Computers and Operations Research CAOR-D-21-00152R1 "Coordinating drones with mothership vehicles: The mothership and drone routing problem with Graphs"

Answer to Reviewers' Comments

June 21, 2021

We wish to thank the Editors and the Reviewers for their valuable comments and advices which allowed us to further improve the quality of our paper. We revised the manuscript by taking into account all the suggestions of reviewer 1. We report below our answers and changes inside the colored textboxes.

Editors' Comments The reviewers have commented on your above paper. They indicated that it is not acceptable for publication in its present form. However, if you feel that you can suitably address the reviewers' comments (included below), I invite you to revise and resubmit your manuscript. You will find your submission record under the menu item, 'Submissions Needing Revision'. Please carefully address the issues raised in the comments.

Answer E

Thank you for the feedback. We revised the manuscript following the reviewer advices. We outlined in blue each change made in the revised version of the paper.

Reviewer 1

Most of my comments have been succesfully addressed. Please find a list of remaining comments below (pages refer to submitted pdf (including answers to the reviewers).
The introduction of the problem variants is inconsistent: While on page 9 you describe one situation and two 'alternative situations', on page 10 you describe only two situations.

Answer R1.1

Thanks for carefully reading our paper. We think the reviewer means page 9 and 11. In that case, we rephrased the sentence in page 3 of the manuscript as follows: "Depending on the assumptions made on the movements of the mothership vehicle, this problem gives rise to three different versions: a) the mothership vehicle can move freely on the continuous space (all terrain ground vehicle, boat on the water or aircraft vehicle); b) the mothership can move on a connected piecewise linear polygonal chain; and c) the mothership can move on a road network (that is, it is a normal truck or van)."

P10: It is unclear how the graph is accessed/exited. Can it be accessed/exited on any point (also mid edge)? Only at the nodes? Only at prespecified entry and exit points? If there would be one fixed entry and one fixed exit point, would that make the problem decomposable? I.e.: could you first solve the graph routing problems, one by one, and the solve the mothership routing and drone launching problem?

Answer R1.2

The model that we analyze in this paper allows entering and leaving edges of the target graphs at any point. The only condition to be fulfilled is the percentage of the length of the edge (or the whole graph) that the drone must visit to consider the operation completed.
As reported in Table 2 and explained in page 6 of the manuscript, the entry and exit points R^{e_g} and L^{e_g} associated with a given edge e of a given target graph g are variables by means of the variables parameters $\rho^{e_g} \in [0,1]$ and $\lambda^{e_g} \in [0,1]$ to be determined by solving the mathematical formulation. Thus, they are not pre-specified points and they can be potentially located in any point of the segment/edge e.
However, as explained in Section 5 of the manuscript, to deal with large size instances, we already presented a matheursitc algorithm based on the problem decomposition, by decoupling the decisions made on the route followed by the mothership and the ones made on the drone.

p10: 'The reader should observe that, since we assume constant velocities, the minimization of the travel distances is a natural proxy for the minimization of the overall time needed to complete the visits to all target graphs.' If 'overall time' is read as 'the sum of traveling time of the mothership and traveling time of the drone': yes. I would, however, normally interpret 'overall time' as the time between departure of mothership and drone from the origin location until return to the destination location - and it is not equivalent to this. Please reformulate so that this becomes clearer. Please also motivate the objective function (based on one or several of the applications that you name).

Answer R1.3

Thanks for this observation. We better explained in the revised version of the paper that we are not minimizing the makespan of the system. Indeed, the length travelled by the drone, and implicitly the travelled time of the drone, has a cost that must be considered in addition to the one associated with the mothership. That is why we minimize the sum of the travelled distances by the mothership and by the drone and thus, because we assume constant velocities, the sum of traveling time of the mothership and traveling time of the drone. In all the cited applications, the adoption of a system like the one described in this paper, implies costs associated with the energy consumption of both vehicles involved (recharges for the drones and fuel consumption of the mothership). Thus, in order to efficiently manage the system and minimize its consumption, we consider as objective function the minimization of the sum of the travelled distances.

p13: Unclear what the function of entry and exit points of an edge is? How can we visit only part of an edge. Do we fly from (exit point on) edge to (entry point on) edge on straight lines? The picture Figure 2 suggests that, but it is left open in the text.

Answer R1.4

The referee guess is correct. The drone can move on straight line from an exit point in the middle of an edge to the next entry point in a different edge. The function of entry and exit points of an edge is to trace the portion of the edge visited by the drone. In the revised version of the manuscript we explicitly stated, even if the adoption of the Euclidian distance implies it, that the drone flies on straight line visiting a portion of an edge.

I appreciate that you have moved the comparison of (AMDRPG-MTZ) and (AMDRPG-SEC) to the appendix. I recommend to move also (the worse-performing) (AMDRPG-SEC) to the appendix (completely). There is not much use for the average reader to read through this lengthy formulation, and the technically interested can find it in the appendix.

Answer R1.5

We suppose that the suggestion of the reviewer was to move the AMDRPG formulation based on stages (the worse-performing) to the Appendix. However, we think that, as this was the first step to model this problem, and it is also the most appropriate one for dealing with future further extensions of this problem to the case in which it is permitted to the drone to visit multiple targets in the same mission (stage), it is useful and important to keep it in the main body of the paper. Alternatively, to reduce the length of the paper we have moved to the appendix former Section 4.3 devoted to the case where the mothership moves on a general graph.

Also for the reformulations of (NMDRPG) I wonder how useful it is for the reader to see the 'same trick' again in the main body of the paper - maybe this could also go to the appendix?

Answer R1.6

Thanks for the suggestion. In the revised version of the paper we moved the whole Section 4.3 to the Appendix, by adding a paragraph at the end of Section 4.2 which refers to the Appendix for the details related to the extension of the problem on a general network.

p32: What does 'XPPN' stand for?

Answer R1.7

In the revised version of the manuscript we explained that XPPN is an extension of the crossing postman problem where the Hamiltonian routes have to visit neighborhoods or polygonal chains rather than edges and refer the reader to a reference where he/she can find details on formulations and algorithms for this problem.