The simulation model aircraft L410 UVP-E20 - basic description of modeling

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ABSTRACT - The article is focused on the application of information technology on the airplane. The article describes a basic approach to simulate aircraft L410. Defines starting conditions, basic parameters and sets the initial conditions of the simulation model aircraft.

KEYWORDS – simulation, aircraft, L410, model

INTRODUCTION

Flight L-410 Turbolet is a Czech transport and transport airplane designed for regional transport. It is a high-rise, self-supporting monoplane. The fuselage consists of all-metal half-shell, the wing is two-armed, equipped with double-wing flaps and spoilers. The propulsion unit consists of two Walter M 601 turboprop engines and an Avia V508 or V 510 propeller - a fixed-speed propeller with the ability to fire and reverse. The electrical system is powered by a direct voltage of 28V. The aircraft is equipped with a main and backup hydraulic system. The chassis is hydraulically retractable. The machine is capable of landing in small and untouched aerodromes and capable of operating under extreme conditions from +50°C to -40°C, is certified for IFR, accurate ILS CAT 1 approach. Over 1 100 pieces were produced, the main the buyer of airplanes was Soviet Aeroflot, but were further re-sold to countries in Asia, Africa and South America.

Another variant was the L-410UVP (STOL), which has an extended fuselage, an enlarged wing span and stabilizer uplift was adjusted to +7°. An automatic bank control (ABC) has been added to the automatic battle system. This is a wing at the end of the wing, which opens automatically when a single engine fails, but only at a speed of 205 km/hour. The wing was equipped with interceptors. Equipment and brakes have been improved. First, the M601B engines with the same performance were installed, but at higher temperatures it was more efficient, but the M601D and the V508D propellers were later installed. The number of seats is 15. The take-off is approximately 456 m.

The most common variant is the L-410UVP-E with increased maximum take-off mass, stronger Walter M601E engines, five-propelled V510 propellers. At the end of the wings, external (sometimes mistakenly called additional) tanks can be mounted. The prototype took off in 1984 and started production in 1985. There are other UVP-E submarines: UVP-E9 and UVP-E20, which differ in detail due to the periodic requirements for complying with JAR 25 and, respectively, FAR-23. The latest version of the Turbolet is the L-420 with the M601F, which has been certified by the US FAA. The L-410 versions M to E (including E9 and E20) have a type certificate issued by EASA [11].

SIMULATION OF AIRCRAFT – BASIS

Movement in space and time L410 UVP aircraft simulator is described by mathematical equations systems that include all the external influences acting on the aircraft during flight and while moving along the runway. Simplified mathematical model is only within the specified technical and technological parameters.

- Admission requirements:
    - The aircraft is considered to be a perfect rigid body with the possibility of six degrees of freedom of movement,
    - The aircraft's geometry and the mass (weight) symmetrical about the vertical symmetry plane xy,

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- o The main axes of inertia of the aircraft are identical to the axes of the coordinate system of the aircraft,
  - o Gravitational acceleration is constant throughout the range of operating heights and is equal to $g = 9,81$ m/s^{-2},
  - o Changes in temperature and pressure with a height equivalent to MSA (Standardisation System of Units),
  - o runway is horizontal,
- The basic dynamic equations of motion of the aircraft
  - o coefficient buoyancy,
  - o Coefficient of Resistance,
  - o The coefficient of lateral force,
  - o The coefficient of torque banked,
  - o The coefficient of torque-turn,
  - o coefficient of roll moment,
- Environmental specifications:
  - o Acceleration of gravity $g = 9,81 \frac{m}{s^2}$,
  - o Specific air density $\rho = \rho(H, \Delta t)$,
- Geometric and mass (weight) parameters:
  - o S - wing area, the L410 UVP = 35,18 m^2,
  - o l - the wingspan of L410 UVP = 19,479 m,
  - o bMAC - mean aerodynamic chord for L410 UVP = 3,84 m,
  - o weight of the aircraft,
  - o aircraft cg = 17 - 28%,
  - o moments of inertia,
- Reaction forces and torques the chassis:
  - o vertical component of ground reaction to the front wheel,
  - o Vertical (perpendicular) components of the response of the Earth to the main chassis,
  - o tangential reaction wheel chassis,
  - o torque turning the wheels responses,
  - o diving moment reaction wheels,
- Equations calculate the basic flight parameters
  - o Airspeed,
  - o angle of attack,
  - o Angle of turn,
  - o a rate of roll,
  - o Angular speed cornering,
  - o Longitudinal inclination plane,
  - o Bank angle plane,
  - o Course Plane,
  - o The slope of the flight path,
  - o Vertical speed,
  - o Flight altitude,
  - o Multiples overload,
  - o Instrument flight speed.

Simulation aircraft L410 UVP-E20 is designed simulation program, which has the following key elements:
- Solution initial conditions - this is simulated setting the initial conditions before flight,
- Solution the flight (flight dynamics) - simulated solution are dynamic elements of flight with the equations that describe the movement of aircraft,
- Solution powerplants - here is simulate the static and dynamic properties of the turbo-propeller propulsion units,

- navigation solution - this simulated flight path with the help of solutions to compute flight path scale servo control aircraft, radio communications and radio navigation systems, aircraft systems and terrestrial (satellite) systems.

CREATING AIRCRAFT SIMULATION USING MATLAB / SIMULINK

Once we determine aerodynamic stability and control derivatives, we can build a model to evaluate longitudinal dynamics. Once the model is complete, we can export it to a web view.

A typical model includes the following components:

- Equation of motion: calculation of aircraft position,
- Forces and moments: calculation of aerodynamics, gravity, tensile forces and moments,
- actuator positions: calculate the shift based on the instructions,
- Environment: includes environmental effects, wind, gravity, and atmosphere,
- Sensors - model the behavior of measuring devices.

We can implement most of these features using blocks from Aerospace Blockset™. Subsystems containing the Aerospace Blockset blocks are highlighted in orange, and the Aerospace Blockset blocks are red.

Model construction begins with the use of the 3DOF from the Equations of Motion library from the Aerospace Blockset library - Fig. 4. This model will help us determine whether the aircraft is longitudinally stable and verifiable. We design the subsystem so that it has the same interface as the 6DOF version. When we are satisfied with the three DOFs in terms of performance, stability and handling, we can implement the six DOF version until we reach the required aircraft behavior.

To calculate aerodynamic forces and momentum on an aircraft, we use the Digital DATCOM block and moments from the Aerospace Blockset library – Fig. 5. This block uses the structure that Aerospace Toolbox creates when importing aerodynamic coefficients from Digital DATCOM.

In some cases Digital DATCOM, a dynamic derivative has values only at the first rise angle. Missing data points can be filled with values valid for the first rise angle, as these derivatives are independent of the rise angle.

We also use Aerospace Blockset blocks to create models of actuators, sensors and environmental models (Fig. 6, 7 and 8).

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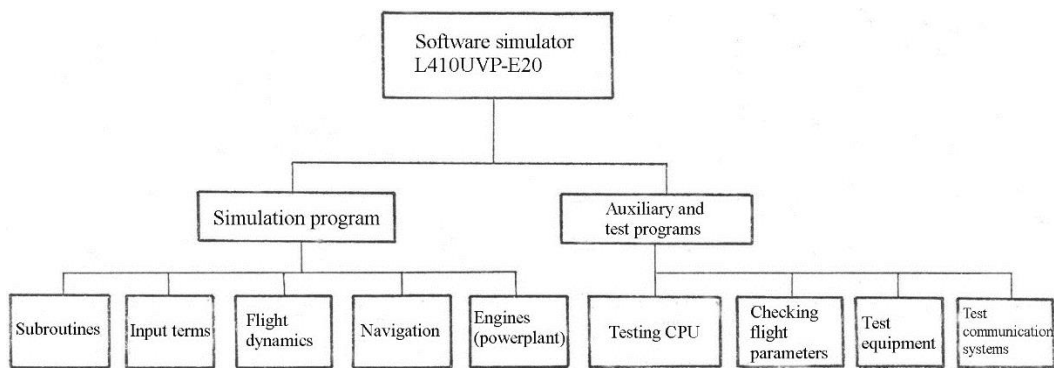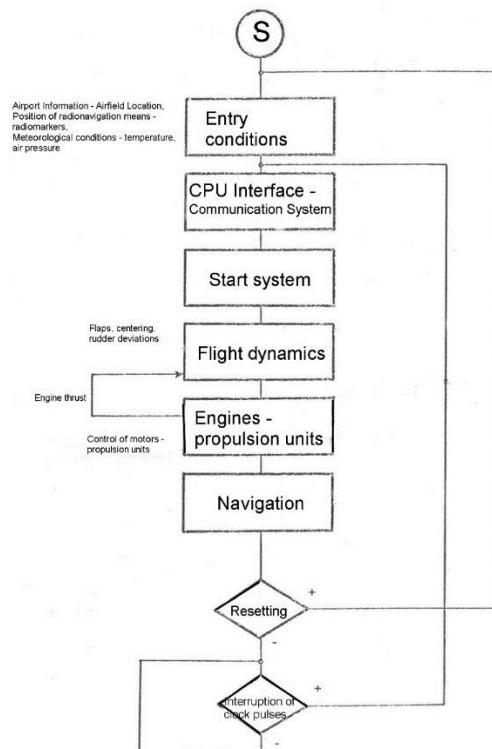
Fig. 1 The total scheme of software simulator

Fig. 2 The flowchart simulation aircraft L410 UVP-E20
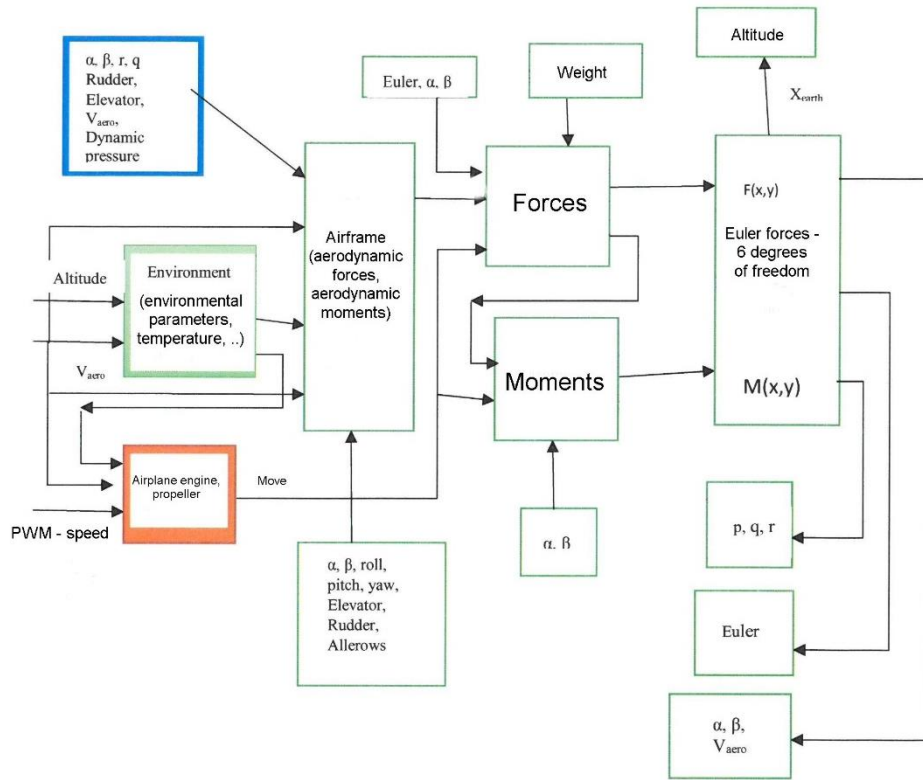
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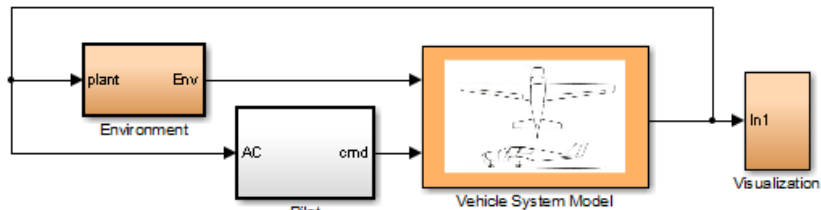Fig. 3 Basic diagram of simulation aircraft

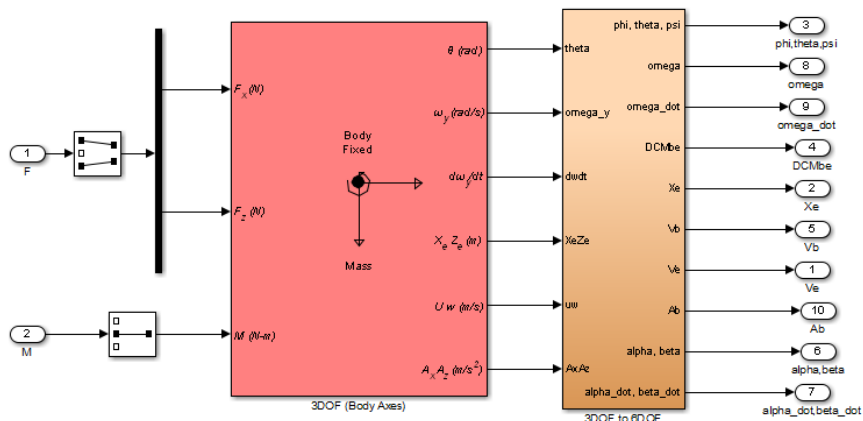Fig. 3 Basic layout of aircraft in Matlab

Fig. 4 Motion equations implemented with the 3DoF Euler block
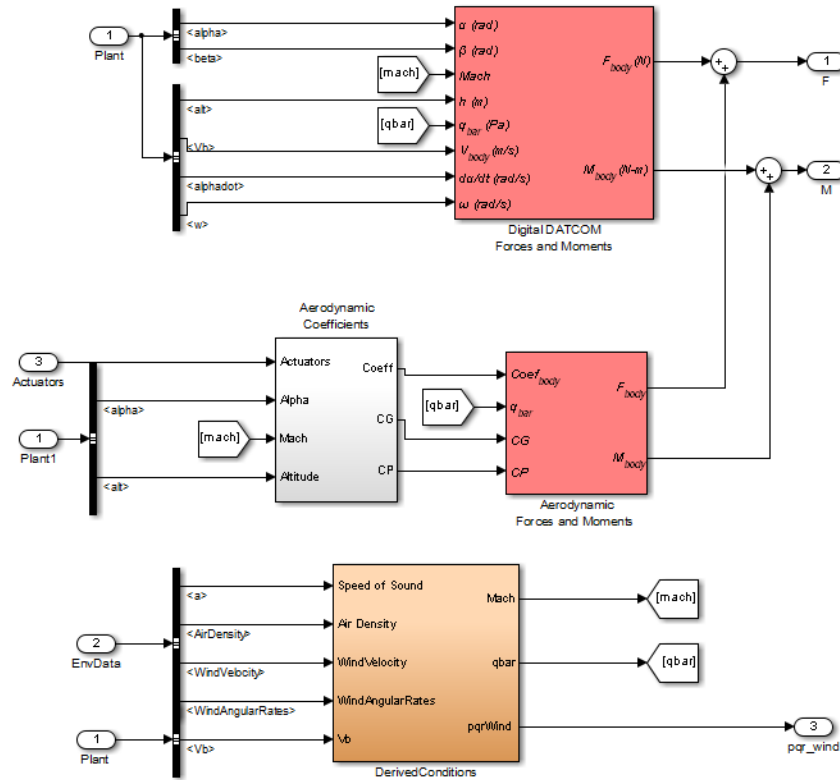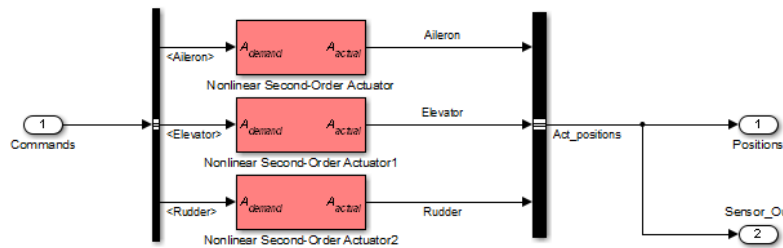
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Fig. 5 Aerodynamic forces and moments implemented
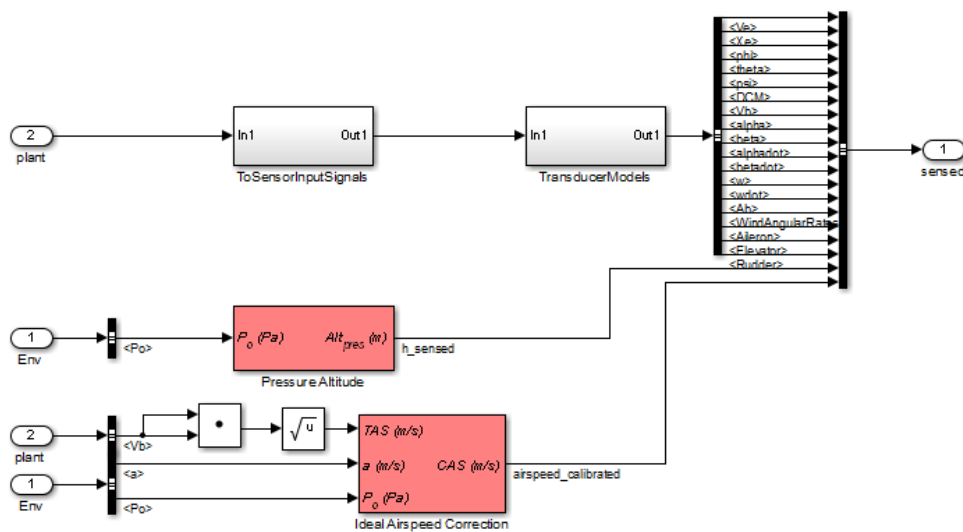

Fig. 6 Implementation of Actuator Models
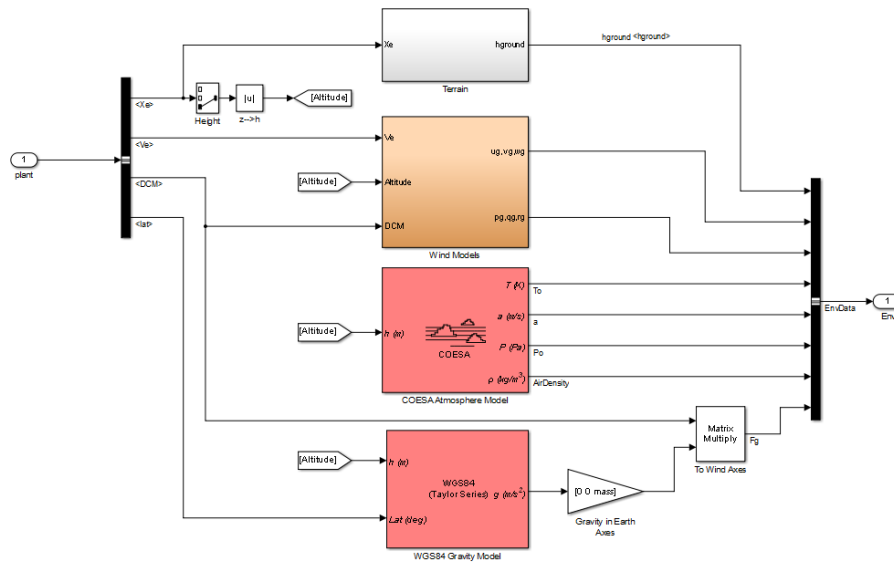

Fig. 7 Implementation of a flight sensors model

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Fig. 8 Environmental Impact of Wind, Atmosphere and Gravity

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