



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

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- 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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Introduction to Airport 2030 and Box Wing Aircraft

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

Introduction to Airport 2030 and Box Wing Aircraft

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.

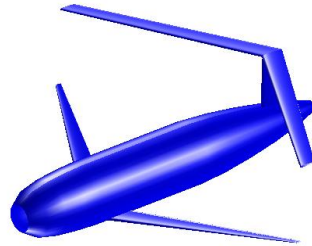
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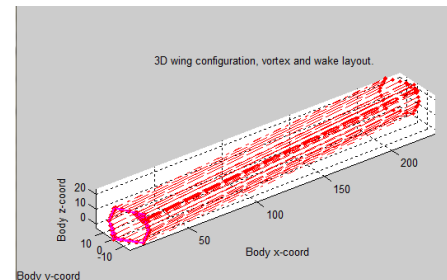
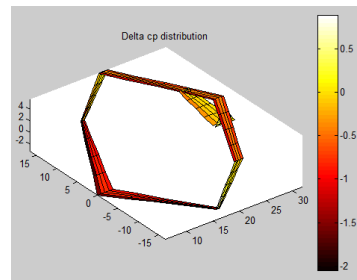
Stability and Control Derivatives

- 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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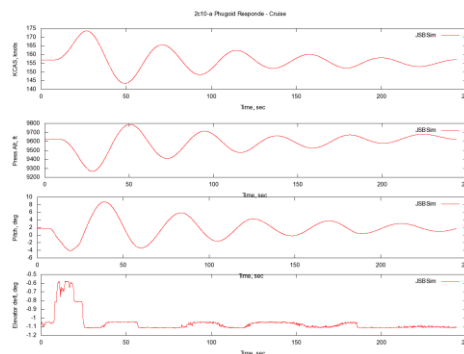
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Flight Dynamics Model (FDM) - JSBSim

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++

- 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 FlightGear, 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**).



Screenshot of FlightGear
(www.flightgear.org)

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Thank you very much for your attention!

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Backup

Cooper-Harper Rating Scale

