TSP model for electric vehicle deliveries, considering speed, loading and road grades

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1 Introduction

In the current Transport White Paper [1], the European Union presents a roadmap for a more competitive and sustainable European transport system. Concerning Urban Freight Transport, responsible for about a quarter of CO_2 emissions of the transport sector, one of the goals of the EU is to achieve essentially CO_2-free city logistics in major urban centers by 2030 by developing and deploying new and sustainable fuels and propulsion systems. The gradual phasing out of 'conventionally-fuelled' vehicles from the urban environment contributes to reduce oil dependency, greenhouse gas emissions and local air and noise pollution. To meet European air quality standards, authorities of some major European cities have already introduced Low Emissions Zones where access to urban areas is limited to freight vehicles that meet certain emissions standards.

A growing use of urban trucks based on electric, hydrogen and hybrid technologies helps reducing not only pollutant emissions, but also noise and road congestion by making night deliveries and avoiding morning and afternoon peak periods. In addition, the use of low-emission fleets also allows to mitigate the transportation sector dependency on volatile fuel prices [2] as electric engines may be powered using various energy sources including wind and solar energy.

The objective usually considered in sustainable transportation is to minimize pollution due to emissions, and equivalently energy consumption. Turning to electric mobility, pollution is related to electricity production technology, not considered in this research; driving range is the major concern nowadays, due to the limited capacity of batteries and long recharge times . Maximizing the driving range or the level of energy (state of charge of the battery) at destination leads to consider the main factors of energy consumption which are : vehicle weight, engine efficiency and consumption models, drive speed and acceleration, drive pattern, road grade, and payload ([3], [4], [5], [6]).

We define the electric vehicle travelling salesman problem (EV-TSP) and the electric vehicle routing problem (E-VRP) based on the classical TSP and on the Pollution Routing Problem (PRP) [4] and present models and preliminary results for those problems.

2 Research problem

This paper focus on the EV-TSP: given n cities find the directed cycle containing all cities that maximizes the level of available energy at the end of the route, knowing that there is no recharge operation on the tour. This objective equally maximizes the driving range of the vehicle. The classical objective of the TSP is to minimize the cost tour scheduling to fulfill delivery requests at each location. In this paper, we present an extension of the classical problem, the objective function accounts not just for travel distance and load of the vehicle on each part of the path, but also depends on electric mobility key factors: vehicle speed, slope of roads, and vehicle recharge ability while driving (as regenerative breaking and kinetic energy capture on downhill paths).

3 Mathematical programming formulation

The EV-TSP is defined on a complete graph $G = (N, A)$ where N is the set of nodes (representing cities) indexed by $i, j \in \{0, \ldots, n\}$ and $A = \{(i, j) : i, j \in N, i \neq j\}$ is the set of arcs. The set $N \setminus \{0\}$ denotes the client locations (i.e. cities) while the unique depot is duplicated into an origin depot, identified as node 0 where the vehicle starts its tour, and a destination depot, identified as node $n + 1$, where the vehicle ends its tour. A tour thus becomes a Hamiltonian path starting at 0 and ending at $n + 1$. A distance d_{ij}, a road angle θ_{ij} and speed limits $\left(v_{ij}^{min}, v_{ij}^{max}\right)$ are associated to all $(i, j) \in A$. The energy e_{ij} used (resp. produced) on the arc $(i, j) \in A$ equals the total power p_{ij} deployed (resp. captured) plus the power p_{ij}^{aux} used for auxiliary devices (such as air conditioner) during the course of the arc. The non-negative demand of each client $i \in N \setminus \{0\}$ is represented by q_i and there is no returning load to the depot. A vehicle, initially located at the depot, has a sufficient loading capacity and battery capacity to find a route and satisfy all demands. The battery level never exceeds the maximum capacity, C, and always has to be non negative since battery cannot be discharged below zero. The total travel time of the vehicle is limited to T. The technical parameters of the vehicle and the energy consumption model are given. The tour starts and ends at the depot, and every client is visited exactly once.

The decision variables used in the formulation are a set of binary variables x_{ij} equal to 1 if and only if arc (i, j) is in the tour; a set of binary variables $y_{ij}^{l} = 1$ if and only if arc (i, j) is in the tour and the demand of client l, q_l, is transported on this arc; and a set of variables v_{ij}, associated to the speed of the vehicle on arc (i, j), which range from v_{min} to v_{max}.

The objective of the EV-TSP is to maximize the level L of available energy (or state of charge of the battery) at the end of the tour. This level is defined using a generic Energy Consumption Model proposed and tested in the literature ([4],[7]) where vehicle weight, speed and road slope are considered.

At the beginning of the tour, the current available energy level L_0 is known. The level of energy is limited by the maximum capacity of the battery and never exceeds it even if more energy is available due to recovery. Moreover, the level L_j of available energy at each node $j \in N \cup \{n + 1\}$ cannot fall below zero. Therefore the level of energy can be calculated as:

$$L_j = \begin{cases} 0 & \text{if } L_i - e_{ij}\ x_{i,j} \leq 0 \\ C & \text{if } L_i - e_{ij}\ x_{i,j} \geq 0 \\ L_i - e_{ij}\ x_{i,j} & \text{otherwise.} \end{cases}$$

The EV-TSP mathematical model states as follows :

$$\text{maximize } L_{n+1} \tag{1}$$

$$\text{subject to :} \quad \sum_{i=0}^{n} x_{ij} = 1 \qquad \forall j \in N \setminus \{0\} \tag{2}$$

$$\sum_{j=1}^{n+1} x_{ij} = 1 \qquad \forall i \in N \tag{3}$$

$$u_0 = 1; u_{n+1} = n+2 \tag{4}$$

$$2 \leq u_i \leq n+1 \qquad \forall i \in N \setminus \{0\} \tag{5}$$

$$u_i - u_j + 1 \leq n(1 - x_{ij}) \qquad \forall i, j \in N, \forall (i,j) \in A \tag{6}$$

$$y_{ij}^l \leq x_{ij} \qquad \forall (i,j) \in A,\ \forall l \in N \setminus \{0\} \tag{7}$$

$$u_j - u_l + y_{ij}^l\ n + (1 - x_{ij})\ 2n \geq 0 \qquad \forall (i,j) \in A,\ \forall j, l \in N \setminus \{0\} \tag{8}$$

$$e_{ij} = (p_{ij} + p_{ij}^{aux})\ \frac{d_{ij}}{v_{ij}} \qquad \forall (i,j) \in A \tag{9}$$

$$p_{ij} = M_{ij}\ g\ v_{ij}\ sin\theta_{ij}\ +\ 0.5\ c_d\ \rho\ A\ v_{ij}^3\ +\ c_r\ M_{ij}\ g\ v_{ij}\ cos\theta_{ij} \qquad \forall (i,j) \in A \tag{10}$$

$$0 \leq L_i \leq C \qquad \forall i \in N \cup \{n+1\} \tag{11}$$

$$L_j = L_i - e_{ij}\ x_{ij} - s_j \qquad \forall j \in N \setminus \{0\}, \forall (i,j) \in A \tag{12}$$

$$\sum_{i=0}^{n} \sum_{j=1}^{n+1} x_{ij}\ \frac{d_{ij}}{v_{ij}} \leq T \tag{13}$$

$$v_{min} \leq v_{ij} \leq v_{max} \qquad \forall (i,j) \in A \tag{14}$$

$$x_{ij}, y_{ij}^l \in \{0,1\} \qquad \forall (i,j) \in A \tag{15}$$

$$u_i \in \mathbb{N}, s_j \in \mathbb{R}_+ \qquad \forall i \in N, \forall j \in N \setminus \{0\} \tag{16}$$

The objective function (1) consists in maximizing the level of available energy at the end of the route. Constraints (2) indicate that the vehicle leaves each node i exactly once, and constraints (3) state that a vehicle enters each node j exactly once. Constraints (4)-(6) ensure to exclude subtours using integer variable $u_i,\ i \in N \cup \{n+1\}$, that determine the sequence number in which node i is visited as in the formulation of Miller-Tucker-Zemlin [8]. Constraints (4) ensure that the starting and arrival nodes are the depot. Constraints (5) ensure that for each node i, excluding the depot, the integer variable u_i ranges from 2 to $n+1$. Constraints (6) define each node rank : if $x_{ij} = 1$, the next node j has to satisfy constraints $u_j \geq u_i + 1$; otherwise if $x_{ij} = 0$, constraints (6) become $u_i - u_j \leq n - 1$ that is always true, as $2 \leq u_j$ and $u_i \leq n+1$. Constraints (7) guarantee that if $x_{ij} = 0$ (i.e. arc (i,j) is not in the tour) then there is no load transported on this arc: $y_{ij}^l = 0$. Otherwise, if $x_{ij} = 1$, constraints (8) ensure that $y_{ij}^l = 1$ for all arcs (i,j) such that $u_l > u_j$. Note that for nodes already visited, $u_l \leq u_j$, $y_{ij}^l = 0$ due to the objective function.

Constraints (9) represent the energy e_{ij} required (resp. produced) when the vehicle travels the arc, and constraints (10) define the instantaneous power p_{ij} needed to overcome gravity, drag and rolling resistance forces (cfr. [4]), p_{ij} is negative when energy is recovered. In this model we consider that speed is constant on any arc (acceleration is null). In (10) $M_{ij} = M_E\ +\ \sum_{l=1}^{n} q_l\ y_{ij}^l$ is the mass of the vehicle (in kg), i.e. the empty vehicle weight, M_E, plus carried load on arc (i,j) ; g is the gravitational constant ($9.81 m/s^2$), ρ is the air density (kg/m^3), A is the frontal surface area of the vehicle (in m^2), and c_r and c_d are the dimensionless coefficients of rolling resistance and drag, respectively. As in [4] all parameters are constant on a given arc but load and speed may change from one arc to another.

Battery-relative constraints (11)-(12) imply that the level of energy in the battery, L_i, cannot fall below zero nor exceed the capacity of the battery, s is a non negative slack variable that allows to include in the tour arcs for which energy gain would overcome the battery capacity (but no storage is performed beyond the limit), and excludes arcs for which energy is missing. As the energy function is monotonic on each arc, the constraints at each node imply that this property is valid at any point of the arc.

Constraint (13) ensures that travel time limit is not exceeded. Constraints (14) define lower and upper bounds for the speed on each arc. Finally, constraints (15)-(16) define binary and non-negativity conditions on the variables.

4 Results and perspectives

This paper presents a new TSP model for transportation using electric vehicles. The problem is to deliver each customer order, and optimize the battery state of charge at the end of the route. It deals with orders weights, road characteristics and vehicle specifications. An important feature of our approach is the generic formulation adaptable to all types of vehicles.

In order to test the model, we build small instances to represent real-life cases. The distances between the nodes, the altitude of different locations, etc. have been taken into account to ensure the consistency of the data. The goal is to check the validity of the model and obtain useful insights for the development of algorithms for realistic large size problems. Preliminary results guide future work towards optimization methods combining heuristics and exact algorithms.

References

[1] European Commission. "White Paper - Roadmap to a Single European Transport Area - Towards a competitive and Resource Efficient Transport System". *COM*(2011)-144.

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ODYSSEUS 2012

5th International Workshop on Freight Transportation and Logistics

May 21 - 25, Mykonos, Greece

Workshop Schedule

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ORDES

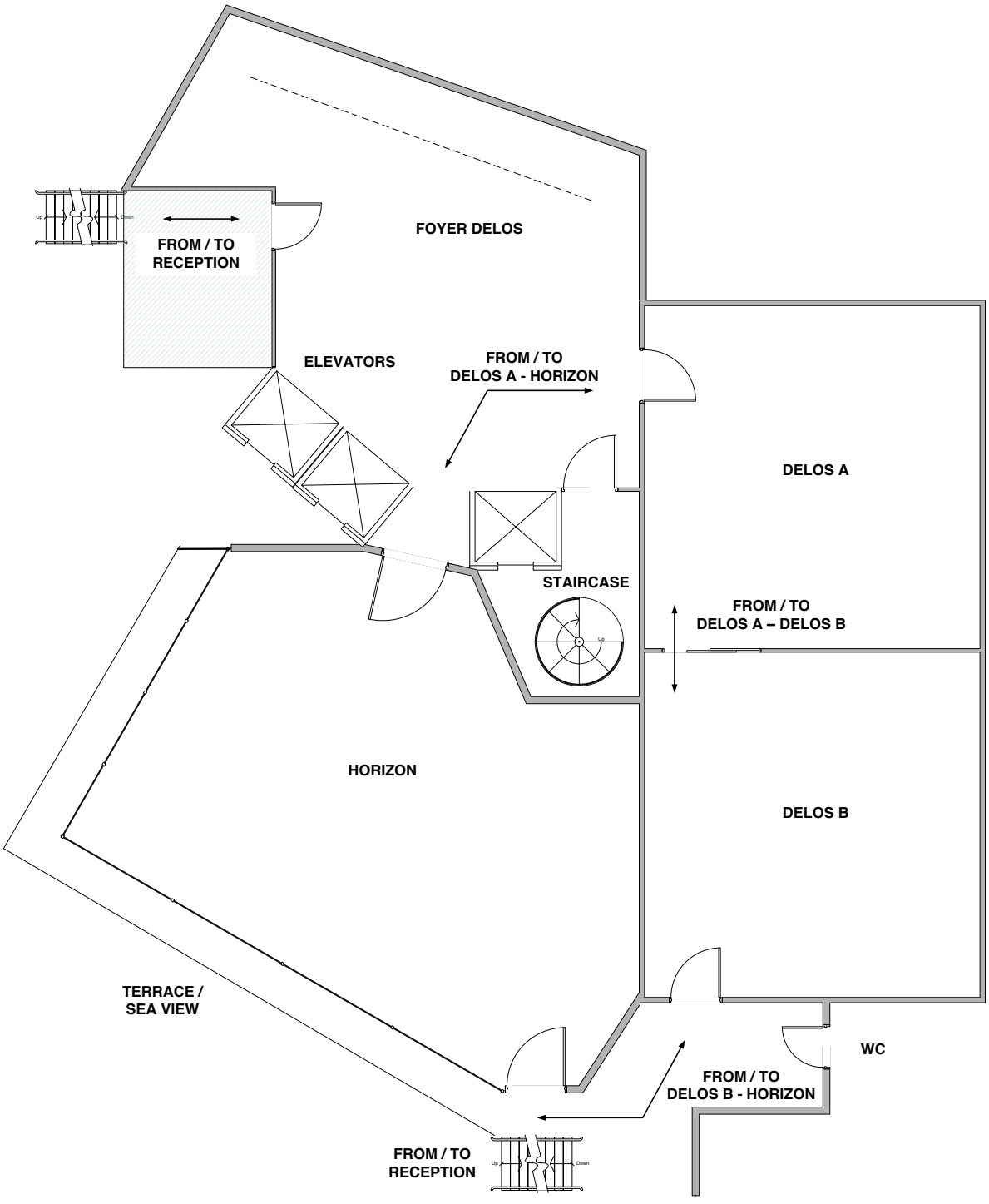
Event Timeline

DATE		TIME	EVENT
May 20	**Sunday**	20:00	Welcome Reception
May 21	**Monday**	08:30 – 08:50	Opening Session
		09:00 – 10:30	Sessions Mo.1.(a,b,c)
		10:30 – 11:00	Coffee Break
		11:00 – 12:30	Sessions Mo.2.(a,b,c)
		12:30 – 14:30	Lunch
		14:30 – 16:00	Sessions Mo.3.(a,b,c)
		16:00 – 16:30	Coffee Break
		16:30 – 18:00	Sessions Mo.4.(a,b,c)
May 22	**Tuesday**	09:00 – 10:30	Sessions Tu.1.(a,b,c)
		10:30 – 11:00	Coffee Break
		11:00 – 12:30	Sessions Tu.2.(a,b,c)
		12:30 – 14:30	Lunch
		14:30 – 16:00	Sessions Tu.3.(a,b,c)
		16:00 – 16:30	Coffee Break
		16:30 – 18:00	Sessions Tu.4.(a,b,c)
May 23	**Wednesday**	07:45 – 15:00	Excursion to Delos
		15:00 – 16:00	Lunch
May 24	**Thursday**	09:00 – 10:30	Sessions Th.1.(a,b,c)
		10:30 – 11:00	Coffee Break
		11:00 – 12:30	Sessions Th.2.(a,b,c)
		12:30 – 14:00	Lunch
		14:00 – 15:30	Sessions Th.3.(a,b,c)
		15:30 – 16:00	Coffee Break
		16:00 – 18:00	Sessions Th.4.(a,b,c)
		20:30	Workshop Dinner and Party
May 25	**Friday**	09:00 – 10:30	Sessions Fr.1.(a,b,c)
		10:30 – 11:00	Coffee Break
		11:00 – 12:30	Sessions Fr.2.(a,b,c)
		12:30 – 14:30	Lunch
		14:30 – 16:00	Sessions Fr.3.(a,b,c)
		16:00 – 16:30	Coffee Break
		16:30 – 18:00	Sessions Fr.4.(a,b)
		20:00	Farewell Drinks

Facilities Layout

Event	Meeting Room
Opening Session	DELOS A + DELOS B (joined)
Sessions ".a"	DELOS A
Sessions ".b"	DELOS B
Sessions ".c"	HORIZON

All meeting rooms are located one level above the Reception Desk of the *Royal Myconian Resort.*



Regular Sessions

TIME SLOT \ ROOM		DELOS A	DELOS B	HORIZON
Monday	09:00 – 10:30	Vehicle Routing I	Railway Logistics	Ship Routing and Scheduling
	11:00 – 12:30	Stochastic Routing I	Capacitated Vehicle Routing Problem	City Logistics I
	14:30 – 16:00	Inventory Routing I	Network Models for Humanitarian Logistics	Maritime Logistics I
	16:30 – 18:00	Network Design I	Dial-a-Ride Routing	Stochastic Routing II
Tuesday	09:00 – 10:30	Multi-Period Routing	Maritime Logistics II	Vehicle Routing II
	11:00 – 12:30	Arc Routing I	City Logistics II	Sustainable Routing
	14:30 – 16:00	Two-Echelon Routing	Vehicle Routing III	Routing and Scheduling I
	16:30 – 18:00	Arc Routing II	Home Health Care Logistics	Routing and Scheduling II
Thursday	09:00 – 10:30	Traveling Salesman Problem Variants	Container Logistics	Routing I
	11:00 – 12:30	Transportation Risk	Packing Logistics	Dynamic Routing
	14:00 – 15:30	Time-Dependent Routing	Scheduling	Inventory Routing II
	16:00 – 18:00	Production -- Distribution	Freight Transportation Networks	Vehicle Routing IV
Friday	09:00 – 10:30	Vehicle Routing V	Maritime Transportation I	Network Design II
	11:00 – 12:30	Maritime Transportation II	Emergency Logistics	Dynamic Vehicle Routing
	14:30 – 16:00	Routing with Loading Constraints	Routing II	Network Design and Uncertainty
	16:30 – 18:00	Location-Routing	Supply Chain Logistics	–

Monday, 09:00 – 10:30

Session Mo.1.a: Vehicle Routing I — DELOS A

Chair: *Frédéric Semet, École Centrale de Lille*

09:00 – 09:30	A Continuous Approximation Model for the Fleet Composition Problem *Ola Jabali, Gilbert Laporte and Michel Gendreau*
09:30 – 10:00	A Polyhedral Approach for Generalizing the Miller-Tucker-Zemlin Subtour Elimination Constraints for Routing Problems *Tolga Bektaş and Luis Gouveia*
10:00 – 10:30	An Exact Method to Solve the Multi-trip Vehicle Routing Problem with Multi Time Windows *Florent Hernandez, Frédéric Semet, Rodolphe Giroudeau and Olivier Naud*

Session Mo.1.b: Railway Logistics — DELOS B

Chair: *Michel Bierlaire, École Polytechnique Fédérale de Lausanne*

09:00 – 09:30	Optimal Loading Plan for Multiple Trains in Container Terninals *Davide Anghinolfi, Lorenzo Foti, Marco Maratea, Massimo Paolucci and Silvia Siri*
09:30 – 10:00	The Locomotive Fleet Fueling Problem *Mor Kaspi and Tal Raviv*
10:00 – 10:30	Cost Optimization for the Capacitated Railroad Blocking and Train Design Problem *Burak Boyaci, Viswanathan Prem Kumar, Stefan Binder and Michel Bierlaire*

Session Mo.1.c: Ship Routing and Scheduling — HORIZON

Chair: *Kjetil Fagerholt, Norwegian University of Science and Technology*

09:00 – 09:30	Robust Planning of Refinery Operations with Uncertain Ship Arrivals *Jens Bengtsson, David Bredström, Patrik Flisberg and Mikael Rönnqvist*
09:30 – 10:00	A Branch-and-Price Method for a Ship Routing and Scheduling Problem with Coupling and Synchronization Constraints *Magnus Stålhane, Henrik Andersson and Marielle Christiansen*
10:00 – 10:30	A Branch-and-Price Algorithm for a Fleet Deployment Problem with Fairly Evenly Spread Voyages *Inge Norstad, Henrik Andersson, Kjetil Fagerholt and Magnus Stålhane*

Monday, 11:00 – 12:30

Session Mo.2.a: Stochastic Routing I — DELOS A

Chair: *Patrick Jaillet, Massachusetts Institute of Technology*

11:00 – 11:30	The Robust Rounded Capacity Inequalities *Chrysanthos E. Gounaris, Wolfram Wiesemann and Christodoulos A. Floudas*
11:30 – 12:00	A Pickup and Delivery Single Vehicle Routing Problem with Stochastic Demands *Dimitrios G. Pandelis, Constantinos C. Karamatsoukis and Epaminondas G. Kyriakidis*
12:00 – 12:30	Routing Optimization with Deadlines under Uncertainty *Patrick Jaillet, Jin Qi and Melvyn Sim*

Session Mo.2.b: Capacitated Vehicle Routing Problem — DELOS B

Chair: *Jens Lysgaard, Aarhus University*

11:00 – 11:30	An Exact Approach for the Clustered Vehicle Routing Problem *Maria Battarra, Güneş Erdoğan and Daniele Vigo*
11:30 – 12:00	Circuit based formulations for the Unit Demand Vehicle Routing Problem *Luis Gouveia, Pierre Pesneau and Maria Teresa Godinho*
12:00 – 12:30	Dual-Optimal Inequalities for the Capacitated Vehicle Routing Problem *Jens Lysgaard*

Session Mo.2.c: City Logistics I — HORIZON

Chair: *Teodor Gabriel Crainic, Université du Québec à Montréal and CIRRELT*

11:00 – 11:30	A Collaborative Freight Transportation System in City Logistics *Frédéric Semet, Luce Brotcorne and Alexandre Huart*
11:30 – 12:00	The City Logistics Facility Location Problem *Nabil Absi, Dominique Feillet, Thierry Garaix and Olivier Guyon*
12:00 – 12:30	Modelling Demand Uncertainty in Two-Tiered City Logistics Planning – A Monte Carlo Study *Fausto Errico, Walter Rei, Nicoletta Ricciardi and Teodor Gabriel Crainic*

Monday, 14:30 – 16:00

Session Mo.3.a: Inventory Routing I — DELOS A

Chair: *Ann Melissa Campbell, University of Iowa*

14:30 – 15:00	A Two-Stage Decomposition Algorithm for Single Product Maritime Inventory Routing *Dimitri J. Papageorgiou, George L. Nemhauser, Joel Sokol and Ahmet B. Keha*
15:00 – 15:30	Efficient Inventory Routing in an Automated Teller Machine Network *Roel G. van Anholt and Iris F.A. Vis*
15:30 – 16:00	The Use of Telemetry to Improve Routing Costs *Ann Melissa Campbell and Amit Verma*

Session Mo.3.b: Network Models for Humanitarian Logistics — DELOS B

Chair: *Tadashi Yamada, Kyoto University*

14:30 – 15:00	Flow-based Mathematical Formulation and Strengthening Cuts for the Cumulative CVRP *Sandra Ulrich Ngueveu and Mathieu Lacroix*
15:00 – 15:30	Exact and Heuristics Strategies for Solving the Generalized Vehicle Routing Problem *H. Murat Afsar, Christian Prins and Andréa Cynthia Santos*
15:30 – 16:00	Designing Supply Chain–Transport Supernetworks within the Framework of MPEC *Tadashi Yamada, Yuki Nakamura and Eiichi Taniguchi*

Session Mo.3.c: Maritime Logistics I — HORIZON

Chair: *Marielle Christiansen, Norwegian University of Science and Technology*

14:30 – 15:00	A Hybrid Approach for Loading Liquid Bulk Vessels *Rowan Van Schaeren, Wout Dullaert, Birger Raa and Pierre Schaus*
15:00 – 15:30	Ship Scheduling with Time-Varying Draft *Elena Kelareva, Philip Kilby, Sylvie Thiébaux and Mark Wallace*
15:30 – 16:00	Branch-and-Price for Creating an Annual Delivery Program of Multi-Product Liquefied Natural Gas *Jørgen Glomvik Rakke, Henrik Andersson, Marielle Christiansen and Guy Desaulniers*

Monday, 16:30 – 18:00

Session Mo.4.a: Network Design I — DELOS A

Chair: *Tolga Bektaş, University of Southampton*

16:30 – 17:00	Designing Service Networks in Liner Shipping *Judith Mulder and Rommert Dekker*
17:00 – 17:30	A Hybrid Evolutionary Algorithm for the Fixed-Charge Capacitated Multicommodity Network Design Problem *Dimitris Paraskevopoulos, Tolga Bektaş, Chris N. Potts and Teodor Gabriel Crainic*
17:30 – 18:00	The Congested Multicommodity Network Design Problem *Dimitris Paraskevopoulos, Sinan Gürel and Tolga Bektaş*

Session Mo.4.b: Dial-a-Ride Routing — DELOS B

Chair: *Stefan Irnich, Johannes Gutenberg University Mainz*

16:30 – 17:00	The Dial-a-Ride Problem with Split Requests and Profits *Sophie N. Parragh, Bernardo Almada-Lobo and Jorge Pinho de Sousa*
17:00 – 17:30	Hybrid Variable Neighborhood Search for the Dial-a-Ride Problem *Verena Schmid and Sophie N. Parragh*
17:30 – 18:00	Efficient Handling of Ride-Time Constraints in Column Generation Subproblems for the Dial-a-Ride Problem *Timo Gschwind and Stefan Irnich*

Session Mo.4.c: Stochastic Routing II — HORIZON

Chair: *Michel Gendreau, École Polytechnique de Montréal and CIRRELT*

16:30 – 17:00	A Stochastic Inventory Routing Problem for Infectious Medical Waste Collection *Pamela C. Nolz, Nabil Absi and Dominique Feillet*
17:00 – 17:30	Real-World Patient Transportation *Ulrike Ritzinger, Jakob Puchinger, Christian Rudloff and Richard F. Hartl*
17:30 – 18:00	Vehicle Routing with Soft Time Windows and Stochastic Travel Times: A Column Generation and Branch-and-Price Solution Approach *Duygu Taş, Michel Gendreau, Nico P. Dellaert, Tom van Woensel and A.G. de Kok*

Tuesday, 09:00 – 10:30

Session Tu.1.a: Multi-Period Routing — DELOS A

Chair: *Claudia Archetti, University of Brescia*

09:00 – 09:30	A Column Generation Algorithm to Solve a Synchronized Log-Truck Scheduling Problem *Rix Greg, Louis-Martin Rousseau and Gilles Pesant*
09:30 – 10:00	Collaborative Template-based Tabu Search and Branch-and-Cut Methods for the Consistent Vehicle Routing Problem *Panagiotis P. Repoussis, Chrysanthos E. Gounaris, Foteini Stavropoulou, Christos D. Tarantilis and Christodoulos A. Floudas*
10:00 – 10:30	Free Newspaper Delivery Optimisation *Claudia Archetti, Karl F. Doerner and Fabien Tricoire*

Session Tu.1.b: Maritime Logistics II — DELOS B

Chair: *Rommert Dekker, Erasmus University Rotterdam*

09:00 – 09:30	Modeling the Maritime Fleet Size and Mix Problem: A Case Study *Giovanni Pantuso, Kjetil Fagerholt and Stein W. Wallace*
09:30 – 10:00	A Bi-Level Modeling Approach Capturing Interactions between Shippers and Carriers *Hyangsook Lee, Maria Boile and Sotirios Theofanis*
10:00 – 10:30	Optimizing Recovery Actions and Buffer Times in Liner Shipping Networks *Judith Mulder, Mehdi Sharifyazdi and Rommert Dekker*

Session Tu.1.c: Vehicle Routing II — HORIZON

Chair: *Ulrich Derigs, University of Cologne*

09:00 – 09:30	Constraint Violation in Real-World Vehicle Routing *Matteo Salani, Lorenzo Ruinelli and Luca Maria Gambardella*
09:30 – 10:00	Milk Collection in Western Norway Using Trucks and Trailers *Arild Hoff*
10:00 – 10:30	On a Multi-Trip Tractor and Trailer Vehicle Routing Problem with Driver Regulations *Ulrich Vogel and Ulrich Derigs*

Tuesday, 11:00 – 12:30

Session Tu.2.a: Arc Routing I — DELOS A

Chair: *Ángel Corberán, University of Valencia*

11:00 – 11:30	Analysis of Pricing Problem Relaxations for the Capacitated Arc Routing Problem *Claudia Bode and Stefan Irnich*
11:30 – 12:00	Profitable Mixed Capacitated Arc Routing and Related Problems *Enrique Benavent, Ángel Corberán, Luis Gouveia, Maria Cândida Mourão and Leonor Santiago Pinto*
12:00 – 12:30	A Branch-and-Cut Algorithm for the Team Orienteering Arc Routing Problem *Claudia Archetti, Ángel Corberán, Isaac Plana, Maria Grazia Speranza and José María Sanchis*

Session Tu.2.b: City Logistics II — DELOS B

Chair: *Angélica Lozano, National Autonomous University of Mexico*

11:00 – 11:30	Impact of Time-Dependent Travel Times on Routing in City Logistics *Jan Fabian Ehmke, Carsten Tilger and Dirk Christian Mattfeld*
11:30 – 12:00	Optimization of a Shared Passengers and Goods Urban Transportation Network *Renaud Masson, Anna Trentini, Fabien Lehuédé, Olivier Péton, Houda Tlahig and Nicolas Malhéné*
12:00 – 12:30	Impacts of Time Windows Restrictions on Urban Freight Corridors: Mexico City Case *Liliana Lyons, Angélica Lozano, Francisco Granados, Alejandro Guzmán and Juan Pablo Antún*

Session Tu.2.c: Sustainable Routing — HORIZON

Chair: *Gilbert Laporte, HEC Montréal and CIRRELT*

11:00 – 11:30	A Real-life Application of the Dynamic Waste Collection Vehicle Routing Problem with Time Windows *Allan Larsen, Kristian Milo Hauge, Allan Olsen and Stefan Ropke*
11:30 – 12:00	Modeling and Solving the Time Dependent Vehicle Routing and Scheduling Problem with Environmental Considerations *Konstantinos G. Zografos and Konstantinos N. Androutsopoulos*
12:00 – 12:30	The Time-Dependent Pollution Routing Problem *Anna Franceschetti, Tom van Woensel, Dorothée Honhon, Tolga Bektaş and Gilbert Laporte*

Tuesday, 14:30 – 16:00

Session Tu.3.a: Two-Echelon Routing — DELOS A

Chair: *Roberto Tadei, Politecnico di Torino*

14:30 – 15:00	A Branch-and-Cut Algorithm for the Two-Echelon Location-Routing Problem *Viet Phuong Nguyen, Christian Prins, Caroline Prodhon and Juan Guillermo Villegas*
15:00 – 15:30	Solving the Two-Echelon Capacitated Vehicle Routing Problem to Optimality *Aristide Mingozzi, Roberto Roberti, Roberto Wolfler Calvo and Roberto Baldacci*
15:30 – 16:00	A Reactive GRASP with Path Relinking for the Two-Echelon Vehicle Routing Problem *Teodor Gabriel Crainic, Simona Mancini, Roberto Tadei and Guido Perboli*

Session Tu.3.b: Vehicle Routing III — DELOS B

Chair: *Fabien Tricoire, University of New South Wales*

14:30 – 15:00	Operational Transportation Planning of Freight Forwarding Companies in Carrier Coalitions *Xin Wang, Herbert Kopfer and Michel Gendreau*
15:00 – 15:30	Joint Demand Management and Vehicle Routing in E-fulfillment *Christine Currie, Richard Eglese and Arne K. Strauss*
15:30 – 16:00	An Adaptive Metaheuristic Framework for Vehicle Routing Problems with Fixed Fleet Size *Stefanie Kritzinger, Karl F. Doerner, Richard F. Hartl and Fabien Tricoire*

Session Tu.3.c: Routing and Scheduling I — HORIZON

Chair: *Jacques Desrosiers, HEC Montréal and GERAD*

14:30 – 15:00	Logistics of Clinical Testing: A Prioritized Bicriteria Heuristic for Collection for Processing Problem *F. Sibel Salman, Eda Yücel, E. Lerzan Örmeci and Esma S. Gel*
15:00 – 15:30	Vehicle Routing with Time Windows Considering Driving and Working Hour Regulations *Maryam Steadie Seifi, Said Dabia, Tom van Woensel and Nico P. Dellaert*
15:30 – 16:00	Workforce Routing and Scheduling for Maintenance Operations in Electricity Networks *Frank Meisel and Asvin Goel*

Tuesday, 16:30 – 18:00

Session Tu.4.a: Arc Routing II — DELOS A

Chair: *Bruce Golden, University of Maryland*

16:30 – 17:00	The Road Marking Problem with Refill Operations *Maria Angélica Salazar-Aguilar, André Langevin and Gilbert Laporte*
17:00 – 17:30	A Matheuristic for the Team Orienteering Arc Routing Problem *Ángel Corberán, Isaac Plana, José María Sanchis, Maria Grazia Speranza and Claudia Archetti*
17:30 – 18:00	The Downhill Plowing Problem with Multiple Plows *Benjamin Dussault, Bruce Golden and Edward Wasil*

Session Tu.4.b: Home Health Care Logistics — DELOS B

Chair: *Mike Hewitt, Rochester Institute of Technology*

16:30 – 17:00	Routing of Home Care Staff Members with Synchronization Requirements *Dorota Slawa Mankowska, Christian Bierwirth and Frank Meisel*
17:00 – 17:30	Medium Term Planning for Home Health Care Services *Andrea Trautsamwieser and Patrick Hirsch*
17:30 – 18:00	Estimating the Cost of Continuity of Care in Home Health Care Delivery *Mike Hewitt and Maciek Nowak*

Session Tu.4.c: Routing and Scheduling II — HORIZON

Chair: *Guy Desaulniers, École Polytechnique de Montréal and GERAD*

16:30 – 17:00	A Branch-and-Cut Algorithm for the Single Truck and Trailer Routing Problem with Satellite Depots *José M. Belenguer, Antonio Martínez, Christian Prins, Caroline Prodhon, Juan G. Villegas and Enrique Benavent*
17:00 – 17:30	Stabilized Dynamic Constraint Aggregation for Solving Set Partitioning Problems *Pascal Benchimol, Guy Desaulniers and Jacques Desrosiers*
17:30 – 18:00	A Branch-Price-and-Cut Algorithm for the Workover Rig Routing Problem *Guy Desaulniers, Glaydston Mattos Ribeiro and Jacques Desrosiers*

Thursday, 09:00 – 10:30

Session Th.1.a: Traveling Salesman Problem Variants — DELOS A

Chair: *Renata Mansini, University of Brescia*

09:00 – 09:30	The Bicycle Repositioning Problem with Demand Intervals *Güneş Erdoğan, Gilbert Laporte and Roberto Wolfler Calvo*
09:30 – 10:00	The Clustered Orienteering Problem *Enrico Angelelli, Claudia Archetti and Michele Vindigni*
10:00 – 10:30	The Capacitated Traveling Purchaser Problem with Total Quantity Discount *Renata Mansini and Daniele Manerba*

Session Th.1.b: Container Logistics — DELOS B

Chair: *Der-Horng Lee, National University of Singapore*

09:00 – 09:30	Real-Time Container Storage Location Assignment at a Seaport Container Transshipment Terminal Part II *Matthew E.H. Petering*
09:30 – 10:00	An Optimization Model for Container Distribution with Inventory and Time Constraints *Kristina Sharypova, Teodor Gabriel Crainic, Tom van Woensel and Jan Fransoo*
10:00 – 10:30	Tactical Feeder Scheduling Problem in a Container Transshipment Hub *Der-Horng Lee and Jian Gang Jin*

Session Th.1.c: Routing I — HORIZON

Chair: *Giovanni Righini, University of Milan*

09:00 – 09:30	An Iterated Local Search to solve the Node, Edge and Arc Routing Problem *Mauro Dell'Amico, José Carlos Díaz Díaz, Geir Hasle and Manuel Iori*
09:30 – 10:00	Integrating Return Flows in Warehouse Order Picking *Susanne Wruck, Kees Jan Roodbergen, Iris F.A. Vis and Jaap Boter*
10:00 – 10:30	Optimizing Waste Collection: A Branch-and-Cut-and-Price Algorithm *Alberto Ceselli, Giovanni Righini and Emanuele Tresoldi*

Thursday, 11:00 – 12:30

Session Th.2.a: Transportation Risk — DELOS A

Chair: *Irina Gribkovskaia, Molde University College*

11:00 – 11:30	A Lagrangean Decomposition for Tunnel Interdiction in Hazmat Transportation *Edoardo Amaldi, Maurizio Bruglieri, Roberto Maja and Alessandro Laurita*
11:30 – 12:00	Risk based Routing and Scheduling of Hazardous Material in Urban Areas *Rojee Pradhananga, Eiichi Taniguchi and Tadashi Yamada*
12:00 – 12:30	Passenger and Pilot Risk Minimization in Offshore Helicopter Transportation *Fubin Qian, Irina Gribkovskaia, Gilbert Laporte and Øyvind Halskau sr.*

Session Th.2.b: Packing Logistics — DELOS B

Chair: *Guido Perboli, Politecnico di Torino*

11:00 – 11:30	An Exact Algorithm for Bin Packing Problems with Item Fragmentation *Marco Casazza and Alberto Ceselli*
11:30 – 12:00	The Generalized Bin Packing Problem: Models and Bounds *Teodor Gabriel Crainic, Roberto Tadei, Guido Perboli and Mauro Maria Baldi*
12:00 – 12:30	A Stochastic Bin Packing Model for Logistical Capacity Planning *Teodor Gabriel Crainic, Guido Perboli, Jean-Paul Watson, David L. Woodruff and Walter Rei*

Session Th.2.c: Dynamic Routing — HORIZON

Chair: *Alan Erera, Georgia Institute of Technology*

11:00 – 11:30	Heuristics for Stochastic and Dynamic Maritime Pickup and Delivery Problems *Gregorio Tirado, Lars Magnus Hvattum, Kjetil Fagerholt and Jean-François Cordeau*
11:30 – 12:00	Dynamic Tracking and Rerouting Strategies with Real-Time Traffic Information *Jesús-Arturo Orozco and Jaume Barcelo*
12:00 – 12:30	Improved Tour Determination for the Dynamic Traveling Salesman Problem *Taesu Cheong, Alan Erera and Chelsea C. White III*

Thursday, 14:00 – 15:30

Session Th.3.a: Time-Dependent Routing — DELOS A

Chair: *Richard Eglese, Lancaster University*

14:00 – 14:30	A Note on the Ichoua *et al.* (2003) Travel Time Model *Gianpaolo Ghiani and Emanuela Guerriero*
14:30 – 15:00	A Tabu Search Approach for Daily Scheduling of Home Health Care Services using Multi-Modal Transport *Klaus-Dieter Rest and Patrick Hirsch*
15:00 – 15:30	Variable Neighborhood Search for the Time-Dependent Prize-Collecting Arc Routing Problem *Sanne Wøhlk, Daniel Black and Richard Eglese*

Session Th.3.b: Scheduling — DELOS B

Chair: *L. Douglas Smith, University of Missouri-St. Louis*

14:00 – 14:30	Refuel Decisions and Driver Time Management in Long-Haul Freight Transportation *Alexandra Hartmann, Teresa Melo, Thomas Bousonville and Herbert Kopfer*
14:30 – 15:00	The Influence of Accurate Travel Times on a Home Health Care Scheduling Problem *Matthias Prandtstetter, Andrea Rendl and Jakob Puchinger*
15:00 – 15:30	Scheduling Transportation and Logistics Events in Staged Queues *L. Douglas Smith, Robert M. Nauss, Jan Fabian Ehmke, Florian Bahr and Dirk Christian Mattfeld*

Session Th.3.c: Inventory Routing II — HORIZON

Chair: *Maria Grazia Speranza, University of Brescia*

14:00 – 14:30	Hybrid Heuristic for the Inventory Location-Routing Problem with Deterministic Demand *William J. Guerrero, Caroline Prodhon, Nubia Velasco and Ciro Alberto Amaya*
14:30 – 15:00	Designing Nested Routes for Cyclic Inventory Routing Problems *Birger Raa*
15:00 – 15:30	Exact Solution of an IRP with Multiple Vehicles *Claudia Archetti, Nicola Bianchessi, Stefan Irnich and Maria Grazia Speranza*

Thursday, 16:00 – 18:00

Session Th.4.a: Production – Distribution

DELOS A

Chair: *Jean-François Cordeau, HEC Montréal and CIRRELT*

16:00 – 16:30	Multi-Period Vehicle Loading with Stochastic Release Dates *Yasemin Arda, Yves Crama, David Kronus, Thierry Pironet and Pascal Van Hentenryck*
16:30 – 17:00	Divergent Supply Chain in an Oil Company - Decoupled and Integrated Planning *Mario Guajardo, Martin Kylinger and Mikael Rönnqvist*
17:00 – 17:30	Optimization-Based Adaptive Large Neighborhood Search for the Production Routing Problem *Yossiri Adulyasak, Jean-François Cordeau and Raf Jans*
17:30 – 18:00	–

Session Th.4.b: Freight Transportation Networks

DELOS B

Chair: *Bernard Gendron, Université de Montréal and CIRRELT*

16:00 – 16:30	Robust Empty Repositioning in Large-scale Freight Consolidation Networks *Antonio Carbajal, Martin Savelsbergh and Alan Erera*
16:30 – 17:00	Transport Mode Selection for Hazardous Materials *Vedat Verter, Morteza Bagheri and Manish Verma*
17:00 – 17:30	Hazmat Transportation by Game Theory *Lucio Bianco, Massimiliano Caramia, Stefano Giordani and Veronica Piccialli*
17:30 – 18:00	A Lagrangian-Based Branch-and-Bound Algorithm for the Two-Level Uncapacitated Facility Location Problem *Paul-Virak Khuong, Bernard Gendron and Frédéric Semet*

Session Th.4.c: Vehicle Routing IV

HORIZON

Chair: *Roberto Wolfler Calvo, Université Paris 13*

16:00 – 16:30	The Distance-Constrained Vehicle Purchaser Problem *Nicola Bianchessi, Maria Grazia Speranza and Renata Mansini*
16:30 – 17:00	Incomplete Service and Split Deliveries in a Routing Problem with Profits *Claudia Archetti, Alain Hertz, Maria Grazia Speranza and Nicola Bianchessi*
17:00 – 17:30	The Static Multi Vehicles Rebalancing Problem *Daniel Chemla, Frédéric Meunier and Roberto Wolfler Calvo*
17:30 – 18:00	–

Friday, 09:00 – 10:30

Session Fr.1.a: Vehicle Routing V — DELOS A

Chair: *Christian Prins, Université de Technologie de Troyes*

09:00 – 09:30	Load Balancing for the Skill Vehicle Routing Problem *Silvia Schwarze and Stefan Voss*
09:30 – 10:00	The Bi-Objective Multi-Vehicle Covering Tour Problem: Formulation and Lower Bound *Boadu Mensah Sarpong, Christian Artigues and Nicolas Jozefowiez*
10:00 – 10:30	Towards a General Heuristic for Multi-Attribute Vehicle Routing Problems *Thibaut Vidal, Teodor Gabriel Crainic, Michel Gendreau and Christian Prins*

Session Fr.1.b: Maritime Transportation I — DELOS B

Chair: *Harilaos Psaraftis, National Technical University of Athens*

09:00 – 09:30	*A Fleet Deployment Problem in Liner Shipping* *Henrik Andersson, Kjetil Fagerholt and Kirsti Hobbesland*
09:30 – 10:00	Reducing Emissions in Offshore Supply Vessel Planning by Speed Optimization *Ellen Karoline Norlund and Irina Gribkovskaia*
10:00 – 10:30	A Ship Pickup and Delivery Model with Multiple Commodities, Variable Speeds, Cargo Inventory Costs and Freight Rates *Harilaos N. Psaraftis*

Session Fr.1.c: Network Design II — HORIZON

Chair: *Nicoletta Ricciardi, Sapienza University of Rome*

09:00 – 09:30	A CAT Metaheuristic for the Design of Activity-Based Supply Chain Networks Under Uncertainty *Marc-André Carle and Alain Martel*
09:30 – 10:00	Incremental Network Design with Shortest Paths *Matthew Baxter, Tarek Elgindy, Andreas Ernst, Thomas Kalinowski and Martin Savelsbergh*
10:00 – 10:30	Modelling Dry-Port-based Freight Distribution through Service Network Design *Teodor Gabriel Crainic, Paolo Dell'Olmo, Nicoletta Ricciardi and Antonino Sgalambro*

Friday, 11:00 – 12:30

Session Fr.2.a: Maritime Transportation II — DELOS A

Chair: *Mikael Rönnqvist, Université Laval*

11:00 – 11:30	Dynamic Vessel Navigation *Irina S. Dolinskaya and Robert L. Smith*
11:30 – 12:00	Large Scale Robust Optimization of Bulk Seaport Operations *Nitish Umang and Michel Bierlaire*
12:00 – 12:30	Vessel Routing and Scheduling under Uncertainty in the Liquefied Natural Gas Business *Elin Espeland Halvorsen-Weare, Kjetil Fagerholt and Mikael Rönnqvist*

Session Fr.2.b: Emergency Logistics — DELOS B

Chair: *Alain Martel, Université Laval and CIRRELT*

11:00 – 11:30	A Bilevel Partial Interdiction Problem With Capacitated Facilities and Demand Outsourcing *Sema Şengül Akca, Necati Aras and Deniz Aksen*
11:30 – 12:00	Stochastic Optimization for Warehouse Location for Flood Disaster Relief Preparation in Brazil *Adriana Leiras, Irineu de Brito Junior and Hugo Yoshizaki*
12:00 – 12:30	Designing Emergency Supply Networks for Responsive Disaster Support *Walid Klibi, Soumia Ichoua and Alain Martel*

Session Fr.2.c: Dynamic Vehicle Routing — HORIZON

Chair: *Cristián Cortés, University of Chile*

11:00 – 11:30	On the Dynamic Technician Routing and Scheduling Problem *Victor Pillac, Christelle Guéret and Andrés L. Medaglia*
11:30 – 12:00	Rollout Algorithms with Restocking for Dynamic Vehicle Routing with Stochastic Demand and Duration Limits *Justin C. Goodson, Barrett W. Thomas and Jeffrey W. Ohlmann*
12:00 – 12:30	Dynamic Column Generation Approach for Space Covering and Time-Space Covering Traveling Technician Problem *Cristián E. Cortés, Michel Gendreau, José Rojas, Louis-Martin Rousseau and Andrés Weintraub*

Friday, 14:30 – 16:00

Session Fr.3.a: Routing with Loading Constraints — DELOS A

Chair: *Manuel Iori, University of Modena and Reggio Emilia*

14:30 – 15:00	An Exact Algorithm for the Double Traveling Salesman Problem with Multiple Stacks *Alberto Ceselli and Roberto Wolfler Calvo*
15:00 – 15:30	A Strategic Oscillation Heuristic for the Double Traveling Salesman Problem with Multiple Stacks *Sebastián Urrutia, Anolan Milanés and Arne Løkketangen*
15:30 – 16:00	A Rich Vehicle Routing Problem with Three-Dimensional Loading Aspects *Emmanouil E. Zachariadis, Christos D. Tarantilis and Chris T. Kiranoudis*

Session Fr.3.b: Routing II — DELOS B

Chair: *Sanne Wøhlk, Aarhus University*

14:30 – 15:00	Column Generation for the Multiple Vehicle Covering Tour Problem *Nicolas Jozefowiez*
15:00 – 15:30	An Aggregate Multi-Step Model of the Urban Freight Delivery Tours *Agostino Nuzzolo and Antonio Comi*
15:30 – 16:00	Lower Bound for the Node, Edge and Arc Routing Problem *Lukas Bach, Geir Hasle and Sanne Wøhlk*

Session Fr.3.c: Network Design and Uncertainty — HORIZON

Chair: *Stein W. Wallace, Lancaster University*

14:30 – 15:00	The Impact of Uncertainty on Closed-Loop Supply Chains *Beste Kucukyazici Verter, Wenyi Chen and Vedat Verter*
15:00 – 15:30	Demand Uncertainty in Network Design Problems *Teodor Gabriel Crainic, Walter Rei and Mike Hewitt*
15:30 – 16:00	Multi-Commodity Stochastic Network Design: Dynamic Formulation without Conservation-of-Flow on the Design Variables *Stein W. Wallace and Xin Wang*

Friday, 16:30 – 18:00

Session Fr.4.a: Location-Routing

DELOS A

Chair: *Louis-Martin Rousseau, École Polytechnique de Montréal and CIRRELT*

16:30 – 17:00	A Comparison of Three Metaheuristic Algorithms for the Capacitated Location-Routing Problem *John W. Escobar, Rodrigo Linfati, Paolo Toth and Maria Gulnara Baldoquin*
17:00 – 17:30	Solving Network Design and Routing Problems for Urban Freight Distribution *Paolo Gianessi, Laurent Alfandari, Lucas Létocart and Roberto Wolfler Calvo*
17:30 – 18:00	Location-Routing Problems with Pickup and Delivery and Time Windows constraints *Thomas Capelle, Cristián E. Cortés, Michel Gendreau, Louis-Martin Rousseau and Pablo A. Rey*

Session Fr.4.b: Supply Chain Logistics

DELOS B

Chair: *Barrett Thomas, University of Iowa*

16:30 – 17:00	Solving the Raw Materials Reception Problem using Revenue Management Principles: An Application to a Portuguese Pulp Mill *Mikael Rönnqvist, Sophie D'Amours, Andrés Weintraub, João Gonçalves, Jose G. Borges and Alexandra F. Marques*
17:00 – 17:30	A Stockyard Planning Problem *Natashia Boland, Damon Gulczynski and Martin Savelsbergh*
17:30 – 18:00	Coordinated Logistics for Sugarcane Harvests in Brazil *Barrett W. Thomas, Kamal Lamsal and Philip C. Jones*

Social Program

Welcome Reception — SUNDAY

Starts at:	*20:00*
Place:	*Lobby Veranda*
Features:	*Drinks and light snacks*

Excursion to Delos — WEDNESDAY

Timeline:

07:45	Departure from *Royal Myconian Resort*
08:20	Arrival at Chora of Mykonos, rendezvous with our guides and walk towards the old harbor
08:40	Embarkation
09:00	Ferry departure
09:25	Arrival at Delos and disembarkation
09:30	Start of the guided tour
13:20	End of visit and embarkation
13:30	Ferry departure
14:00	Arrival at Chora of Mykonos, disembarkation and walk to the buses
14:15	Departure from Chora of Mykonos
14:45	Arrival at *Royal Myconian Resort*

Workshop Dinner and Party — THURSDAY

Starts at:	*20:30*
Place:	*Horizon room and terrace*
Features:	*Drink reception* *Full course dinner* *ODYSSEUS 2015 candidacies and vote* *Music and dancing*

Farewell Drinks — FRIDAY

Starts at:	*20:00*
Place:	*Sunset Veranda*
Features:	*Drinks and light snacks*

ODYSSEUS

2012

Farewell !