

Dear Dr. Schwane,

Thank you for your email including the responses of the reviewers to Manuscript 2017-10-A34107. The authors have reviewed the manuscript and have made changes according to the reviewer's comments. Within the manuscript these changes have been highlighted in red. The reviewer's comments are included below, along with the resulting modification to the manuscript.

We would like to thank the reviewers for their time, and for their comments which have helped to improve this manuscript.

Reviewer 1:

1. *In sections IV.B.2-4 it is explained that the number of collocation nodes at each of the stage optimisations is varied. The variation of the number of nodes is however small. For example, from 90 to 92 nodes for the first-stage optimisation. [Page 15, line 52-55] This is not a convincing convergence study.*

The number of nodes has been increased to 10, in line with the other ascent sections. This is detailed at the end of Page 15. Table 1 has been updated with the new first stage structural mass fraction values found from this expanded study. Section V.A has also been updated with a slightly improved first stage result.

2. *Would the same results be obtained with a significantly increased number of nodes, e.g. 130? Or would a different (local) minimum be reached?*

Similar local minima would be reached. At the node numbers tested, changing the node number does not impact on the quality of results significantly, and increasing the number of nodes does not necessarily improve the results. Changing the number of nodes is done to drive the solver to approach distinct local minima, so that the 'most optimal' may be selected. Increasing the node number significantly produces very similar results which are not necessarily more optimal.

3. *It is said that convergence is reached because "(...) converge to a very similar minima, and the fuel mass usage is observed to vary very little" [Page 15, line 55]. This should be quantified.*

This line has been removed, as this qualification is no longer necessary due to the number of tested nodes being increased.

4. *It is said that "the final solution chosen corresponds to the node value which most maximises the payload-to-orbit of the vehicle" [Page 15, line 11] or "the final result is chosen as the solution which uses the least fuel" [Page 15, line 55]. Shouldn't the final result be the most converged solution, i.e. the solution with the most amount of collocation nodes?*

The number of collocation nodes are fixed in DIDO, and do not relate explicitly to the optimality of the solution. The node number allows more complicated variable time histories to be resolved, but does not necessarily indicate a 'better' solution. The solutions used have all converged sufficiently so that each

represents a valid and accurate local minimum solution. Picking the minimum fuel solution ensures that the 'most optimal' local minima is selected in this case.

Reviewer 2:

1. *In the dynamic equations, the Eq (10) for the  $d(\text{heading})/dt$  is missing the force terms (i.e.,  $T$  and  $L$ ).*

It has been clarified in the paragraph preceding these equations that the roll and yaw angles are set to zero. Thrust and lift have been omitted as they do not affect the heading angle in this case.

2. *In Table 1,  $L/d$  should be  $L/D$ .*

This has been corrected.

The authors hope that the reviewer's comments have been properly addressed.

Regards,

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