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Special Issue on Uncertainty in Logistics and Transportation Systems

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This special issue is inspired by the third workshop of the INFORMS Transportation Science and Logistics Society that was held at Loyola University Chicago in 2014. The theme of that workshop was “Handling uncertainty in planning logistics and transportation systems” and was motivated both by advances in computational tools and techniques for solving/evaluating models that recognize uncertainty and increased opportunities to accurately estimate and model uncertainty due to the rise of “big data.” This special issue reflects the broad scope of that workshop and includes papers that study a wide variety of planning problems seen in transportation and logistics. Most importantly, the papers in this special issue repeatedly demonstrate the value that solutions to stochastic models offer over their deterministic analogs and offer researchers a broad overview of modeling and solution techniques for planning problems that recognize uncertainty.

Not surprisingly, a subset of the papers in this special issue focuses on routing problems, albeit in different modes and with different sources of uncertainty. In “Strategies for Handling Temporal Uncertainty in Pickup and Delivery Problems with Time Windows,” Srour, Agatz, and Oppen focus on a novel application in which the time at which a customer is to be transported is unknown, even though the provider knows that the service will need to be performed. The authors propose a sample-scenario planning approach to effectively exploit stochastic information for making better decisions. “Budgeting Time for Dynamic Vehicle Routing with Stochastic Customer Requests” by Ulmer, Mattfeld, and Köster take a different approach to handling the uncertainty of customer requests. In contrast to the work of Srour, Agatz, and Oppen that relies on computation in real time, Ulmer, Mattfeld, and Köster shift the majority of computation offline using a variant of approximate dynamic programming. The novelty in the paper comes from the manner in which approximated values are stored for use in future decision making. “Robust Strategic Route Planning in Logistics” by Richter and Stiller follow yet another approach to handling uncertainty in routing. Focusing on a situation in

which routes must be determined well in advance of the realization of demand, Richter and Stiller present a robust optimization approach and solve the resulting optimization problems using a clever linear relaxation.

While the availability of information is changing our approaches to routing, new technology, particularly in the form of electric vehicles, will change the execution of routes. An important consideration with electric vehicles is refueling. Battery swapping is often cited as a solution to the refueling question. In “Optimal Policies for the Management of an Electric Vehicle Battery Swap Station,” Widrick, Nurre, and Robbins explore the commercial viability of battery swap stations. Facing uncertain demand, the stations must manage battery charging and pricing to be able to maximize expected total profit. The paper demonstrates the existence of an optimal monotone policy and derives policy insights from computational experiments.

Another opportunity resulting from the significant increases in data collection is the ability to recognize and model correlation in networks. A number of papers in the special issue examine how researchers can account for this information. In “Pruning Algorithms to Determine Reliable Paths on Networks with Random and Correlated Link Travel Times,” Prakash and Srinivasan consider a robust modeling approach for determining shortest paths in such networks. The authors show that traditional path-pruning approaches do not work for the given objective and introduce a new and efficient approach for pruning non-optimal subpaths. In “Trajectory-Adaptive Routing in Dynamic Networks with Dependent Random Link Travel Times,” Huang and Gao minimize expected disutility in finding paths in a stochastic, correlated network. The paper introduces a method for overcoming the “curse of dimensionality” while still returning optimal policies. “Robust Aircraft Routing” by Yan and Kung considers correlation in aircraft routing and presents a robust modeling approach for minimizing propagated delay. The authors introduce an exact approach capable of solving realistically-sized problems and provide an interesting comparison of the results of their robust

approach with a state-of-the-art approach for minimizing expected total propagated delay.

Two other papers in the special issue also examine stochastic models for planning in airline flight operations. In “Stochastic Optimization Models for Transferring Delay Along Flight Trajectories to Reduce Fuel Usage,” Jones, Lovell, and Ball take advantage of stochastic information to alter flight speeds to avoid holding patterns resulting from runway congestion. The authors demonstrate the value of incorporating stochastic information in their model and introduce a functional approximation of future values that offers a computationally efficient method for solving instances of the problem. “Optimal Metering Point Configurations for Optimized Profile Descent Based Arrival Operations at Airports” by Solak and Chen focuses on the landing of aircraft and presents new techniques for optimizing the configuration of a monitoring system for a new aircraft arrival procedure, Optimized Profile Descent (OPD). While OPD has been shown to reduce noise, emissions, and fuel usage, controlling OPD requires the specification of points, called metering points, on an aircraft’s descent path wherein a controller monitors and adjusts the spacing between flights to ensure safety and efficiency. This paper proposes techniques for optimizing the number and location of these metering points to both reduce costs and increase runway utilization.

Disasters are a major source of uncertainty in transportation and logistics systems, particularly those that focus on emergency response. To that effect, “Combining Worst Case and Average Case Considerations in an Integrated Emergency Response Network Design Problem” by Dalal and Üster proposes a stochastic programming-based framework for designing a three-tier disaster response network in which the first tier consists of distribution centers for relief supplies, the

second tier consists of shelters wherein evacuees can receive supplies, and the third tier represents regions from which individuals evacuate. They propose a bi-objective stochastic programming model that considers both worst and average-case measures in the second stage and a Benders decomposition-based method for solving that model.

The last two papers focus on classical problems in supply chain design and operations. “The Value of Flexibility in Robust Location-Transportation Problems” by Ardestani-Jaafari and Delage focuses on the location and capacity of production facilities, while recognizing that the determination of production and distribution plans can be deferred until more is known regarding customer orders. As they presume little is known regarding future customer demands, they present a robust optimization model of the problem. Given the difficulty associated with solving this class of optimization model, they also propose computationally tractable approximations for the problem as well as a row generation-based algorithm for solving large instances of (some of) these approximations. Turning to supply chain operations, “Flow Balancing with Uncertain Demand for Automated Package Sorting Centers” by Novoa, Jarrah, and Morton focuses on the operations of sorting facilities, a problem of particular importance given the dramatic increase seen in e-commerce volumes over the last two decades. Specifically, they optimize the assignment of packages to the sorting workcenters that segregate packages by outbound loading destination, while recognizing day-to-day fluctuations in package volumes and workcenter capacity. They present stochastic models of this problem that seek to balance workcenter utilization and assess the value of modeling uncertainty in package volumes using a data set from an international package carrier.