Hochschule für Angewandte Wissenschaften Hamburg
Hamburg University of Applied Sciences

AERO – AIRCRAFT DESIGN AND SYSTEMS GROUP

Flight Dynamics Analysis of a Medium Range Box Wing Aircraft

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Airport2030

Airport2030 – Work Package 4.1:

Aircraft Configurations for Scenario 2015

Contents

- Introduction to ‘Airport 2030’ and Box Wing Aircraft
- Stability and Control Derivatives
- Flight Dynamics Model (FDM) – JSBSim
- Integration of FDM in Flight Simulator – Flight Gear
- Analysis of Eigenmodes and Handling Qualities
- Conclusions

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Box Wing configuration

- A conventional wing is split along the wing span into two wings
- Reduction of induced drag

Fuel savings because of the wing configuration

Current version

- Based on Airbus A320 (same design mission)
- 9% fuel savings
- Twin aisle layout

Advantages with regard to 'Airport 2030'

- Less emissions during landing and take off (induced drag = 80-90 % of the total drag)

- More efficient ground handling because of undivided cargo compartment (usually the center wing box divides the cargo compartment) and the twin aisle layout

1) **Conceptual design** (Schiktanz 2011) ✔

Next step:

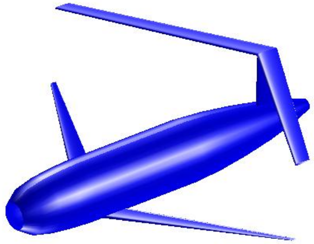
2) **Flight Dynamics Analysis**

- An accurate description of the flight-dynamics of the aircraft is necessary to decide whether its design is feasible (especially for unconventional configurations).
- Need to increase the knowledge about stability and control (S&C) as early as possible in the aircraft development process in order to be first-time-right with the FCS design architecture, in later stages of design.

Contents

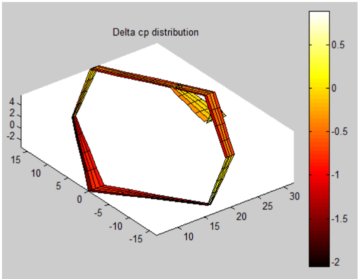
Stability and Control Derivatives

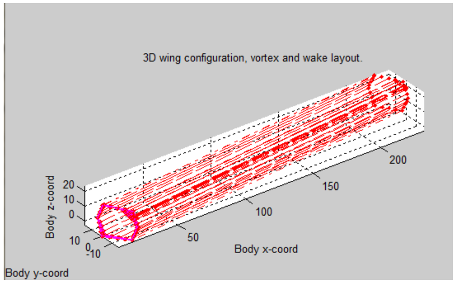
- Definition of stability and control derivatives necessary for the flight dynamics analysis
- Modeling of aircraft geometric model and derivatives calculation:
  - **USAF Digital Datcom**: problems with geometry, winglets cannot be modeled



Aircraft geometric model obtained with Digital Datcom (no possibility of winglets)

  - **Tornado**: - Vortex Lattice Method (VLM) for linear aerodynamic wing design applications, implemented in MATLAB
    - Aircraft is built up by multiple wings which can have a full 3D orientation (no fuselage)





Screenshots of Tornado calculations

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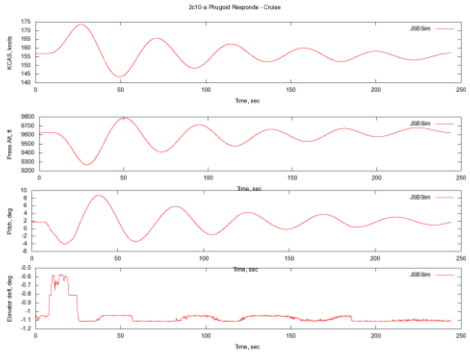
Flight Dynamics Model (FDM) - JSBSim

FDM: Physics/math model that defines the movement of an aircraft under the forces and moments applied to it using the various control mechanisms and from the forces of nature

JSBSim: open source FDM compiled in C++

- Fully configurable flight control system, aerodynamics, propulsion, landing gear arrangement, etc. through XML-based text file format.
- It can be run as a stand-alone program, taking input from a script file and various vehicle configuration files or incorporated into a flight simulator (real time) with a visual system.
- JSBSim also allows to perform flight tests (ie. FAA-style tests) and evaluate the behavior of the aircraft from graphic plots: Flap change dynamics, Phugoid dynamics…



Results of the Phugoid response for a business-class turbojet aircraft

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Integration of FDM in Flight Simulator – FlightGear

FLIGHT GEAR: Open-source flight simulator, mostly written in C++

Screenshot of FlightGear (www.flightgear.org)

- Intended to use in research or academic environments, pilot training, as an industry engineering tool, etc.
- Currently supports several FDM's: **JSBSim** (default since 2000), YASim (the only FDM providing simulation for rotorcraft), UIUC.
- Once implemented in FlighGear, it will be possible to observe the behaviour of the Box Wing aircraft from a more subjective point of view (that of a pilot), and find out whether it "handles nicely" (**Cooper-Harper-Rating-Scale**).

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Thank you very much for your attention!

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Backup

Cooper-Harper Rating Scale