Modeling of wind and turbulence for a high-fidelity flight simulation model

A Popular Science Article of this Master Thesis

An airplane without a functioning flight control system might crash. Therefore such systems will not be developed in flight but with help of simulations and measured data. At the Institute of Flight System Dynamics at the TU Munich a flight control system for a small unmanned aircraft (UAV) is currently being developed using the software *Matlab/Simulink*. The belonging simulation model includes a module which simulates wind, turbulence, wind gusts and wind shear. This module is suitably controllable by the user and reflects the flight conditions in a realistic manner. Furthermore the module has to meet the compliance with its master system and with the general requirements of the Institute. The aim of this thesis was to develop such a module.

Wind will be generated by the module in form of wind velocities and accelerations. These can be directly integrated in the equations of movement of any desired aircraft in the simulation. Turbulence describes small and unordered fluctuations of the mean wind which occur due to frictions with the ground or between atmospheric layers. In contrast to turbulence are wind gusts prolonged and can result in large deviations of the mean wind. Wind shear describes a change in direction and amount of the mean wind between two considered points in the atmosphere.

To measure data in the atmosphere and build functions from scratch would have been beyond the scope of this thesis. Instead the model is based on a military specification of the US Department of Defense which contains established functions for the behavior of turbulence, wind gusts and wind shear.

The behavior of turbulence is only defined in so called power density spectra which reflect the intensity of turbulence and its probability of occurrence depending on the flight conditions. These spectra are unsuitable for an implementation that meets the

requirements for the simulation model. The transformation of these spectra by methods of control engineering to suitable algorithms was a major part of this thesis.

Finally the programmed model has been verified extensively according to the strict requirements of the aviation sector. A few problems occurred during the verification. These problems have been directly solved respectively it has been shown that the problems only occurred outside the range of application. Thus the reliable application of the programmed model in flight simulations is totally ensured. The model meets all requirements and can even be integrated easily in future simulations.