AERODESIGN

Preliminary Design Methodologies

State of the art – Background

Aircraft design encompasses different areas of knowledge ranging from aerodynamics to structures and flight dynamics. It is the combination of these areas of expertise, in a multidisciplinary environment combined with design requirements that will allow a successful design. Combination of different fields where data/information is needed as input to another field of analysis automatically increases the number of design cycles necessary for the development of a product, increasing overall cost. Furthermore, at an initial phase of design, various unknowns are still present, data may be unavailable and requirements can suffer several changes, increasing the overall cost even further through more design cycles, creating the need for a tool/framework capable of performing initial and realistic analysis of different design solutions with little effort in a multidisciplinary design environment.

The initial conceptual and preliminary design phase drives most of the cost of the airplane project and lifecycle costs. Incorporating cost models in the early design enables the realization of even further cost reduction measures and trade-offs at the preliminary design level. Hence adequate design support tools are required in the early design process to handle in the most efficient way the largest amount of multidisciplinary variables, making sure the best concept is selected as a starting point to the detailed design phase.

Many companies and universities have developed conceptual/preliminary airplane design systems over the years, some of them with a wider, broad approach to the aircraft design problem, while others have focused on smaller subsets of design systems, such as geometry representation or concentration on Computational Fluid Dynamics (CFD) and/or finite element analysis (FEA).

Objectives

To study the future configuration of commercial aircrafts, it is important to have the most efficient method of preliminary design supported by the most complete database with information on existing assets and validated results. The initial conceptual and preliminary design phase drives most of the cost of the airplane project and lifecycle costs. Incorporating cost models in the early design enables the realization of even further cost reduction measures and trade-offs at the preliminary design level.

Adequate design support tools are required in the early design process to handle in the most efficient way the largest amount of multidisciplinary variables, making sure the best concept is selected as a starting point to the detailed design phase. The overall tool design is based on a multi-segment and multi-level technical framework. The AERODESIGN project has developed and validated a design tool capable of performing a preliminary design and analysis of an aircraft in the preliminary design phase, and enable achieving the pollution and noise reduction targets for the regional aircraft entering the market in the coming decades.

Description of work

The AERODESIGN project provides a design tool for the analysis and optimization of preliminary aircraft configurations. The overall tool design is based on a multi-segment and multi-level modular framework that divides the preliminary design methodology scope into eight different modules: geometrical, aerodynamic, engine data, weight and balance, mission and low speed performance, costs analysis, emissions and noise analysis. In an integrated process of design optimization, these modules are integrated by various technologies into a cost-effective solution. The tool performs aircraft design optimization based on changing the shape of its lifting surfaces, which are provided to the tool as input. The software tool was developed in a modular fashion so as to easily adjust, update, modify or enhance any of the modules individually, whilst the end result is strictly an application. The AERODESIGN tool is stand-alone, although it requires the availability of external resources (applications) to work properly. It includes a Human Machine Interface (HMI) that allows the user to operate the tool and obtain feedback information on the design results.

Expected results

The software tool is decomposed into three main components:

- Interface: provides the Human Machine Interface (HMI) and Batch Mode interface. The user interface is composed of a Graphical User Interface (GUI) through which the user is allowed to change mission requirements and technological coefficients relevant to the analysis or optimization procedure. Through the GUI the user

can also require the generation of reports both for a configuration analysis or a full optimization procedure.

- Core: this is the application task manager. It is an intermediate layer of the tool, which works as an intermediary/translator between the interface and the System module of the software application. It is responsible for managing the application files integrity used as data exchange medium and the application flow by requiring each of the independent modules to perform its specific task.

- System: is a collection of modules that perform specific analyses. Each module is a component of the tool, with a built-in interface that respects a pre-defined protocol determining a structure for the inputs of the module, a structure for the outputs of the module, and a pre-defined process for activating or calling the module.

The AERODESIGN software tool is capable of performing a preliminary design and analysis of an aircraft, to support the CLEANSKY Green Regional Aircraft development process in the preliminary design phase, and enable achieving the pollution and noise reduction targets for the regional aircraft entering the market in the coming decades. The following modules were implemented:

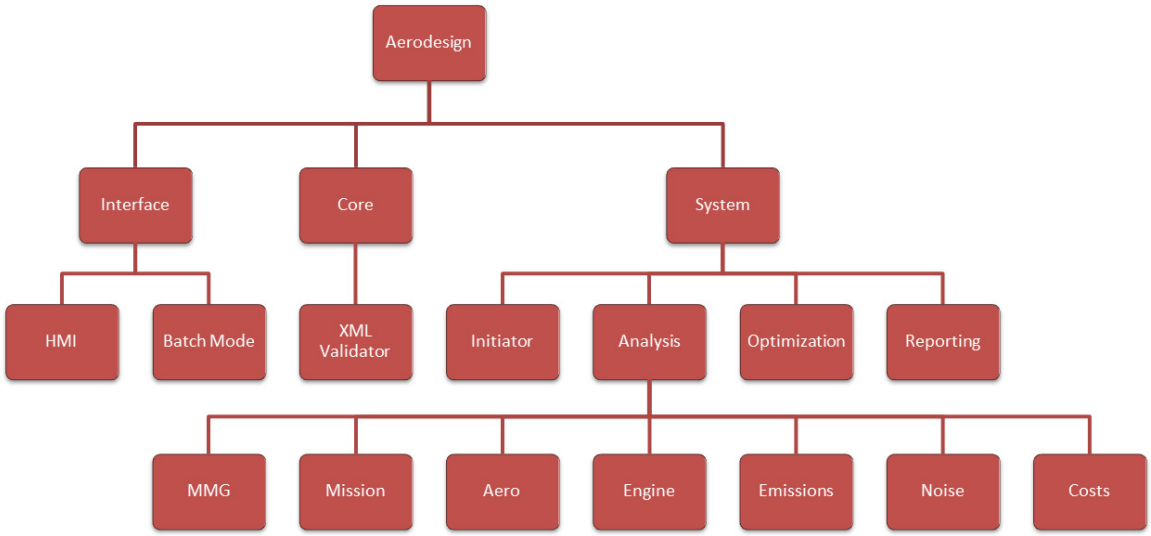
- Initiator: is a general statistical module that is used to obtain a general aircraft architecture starting from the aircraft requirements and a large database of reference aircraft. The general aircraft architecture defines an initial aircraft configuration solution that will be the base for the Multi-Model Generator.
- Optimization: shall perform optimization of the lifting surfaces, through the optimization of a set of design variables (parameters) that define the form of the lifting surfaces. The optimization shall find an aircraft design that achieves one of the following (user selected) goals:
    - Cost;
    - Noise;
    - Emissions;

And still satisfies the aircraft requirements expressed as constrains and bounds. The Optimization module shall implement a gradient based method, starting from an initial design point (an initial aircraft configuration) and shall be restricted to small changes in the design variables.

- Reporting Module: The Reporting Module will be responsible for presenting the analysis and optimization information on a tabular or graphical mode. This output will report the following information: Geometry of Aircraft and Engine; Characteristic weights; Weight Breakdown; Aerodynamic Data; Mission Results; Noise levels and footprints and Engine Emissions.

The Analysis module is divided in the following sub-modules:

- Multi-Model Generator: shall implement and execute all the required computations for deriving all the geometrical parameters necessary for the subsequent analysis and weight and balance computations. It can be divided in Geometry Model and Weight and Balance Module;
- Mission and Low Speed Performance Module: This module will calculate aircraft performance at different flight segments (eg. Take off, Climb, Cruise, etc.);
- Aerodynamic module: shall determine the aerodynamic loads and moments acting on the aircraft;
- Engine Data Module: will provide fuel consumption and thrust for each flight phase/engine ratings;
- Engine Emissions Module: module responsible for the calculation of engine emissions for a specific trajectory in various flight phases;
- Noise Module: The NOISE Module will be responsible for the calculation of internal and external noise levels, including noise iso-level curves around the airport;
- Costs Module: The Costs Module will be responsible for the calculation of Direct Operating Costs as well as Recurring production costs.


Aerodesign
Interface
Core
System
HMI
Batch Mode
XML Validator
Initiator
Analysis
Optimization
Reporting
MMG
Mission
Aero
Engine
Emissions
Noise
Costs

Project Summary

Acronym: AERODESIGN

Name of proposal: Preliminary Design Methodologies

Technical domain:

Involved ITD

Grant Agreement: 255851

Instrument:	Clean Sky
Total Cost:	189.395,40 €
Clean Sky contribution:	135.571,90 €
Call:	
Starting date:01/01/2010	
Ending date:31/08/2013	
Duration:43 months	

Coordinator contact details: Mr. Rui Venâncio
GMVIS SKYSOFT SA
Av. D. João II, Lote 1.17.02
Torre Fernão de Magalhães, 7º
1998-025 Lisboa
Tel. +351 21 382 93 66
Fax +351 21 386 64 93

Project Officer: Andrzej Podsadowski

Andrzej.Podsadowski@cleansky.eu

Participating members GMVIS Skysoft (Portugal)

Spin.Works (Portugal)

KE-Works (Netherlands)

Delft University of Technology