Case Study Descriptions

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Revision control / involved partners

Following table gives an overview on elaboration and processed changes of the document:

Revision	Date	Name / Company short name	Changes
1	09/03/22	Paola Pellegrini / univEiffel	Schema
2	07/04/22	Fabrizio Cerreto / BDK	Chapter 4
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4	03/05/22	Fabrizio Tavano / RFI	Chapter 3
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6	17/05/22	Nathalie Botticchio / univEiffel	Quality check

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Executive Summary

The objective of D5.1 Case Study Description is to detail all relevant characteristics of the three case studies which will be considered for the assessment of the SORTEDMOBILITY self-organization approach.

For each case study, this deliverable reports on the available information on: railway infrastructure and rolling stock; current timetables; demand patterns. Based on these data, simulation models are generated in WP5. Moreover, relevant perturbations that will be used in the impact assessment are described in this deliverable.

After an introduction in Chapter 1, Chapter 2 concerns the Guingamp Paimpol line, in France

Chapter 3 presents the network linking the stations of Pioltello and Rovato, in Italy.

Chapter 4 deals with the Copenhagen suburban rail network, in Denmark.

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ACCM	Apparato Centrale a Calcolatore Multistazione (Multistation central interlocking)
CBTC	Communication Based Train Control
DCO	Dirigente Centrale Operativo (Central Operational Director)
EMU	Electric Multiple Unit
HS	High Speed
IM	Infrastructure Manager
LFDT	Ligne de Desserte Fine Du Territoire (Line of territory extensive service)
LH	Long Haul
RU	Railway Undertaking
SCMT	Sistema di Controllo della Marcia del Treno (Train run control system)

1 INTRODUCTION

The self-organization traffic management principles proposed by SORTEDMOBILITY will be assessed in three case studies. The description of these case studies makes the object of this document.

The first case study is supplied by the French railway infrastructure manager (SNCF). It concerns a regional, low traffic line in the Britain region, connecting the cities of Guingamp and Paimpol. Transport demand is quite low on this line, but its role is critical to ensure accessibility in the area. This line is highly critical for the region accessibility. In the future, it may be equipped with modern and specific types of light vehicles. Such vehicles open interesting and innovative possibilities as for traffic management.

The second case study is supplied by the Italian railway infrastructure manager (RFI). It concerns the line section between Pioltello and Rovato, near the city of Milan in the Lombardy region. This line hosts mixed high speed, regional and freight traffic. The share of each type of traffic is remarkable. In this line, railway plays a threefold role, which can be enhanced through self-organizing traffic management. First, it favours the accessibility of the small urban centres it serves through its regional traffic. Second, it enables cargo transport sustainability through its freight trains. Third, it ensures the high-speed connectivity between the main cities in the north of Italy (Turin, Milan, Padua and Venice).

The third case study is supplied by the Danish railway infrastructure manager (BDK). It concerns the Copenhagen suburban network. This network is particularly interesting for its fundamental role in the urban passenger mobility in this capital city. Moreover, a very large amount of data on passenger behaviour and preferences are available, and this is a major benefit SORTEDMOBILITY will exploit in WP2.

In addition to the description of the infrastructure, rolling stock, timetable and demand characteristics, this deliverable also describes the type of perturbation scenarios that will be considered in the self-organization performance assessment. As detailed in deliverable D1.1 - Operational Principles and Key Performance Indicators for Self-Organizing Railway Operations, these scenarios represent perturbed traffic situations due to different causes. Such situations are today managed by IMs without negotiation with other stakeholders. As such, they are a good first test-bed for the self-organization principles, which may operate in a fully automated traffic management context.

2 GUINGAMP-PAIMPOL CASE STUDY

The Guingamp-Paimpol line is located in French Brittany and belongs to the French “LDFT” category (Line of territory extensive service), which gathers the small lines with very weak train traffic and people flows (Ministère de la Transition Ecologique et Solidaire, 2020). In a context of mobility problems in sparse and inter-urban areas, SNCF has recently developed very light trains. They are adapted to these territories and to the weak traffic and crowding. They are expected to progressively replace the classic regional trains which are oversized and too heavy for the needs observed. In addition, given that they are very light, the rail wear will be strongly mitigated, as well as the maintenance cost.

Furthermore, it has to be noted that a great part of the controllers’ work concerns the small lines. Concretely, they have to pay a lot of attention to these areas, with very little traffic, whereas they should focus more on those with higher traffic and more crowded trains.

For SNCF, the self-organising traffic management presents several advantages, listed below:

- Make the least dense traffic areas autonomous, so as to let controllers focus on parts of the network with higher traffic density and more crowded trains,
- Provide highly flexible and on-demand railway transportation connected to regional railway traffic,
- Let concurrent RU’s operate their trains with different utility functions,
- Recover more rapidly from perturbations than a centralised approach.

The Guingamp-Paimpol is particularly suitable to assess these advantages. The main peculiarity of this case study is hence its being a small line which could be used in a first real-life demonstration, before considering passing on a greater control area. Moreover, its short infrastructure favours algorithm checking and validation.

2.1 Infrastructure description

The Guingamp-Paimpol line, depicted in Figure 1, is referenced as line 486 000 of the French network, connected to lines 420 000 (Paris Montparnasse - Brest) and 485 000 (Guingamp – Carhaix). The line is mainly a single track with one siding way in the Pontrieux station in the middle. Second tracks available for operations are also present in the end stations: Guingamp and Paimpol.

The line has the following characteristics:

- Length 36.8km
- Single track with simplified signalling
- Served stations: Guingamp, Gourland, Trégonneau-Squiffiec, Brélidy-Plouec, Pontrieux halte, Pontrieux, Frynaudour, Traou-Nez, Lancerf, Paimpol.
- Not electrified.

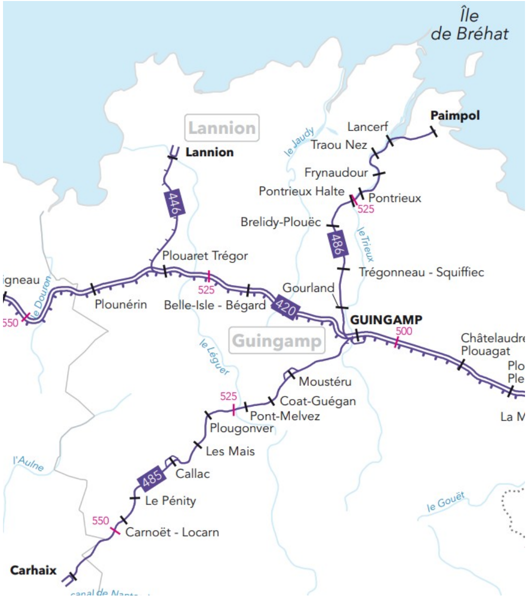

Figure 1 Map of the railway network in North Brittany (France)

As shown in Figure 2, the signalling is very simple, with just a signal in the Pontrieux station corresponding to a “*carré*” in French signalling. It stands for absolute restriction of trespassing. Concretely, the train driver must wait to be authorized by the controller to enter the next section. The order is given by phone call. As a consequence, the line sectioning is composed of only two sections: Guingamp-Pontrieux and Pontrieux-Paimpol. Peculiar operations such as meeting and overtaking can only be done in Pontrieux station by using the second track. A description of the Guingamp station is also given in Figure 2. It shows the junction that allows interactions with the regional (Brest and Saint-Brieuc) and national traffic (towards Paris-Montparnasse).

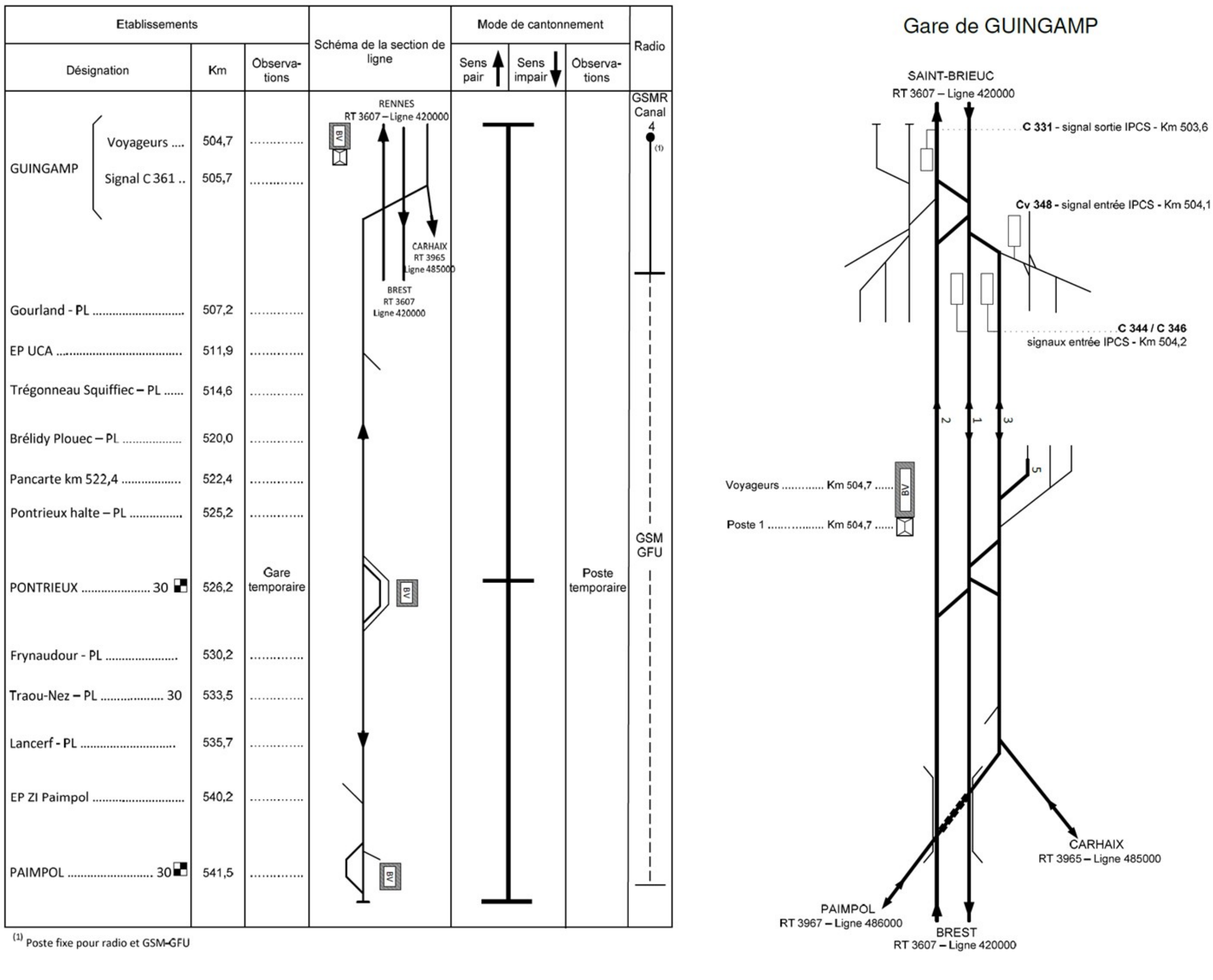

Figure 2 Guingamp-Paimpol line infrastructure description: station positions, sections, signalling and Guingamp station

The speed limitations applicable to passenger trains are given in Table 1. For freight trains other speed limitations would be applicable.

Table 1 Speed limitations on the Guingamp-Paimpol line

Guingamp..................		Paimpol.......................	
	70		70
Km point 522,4...........		Lancerf.......................	
	55		55
Lancerf.....................		Km point 522,4...........	
	70		70
Paimpol....................		Guingamp..................	

Proposal of infrastructure evolution

To make more decisions and actions possible, e.g., meeting, crossing, overtaking, two siding tracks may be added in the perimeter. To do so, two stations seem to be good candidates with regards to their configuration and their location: Brélidy and Lancerf, as depicted in Figure 3. These two stations are indeed buildings and not simple halts, and they are located in the central positions of their respective sections: Guingamp-Pontrieux and Pontrieux-Paimpol. The case study considered in SORTEDMOBILITY includes these two additional sidings.

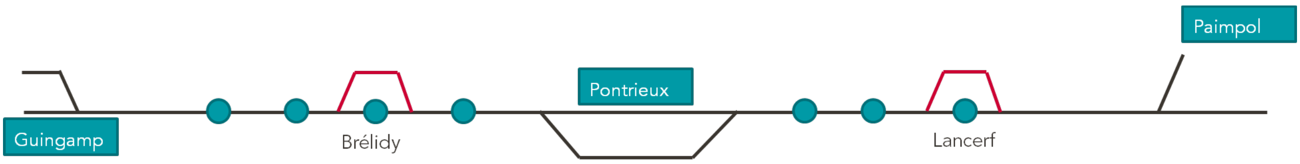

Figure 3 Evolution of the infrastructure: additional siding tracks in Brélidy and Lancerf stations

2.2 Timetable description

One trip lasts around 45 minutes. Due to the very weak traffic and except between 6am and 7am, only one train circulates at a time. The frequency is of six trains a day per direction. Between 6am and 7am, two trains circulate simultaneously on the line. Each of them departs from an end of the line, and they meet in Pontrieux station.

In the SORTEDMOBILITY project, a higher frequency will be considered. Through such frequency, SNCF aims to incite and increase the modal shift to train transportation. The increase will consist in at least doubling the number of circulating trains.

2.3 Rolling stock description

In replacement of the heavy regional trains, not adapted to the sparse areas and to the weak people flows, SNCF is currently developing very light trains. One of them is named DRAISY (see Figure 4) and it is expected to be deployed in the coming years. The technical data of the DRAISY train are given in Table 2.

Figure 4: DRAISY train

Table 2 DRAISY technical data

A, B, C	800, 0.12, 0.8
Max speed	100 km/h
Max gradient	30 ‰
Max acceleration	1.3 m/s²
Service braking	1.5 m/s²
Emergency braking	3.0 m/s²
Empty weight	17,000 kg

Max weight	24,000 kg
Maintenance cost	1€/km

The DRAISY operating system may be different from the actual ones given that DRAISY trains will be operated on lines separated from the rest of the network: the control areas will be thus different. The operating system, which has still to be defined, will have to be able to give flexibility to operations, unlike the current one. Traffic self-organization might be a good solution to operate such new rolling stock in sparse areas where the demand is low.

Introduction of virtual coupling

Given that DRAISY vehicles have little capacity, it might sometimes be necessary to couple vehicles to compose a train. This will, on the one hand, increase boarding capacity and, on the other hand, limit the railway capacity utilization. Up to three DRAISY vehicles can be virtually coupled simultaneously.

The interest of such a manoeuvre is to adapt train compositions to passenger flows and travelling demand. Indeed, based on demand forecasts, multiple vehicle compositions may leave a terminal station, have the head vehicle eventually uncoupling and continuing directly towards the opposite terminal station, possibly coupling with other DRAISY units.

The above mentioned introduction of additional siding tracks and the virtual coupling may make the system very flexible and efficient to match demand. The example in Figure 5 illustrates the recomposition of two trains with the coupling/uncoupling capability.

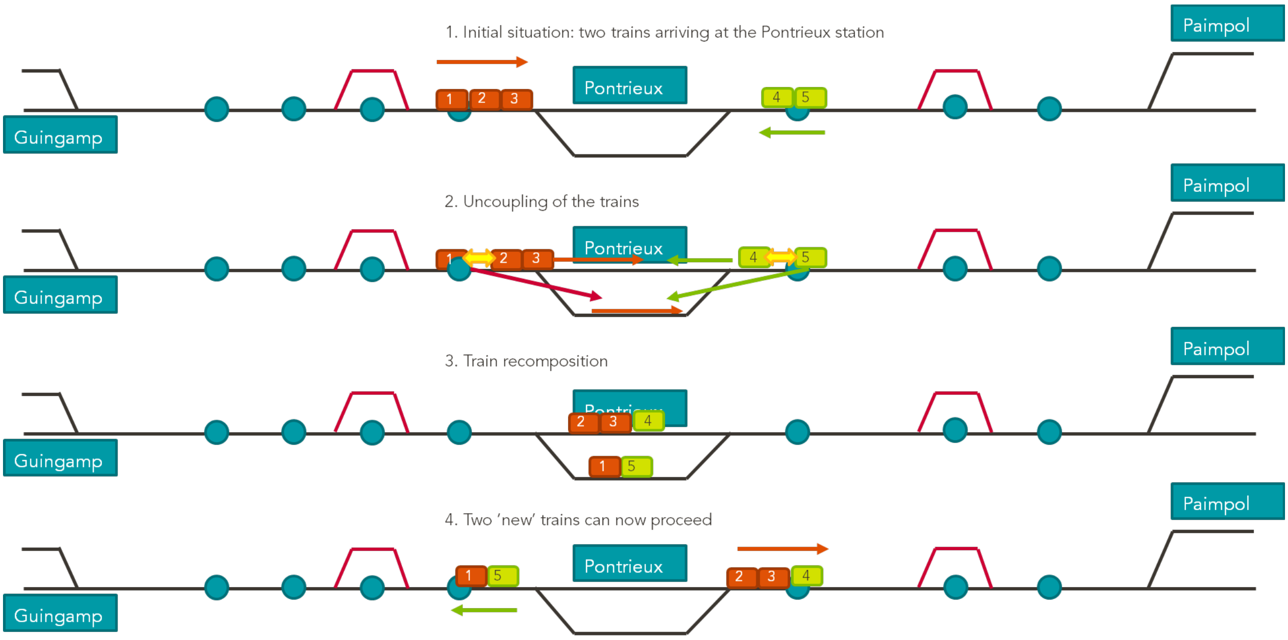

Figure 5 Example of recomposition of two trains at the Pontrieux station

2.4 Demand characteristics

Current demand consists in an average of 192 passengers transported per day. Ideally, the modal shift toward railway allowed by increased frequency may bring to double this number.

Unfortunately, detailed counting on the distinct OD pairs is not available. Hence, assumptions are made on passenger flows based on socio-economic and demographic data. This assumption will essentially rely on a gravity model to estimate flows.

2.5 Relevant perturbation scenarios

In a classic situation with a planned transport and a timetable, variations may be applied on:

- Departure times: a random delay can be added, following a truncated Gaussian distribution in an interval to be defined, e.g., [0, +120s], average 30s.
- Travel times: an additional time can be added, following a truncated Gaussian distribution in an interval to be defined, e.g., [-5%, +50%], average +10%.

- Stopping times in station: an additional time can be added, following a truncated Gaussian distribution in an interval to be defined, e.g., [-5%, +15%], average 0.

Variations on the demand could also be introduced. Given that one of the main activities in this area is tourism, we can imagine scenarios in which unexpected traveler flows coming from Paris alight in the Guingamp station for a connection towards Pontrieux and Paimpol. The sudden rise in the demand would incite the system to engage more DRAISY vehicles to take travelers in charge, exploiting virtual coupling. Vehicles may have different service end, some keeping operating the planned service.

3 PIOLTELLO-ROVATO CASE STUDY

The Italian case study focuses on a line with a high heterogeneous traffic (regional trains that make all stops or are express, freight, long haul (market and non-market)). This traffic mix is a main peculiarity of this case study. It makes this line particularly challenging for self-organization, as different types of trains, operated by different RU’s and with different performance measures, have to participate to the consensus seeking process.

The chosen line is a portion of the Milan-Brescia one, in the Lombardy region. Specifically, we focus on the section from Pioltello to Rovato. This line is heavily trafficked and requires complex management by the DCO, whose choices are critical for service regularity. To ensure the correct adherence to the planned timetable, strongly periodic, and guarantee an adequate level of service, it is necessary to respect set punctuality standards.

The line is also strongly characterized by traffic of commuting passengers that reach the Milan hub.

3.1 Infrastructure description

The infrastructure taken into account concerns the Milan-Brescia line, in the about 40 km section from Pioltello to Rovato. Its infrastructure is schematized in Figure 6.

Two lines branch off from Pioltello station:

- Pioltello-Treviglio-Rovato (VE LL) line which from Pioltello reaches Rovato, encountering a large number of stations and stops,
- Pioltello - Bivio Casirate - Treviglio (VE AVAC) line which runs parallel to the VE LL line up to Melzo Scalo, and then enters the Milan-Brescia high-speed line at the Casirate junction. From Casirate, through an interconnection, the line also branches off to Treviglio.

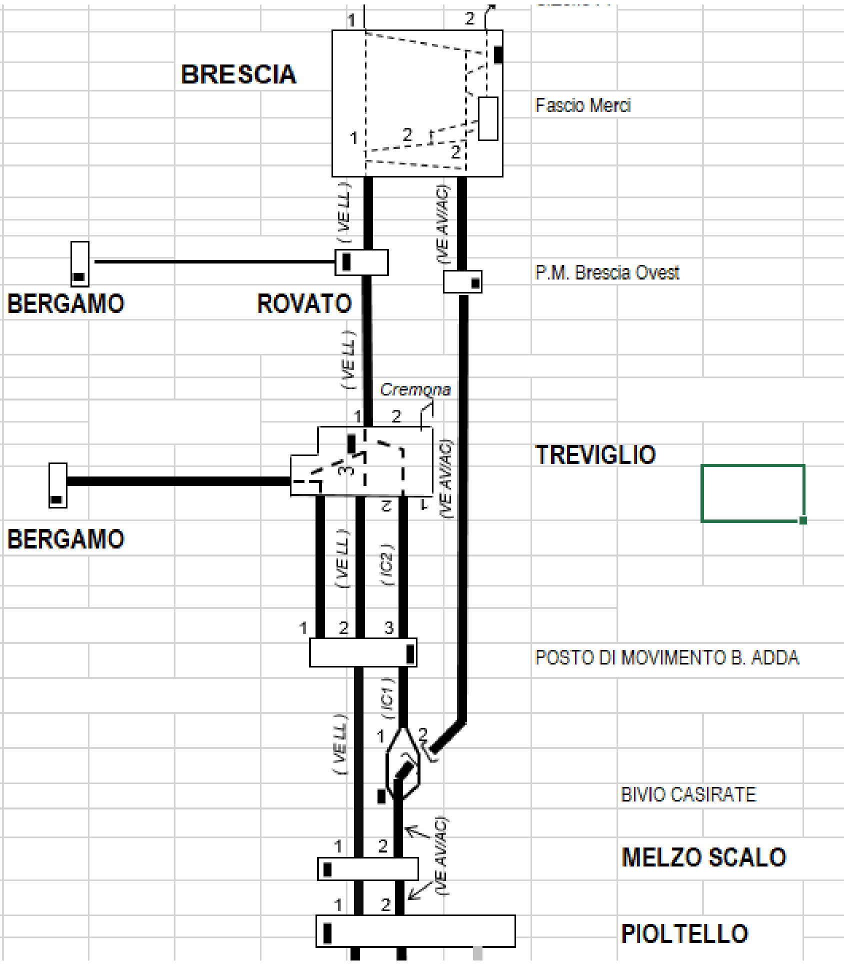

Figure 6: Schema of the Pioltello-Rovato line

The line is operated by a DCO (DCO Brescia) with an ACCM equipment, equipped with SCMT and Automatic Electric Block. All intermediate stations are, therefore, unattended and managed remotely (possibility of active on-site presence of human resources).

The Treviglio and Rovato stations are branch stations where other lines / traffic connections converge with the considered line.

Along the VE LL line there are 15 Service Locations, shown in Figure 7. They correspond to:

- six stations: Pioltello, Melzo Scalo, Cassano d'Adda, Treviglio, Romano and Rovato
- eight stops: Vignate, Melzo, Pozzuolo Martesana, Trecella, Vidalengo, Morengo B, Calcio and Chiari
- one Movement Station: PM Adda

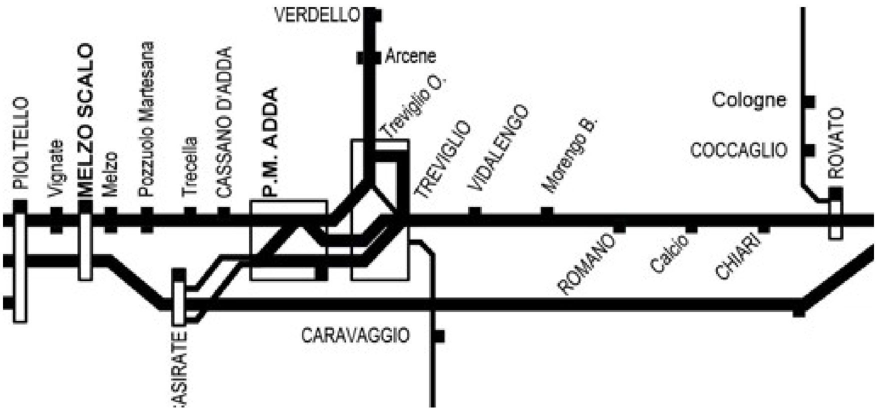

Figure 7: Service locations on the Pioltello-Rovato line

3.2 Timetable description

Traffic is mixed between Pioltello and Rovato. Passenger trains, both regional and long haul, and freight trains circulate there.

On the HS line between Milano Lambrate (further on the line besides Pioltello) and Bivio Casirate there are nightly interruptions for 5 nights a week, from Sunday / Monday to Thursday / Friday, to allow maintenance. The longer interruption occurs on the Pioltello - Melzo scalo section and lasts three hours.

Freight traffic is particularly congested at night and runs, with few exceptions, on the high-speed line between Treviglio and Pioltello, with volumes of about 40 trains per day in each direction. Between Treviglio and Rovato, on the other hand, there are about 30 trains per day in each direction. The difference is mainly due to the fact that some trains have their origin or destination in Melzo Scalo, which is an important intermodal airport, also specialized in the management and stock of dangerous goods.

Passenger traffic consists of regional and long haul trains. It is concentrated during the day, with the exception of two pairs of international trains Milan - Vienna and Venice - Paris, which run at night.

Erreur : source de la référence non trouvée graphically represents passenger traffic on the considered line. Long haul traffic is shown in red. It includes about 30 trains per day in each direction, consisting mainly of Milan - Venice connections. It is concentrated in the Pioltello – Casirate junction section. From Casirate junction the flow diverges, with the exception of 5 couples, along the HS section Casirate junction - Brescia, which equipped with the ETCS / ERTMS system.

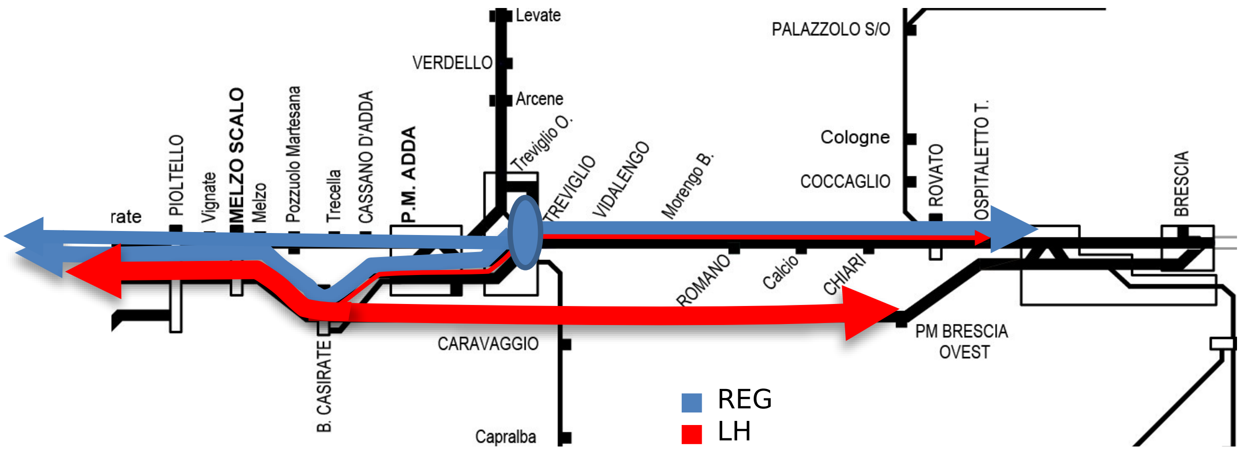

Figure 8: Representation of passenger traffic in the Pioltello-Rovato line

Regional traffic covers three routes with different types of services. About 35 trains per day in each direction run the Treviglio - Rovato route. The Pioltello - Treviglio route is crossed by about 120 trains per day in each direction, divided equally between the HS and the conventional line. Treviglio is a critical hub for regional traffic, with about 50 trains per day in each direction.

Overall, the regional services can be divided into fast regional trains, which run along the HS line, and regional trains that run along the traditional line and stop in intermediate locations.
Rolling stock description

The rolling stock used in the line section considered differs depending on the type of service it carries out.

In particular:

• Suburban and regional services: standard or electric rolling stock, which reaches a speed of up to 160 km / h (E464 locomotives + 6/8 carriages or electric train equipment Ale 711/710).

• Long distance trains: rolling stock that reaches speeds of up to 250 km / h

• Freight traffic: an average maximum speed of 80 km / h can be considered.

3.3 Demand characteristics

Figure 9: Position of the Pioltello-Rovato section on the Milan-Venice line

As shown in Figure 9, in relation to long haul traffic, the considered section is part of the Milan - Venice line. LH trains originate largely from Milan or Venice, other services are originated in Bolzano, Brescia, Trieste and Udine. There are also international trains from Geneva, Zurich, Vienna and Paris. These trains mostly serve leisure or work travelers.

At the regional level, the section serves direct commuter traffic to Milan in the morning and from Milan in the evening. Commuters who converge to the stations between Treviglio and Pioltello have slower services available with longer intermediate stops, while fast services collect demand from a larger area that can be considered extended to Bergamo and Brescia. Integrated day tickets and season tickets are available, at a distance-increasing rate, according to an integrated zone tariff system, which affects Milan and the neighboring municipalities (Figure 10).

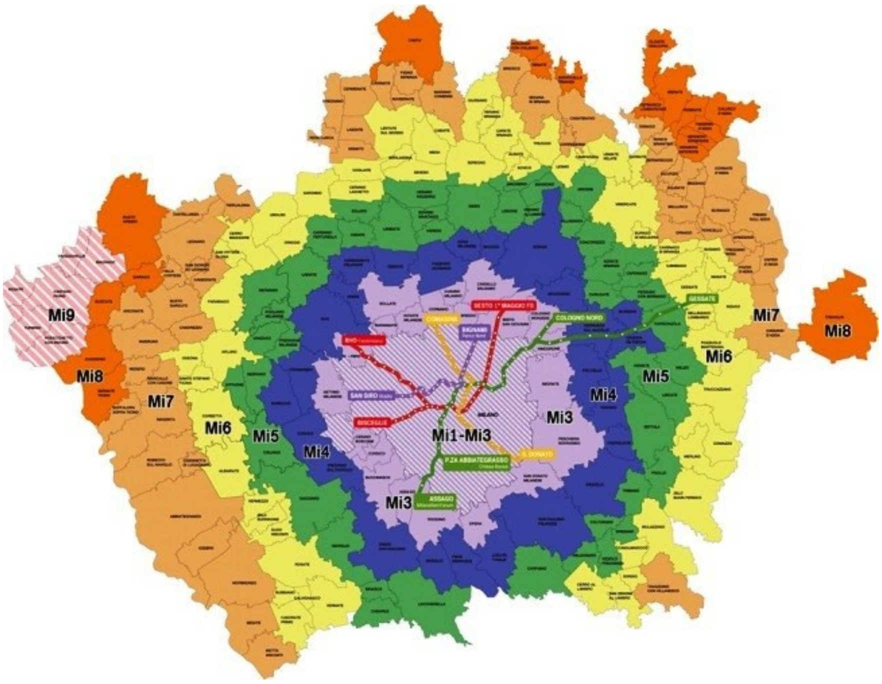

Figure 10: Geographical organization of distance-increasing ticket rates in the Milan area

As mentioned in Section 3.2, freight traffic is concentrated at night. This section includes the locality of Melzo Scalo, which is an important intermodal port. In addition, the Pioltello-Rovato section is inserted within the European Mediterranean freight corridor (Figure 11). This is the most important European horizontal freight railway axis, connecting the Mediterranean basin with central Europe and Ukraine. The Corridor connects over 100 Intermodal Terminals, five of the main Mediterranean Sea Ports and two important River Ports (Lyon and Budapest).

Figure 11: European Mediterranean freight corridor

3.4 Relevant perturbation scenarios

Perturbation scenarios considered in SORTEDMOBILITY will be of the following types:

- endogenous small sisturbances: e.g., a problem to a door increasing the dwell time of a train in a station, or a delayed train entrance in the network;
- temporary speed limitation;
- unavailable track at a station where re-routing through alternative tracks is possible;
- exceptional demand peaks: e.g., due to special events or multi-modal transport issues.

For the first three types, demand will be considered inelastic: dwell times will depend on train schedules, and they will depend on the number of passengers boarding and alighting, but there will not be a change in demand based on the characteristics of the service.

For the fourth type, national studies (including the white paper from nuovo trasporto viaggiatori and other reports from transport authorities) will be exploited to properly model multi-modal elasticity.

Copenhagen case study

The Copenhagen case presents a radial infrastructure design accommodating very dense traffic: all trains coming from different branches meet at a central section with a 1.5-2 minute headways through the day. In such a network, the shared central section constitutes an intrinsic capacity constrain for all the branches, making it difficult to raise frequencies on each branch over 1 train every 5-10 minutes. The introduction of self-organization among trains can bring improvement on different aspects of operations. Assuming individual trains to negotiate priorities and the passing order at junctions can be beneficial in the traffic management, reducing the interdependences between different lines in the timetable. The headway buffers might then be reduced, with positive effects on frequencies on both the common section and the branching lines.

The negotiation possibilities in such a network type range on different types. Based on the current demand, negotiations might include changes on-the-go in the stopping patterns on the fingers, possibly transferring some of the stops from a slow service to the next fast service, to increase the overall experienced punctuality, or to better combine the arrival and departure times with other modes of transport at exchange-stations. In addition, trains with different origins and destinations might virtually couple and decouple on the go. A distributed intelligence will make it possible to bundle together trains entering and leaving the central stretch from different origins but to common destinations without the need for strict operational rules in the planning phase, such as specific sorting of compositions with multiple destinations.

3.5 Infrastructure description

For the SORTEDMOBILITY research project, the current infrastructure will be enriched by hypothetical network extensions that have been under discussion in the recent years. The central shared section will be flanked indeed by a parallel tunnel connected to all the branching lines, doubling theoretically the capacity on the network (Holgersen, 2020). This scenario is chosen over the current infrastructure or planned developments as it challenges the whole concept of self-organized rail traffic even on a higher level than the original network. There will be introduced several new junctions, extending both the quantity and quality of decisions to negotiate among trains. Individual services might decide whether they should cross the central section through the old or new central section, based on the operations circumstances and expected demand. Moreover, the number of connections to other means of transport would increase considerably, giving more possibilities to develop the demand prediction models.

Figure 12 depicts the current S-bane network. Exception made for the "Ring line" (880, light blue, Hellerup – Ny Ellebjerg), which track layout only connects to the rest of the network at Hellerup, the lines form a radial-shaped network: the central section Svanemøllen – København H is double-tracked and is shared among all the services. The six fingers branch out as follows:

- Svanemøllen – Farum (840)
- Svanemøllen – Hillerød (820)
- Hellerup – Klampenborg (860)
- Dybbølsbro – Køge (850)
- Dybbølsbro- Høje Taastrup (810)
- Valby – Frederikssund (830)

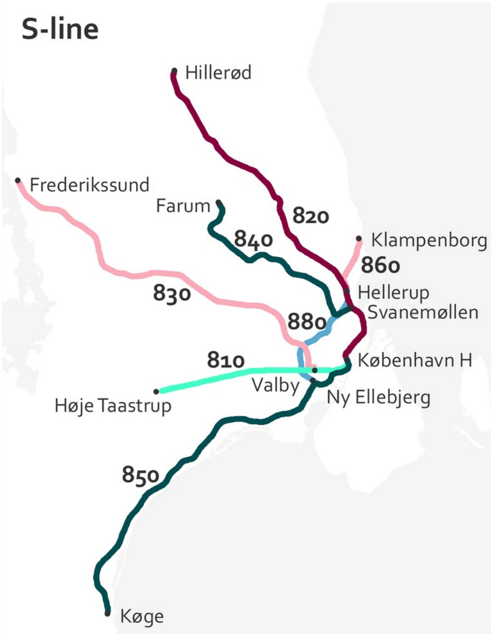

Figure 12: The current S-bane network (Banedanmark, 2022a)

The detailed track layout of the network can be retrieved on Banedanmark's webpage, technical drawings section (Banedanmark, 2022b, 2022c).

The network is undergoing a massive change in the signalling system, switching from ETCS-L2-like system, based on track sections and continuous communication ground-train, to a CBTC system with train-integrity check, and train-borne positioning system. Therefore, track sections are being dismissed on the open line and only kept at stations, which boundaries are protected by axle-counters. The Danish ministry of transport and the Danish State Railways are investigating the feasibility of driverless operation in the coming future (DSB, 2021), where self-organizing rail traffic would be the natural conceptual evolution.

3.6 Timetable description

The S-tog services reflect the network structure and depart typically at the end of a finger, cross the shared section in Copenhagen, to eventually reach the end of another finger on the opposite side. The combination of the fingers has changed several times during the years to accommodate both demand expectations and technical constraints, but it is kept constant during a timetable-year. On the central section, trains run on a metro-style pattern, stopping at all stations, and running as fast as possible to minimize the capacity consumption. On the fingers, trains typically alternate between a fast, long-reaching service, and a slow, short-ended one. The fast services skip minor stops to run faster and depart typically from the central section just before a slow service to reach the previous slow service at the end of the line, and vice versa in the opposite direction.

When considering the new tunnel under Copenhagen, the service structure will be adjusted multiplying the service lines, which will be distributed over the two tunnels.

In both cases, the so-called “Ring line” will be operated independently from other lines as it is almost entirely independent and only shares the infrastructure at Hellerup station in specific circumstances.

The two different service structures are visible in Figure 13.

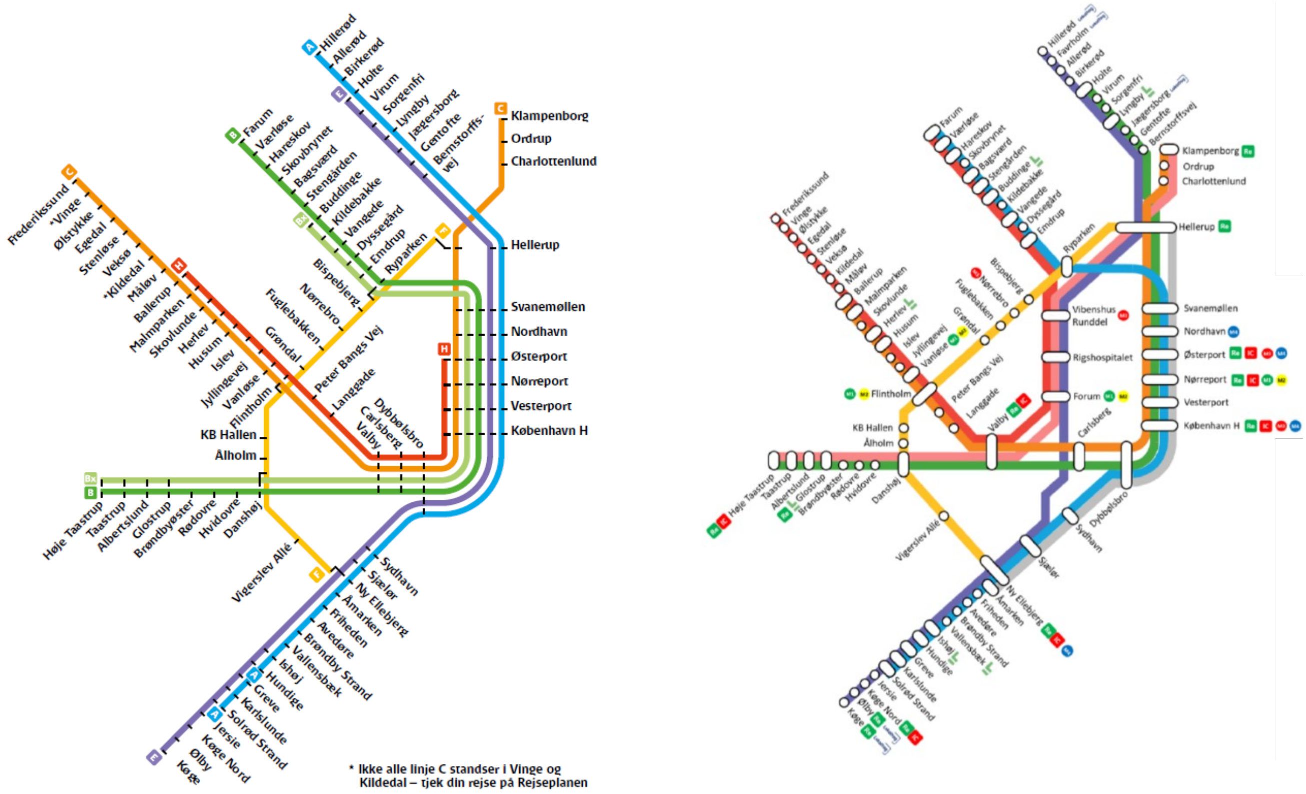

Figure 13: The S-tog service structure in 2022 (left) (DSB, 2021), and assuming two tunnels in the central section (right) (Holgersen, 2020)

3.7 Rolling stock description

The Copenhagen suburban rail network is currently operated by a homogeneous fleet built purposedly for the context. Although the process for the acquisition of a new fleet in the coming years is in progress (DSB, 2021), simulations will be based on the rolling stock currently running in the network, as the main characteristics are expected to be kept in the new fleet.

The current fleet consists of high-density wide-body EMUs (“Litra SA”), built by Alstom-Siemens around the year 2000 (Figure 14). The 84-m-long trainsets host around 700 passengers and have dedicated room for bicycle transport, which is one of the most relevant success factors for the attractiveness of the suburban rail service in the area. The axle-arrangement is rather peculiar, having the individual coaches single motor-axles. The in-total 1720 kW are distributed over 80% of the axles, and guarantee high acceleration, up to 1,3 m/s², necessary for frequent stops. Around a quarter of the trainsets are built in shorter version

("Litra SE"), approximately 43 m, 860 kW, with same characteristics, increasing the operations flexibility and responsiveness to demand variation. All the trains can operate speeds up to 120 km/h.

Figure 14: The S-tog trainsets (DSB, 2021)

3.8 Demand characteristics

The network acts primarily as a commuter service during the weekdays where most of the stations on the branches serve the homes of commuters travelling to commercial areas of the city centre of Copenhagen in the morning, and back again in the afternoon. There are noteworthy exceptions of cities with large industrial and commercial areas that also attract commuter demand, other than Copenhagen, but, due to the limited supply of rail across the fingers, most of this demand is carried by either bikes, buses, or private cars. This is one of the issues that the proposed extra "express" tunnel has been speculated to solve as the travel time through the city centre would be cut considerably, enabling more efficient transit between fingers. A peculiarity of the demand on the S-bane network is the high number of bicycle-carrying-passengers. This is strongly incentivized by the free fare for bikes onboard, and by large spaces dedicated to bicycles distributed along the trains. The reach of the network is considerably extended in this way, making the suburban rail the preferrable alternative even for households located up to 5-7 km away from stations.

The whole transport network is divided into fare-zones, approximately corresponding to main stations in the areas outside the large cities, and the fare structure is based on the distance between zones of origin and destination. The fare collection system in the S-tog network is a hybrid integration into the wider fare collection system. The most prominent one is an automated fare collection system (AFC), also known as a "smart card" system, namely the "Rejsekort" ("Travel Card") which is a nation-wide system interoperable between all public transport modes. It is possible to get discounted versions of the card as a commuter. Generally, travel outside of peak-hours is encouraged with the Rejsekort through fare discounts for the intervals 11h-13h and 18h-07h during weekdays as well as all through weekends and holidays. Furthermore, both period subscription cards and single ticket options are available, though the latter is markedly more expensive than the Rejsekort. All tickets are, however, interoperable between public transport modes.

3.9 Relevant perturbation scenarios

Historical data from realized traffic will be analyzed to identify the delay distributions at individual stations. The focus will be on daily deviations from the schedule. Examples of perturbations of interest are:

- Delayed entry of a trin in the network, e.g., from a depot
- Extended dwell times at stations due, e.g., to passenger flow
- Longer running times between stations due to, e.g., slow-running trains.

These deviations are particularly relevant in such a dense context, where meeting appointments between trains are tight at the junctions and have an impact on the passing order through the central section.

4 CONCLUSION

In this document, we described the three case studies considered in SORTED-MOBILITY. For each of them, we pointed out the peculiarities which make them particularly interesting for assessing self-organizing traffic.

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