

---

# Waste Collection with Route Balancing Concerns: A real-world application

Ana Raquel De Aguiar<sup>\*†1</sup> and Tânia Ramos<sup>‡1</sup>

<sup>1</sup>Centro de Estudos de Gestão, Instituto Superior Técnico, Universidade de Lisboa (CEG-IST) – Av. Rovisco Pais, 1049-001 Lisboa, Portugal

## Abstract

The optimization of waste collection typically focuses on the minimization of distance, route time or the maximization of profit while assuring a service level to the population. However, when dealing with real-world cases other concerns may arise. That was the case of a Portuguese waste collection company that covers a wide area of 7 000 km<sup>2</sup>. This area is highly heterogeneous, covering urban and rural territories, where some rural areas are characterized by a high degree of roughness (mountains and hills). Defining routes that minimize distance or maximize profit may result in unbalance routes from the human resources perspective, leading to a generalized dissatisfaction among the drivers. Moreover, the term "unbalance" could be measured in different ways. The drivers would prefer a routing plan where all routes visit the same number of waste bins, or have the same duration? Should the driving difficulties at rural roads be somehow incorporated? A literature review was conducted, and different ways of measure the balance/fairness of a routing plan were found, namely route workload, quantities transported, route length and route duration. In this work, we apply some of those measures to define a balanced routing plan to the company and compare the results among them. Moreover, a new measure is developed to account for the different characteristics of the territory. The problem is modeled as a CVRP with balancing concerns. The results show that the incorporation of a coefficient that translates the driving difficulties promotes a balanced routing plan from the driver's perspectives.

**Keywords:** Waste Management, Route Balancing, CVRP, Real Applications

---

\*Speaker

†Corresponding author: a.raquel.aguiar@ist.utl.pt

‡Corresponding author: tania.p.ramos@tecnico.ulisboa.pt