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Editorial: Special Issue on Transportation in Simulation of Journal of Simulation

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Transportation systems and related policies are complex and cross-sectoral, covering different socio-economic and management aspects, and involving multiple stakeholders (such as users, operators and public policy makers). Mobility and accessibility are central to economic and societal well-being, yet the process of doing so may have significant impacts on land use, environment and public health. Furthermore, the many feedbacks involved occur at varying degrees of spatial, temporal and socio-demographic granularity and levels of uncertainty. Simulation models are well established in transportation-related operational research and management science, and the alternate approaches of System Dynamics (SD) (Abbas and Bell, 1994, Bivona and Montemaggiore, 2010, Shepherd, 2014, Pasaoglu et al., 2016) and Agent-Based Modelling (ABM) (Davidsson et al., 2005, Maggi and Vallino, 2016, Rossetti and Liu, 2014) not only offer different perspectives to transport planning, but also demonstrate to policy makers the importance of understanding cause-and-effect relationships. Further to this, these platforms also offer specialised tools and approaches for hybridisation with other simulation techniques, which aid in the understanding of the whole underlying system, calibration of models, optimisation of policies and ease of use through simple front-end decision support tools.

This Special Issue has been arranged through the System Dynamics Society Special Interest Group in Transportation, so particular interest has been given to SD, though ABM is also considered. We aim to demonstrate the success of such simulation models in transport-related operational and management research. Furthermore, we offer insights into the potential of cross-fertilisation between simulation modelling techniques within transportation systems. In doing so, we show-case six state-of-the-art papers, primarily focused on sustainable future mobility, covering technologies, services and decision support tools.

The special issue starts with two contributions focusing on the introduction of Alternative Fuel Vehicles (AFVs). This is possibly the area that has been most increasingly and widely applied in SD in transportation, with numerous papers produced on the subject over the past decade (Gómez Vilchez and Jochem, 2019), and these two papers offer novel insights.

In *Simulating the battery price and the car-mix in key electromobility markets via model coupling* the authors **Gomez-Vilchez and Thiel** soft-link complementary SD models of the automotive market to explore the deployment of electric vehicles across multiple regions. The linking of models is a novel approach allowing for the combination of different levels of detail for which the individual models were optimised for – stakeholder interactions, energy demand, customer segmentation and the influence of the electric bus market on the light duty vehicle market. The results suggest that even under strict regulations and strong financial incentives the conventional car may dominate, though evolution in battery price is a key parameter in deployment.

The importance of strong policy signals for the uptake of AFVs was also explored by **Keith, Struben and Naumov** in *The Diffusion of Alternative Fuel Vehicles: A Generalized Model and Future Research Agenda*. Similar to Gomez-Vilchez and Thiel, the authors recognise the shortcoming of existing individual models tailored to specific contexts or with narrow model boundaries. They present (and

make available to readers) a generalised SD model of AFV diffusion to explore the potential impacts of AFV policies in overcoming critical barriers to adoption. The model is flexible and can be adapted to address various policy and strategy questions. In the work presented here, it is suggested that market structure and stakeholder actions strongly influence the successful penetration of AFVs.

One of the important features of simulation modelling is to be able to consider future technologies and services, i.e. those that do not yet exist, in order to inform design and policy, and predict potential benefits. The next two papers are concerned with emerging transportation offerings, shared mobility and Automated Vehicles (AV).

Fernandez, Billhardt, Ossowski and Sanchez used agent-based simulation to understand the relative performance of operational strategies for smart bike-sharing systems in *Bike3S: A Tool for Bike Sharing Systems Simulation*. They present a simulator that performs semi-realistic bike-sharing operations to evaluate management decisions on key characteristics such as station capacity and distribution, and balancing strategies. ABM is ideally placed for studying such dynamics, which involve multiple user types with differing goals and motivations. The model is validated against data from both Madrid and London to develop evaluation scenarios.

Although bike-sharing services may be already becoming a common sight in larger cities, automated vehicle technologies are yet to be deployed beyond small-scale testing. The introduction of such technologies may have a profound impact on both travel behaviour and urban development, but however operate under deep uncertainties. This future focused study is addressed in *Spatial impact of automated driving in urban areas* using SD and Exploratory Modelling and Analysis by **Legene, Auping, Correia and van Arem**. Using the region of Copenhagen as a case study, and SD sub-scripting to represent spatial zones, twelve key uncertainties of AV on urban development are considered and lead to the conceptualisation of two distinct scenarios, indicating the shared AV ownership will be critical in reducing congestion and urban sprawl.

One practical example of the representational potential of hybrid modelling approaches in transportation is reported by **Man, Shyr, Shepherd, Lin and Tu**, in their paper *Tourism, Transport, and Land use: A Dynamic Impact Assessment for Kaohsiung's Asia New Bay Area*. Their methodology relies on three main models, each resorting to a different technique most suitable to represent intrinsic characteristics and granularities of their problem. Firstly, the authors use the SD concept of causal loops to capture five main dimensions of the problem, namely tourism, transport, population, dwelling, and economy. Second, a Geographical Information System is employed to underlie the physical environment representation, featuring a cellular-automata Markov approach to predict the probability of tourism-related land-use changes. An agent-based model is the third component, in which a synthetic population of agents is derived based on the rules inferred from spatial patterns emerging in the second model and influencing spatial units, such as tourism propensity and land use. This methodology is particularly suitable to aid the understanding of the causal relations between public transportation development, tourism and land use, and is employed in a practical case study to support decision-making in a two-phase light-rail transit scheme under development.

As well as its application to generic or multi-regional simulation models, SD can be applied to specific case studies as a decision support tool. To this end, in the final paper of this issue **Fontoura, Riberio and Chaves** use SD in the case of urban mobility planning in Rio de Janerio, *A framework for evaluating the dynamic impacts of the Brazilian Urban Mobility Policy for transportation socioeconomic systems: a case study in Rio de Janeiro.* Building on existing SD literature, the authors note that many models consider only one form of Public Transport and generally omit non-motorised modes, and seek to fill this gap. The model is based on nine sub-models: population,

economy, air-pollutant emissions, travel demand, transport supply, non-motorised transport, public transport, private transport and traffic congestion. Their findings indicate the importance of demand management strategies to reduce non-motorised and individual-vehicle trips in order to reduce negative externalities.

The six papers included in this special issue exemplify the current status and future opportunities that System Dynamics and Agent Based Modelling can offer in the understanding of transportation and mobility behaviour in operational and management research. A common aspect and, at the same time, a richness of these papers consist in the effort done by the authors to integrate different complexity dimensions and multiple stakeholders present in transportation systems. In our opinion, in order to make advancement in transport-related operational and management research scholars and practitioners should always bear in mind the search for such holistic perspectives. This special issue thus provides additional insights to traditional transport modelling practises (e.g., equilibrium approaches and four-step models). Hybrid approaches could further enhance and enrich conventional approaches, as our transport systems become ever more complex and integrated into wider cross-sectoral (public and private) policy and planning, alongside increasing availability of highly-grained data. We hope that the papers presented in this special issue of the Journal of Simulation will not only advocate for the engagement in transport studies by operational and management research practitioners, but specifically for the recognition of the merits of SD and ABM approaches leveraging much development in these fields.

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