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Technologies and Control for Sustainable Transportation

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The scarcity of natural resources, rising traffic congestion and air pollution have increased the interest for sustainable transportation systems. The transition to more societally, environmentally and economically sustainable transportation can be achieved through various means, including adoption of alternative fuel and vehicle technologies, consolidation of logistic flows and services, and energy efficient transit and traffic operations. To assess the impact of different technologies and control systems with respect to both traditional performance measures and sustainability indicators new methods and tools are required. This Special Issue contains a selection of the state-of-the-art research on mathematical models, methodologies, quantitative analyses, and advanced applications that address the impacts of these technologies and control for the sustainability of transportation systems, services and components — across all modes of transportation.

After several rounds of peer reviews, we selected ten papers for publication in this special issue. The first four papers study novel routing and scheduling strategies to support different sustainable transportation concepts.

Cherrett et al. (2017) present an empirical study on the deliveries of goods ordered online to several halls of residence in Southampton in the UK. Data is collected through audits and surveys. Based on the collected data, the authors describe how a delivery service provider could consolidate the deliveries to these student halls via an urban consolidation center. Their analysis suggests that the consolidation of the deliveries may reduce the number of required delivery trips, thereby potentially reducing congestion, parking infringements and improving air quality.

Evertse and Visser (2017) address the scheduling of taxiing aircraft operations to minimize the associated emissions. They developed a real-time airport surface movement planning tool which solves a MILP every 15 seconds. With a thorough analysis on a test case around Amsterdam Schiphol Airport they discuss the effects of different priorities in the objective function value on fuel consumption, emissions, taxiing time and departure slot time deviations. When focusing on the environmental benefit, the total emissions per product (CO, PM, NOx and UHC) can be reduced with 1 to 3%. In the near future, when technology makes it possible for pilots to follow a timed taxiing route, this tool can be of great usage in reducing the environmental impact of airport surface movement.

Reyes et al. (2017) study the delivery costs savings and environmental benefits associated with the concept of car-trunk delivery, where a customer's order is delivered to the trunk of his or her car. To do so, they develop problem-specific construction and improvements heuristics to solve the associated route planning

problems. Their computational study shows a significant reduction in total distance travelled, especially when trunk delivery is combined with traditional home delivery.

Turkensteen and Hasle (2017) analyse the impact of combining pickups and deliveries on transportation costs and emissions. They look at transport service providers who perform customer orders for outbound deliveries and pickup orders from supply locations. They analysed the effect on carbon emissions of consolidating those two streams into one routing problem. Combining the pickup and delivery streams can lead to large reductions in emissions, especially in cases with small vehicles and long distances from the depot. However, interestingly, they also find cases where there is an increase in emissions by consolidation of the inbound and outbound transport.

Then the next three papers relate to sustainable road traffic control and operations.

Pasquale et al. (2017) propose a feedback control strategy combining ramp metering and route guidance, which aims to reduce both vehicle delays and emissions. One of the advantageous features of their control strategy is that it explicitly considers different classes of vehicles, i.e. cars, trucks, or specific vehicles, and thus accounts for their different driving dynamics and different environmental impacts. These different classes of vehicles are represented in a multi-class traffic flow model, a multi-class emissions model, and a multi-class model-predictive controller that allows separate control actions for different vehicle classes. An illustrative simulation test case analyses five control policies, showing their results in terms of control actions for cars and trucks as well as the travel times and traffic emissions.

Yang and Rakha (2017) propose a feedback control strategy aimed at speed harmonization to prevent or delay the onset of traffic congestion, and shows how this strategy not only reduces vehicle delays, but also reduces fuel consumption and emissions. The control strategy is innovative as it is both proactive and reactive. The optimum throughput is proactively determined based on a calibrated fundamental diagram, while also the speed limits (i.e. metering rate) are reactively adjusted based on monitoring the stochastic traffic conditions directly upstream of the bottleneck. The authors then present a sensitivity analysis on the various algorithm parameters, and use a microscopic simulation case to evaluate the benefits of the control strategy in terms of vehicle delays, fuel consumption, and traffic emissions.

Maiti et al. (2017) propose an ontological model for vehicle platoon operations, which enables the further development and deployment of such operations and their environmental benefits. Where other studies have shown that vehicle platooning has the potential to improve traffic flow throughput, safety and fuel efficiency, this paper addresses the issue of standardized intra-platoon communication that enables vehicle coordination of complex platooning behaviour. The authors develop a model for platoon objects, properties, and operations, and demonstrate how these collectively enable any complex platooning behaviour, as well as can be extended towards vehicle-to-infrastructure communication.

Then the next two papers relate to electric vehicles and charging networks.

Marmaras et al. (2017) analyse how the adoption of electric vehicles (EV) and the behaviour of their drivers affects the road transport and electricity systems. A multi-

agent system based simulator is developed, which is capable of reproducing the behaviour of an EV agent co-existing in the transport as well as electricity system. The model is used to simulate the impact of two realistic behavioural profiles in a fleet of 1000 EV agents. The behavioural profile of EV drivers affects the traffic on the roads, stress on the distribution network and utilization of charging infrastructure. The model can be used to observe EV behaviour in different situations which allows authorities to detect possible irregularities or needs for adjustments.

Xylia et al. (2017) develop a model to address the problem of locating charging infrastructure for electric buses with respect to minimizing costs and energy. The optimization is based on mixed integer linear programming. Compared to previous studies that identify the location of charging stations, this study focuses on heavy-duty vehicles that are subject to more constraints. The model is tested for the large scale bus network in Stockholm. Results show the number and location of stops that require charging infrastructure, the optimized mix of buses running on biodiesel and electricity in a cost-competitive way, and the related costs, energy consumption and emissions. The model can be adapted to the transition to fossil-free bus transport in different urban contexts.

Finally, the last paper studies pricing measures for sustainable transport.

Aboudina and Abdulhai (2017) use a simulation-based case study on the Greater Toronto Area to analyze how time-dependent congestion pricing can alleviate both congestion delays as well as environmental externalities. The integrated system provides a unified congestion pricing approach that determines optimal tolling and evaluates its impact on road traffic congestion and travelers' behavioral choices, including departure time and route choices. The main results suggest that the optimal tolling policies offer a win-win solution in which travel times are improved while also raising funds to invest in sustainable transportation infrastructure.

We thank the authors of the papers submitted to this special issue, and the reviewers whose efforts help to ensure the high quality of the journal. We welcome and encourage more research in this area of Technologies and Control for Sustainable Transportation to be submitted and published in Transportation Research Part C: Emerging Technologies.

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