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APPLICATION OF GENETIC ALGORITHMS TO HELICOPTER FLIGHT TEST PLANNING

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Abstract

The methodology proposed in this paper is based on Genetic Algorithms applied to the phase of test planning, in order to use results of simulation processes for improve flight safety in testing activity that will be performed. Genetic Algorithms (G.A.) method is founded on computer capability to perform a high number of operations oriented at search of the best solutions in a large envelope by a specific strategy (generation, crossing-over, mutation, selection), and it is a flexible method, with possibility to increase step by step accuracy of G.A. code prediction. G.A. method is proposed in order to support mission planning, to obtain optimized complete flight paths (for fuel consumption, for time of flight, for payload) for various take-off Gross Weights, in relation with particular environmental conditions (mountainous areas, significant obstacles), for a complete mission when target positions are given, or for moving in the area where helicopter will be tested in specific maneuvers. The core of the G.A. code is a mathematical model that may be developed by two different approaches: using an analytical technique founded on expressions and equations of functions (main function to be estimated: total power required for each leg of mission), or using an approach based on matrices of available data (main matrix: matrix of available values of total power required for different combinations of airspeed/weights). The results presented in this work are estimated by a mathematical model with a simplified analytical approach. A hypothetical helicopter (Maximum Take-off Gross Weight: 3000 kg) with single main rotor (number of blades: 4; rotor diameter: 12 m) is chosen to illustrate the application of Genetic Algorithms to flight trials. Mathematical model includes helicopter characteristics (basic aerodynamics data of main rotor, tail rotor, fuselage; basic power-plant parameters, transmission parameters), equations (based on simplified assumptions) for determination of helicopter trim and prediction of total power required, and expressions of constraints (power available, ref. Maximum Continuous Power; specific fuel consumption), and other constraints (main points of H-V Diagrams, max fuel, max payload, max rates of climb, service ceiling). Then, with reference to a definite mission at ISA conditions (take-off, climb, forward level flight, descent, hover, forward level flight, hover with payload increase, level flight, landing), mathematical model will provide prediction of the best set of solutions: forward velocities on each leg (and rate of climb, rate of descent), altitude, total fuel required, in order to have optimization of a single objective function (fuel consumption, or total time of flight, or payload) or to have a multi-objective optimization (fuel consumption and total time of flight, with a definite payload). The results obtained may be confronted with Power/Velocity curve (Fuel Consumption/Velocity) for verification of performances. Definitive version and validation of mathematical model (associated with a grade of prediction accuracy) for a given helicopter will be based on confrontation with available flight test data and/or specific flight test activities. Once validated model is available, planning activities may be reduced (to confirm the use **a cost efficient technique**). **Impact on safety** is due to possibility of use all advantages of simulation process:

a) prediction and preliminary verification of helicopter configuration (Gross Weight) and time of flight on each leg of the complete flight trials;
b) preliminary analysis and confrontation of optimized flight paths (single or multi-objectives optimization of total time of flight, total fuel consumption) proposed by the code with real conditions of the area interested by flight test, in order to supply data for decision in descent approaches, to reduce pilot (and crew) work load during flight. Then, simulation can help also to verify safety flight paths and can help to have risk mitigation.

References:

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