Exploitation Plan

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PU	Public	**X**
RE	Restricted to a group specified by the consortium and funding agencies	
CO	Confidential, only for members of the consortium and funding agencies	

Revision control / involved partners

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

Revision	Date	Name / Company short name	Changes
1.0	13/12/2022	Fabrizio Cerreto / Banedanmark	First partial draft
1.1	30/9/2023	Fabrizio Cerreto / Banedanmark	First draft completed with assets exploitation
1.2	2/10/2023	Johan Victor Flensburg / Banedanmark	Quality check and completion of the demand forecasts output
1.3	3/10/2023	Paola Pellegrini / univEiffel	General verification and completion of self-organization algorithm output
1.4	6/10/2023	Egidio Quaglietta / TU Delft	Minor comments

Following project partners have been involved in the elaboration of this document:

Partner No.	Company short name	Involved experts
1	UnivEiffel	Paola Pellegrini
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3	TUD	Egidio Quaglietta

Executive Summary

This document provides a plan for using the knowledge gained during the project SORTEDMOBILITY.

The objective of D6.2 Exploitation Plan is to identify the potential beneficiaryies of the project output, the advantage that these stakeholders can obtain utilizing the individual outputs identified, and a rough description of how this utilization could take place.

Chapter 1 introduces the intended stakeholders, sorted in three groups of beneficiaries of the SORTEDMOBILITY outputs, also listed in the chapter.

Chapter 2 explains the expected benefit and beneficiary group for each output listed. Every output is explored more in detail, and the strategy to make it available for the stakeholders is drafted.

Table of contents

1 INTRODUCTION

Exploitation is a key concept for H2020 projects, alongside Communication and Dissemination. While communication and dissemination promote the project itself and ensure available results for others to use, exploitation is the focus on the actual application of the research results and outputs of the projects beyond its duration.

This document is meant as an initial exploitation plan, possibly to be updated during the development of the SORTEDMOBILITY project. This document complements *D6.1 Dissemination and Communication Plan* developed under *WP6 Dissemination and Exploitation* in November 2021.

1.1 Mapping of SORTEDMOBILITY stakeholders

SORTEDMOBILITY considers 3 target stakeholder groups as main beneficiaries of the project output. These stakeholders will be expectedly able to deploy the knowledge, assets, and solutions listed among the SORTEDMOBILITY output.

- Scientific and research community
- Industrial community
- Decision makers

The stakeholder analysis focuses on the post-SORTEDMOBILITY era. The exploitability is also investigated and supported by the Advisory Board, composed of representatives of the project partners and external partners, representing academics, users, and stakeholder.

1.1.1 Scientific and research community

The scientific and research communities are mainly approached within WP6. As some of the partners of SORTEDMOBILITY such as UnivEiffel, TUDelft, and DTU are academic institutions, many of the scientific and research communities are engaged through those partners. Most of the participants in SORTEDMOBILITY are members of the International Association of Railway Operations Research (IAROR) and have the possibility to carry out the exploitation of the results from the project through their relations and exchanges within the scientific community.

1.1.2 Industrial community

Relevant stakeholders of the railway as well as the wider transportation industry are involved in the project through the dissemination and exchange activities, such as presentations at industrial conferences (e.g., RailCPH) and input collection from practitioners (e.g., surveys within WP1 for the generation of operational principles). The main aim of their engagement is to spread the base-concept of decentralized self-organized traffic in the industrial community to attract its interest and guidance to researchers in the project implementation.

1.1.3 Decision makers

Transportation is often a topic for public discussion as it involves large investments and requires long-term planning of social and urban development. Political decision makers fall within a third stakeholder group, which often already uses some of the models developed in the scientific community and could improve the allocation of investment using more detailed information or utilizing new technologies that allow for higher efficiency in transportation supply.

This stakeholder group includes e.g., municipalities, other local administrations, transport ministries, technical bodies for transport safety and regulation. Part of these stakeholders is reached via semi-governmental partners of the project such as Banedenmark, SNCF and RFI. Others, such as local transport authorities, are instead reached via the periodic newsletter issues as well as the project dissemination events.

1.2 Assets made available by SORTEDMOBILITY

The following assets are identified as main outputs from SORTEDMOBILITY that can be exploited by the target groups:

- Principles for self-organizing rail traffic
- Closed-loop simulation framework
- Demand models
- Self-organizing railway operations
- Simulation models
- Dwell time model

- Data from case studies

These assets are described more in detail in Chapter 2, where characteristics and exploitation possibilities are described individually for the listed assets.

2 EXPLOITABLE RESULTS

2.1 Principles for self-organizing rail traffic

The document Operational Principles and KPIs for Self-Organizing Railway Operations was produced within WP1 (Deliverable D1.1) at the beginning of the project to define the decision-making objectives driving the self-organizing traffic and related KPIs, together with the general operational principles for the traffic management system.

The document lists decision-making objectives and KPIs to assess rail traffic operation, with particular focus on self-organized rail traffic, but also applicable in standard traffic management.

The identified general objective for traffic management is the minimization of system delay, with different weights for Train delays, Passenger delays, and Cargo delays. The weights reflect different aspects of the operations impacted by delays in different ways.

A list of KPIs was then created looking at different aspects of the rail traffic operations, including:

- Travellers
- Train performance
- Financial impact
- Resource utilization
- Environment
- Organization
- System
- Safety

The KPIs may either refer to the applied traffic management strategies in specific context or to the generalized performance of the strategies on the long run. This exhaustive list, generated with direct contribution of both industrial and academic partners is made available [3] to all the partners and external users, who can implement the KPIs for performance monitoring of real or simulated rail traffic scenarios.

2.2 Closed-loop simulation framework

The main asset of the project is the closed-loop simulation framework, which includes both demand models and self-organizing railway operations. The framework is defined in its components and the interfaces between them. Out of the characteristics and results of a simulated railway system model, the rail ridership is estimated in the passenger assignment module, so that the effects of traffic management decisions on passenger behaviour can be estimated, alongside with the possible effects of passenger crowding that can arise under given circumstances and traffic management decisions.

The interaction and interface between the different modules in the loop are defined in Deliverable D4.1, Data Exchange Format and Software Interfaces [1]. The document depicts the modelling framework and related software architecture, with every software component, its functioning principles, input, and output. This document is made available for the public on the project’s portal. The main beneficiary is the research community, both within and outside SORTED-MOBILITY. The closed-loop simulation framework expands the possibilities for simulation-based optimization, considering the passenger reactions and influences directly and can be used in contexts other than assessment of self-organizing rail traffic.

The closed-loop framework is also expected to support transportation system design among the political decision makers. Passenger assignment models are already commonly used to assess the social impact of changes in the transportation systems. The integration and estimation of the inverse influence of altered ridership on the transportation system itself allows the better estimation of the final results, avoiding, e.g., that concentrated improvements of attractiveness of single elements of the transportation system will be compensated by increased congestion.

2.3 Demand models

The long term and real time passenger models elaborated in WP2 contribute to the growing scientific literature on the utility of smart card data by documenting a use-case for networks with moderate demand volumes such as the Copenhagen suburban railway. Furthermore, the models incorporate the reliability of the service in the estimation of short-term demand, demonstrating that passenger behaviour changes noticeably in cases of irregular operations. Future research can explore this reliability aspect, specifically by explaining the link between reliability and short-term changes in demand. Finally, the demand models have been integrated in an automated traffic management framework and embedded in a simulated environment, which shows the potential of predicting demand for optimizing traffic to the benefit of passengers. The modular nature of the framework enables incremental research on different parts of the framework to improve its overall performance. This also enables simple baselining and comparison for future research, an important part of applied science.

The real time passenger demand models are also expected to support extensively the industrial partner in different aspects of the operations. Even though the elaboration of these models is oriented at self-organized rail traffic within SORTEDMOBILITY, the models work for standard traffic management too and can be exploited on current rail networks. When the dispatchers know the passenger distribution across train services, the prioritization of trains can be oriented at the minimization of total passenger delay in the short run. In addition, the traffic information can be routed to specific passenger groups, when the instant OD matrices are known, the distribution of intended destinations among passenger waiting at a station platform is known, alongside the current occupation of every single train. Lastly, the follow-up punctuality analysis for service quality assessment will also benefit from the estimation of passengers onboard individual train services as passenger punctuality will be more accurate. The current distribution of passengers on trains is based on stated preferences, which can be inaccurate and is only updated once a year.

When the models will be finalized, a continuous data exchange will be arranged with the data provider to feed the machine learning models with daily and hourly tap-in and tap-out passenger records. In the specific case of Copenhagen, the partners Banedanmark and DTU allocated part of the PhD time to take the models into use in the industry after the development completion.

2.4 Self-organizing railway operations

The models and algorithms developed for self-organizing rail traffic are a main output of the project. In particular, the self-organization process definition detailed in Deliverable D3.1, Design Choices for Self-Organizing Railway Operations [7], is a SORTEDMOBILITY output exploitable by both the scientific and research and the industrial communities. It decomposes the whole self-organizing decision making approach into individual modules. As such, it is easily re-usable, both for railway and for other transport modes, or even in multi-modal networks. The detailed formalization, which is in itself a very innovative output of SORTEDMOBILITY, can be exploited both to achieve full self-organization, as proposed in the project, or to gently move toward it. In particular, the same modules can be declined in very similar ways to deploy various traffic management concepts, from distributed to decentralized ones. The algorithms developed in SORTEDMOBILITY to concretize each individual module can also be exploited both for pursuing the self-organization principle, and for aiming at a more centrally controlled decision making decentralization. For example, the neighbourhood identification, which groups trains in sets that shall be managed together, will be useful even in the current centralized traffic management context, as a sort of dynamic problem decomposition.

2.5 Simulation models

Three case studies are considered in the project:

- Guingamp-Paimpol line (France)
- Pioltello-Rovato network section (Italy)
- Copenhagen suburban rail network (Denmark)

The case studies were modeled in different rail traffic micro-simulators, including RailSys, OpenTrack, and EGtrain. The models produced do not necessarily mirror the real rail systems as of today, as they were tailored to better suit the goal of the project. Depending on data restrictions from the individual infrastructure managers, the tailored models will be published on research-oriented public databases to be available for further research. The publication of these models is supposed to support further development of advanced rail traffic management systems (centralized, decentralized, or self-organized) both by members of this project and by third parties in the research community. The description of the individual cases and the rationale behind their selection was presented on a conference poster within the IAROR association [2]. The microsimulation models will be made available on data-sharing oriented open-access journals, such as Data in Brief, or similar.

2.6 Dwell time model

One of the interfaces between the demand model from WP2 and the simulation platform developed in WP4 is the dwelling time model at stations as a function of the expected demand. The dwell model itself is developed within WP4 alongside the railway operations simulation model and takes as input the physical characteristics of the station platform to estimate the distribution of the forecasted demand on the platform. The passenger flow is then distributed across the train doors to estimate the time necessary for passenger exchange and, ultimately the dwell time, to be integrated with the microsimulation model to estimate possible route conflicts arisen with other trains.

The asset is expected to both benefit the research community and industrial world. Passenger rail operation can be modelled much more accurately after a precise estimation of the passenger-exchange time at the platform. This sub-process in the rail operations is known to be one of the main sources of primary delays and is currently modelled typically as a distribution of primary delays given to train departures, regardless the physical characteristics of the platform and its interaction with the rolling stock.

As microsimulation of rail operations is a key evaluation element for both industrial projects and research on different aspects of the rail systems, the passenger dwell time model will be exploited both in the industrial world and research community.

2.7 Data from case studies

Input data for both transport supply (timetable, train delays, etc.) and passenger demand (OD matrices per time unit) will be made available to the public, in cases where they can be disclosed. If necessary, the data will be anonymized or aggregated for privacy-related and industrial reasons.

The SORTEDMOBILITY partners are well aware of the need in the research community for real datasets to train and validate simulation, machine learning, and optimization models, and strives to make the data available for the scientific community. The publication of the data will need specific disclosure agreements with the data suppliers, which can challenge the publication feasibility.

The datasets that can be published will be made available on data-sharing oriented open-access journals, such as Data in Brief, or similar.

3 REFERENCES

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