

Optimization of urban delivery systems with drones

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Delivery of goods into urban areas constitutes an important issue for logistics service providers. In order to increase the efficiency of their logistics activities and to improve the environment impact, Amazon and La Poste have launched in December 2016 unmanned drone delivery.

Delivery by drones offers new possibilities, but also proposes new challenging routing problems. How to optimize the total delivery process time by combining vehicles and drones efficiently? Two kinds of problems have been described in the literature : vehicles and drones combination with synchronisation (a drone is launched from a vehicle while it delivers a customer and the vehicle takes it back at its next delivery point) and without synchronisation (drones deliver customers from a depot).

Here, we consider the problem without synchronisation. We propose an original resolution approach based on dynamic programming. It consists in an iterative two-steps heuristic. The first step builds a giant tour, either by solving a TSP with all the customers at the first iteration or by perturbing the previous giant tour. In the second step, the giant tour is optimally splitted in order to determine what customers are delivered by drones and what customers are delivered by vehicles (in the order defined by the giant tour). The objective is to minimize the makespan, i.e. the latest return time of vehicles and drones to the depot.

The results obtained are very promising. The proposed heuristic is applied on a literature benchmark test of 240 instances. We find better solutions for 224 instances.

Key words : *drones, delivery, optimization.*