first ISE version

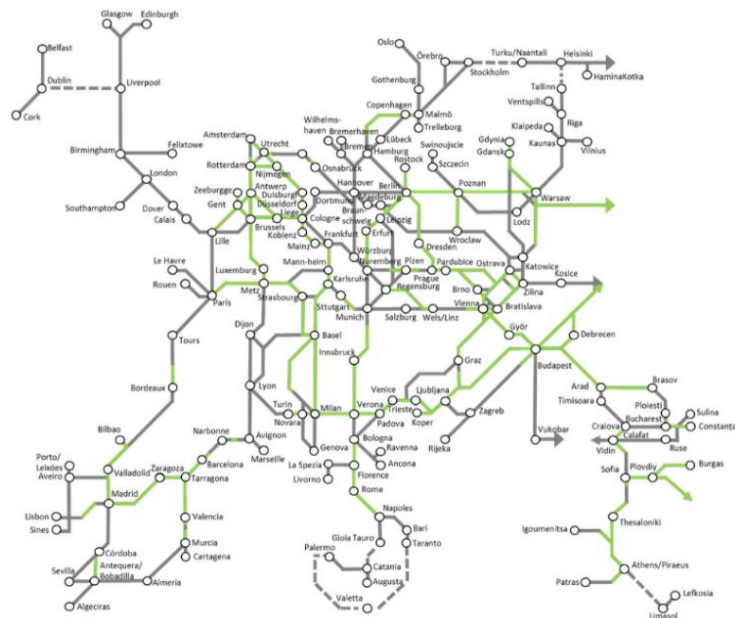
IPEs planned for future release

Capabilities of our roles and software

Efficiency of Rail Operations will be significantly improved through advanced automation and traffic management systems

Diverse Automatic Train Controlling systems being deployed:

- ▶ **Communication-Based Train Control (CBTC)** mainly in metro and regional trains for **optimal throughput and automatic operations**
 - ▷ Remove reliance on track-based equipment
- ▶ **European Rail Traffic Management System (ERTMS / ETCS) for interoperability and increased capacity...** in slow/continuous deployment
 - ▷ level 1: Supplemental on board Cab/driver signaling leveraging Eurobalise installed on track-side
 - ▷ level 3: Full radio-based train spacing without track-side equipment
 - ▷ **Challenges**
 - ▶ Country-specific requirements
 - ▶ High variety of trackside configurations impacting engineering and testing
 - ▶ Slow/costly conformity assessments and authorization
 - ▶ Various Interpretation of ERTMS specs => incompatibilities between ETCS subsystems
- ▶ **Positive Train Control (PTC)** systems in North America **focusing on safety**
 - ▷ Deployed in North America on 53,676 miles of class 1 railroads
 - ▷ Some US rail transit agencies are adopting CBTC at a slow pace



ERTMS/ETCS deployment plan in EUROPE

by 2023
by 2030 (50,000 km)
120,000 km by 2050

https://ec.europa.eu/transport/sites/transport/files/work_plan_ertms_2020.pdf
https://www.railjournal.com/in_depth/will-ertms-reach-critical-mass-europe
<http://www.railway-technical.com/signalling/automatic-train-control.html>

Mastering the deployment of advanced automatic operations and traffic management would benefit to all the rail stakeholders



Transport Authorities Cities

- (Urban) infrastructure saturation
- Sustainability



Citizen Freight Forwarders

- Time lost in transport
- Service quality & punctuality



Infrastructure Builders / Maintenance

- Control of delays
- Heterogeneous technologies / skills



Infrastructure Manager

- Increase capacity & safety with Automatic Train Control System



Railway Undertakings (Train Operators)

- Service Attractiveness
- Minimize operating cost
- Reduce Cost of disruptions



Rolling Stock Manufacturers

- Deliver innovative program on time at controlled cost
- Ensure safety / reliability

Control System & Signaling

MOBILITY SYSTEMS VIRTUAL TESTING

Advanced traffic management systems and automatic operations

Accelerate the deployment through Virtual Testing of Control Command & Signaling



Safety



Designers

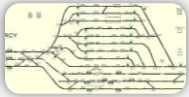


Maintenance

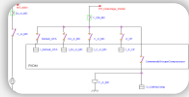


Operators

Virtual Models



Lines & Networks



Signaling & Interlocks



Driver Behavior



Virtual Control Room

Automatic Train Supervision

Automatic Train Operations



Rolling Stock
Vehicle Dynamics



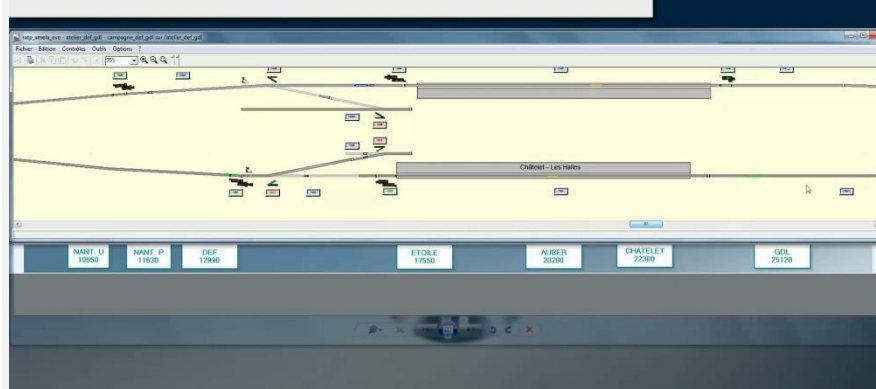
Virtual Controllers

Automatic Train Control

Automatic Train Protection

Real-Time Multi-System Simulation

The physical line part of the simulator is spread over 3 PCs
It represents the RER A line from "La Défense" to "Marne la vallée"



CATIA ControlBuild

Real World

Hardware in the Loop



Software in the Loop



ALSTOM



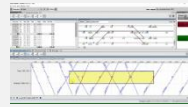
MOBILITY SYSTEMS VIRTUAL TESTING | Overview

- ▶ Advanced automatic operations and traffic management systems can **increase safety, performance and sustainability of mobility services**
- ▶ Especially **rail operations will be significantly improved through automation and advanced traffic management systems**. However, those new systems are **highly complex to deploy** on heterogeneous rail infrastructure and rolling stock.
- ▶ Deployment of **(automatic) (autonomous) transport systems** can be significantly accelerated thanks to **Virtual Real time testing with hardware and software in the loop** which enables to:
 - ▷ Model and simulate metro or train lines including all traffic management, network, wayside equipment and train controls
 - ▷ Model and simulate the rolling stock and safety on-board control systems
 - ▷ Run various scenarios to **check safety and efficiency of the global system**
- ▶ For the provider of system components, virtual testing enables to:
 - ▷ **Discover issues earlier** reducing rework needed and overall lead time
 - ▷ **Reduce the time and the cost of physical test and commissioning**
- ▶ and for the mobility service operator, it enables to:
 - ▷ **Avoid service interruptions** for on-site testing
 - ▷ **Avoid service disruptions** due to operational issues with the new systems.

Comprehensive Solutions for Smart Mobility Operations

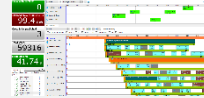
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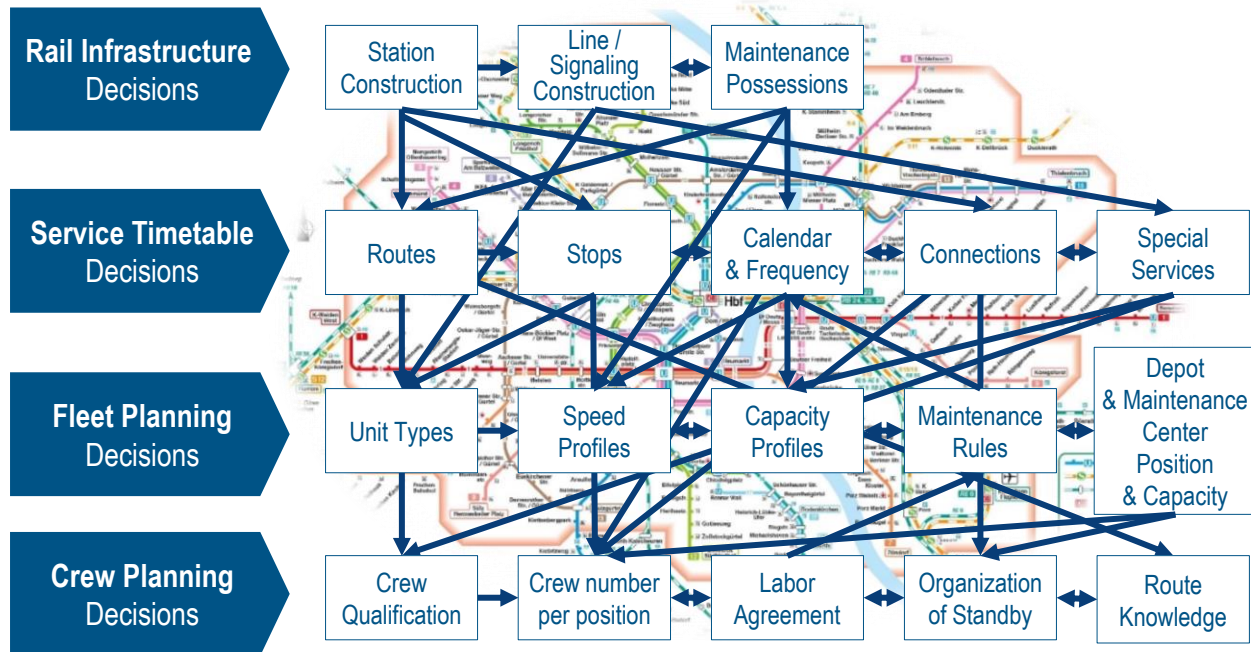
IPEs delivered in this first ISE version

IPEs planned for future release

Capabilities of our roles and software

Rail Operations Efficiency:

Master complexity of Rail Operations Planning

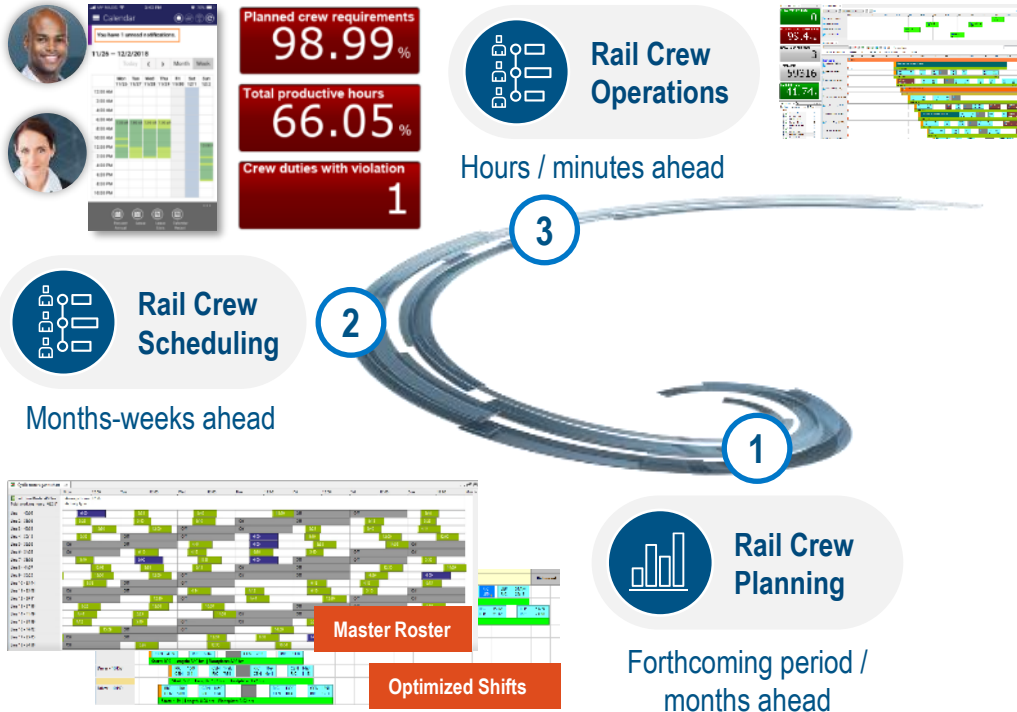


Typical Dimension (European example)

- Lines > 35,000 km
- Stations > 5,000
- Services > 30,000 / day
- Passengers > 5M / day
- Rolling stock > 10,000
- Drivers > 18,000
- Other Crew > 15,000

Efficient rail operations, planning and optimization

Rail Crewing Industry Process Experience



- 1 Rail Crew Planning** creates anonymous Master Roster, covering the Service Timetable for the forthcoming period.
- 2 Rail Crew Scheduling** creates a nominative schedules for each day of the scheduling horizon, covering all the crew activities by suitably qualified and available staff.
- 3 Rail Crew Operations** monitors the execution of crew assignments for the current operational period, ensuring timely response to disruptions.

Challenges of Rail Crew Planning & Scheduling



Railway Undertakings

- **Complexity:** Crew certification, safety rules, multiple base locations
- **Structural constraints / inefficiencies:** Waiting time, deadheading / pass-rides, low footplate time, nights out of home
- **Limited flexibility:** Need to be fair and follow cyclic / regular patterns



Crew

- **Constrained working hours,** Work-life balance, nights out of home
- **Preferences** not considered
- **No easy swapping** of shifts with colleagues
- **Lack of visibility** on changes to assignments




Passengers Freight Forwarders

- Train **punctuality**
- Service **quality**
- Services **adjusted to business context** and exceptional conditions
- **Lack of visibility** on changes to planning

Rail Crew Planning | Planner's Questions

► Forthcoming period / Months ahead



What are the most efficient shifts allowing to cover the train services?

How many drivers are needed in Center A to cover the timetable for next summer?

What is the best sequence of shifts obeying all labor rules?

Can we reduce the number of onboard catering personnel with limited impact on the catering offer?

Rail Crew Planning Overview

- ▶ Forthcoming period / Months ahead



Shift Planning

- ▶ **Minimize the number of working days** (shifts) needed to cover the crew activities
- ▶ **Optimize effective “work” time** performed within shifts (footplate time)


Master Roster Creation

- ▶ **Minimize number of crew members needed** to cover the shifts
- ▶ Ensure roster **adheres to labor rules**
- ▶ **Maximize preference** common to all staff members

KPI-Based Planning & Optimization: Ensuring visibility on the quality of the produced shifts and roster

Rail Crew Scheduling | Planner's Questions

► Months / Weeks ahead



Should I accept the leave request from Mr. Foo on Easter weekend?

Which line of the Master Roster should F. Schmidt cover first at the beginning of the season?
Is it compatible with his previous schedule (and all labor rules)?
How does this match his preferences for bi-weekly Wednesdays off?

Shall we maintain the certification on Line A that Mrs. Durand and Johnson will soon lose?
If yes, when is it best to schedule them on this line?

How can we cover the special train services for the 1st of May?

Rail Crew Scheduling Overview

► Months / weeks ahead



Leave Planning

- **Plan all statutory leave** while covering crew requirements at best

Certification Management

- **Avoid lack of certified crew** for some routes and/or some types of traction

Roster Assignment

- Cover known crew activity requirements
- **Fair distribution** across crew members

Shift Bidding / Swapping


- **Improve employee satisfaction**

Roster Management

- Continuously optimize Crew Schedule to match **crew availability** as well as **latest service and fleet schedules**, **at minimum cost**

Rail Crew Operations | Planner's Questions

► Hours / Minutes ahead and throughout the days of operations



A driver is missing this morning,
who can replace him?

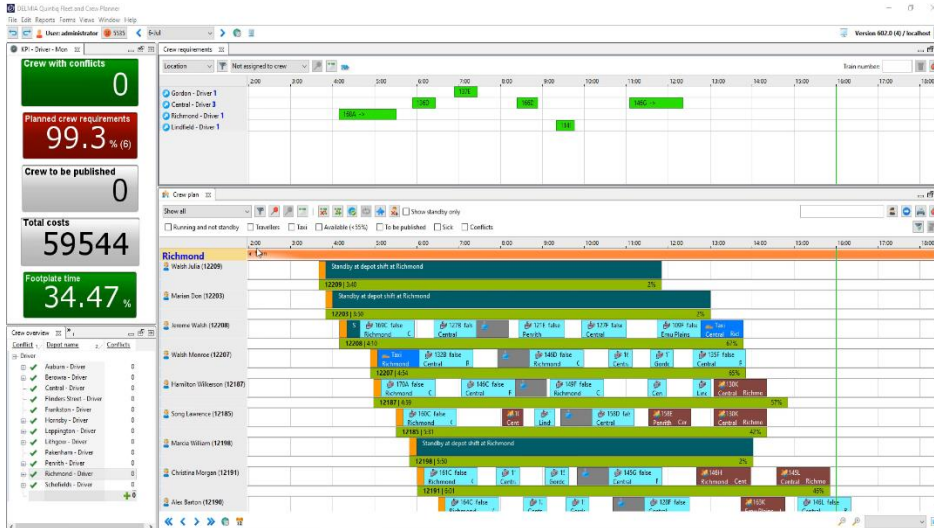
Service XX from A to B is late, its driver cannot
connect in time on service YY from B to C.
Can we avoid a delay of YY waiting for her?

Following a unit breakdown,
fleet schedule is changed.
How can we ensure the
different crew activities for
movements to/from depots?

Shall we use overtime?
Who in stand-by personnel could/
should be mobilized?
Is it worthwhile to call to another
crew depot?

Rail Crew Operations Overview

► Hours / Minutes ahead and throughout the days of operations



Monitor and continuously optimize the execution of crew assignments

Ensure all actual train activities are staffed

Quickly mitigate the many disruptions:

- Crew availabilities / unplanned absences
- Service changes (e.g. delays)
- Fleet operations changes (e.g. unit type..)

Identify alternative adjustments & choose the best compromise between:

- Preserving service quality
- Minimizing the number of affected staff
- Minimizing the actual crew cost
 - ▷ Effective utilization of available staff & standby
 - ▷ Overtime & charges versus deployment of new driver (and need travel time, passenger rides etc.)

Keep stakeholders timely informed of changes impacting them

Benefits of Rail Crew Planning & Scheduling



Railway Undertakings

- **Labor cost control/reduction**
- Maximize efficient (footplate) time
- Minimize transfer time, deadheading
- Reduction of Reserve
- Minimize overtime
- **Efficient Planning administration** (automation, self service)
- **Reduction of unplanned absence**



Crew

- **Crew satisfaction**
- Work life balance (e.g. Reduction of out of home nights)
- Preference considered, Self service to swap shifts
- Better Visibility on their schedule



Passengers and Freight Forwarders

- Perturbation effects reduction:
 - Less cancellation,
 - Better **punctuality**
 - Higher service **Quality**
- Decision based on reliable information

Full visibility allows quick reaction to disturbance of all stakeholders including stations, infrastructure, other modalities,...

Why DELMIA Quintiq for Rail Crewing?



A leader in complex workforce planning.

All of the exotic union rules, including overtime rules, can be covered



Planners quickly balance different goals through **visualization, collaboration and interaction**



Algorithms optimize employee satisfaction, service delivery, productivity and safety.

Real-time propagation of events and decisions effects



A single integrated solution across the entire value chain and across all time horizons

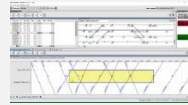
Rail Crewing Industry Process Experience



Comprehensive Solutions for Smart Mobility Operations

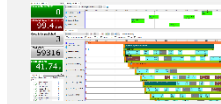
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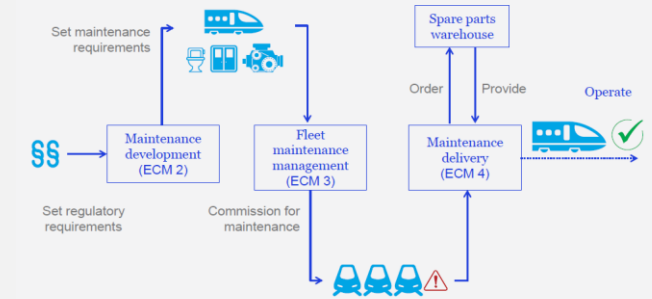
Capabilities of our roles and software

Why: Improve Rolling-Stock Health & Availability

- ▶ **+15% to 25% efficiency possible for rolling-stock maintenance** through “Condition-Based Maintenance” and “Predictive Maintenance”
- ▶ Key for success is the **cooperation between Train Manufacturers and Train Operators**, whoever is the “entity in charge of maintenance”:
 - ▷ Efficient data exchange and digital services
 - ▷ Agile maintenance processes and rules
 - ▷ Synchronization of maintenance operations management

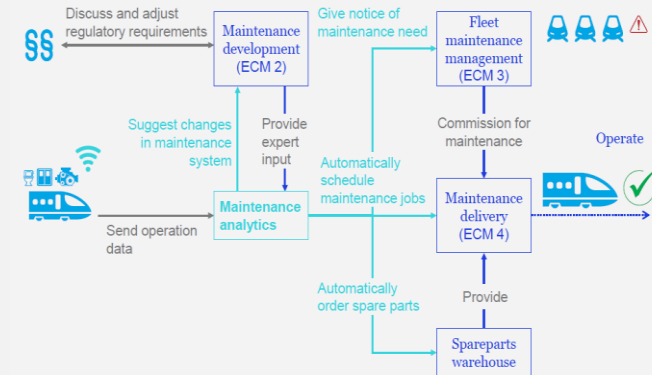
Across segments, today's rail maintenance process is based on a manual fleet commissioning process

Overview of the general maintenance system in rail ⚠ Maintenance required ✓ Maintenance job completed



SOURCE: McKinsey

Overview of the maintenance scheme in rail with condition-based/predictive maintenance ⚠ Maintenance required ✓ Maintenance job completed



SOURCE: McKinsey

Improve Rolling-Stock Health & Availability

Integrated Maintenance Engineering & Execution

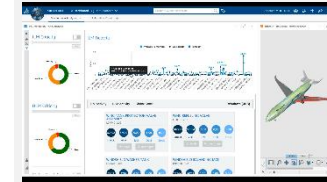


Maintenance

Maintenance Execution & Feedback



Maintenance Analytics



Maintenance Scheduling



Global Maintenance Dashboard



System Engineering

- Requirements
 - Functional Breakdown
 - Logical Structure
-



Manufacturer

Contract & Portfolio Management



Operator

Multi-Discipline Engineering

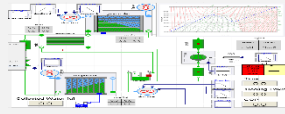
- Mechanical
 - Electrical
 - Electronic
 - Software
-



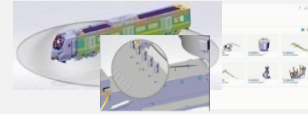
3DEXPERIENCE®

Maintenance Engineering

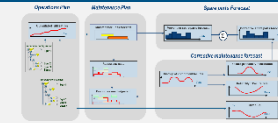
- Service BOM, Service Process,
- Maintenance Task Analysis (MTA)
- Reliability, Availability.... (RAMS)



Tech Pub Engineering



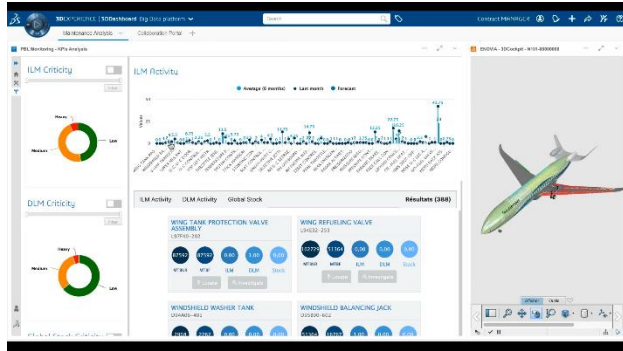
Spare Part Lifecycle



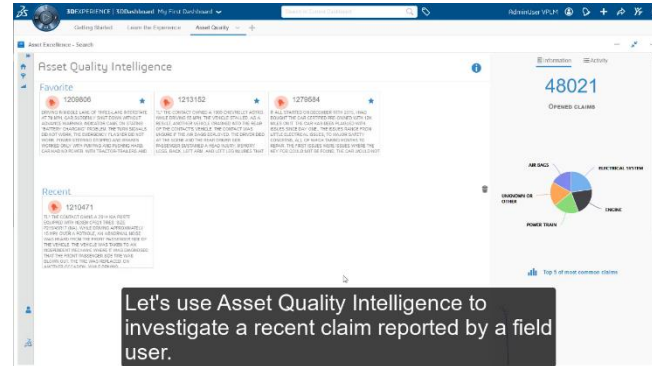
Maintenance Planning



Fleet and Asset Management

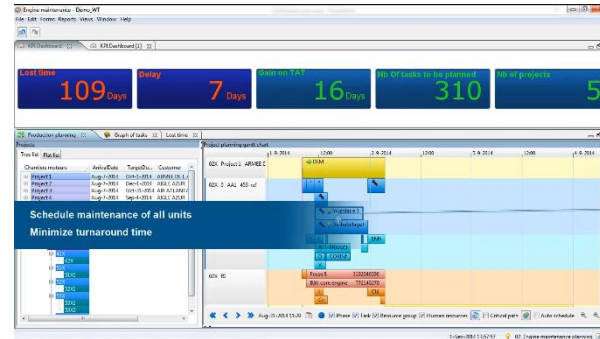


Track assets usage and health, predict risk of breakdown



Let's use Asset Quality Intelligence to investigate a recent claim reported by a field user.

Field Issues Analytics



Fleet Maintenance Scheduling

Increase Rail Attractiveness with Smart Mobility Operations

Public Transport Scheduling

Schedule the resource needed to offer the services in optimal conditions

Public Transport Operations

Mitigate disruptions to preserve the quality and the efficiency of the services

Public Transport Planning

Propose attractive services requiring minimum resources

Rolling Stock Maintenance Management

Ensure health and quality of the fleet for perfect service delivery

Validate / Certify New Mobility Systems

Deploy quicker and at lower cost advanced train control systems and automatic operations

Design New Mobility Services

Design attractive (door to door) Mobility Services across all modalities and systems. Align all stakeholders on common specifications



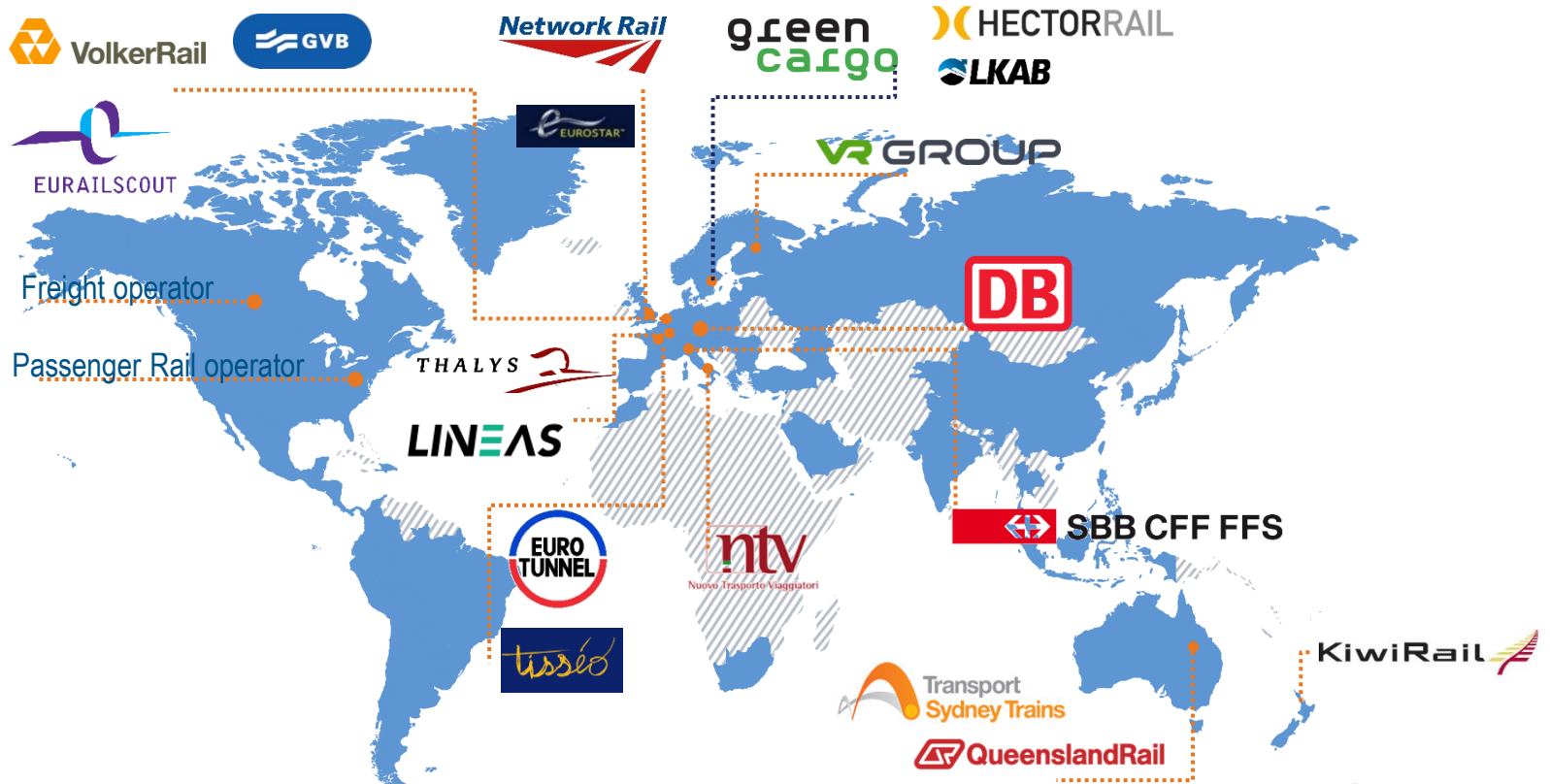
Legend

IPEs delivered in this first ISE version

IPEs planned for future release

Capabilities of our roles and software

Some public Transport and Rail Related Experience



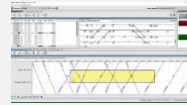
Agenda

- ▶ The new segment «1.7 Mobility Services»
- ▶ Why this new segment?
- ▶ The new solution « Smart Mobility Operations »
- ▶ First focus on rail
- ▶ Beyond rail ?

Comprehensive Solutions for Smart Mobility Operations

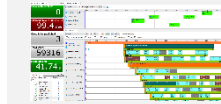
Operate

Public Transport Scheduling



Rail Service Scheduling
 Rail Fleet Scheduling
Rail Crew Scheduling

Public Transport Operations



Rail Service Operations
 Rail Fleet Operations
Rail Crew Operations

Public Transport Planning



Rail Timetable Planning
 Rail Fleet Planning
Rail Crew Planning

Rolling Stock Maintenance Management



Asset Health Intelligence
 Assets Maintenance Planning &
 Scheduling

*Mobility for people
 and business*

Validate / Certify New Mobility Systems



Mobility Systems Virtual Testing
 Software and hardware in the loop

Design New Mobility Services



Mobility Systems Architecture
 Evaluate & Communicate Mobility Concepts

Legend

IPEs delivered in this first ISE version

IPEs planned for future release

Capabilities of our roles and software

Rail Operations Efficiency:

Integrated Mobility Services across all modalities and systems

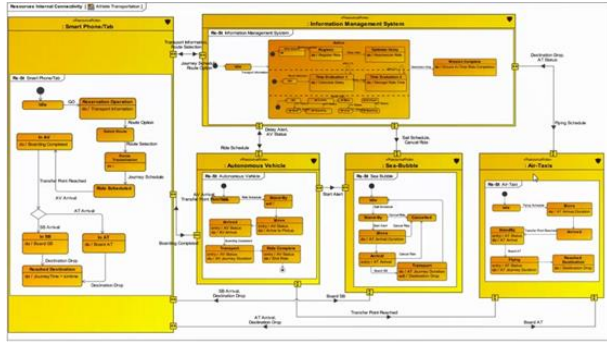
- ▶ Rail is offering a poor mobility experience
- ▶ The door to door mobility requirement is not addressed
- ▶ No integration of various mobility offerings to facilitate:
 - ▷ Physical connections between modalities
 - ▷ Booking of each resource (seats, vehicle, parking/charging space)
 - ▷ Schedule adjustment in case of perturbation



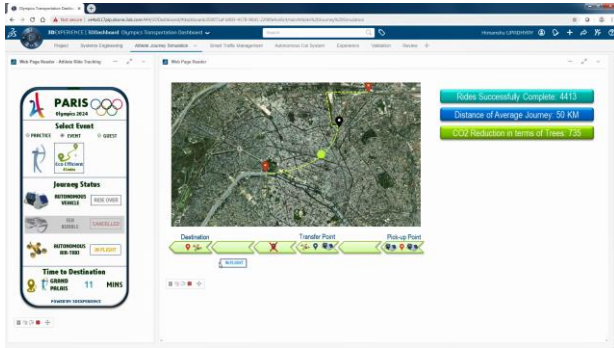
The numerous mobility systems need to be formally designed to create an overall consistent service architecture



Mobility Systems Architecture



Model each supporting systems and their interactions



Simulate the behavior of the overall system of systems

Design attractive (door to door) Mobility Services across all modalities and systems

- ▶ Increase customer/citizen satisfaction
- ▶ Increase the load factor of the mass mobility backbone
 - ▷ Reduce the price of the service and/or the margin of the Service operator

Define the services through multiple connected systems at different lifecycle phases and considering all stakeholders:

- ▶ Understand the envelop of the target mobility services
- ▶ Examine high-level design alternatives
- ▶ Define system configurations **compliant with the operational needs**
- ▶ **Improve communication and buy-in** with standard-based System Architecture definition
- ▶ Deliver consistent and complete specifications of the systems including their interfaces
- ▶ **Automatically verify system requirements**

What: Smart Mobility Operations

For mobility services with a **first focus on Railways and Train Operators (5 Processes)** and already many references

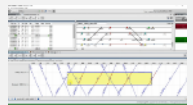
Operate



THALYS



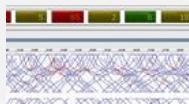
Public Transport Scheduling



Rail Service Scheduling
Rail Fleet Scheduling
Rail Crew Scheduling



Public Transport Planning



Rail Timetable Planning
Rail Fleet Planning
Rail Crew Planning



Public Transport Operations



Rail Service Operations
Rail Fleet Operations
Rail Crew Operations



Mobility Service Operations



On-Demand Transport Planning & Optimization



Mobility for people and business

Rolling Stock Maintenance Management



Maintenance data management
Asset Health Intelligence
Assets Maintenance Planning & Scheduling



Validate / Certify New Mobility Systems



Mobility Systems Virtual Testing



Design New Mobility Services



Mobility Systems Architecture

Design

Legend

IPEs delivered in 21xFD05

IPE in nego 22x

Capabilities of our roles and software

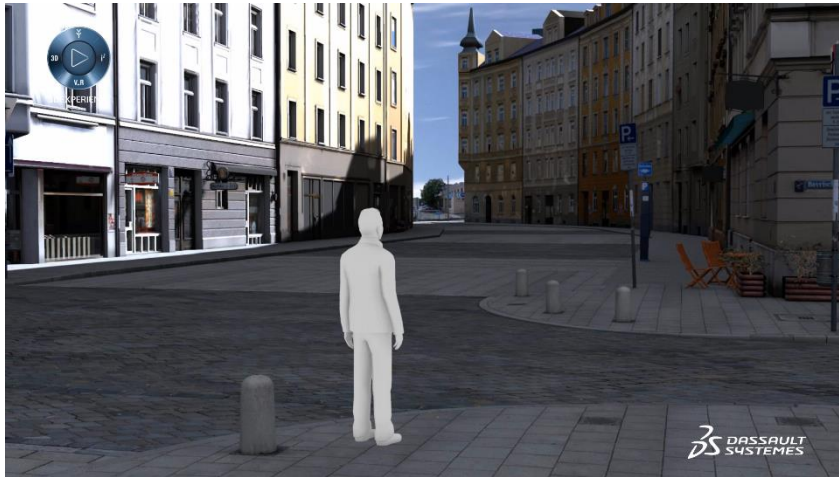


Mobility Service Planning

On-Demand Transport Optimization

Optimize the utilization of a fleet of Shared Vehicles for On-Demand Passenger transport

- ✓ Simulation of alternative scenarios
 - Fleet type and size
 - Covered territory and type of demand
- ✓ Real-time planning & Optimization



Mixed fleet of Shared Vehicles

- Variation in number of seats
- Special seats (baby-seats, special needs)
- Level of autonomy (electric vehicles)

External conditions

- Traffic / congestions
- Traffic management
- Regulations

Optimal transport plan:

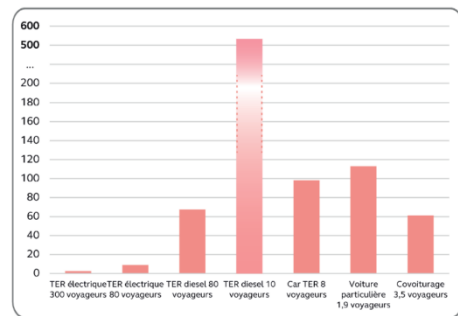
- Vehicle utilization
- Level of Service
- Reduction of costs
- Reduction of emissions

Regional train in France (TER)

- ▶ Operations Statistics
 - ▷ 900,000 daily passengers (excluding Transilien) in 7,000 trains and 1,300 buses
 - ▷ 175 million of train.km, 57.7 billions of seat.km and 13.8 trillion passenger.km (2017)
- ▶ Trains with very **low load factor**
 - ▷ **8.2% with less than 10 passengers** (2,619 / 31,676 counts), 78 passengers per train in average
 - ▶ sample accidents reports: [2 crew members for 5 passengers!](#) and [2 passengers at peak hour \(end of the afternoon\)](#)
 - ▷ 285 stations in France have an average of maximum **3 travelers per day**
- ▶ **High operating cost: average €0.61 per passenger-km** (most expensive transport modality with taxi with 1 or 2 passengers)
 - ▷ Trains service cost = Track Access Charge per train.km = 8.96€ + Crew cost + Unit cost
 - ▷ €1.88 per taxi.km (at least 10 times cheaper)
 - ▷ **Total annual cost of 8.5 B**
 - € (4.1B€ operational cost, 3.6B€ investment, 0.6B€ retirement), 88% subsidized (€3.9 per the regions, €2 per the country)
- ▶ **CO2 emission from diesel TERs:**
 - ▷ Only 57% of tracks used by TER are electrified (11,853 /20,489 km)
 - ▷ **125g of CO2, per passenger-km in average = 2.5 * hybrid car with 1.3 passengers** (+ yard movements, unit and crew repositioning...)
 - ▷ For diesel trains with 10 passengers, it reaches **539g per passenger-km**.
- ▶ **Poor service** because of aging infrastructure and assets
 - ▷ 9 137 km of tracks in poor state (5000 km of track poorly used or not used)
 - ▷ Need to **invest 6.9 B€ before 2028** to get back to nominal speed (1M€ per km of maintenance required)



Émissions de gaz à effet de serre de différents modes de transport en 2016 (en gramme de CO2 par voyageur-kilomètre)



Source : Cour des comptes d'après SNCF Mobilités et Ademe

Context: The SNCF project

Business Drivers

- ▷ Local utility pressure (recently reinforced/yellow vests)
- ▷ End-of-line service by trains with very little capacity and far from profitability
- ▷ 5000 km of tracks currently little or no use
- ▷ Car manufacturers are looking for autonomy experiments in controlled conditions

Scenario considered

- ▷ **Use old lanes such as private paved roads (without special infrastructure)**
- ▷ **Offer a new service**
 - ▶ based on **standard road vehicles** from car manufacturers (9 seats)
 - ▶ initially with a safety driver or operator depending on the evolution of the regulations before gradually becoming autonomous
 - ▶ last service (typically less than 40 kilometres)
 - ▶ **flexible schedules and stops** (partially on demand)
 - ▶ on old tracks with optional roadside stops (bus stop type)
 - ▶ Possibility to exit the network to the final destination of the passenger (or transport node)
 - ▶ Specific business approach for school and health transport (Hospitals, Ephad)
- ▷ **Maximize car filling with return flows and freight**
 - ▶ Flows that the SNCF controls better than a taxi operator!

Benefits

- ▶ **Reduction in investments**
 - ▷ rolling stock
 - ▷ infrastructure maintenance
- ▶ **Reduction in operating costs**
 - ▷ driver/train driver
 - ▷ car/trains
- ▶ **Best service**
 - ▷ Frequency
 - ▷ speed
 - ▷ origin-destination couples
- ▶ **Modal shift to rail**
 - ▷ Better filling of trains on the main segments
 - ▷ Reduced carbon footprint

The SNCF project: challenges and solutions to address them

► Policy, trade union and user acceptance of this transformation

▷ Definition of an offer / scenario / traveler route

Current scope

▷ Simulation of the Passenger Experience

► Passenger's (digital) experience

► Ergonomics

▷ Passenger comfort (services offered by connected cars, etc.)

▷ Privileged access to vehicles on the platforms for people with disabilities with on-board escort service...

▷ Optimisation of supply, sizing of resources and estimation of **operational costs**

Current scope

▷ Measure of impact on **average travel times** and **frequency increase for the population concerned**

▷ Target System System Modelling

▷ Specifications of vehicles on the axes of use (connectivity, capacity, specific needs for passengers with disabilities, freight...)

▷ Animation of the external mobility eco-system at the SNCF

► Safety and Security on closed lanes in case of (semi-)autonomous driving

▷ Simulation of the behaviour of autonomous vehicles in a degraded situation (on closed roads) private

▷ Collision Alert / Control System... consolidating:

► Intrusion information in closed zone limits (simple hardware with for example an open door detector)

► Position information and alerts sent by the vehicles

▷ Specifications for on-board systems for closed-site autonomy

► Minimum signage (white line? road signs...)

► Detection of personal or animal intruders, V2V, V2X...

Mobility Operations

Fleet re-balancing and « Shuttler » re-positioning



The screenshot displays the 'ABG Shuttle Optimization Application' interface. At the top, it shows 'Company: Dallas' and 'Scenario: Manager - Libint - IntegratorProxy - LibKPTTrackerDataset - LibMPPN'. The main dashboard includes several key performance indicators (KPIs):

- Ideal Cost Achievement:** 54.67%
- <1 hr. late moves:** 59.51%
- Planned moves:** 136 / 163
- Planned repositions:** 106 / 112
- Driver shift utilization:** 93.0% (+2B)
- Today's Fulfillment:** 96.72%
- Total Moves:** 13 (+7) / 163
- Demand Moves:** 13 (+7) / 142

The interface is divided into several sections:

- Shipsments, Repositions, Inventory chart, Analysis:** A list of moves with columns for 'Move', 'Pickup', 'Deliv.', 'Deliver by', 'Hours', and 'Team'. A blue box highlights 'Van to reposition Shuttlers' and 'Car moves to be planned'.
- Moves [Van]:** A table listing specific moves with columns for 'Name', 'CO', 'CO status', 'Status', 'CLT', 'CLT', 'Delivery end', and 'VIC'. A blue box highlights 'Shuttler team plan'.
- Map:** A map of the Fort Worth area showing routes between locations like Denton, Fort Worth, and Arlington. A blue box highlights 'Routes of the shuttlers' and 'Routes of the vans'.
- Workflows, Employees, Days:** A section for managing resources, including a table of employees with columns for 'ID', 'Name', and 'ShiftStart'. A blue box highlights 'Shuttlers to execute the moves'.
- Routes [Van]:** A table showing routes with columns for 'Name', 'ID', 'Midday', 'ID', 'ShiftStart', and 'Max.'. A blue box highlights 'Routes of the shuttlers' and 'Routes of the vans'.

Optimize vehicle position
(airport <=> downtown)

Optimize drivers (shuttlers)
pickups with vans

Up to 30% reduction in
shuttling cost

360° Cockpit to track efficiency of city mobility projects



Who to address?

Decreasing priority order

▶ **Railway / Train operator**

- ▷ **Direct replication of our Quintiq references...** even if
 - ▶ Lack of maturity / high project cost
 - ▶ Public sector RfX process and T&C not accepted by DS
 - ▶ Only a few big opportunities per year

▶ **Public Transport**

- ▷ **CATIA System (CATIA Control build) to be promoted to metro companies for acceleration of CBTC deployment**
- ▷ Quintiq: Lack of references in Metro or Buses... strong competition

▶ **OEM diversification towards mobility services**

- ▷ Sample: Toyota, Geely/Caocao, Daimler, SEAT Code VW

▶ **Other mobility services**

- ▷ Fleet management / dispatch (e.g Avis)

▶ **Tactical B2B:**

- ▷ Resorts, Hospital,...
- ▷ Mobility of employees

▶ **Transport Authority / City**



Ecofriendly mobility is Multi-modal

