ADVANCED AIRCRAFT PERFORMANCE ANALYSES

Marc Immer
ALR Aerospace
Gotthardstrasse 52
CH-8002 Zürich
marc.immer@alr-aerospace.ch

Philipp Juretzko
ALR Aerospace
Gotthardstrasse 52
CH-8002 Zürich
philipp.juretzko@alr-aerospace.ch

Abstract: In preliminary aircraft design, a certain aircraft is sought that fulfills defined requirements. Usually, such requirements contain flight performance targets, e.g. payload, range endurance and flight speed. After each iteration in the design process that produces a viable design, the flight performance is checked against the performance requirements. If the result is not satisfactory, the design is changed and re-evaluated.

The preliminary aircraft design process comprises multiple engineering disciplines involving e.g. aerodynamics, propulsion, structure, loads, stability & control and systems. As the design matures, the methods employed change from simple handbook methods (analytic or statistical nature) to more complex simulations (e.g. CFD, FEM). As the fidelity of the model increases, the applicability of methods for the computation of flight performance change: in early stages, where only few data points of the design are known, simple equations such as the Breguet range equation are often sufficient, whereas for the detailed evaluation of high fidelity models, six degrees of freedom (6DOF) simulations are suitable.

The segment based integration method uses numerical integration of the two-dimensional equations of motion. No analytic integrals are used (i.e Breguet range equation) and the mass of the aircraft is modelled as a 2D point mass (no rotational dynamics). This places the method between the simple handbook methods and the full 6DOF simulations. This simulation approach allows for the simulation of complex mission profiles [1], whilst being able to handle different complexities of the aircraft model. This makes the method ideal to couple with existing aircraft design frameworks, e.g. by implementing the CPACS [2] interface.

The current work aims at exploring the possibilities when combining flight performance computations based on the integration method with a powerful scripting environment. This allows for automation of performance computation and numerical optimization. Different numerical optimization methods are evaluated to find optimal flight altitudes of complex mission profiles. For the simulations, the Aircraft Performance Program (APP) [3] is used. *APP* is implemented in C++ and uses tabulated input data for aerodynamics and propulsion. For the scripting environment, *Python* [4] is used.

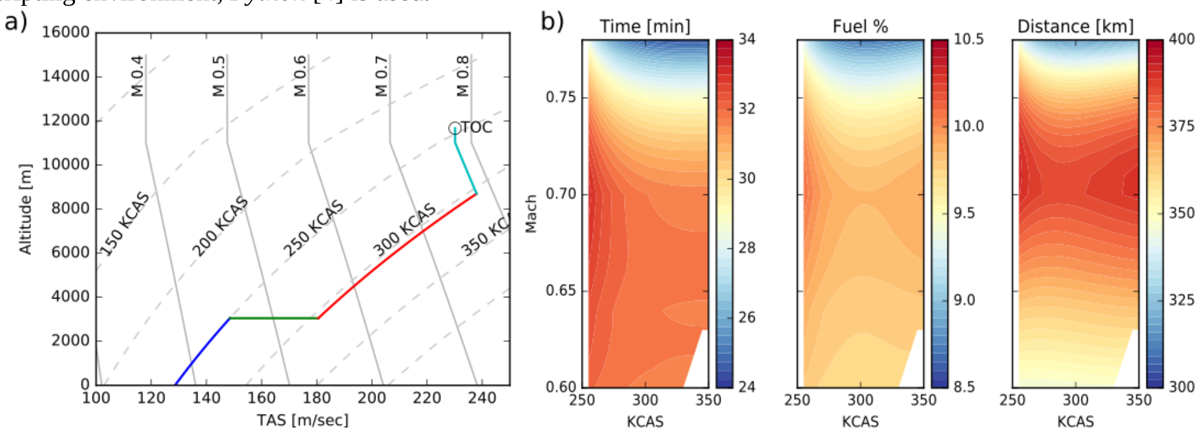

Figure 1: a) CAS-Mach flight profile with b) results for different climb speed scheduls

References

[1] Anemaat, W. A. J., Po, K., & Kaushik, B. (2008). Aircraft Performance Prediction: Comparison of Classical Handbook Methods to Detailed Time Integration Computer-Aided Methods. SAE International Journal of Aerospace, 1(1), 2008–01–2253. doi:10.4271/2008-01-2253
[2] Nagel, B., Böhnke, D., Gollnick, V., Schmollgruber, P., Rizzi, A., La Rocca, G., & Alonso, J. J. (2012). Communication in Aircraft Design: Can We Establish a Common Language? 28th International Congress of the Aeronautical Sciences, 1–13.
[3] APP 6.0 User Manual (2016), ALR Aerospace, Zurich
[4] Python 2.7, Python Software Foundation, Retrieved from https://www.python.org/