Especially for companies operating a heterogeneous fleet of internal combustion engine vehicles and alternative fuel vehicles in areas with green zones, optimal utilization of the fleet becomes vital.

In this work, we introduce a new VRP variant called the Mixed Fleet Green Vehicle Routing Problem with Green Zones (MFGVRP-GZ) that aims to serve all customers at a minimum travelled distance, such that no green zone restrictions are violated. Through computational studies, we (i) investigate different green zones restrictions and their impact on distribution operations and (ii) test the performance of different formulations to solve the problem.

2 - Capacitated Regret p-median model for the location of public facilities
Carolina Castañeda P., Daniel Serra

Location decisions are a key factor in improving the population's access to public services. Accessibility greatly impacts people's quality of life, reduces inequalities, and facilitates the development and growth of regions. Consequently, it is important to make robust location decisions regarding that these are strategic, involve infrastructure that should last in time, and need to respond to the uncertainty that appears in the spatial region, for instance, population dynamics or travel times in different ranges of hours during the day. We propose a capacitated regret p-median model that locates p facilities while minimizing the maximum regret over several scenarios, regarding the capacity associated with the potential facilities. The regret represents the difference between the optimal solution of the p-median problem applied to each scenario and the average distance from facilities to demand nodes computed for all scenarios. Depending on the duration of the period where planners need to make the location decisions, the model considers uncertainty in the demand and/or travel times across scenarios. In addition, we design a solution method based on the Variable Neighborhood Search (VNS) metaheuristic. We use several data sets, testing the method for large instances, including the case study of the location of public pre-schools in Barcelona considering the city's current population projections and socio-economic analysis.

3 - Modeling COVID-19 Optimal Testing Strategies in Retirement Homes: An Optimization-based Probabilistic Approach
Mansoor DavoodiMonfared, Ana Batista, Abhishek Senapati, Weronika Schlechte-Welnicz, Justin Calabrese

Retirement Home facilities have been widely affected by the COVID-19 pandemic. The residents in these homes are usually elderly people with a high risk of mortality from being infected. Since they are in contact with each other, once an infection arrives at the facility, it propagates quickly. To prevent the outbreaks, it has been demonstrated that regular testing of the residents is the most practical approach. However, testing may result in extra time for the staff that performs the test as well as residents' discontent, which presents a trade-off between the time invested in testing, daily caring activities, and viral spread containment. We introduce a novel optimization approach for testing schedule strategies in retirement homes. We develop a mixed-integer linear programming model for balancing the staff's workload while minimizing the expected detection time of a probable infection inside the facility. We present a probabilistic approach in conjunction with the optimization models to compute the risk of infection, including contact rates, incidence status, and the probability of infection of the residents. To tackle the combinatorial nature of the problem, we proved an efficient property, called symmetry property of optimal testing strategy and utilized it in proposing an enhanced local search algorithm. We perform several experiments with real-size instances and show that the proposed approach can derive optimal testing strategies.

4 - Workers-stations assignment in second-hand clothes-processing line with high absenteeism from workers
Marc Juanpera, Ariadna Costas-Mañero, Laia Ferrer-Martí

Different entities in Spain are devoted to the reuse of second-hand clothes, collecting them, separating them according to quality and typology and reintroducing them to local markets and abroad. They employ workers at risk of social exclusion, which can present high unannounced absenteeism that condition the everyday worker-station assignment within the clothes-processing line. This feature motivates an ad-hoc study to optimize the work-station assignment, based on the real case of a Foundation operating in Barcelona with a complex line of 39 workers and 22 stations with different supply forms (conveyor belt or discharge hopper). The aim of the study is to define, for each daily number of available workers, a distribution of them along the work stations to maximize the processing of clothes and reduce the on-going stock below a threshold. Also, management criteria are included to deal with particular expertise of the workers, tackle constraints related to space and characteristics of the work (e.g., supply form of the stations), and avoid unbalanced workloads. Indeed, the exact portion of a day to assign each worker in each station is robustly obtained with a deterministic heuristic complemented with a stochastic analysis using the simulation tool Witness Studio. Results significantly improve the current capacity of clothes-processing of the Foundation while reducing on-going stock and addressing management difficulties.

■ WA-09

Wednesday, 8:30-10:00 - U5

MILP in logistics and last-mile delivery

Stream: Mixed Integer Linear Programming
Invited session
Chair: *Alberto Santini*
Chair: *Diego Delle Donne*

1 - Reinforcement Learning Approaches for the Orienteering Problem with Stochastic and Dynamic Release Dates
Yuanyuan Li, Claudia Archetti, Ivana Ljubic

Orienteering problem with stochastic and dynamic release dates (RD) is a problem in which a company receives goods from its suppliers and distributes them to customers. Each customer is associated with an RD indicating the time when her parcel becomes available at the distribution center. The RDs are considered to be stochastic and dynamically updated during the distribution. We model the problem as a Markov decision process. We generate scenarios representing realizations of RDs and for each of them, we approximate the future value using a batch approach. Two approximation approaches are proposed: policy function approximation through a consensus function in which a deterministic model determines the requests to serve immediately and those included in future routes, and a consensus function over all scenarios determines the final solution; one-step look-ahead policy with value function approximation where we build a two-stage stochastic model in which the first stage is to determine the route leaving immediately, while the second stage concerns future routes.

2 - Extended formulations and column generation for the Freight on Transport problem
Diego Delle Donne, Alberto Santini, Claudia Archetti

The boom of e-commerce in the last decade raises new challenges as retailers and couriers innovate their supply chains to keep up with demand. Last-mile delivery (LMD), the segment of the supply chain which starts at the last distribution centre and ends at the customer's doorstep, is particularly affected. The growth of volume in LMD has also caused concern, especially in dense urban environments where the externalities (traffic, emissions, etc.) have become noticeable. Several authors in Operational Research (OR), Environmental Engineering and Urban Planning have proposed alternative LMD implementations which aim at reducing the externalities while guaranteeing a service level. We focus on one promising operational practice: integrating public transport within LMD, to leverage unused capacity and reduce the number of delivery vehicles in the city. This concept has emerged during the last years and is gaining attraction, both academically and in practice. In our study, we consider a 3-echelon system. In the first echelon, trucks move parcels from distribution centres to public transport depots or large stations. In the second echelon, public transport

vehicles transport the parcels towards the city centre and drop them off at some of their scheduled stops. In the third echelon, zero-emission vehicles (such as cargo bikes) deliver the parcels to the customers' preferred locations. In this work, we propose an extended IP formulation to tackle this problem in practice.

3 - Tactical Green Fleet Sizing Decisions for Last-Mile Delivery Systems
Minakshi Punam Mandal, Claudia Archetti, Alberto Santini

We study a Last Mile Delivery (LMD) problem that deals with fleet sizing decisions of a company. While existing studies primarily focus on the day-to-day operational aspect of the LMD systems, our aim is to explore the problem at a tactical level where the number of freighters to be hired by the company is fixed for a long period of time (e.g. 4 months). We mimic large real cities that are usually divided into regions, and further divided into areas, and packages first reach Local Distribution Centres (LDCs) located within each area, from where they need to be delivered to the end customers using green means like bikes or simply walking. This study is particularly aimed to complement innovative LMD strategies, when the use of delivery trucks is limited. We intend to estimate the number of freighters to be hired by the company not only for the entire city but also for each region and area, to serve the demand during different time periods of the day. The unserved demand is assumed to be outsourced and our objective is to balance the hiring and outsourcing costs over the planning horizon. We propose mixed integer programming techniques to study a stochastic version of the problem. We use an approximation algorithm to capture the operational requirements of the system and embed it into our model. We provide computational studies to support the viability of our system.

4 - A Mixed Integer Programming Approach for Blacklisting Products in E-Commerce
Ahmet Çınar

We study a real-life problem in which a decision maker is required to determine the set of products that will be put into blacklist. Due to the several different performance metrics such as unsupplied ratio, dispatch on time ratio, defective ratio and so on, she needs to find an optimal weight set corresponding to these metrics. Once the optimal weights are decided, using these weights a unique score for each product is calculated. Finally, if the score of a product falls below a predetermined threshold value, the product is put into blacklist and its sales are closed on the e-commerce platform. We propose a mixed integer programming approach to determine the optimal set of weights. The objective is to minimize the gross marginal value (gmv) loss, while keeping the current global performance metrics same or getting them improved. The model is applied for different categories varying from customer electronics to branded textile. Tests on real-life data show that the model produce high-quality solutions and provide substantial revenue gain when compared to the current solution.

■ WA-10

Wednesday, 8:30-10:00 - U6

Robust optimization in Finance

Stream: Financial Risk Measurement and Management
Invited session
Chair: *Cyril Izuchukwu Udeani*

1 - Solution of HJB equation arising from Portfolio Management problem using monotone operator technique
Cyril Izuchukwu Udeani

In this study, we investigate a fully nonlinear evolutionary Hamilton-Jacobi-Bellman (HJB) parabolic equation utilizing the monotone operator technique. We consider the HJB equation arising from portfolio optimization selection, where the goal is to maximize the conditional expected value of the terminal utility of the portfolio. The fully nonlinear HJB equation is transformed into a quasilinear parabolic equation using the so-called Riccati transformation method. The transformed parabolic equation can be viewed as the porous media type of equation with the source term. Under some assumptions, we obtain that the diffusion function to the quasilinear parabolic equation is globally Lipschitz continuous, which is a crucial requirement for solving the Cauchy problem. We employ Banach's fixed point theorem to obtain the existence and uniqueness of a solution to the general form of the transformed parabolic equation in a suitable Sobolev space in an abstract setting. Some financial applications of the proposed result are presented in one-dimensional space.

2 - Estimating the potential of fuel cell buses with real option analysis
Tero Haahtela

This paper investigates the uncertainty and flexibility of gradually investing in fuel cell (FC) driven buses and their re-fueling infrastructure. The prices of fuel cells have steadily declined as well as the production costs of hydrogen. At the same time, fossil fuel prices have increased, and there is a global need to significantly reduce Co2 emissions and oil dependency. The method used for analyzing and comparing the alternatives is based on applying a cash-flow simulation real option valuation approach. Compared alternatives are full electric battery-driven buses, hybrid combustion engine buses (with fossil fuel and biofuel), and fuel cell buses.

The results show that fuel cell buses are viable for longer distances while purely battery-driven buses dominate city transportation. The related infrastructure costs of re-fueling and hydrogen production have a better economies of scale in comparison with the charging infrastructure of the battery-driven buses. Also, optimally expanding and scaling both the FC infrastructure and the bus fleet size are valuable. Furthermore, the operational option to produce and store hydrogen when the electricity prices are lower increases the value of flexibility. Considering the total cost of ownership (TCO), fuel cell buses are soon the optimal choice for long-distance buses.

3 - New Approaches for Identifying Robust Dominating Portfolios Based on Second-Order Stochastic Dominance
Peng Xu

Second-order Stochastic Dominance (SSD) criterion can be used to support portfolio decision making under risk and uncertainty. In this paper, we develop novel robust SSD criteria to capture the strength of dominance and portfolio optimization models utilizing these criteria to identify portfolios whose in-sample SSD dominance over a given benchmark is likely to hold also out-of-sample. The developed models can incorporate incomplete probability information by allowing a set of feasible state probabilities. We also show that these portfolio optimization models can be formulated as linear programming problems. We report results from applying these SSD-based portfolio optimization models with different sets of state probabilities in an empirical application, with a focus on evaluating the out-of-sample portfolio performance of the optimized portfolios.

■ WA-11

Wednesday, 8:30-10:00 - U7

How to support complex decisions. Negotiating the trade-off between Social, Environmental and Economic values 2

Stream: Multiple Criteria Decision Analysis
Invited session
Chair: *Alessandra Oppio*
Chair: *Marta DellOvo*