Solution Space Design for Continuous Descent Operations under Prediction Uncertainties

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Abstract— When planning and predicting a flight trajectory, uncertainties are inherent both in the current values of various influencing factors and in their evolution. These uncertainties can turn initially "optimized" trajectories into impossible or at least less attractive solutions at their activation time. In order to support a more robust trajectory optimization strategy, this paper investigates how those uncertainties affect the trajectory formation process and proposes a solution space, in which the planned optimized trajectories should be found. The trajectory optimization problem needed to design such a solution space is formalized as a multi-phase optimal control problem and is numerically solved with the pseudo-spectral method, which transcribes the continuous problem with discretized representation points. When solving given differential equations with the discretized points, the optimal number of discretized points is determined to grant accuracy of the optimization results. The solution space considers expected prediction errors of wind and temperature from a given reference case. Consequently, uncertain wind conditions cause a larger solution space and more variation in fuel burn than temperature errors. The designed solution space (especially the earliest and latest top of descent locations) gives pilots and air traffic controllers a good reference within which their aircraft is expected to navigate despite prevailing uncertainties. We believe that such additional information supports pilots and air traffic controllers when they robustly plan and execute continuous descent operations thus also improves the throughput on runways.