Editorial special section on robustness and resilience of transport networks

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Editorial
Special Section on Robustness and Resilience of Transport Networks

I. INTRODUCTION

THIS special section on "Robustness and Resilience of Transport Networks" was put together to widen the knowledge on improving the robustness and resilience of transport systems. Developing models and algorithms to deal with disruptions and uncertainties is at the core of moving towards this direction. Therefore, we aimed to receive papers in different domains of transportation that contribute to decisionmaking under uncertainties and disruptions. After a rigorous review process, five scientific papers have been selected to be published in this special section. Those cover both freight transportation and passenger transportation spanning different modes: railways, road transportation, and maritime transportation as well as indications of potential methodologies in air transportation.

Warren Powell contributed with a visionary paper on the use of lookahead policies for dealing with uncertainties in transportation and logistics [A1]. A review paper considering mode shift as a solution to disruptions in freight transportation [A2] has been published. Then we have three papers that address disruptions and uncertainty in different transportation domains. Reference [A3] analyzes the root causes of delays in freight trains and indicates possible improvements in capacity allocation. Disruptions in maritime transportation related to berth planning are addressed through collaborative models by [A4]. On the passenger transportation side, the uncertainty in ride-hailing systems is tackled through data-driven models in [A5]. Next, we provide the main highlights of these five papers.

II. HIGHLIGHTS FROM THE PAPERS

In [A1], Powell discusses sequential decision problems in transportation and logistics providing examples including inventory planning, spot pricing, airline scheduling, truckload trucking, and dynamic vehicle routing. He highlights the need for direct lookahead policies to deal with uncertainty, especially because physical resources are being managed. Deterministic lookahead policies are widely used in practice yet they cannot deal with uncertainties in the system. Parametrized deterministic lookahead models are a rather simple way of addressing this at the expense of parameter tuning. Stochastic lookahead models enable explicit representation of uncertainty, yet come with complexity and need to be handled with approximations. Powell presents six strategies for developing approximate lookahead models discussing their pros and cons. The main takeaway is that lookahead policies are relevant for various transportation and logistics problems to deal with uncertainty and the corresponding models need to be developed with an understanding of the problem characteristics.

In [A2], Lordieck and Corman investigate the potential of mode shift to manage disruptions in freight transportation with a holistic view of infrastructural, decisional and organizational aspects. Key issues of mode shift (e.g., extra delay and/or extra handling cost) are analyzed considering all three aspects and making use of a literature review together with expert surveys. Various reasons are listed for the reality of mode shift being usually a backup measure when everything else fails. It is clear that academic literature focuses more on the technical aspects, yet the enabler of mode shift lies also very much on the organizational parameters. It is clearly concluded that mode shift needs to be supported by various measures in order to reach efficiency such as intelligent decision support tools, IT support, and redundancy building (e.g., spare capacities on alternative modes, and terminals).

In [A3], Palmqvist *et al.* aim to understand the root causes of the discrepancies between the annual timetable and the executed freight train transport for identifying potential improvements with a focus on capacity allocation. The analysis is based on data from Sweden on the railway line between Malmö and Hallsberg as well as semi-structured interviews. It is seen that, in order to deal with the uncertainty of future demand, railway undertakings add extra trains which may later be canceled and these account for a significant portion of the trains. There are also deviations in the form of delays or being ahead of the schedule which underlines the mismatch between the timetables and the actual operational conditions of freight trains. One important improvement lies in reserving more capacity for freight trains in the annual process which is expected to reduce the deviations and ease the (re-)planning efforts. Moreover, IT support has the potential to adapt the timetable to actual operations and make railways more attractive within the context of multi-modal freight transportation.

In [A4], Lyu *et al.* propose a collaborative berth planning approach to deal with disruptive unforeseen events through sharing of berthing resources between terminals. A reactive approach is taken to deal with the uncertainties, namely recovery is considered after disruptions occur. Collaboration entails the transfer of vessels to other terminals in response to disruptions while incorporating transshipment connections between vessels. The results indicate significant benefits of collaboration that can go up to 40% savings in recovery costs. The authors highlight the need for future research on negotiation between different terminal operators to work towards realizing the potential benefits of collaboration.

In [A5], Guo *et al.* focus on rebalancing vacant vehicles to address the uncertainty of future demand in ridehailing systems. They develop a data-driven optimization approach for predictive prescription and evaluate their approach with real-world simulations based on New York City's high-volume ride-hailing data. They compare their approach to the benchmarks of point-prediction-driven optimization, stochastic optimization, and robust optimization methods. The main conclusion is that the proposed predictive prescription approach is beneficial when future demand is volatile and hard to predict. They also highlight that, when future demand is highly volatile, conservative predictions, i.e., demand underestimation provides system-wide benefits.

III. CONCLUSION

The papers in this special section show that there is a consensus on the critical role of uncertainties in transportation and logistics systems. The need for methodologies to deal with uncertainties and disruptions is highlighted for different transportation domains covering passenger and freight transportation with different modes. Understanding the sources of uncertainty is an important step in developing methodologies for improving strategic, tactical, and operational decisions. Some authors focus on predictive methodologies to take into account the uncertainty while optimizing the decisions. Others focus on reactive methodologies to respond to disruptions when they occur. It is clear that the use of data and IT support is essential in carrying these methodologies to reallife implementations. The overall takeaway is that the resources in the transportation system need to be used wisely in order to improve efficiency and sustainability. There are several promising methodologies to improve the utilization of resources including data-driven models, predictive models, lookahead policies as well as collaborative methods. Let it be sharing rides/vehicles/resources or making use of multimodal transport networks both for passenger and freight transportation, the way to increase their attractiveness goes through developing robust and resilient methodologies that can efficiently and effectively use the available resources given all the uncertainties and disruptions inherent to the system.

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APPENDIX: RELATED ARTICLES

[A1] W. B. Powell, "Designing lookahead policies for sequential decision problems in transportation and logistics," *IEEE Open J. Intell. Transp. Syst.*, vol. 3, pp. 313–327, 2022.

[A2] J. Lordieck and F. Corman, "Infrastructural, decisional and organizational aspects to use mode shift to handle disruptions in freight transport: Literature and expert survey," *IEEE Open J. Intell. Transp. Syst.*, vol. 2, pp. 37–46, 2021.

[A3] C.-W. Palmqvist, A. Lind, and V. Ahlqvist, "How and why freight trains deviate from the timetable: Evidence from Sweden," *IEEE Open J. Intell. Transp. Syst.*, vol. 3, pp. 210–221, 2022.

[A4] X. Lyu, R. R. Negenborn, X. Shi, and F. Schulte, "A collaborative berth planning approach for disruption recovery," *IEEE Open J. Intell. Transp. Syst.*, vol. 3, pp. 153–164, 2022.

[A5] X. Guo, Q. Wang, and J. Zhao, "Data-driven vehicle rebalancing with predictive prescriptions in the ride-hailing system," *IEEE Open J. Intell. Transp. Syst.*, vol. 3, pp. 251–266, 2022.

BILGE ATASOY is an Associate Professor of Transport Engineering and Logistics with the Department of Maritime and Transport Technology, TU Delft, The Netherlands. Her research interests lie at the intersection of optimization and behavioral models with applications to transportation systems. More specifically, she is interested in improving the efficiency, robustness, and sustainability of transportation and logistics by developing adaptive models that incorporate the preferences of decision makers. Example applications include on-demand transportation, intermodal freight transportation, and transportation over water.

FRANCESCO CORMAN holds the Chair of Transport Systems with the Institute of Transport Planning and Systems, Swiss Federal Institute of Technology, ETH Zurich, Switzerland. His main research interests are in analytics, quantitative methods, and operations research, for improvement of transport systems, especially on the operational perspective of public transport systems, and logistics. He has large experience in railway traffic control and management to reduce delays for the system and its users.

GONÇALO CORREIA is an Associate Professor and the Co-Director of the hEAT Lab, Department of Transport and Planning, Faculty of Civil Engineering, TU Delft, The Netherlands. His main research interest is in the planning and operations of transport systems in urban environments with the objective of sustainable development. He focuses particularly on studying the use of transport demand management strategies, innovative services, and technologies, such as ridesharing, carsharing, and automated vehicles, to tackle urban congestion, which he studies using mainly operations research (mathematical optimization and simulation), data-driven AI methods, and behavior modeling. At TU Delft, he is looking at the impacts of automated driving on mobility and urban development.

LIJUN SUN received the B.S. degree in civil engineering from Tsinghua University, Beijing, China, in 2011, and the Ph.D. degree in civil engineering (transportation) from the National University of Singapore in 2015. He is an Assistant Professor with the Department of Civil Engineering, McGill University, Montreal, QC, Canada. His research centers on urban computing, spatiotemporal modeling for large-scale and high-dimensional mobility and traffic data, public transport systems, and agent-based simulation.