Aircraft Design Lectures at RWTH Aachen University, Germany

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1. Institute of Aerospace Systems at RWTH Aachen University

2. ILR Fixed Wing Aircraft Course → Practical Aspects
   • Analysing old Concepts
   • Paper & Pencil Aircraft Design

3. Computer-Aided Aircraft Design: Familiarization with MICADO

4. Template for MICADO C++ Tool Development

5. Summary
Vortex Dynamics/Aeroacoustics

Aircraft Design/Technology Integration and Assessment

Air Transport System/Life Cycle Analysis
<table>
<thead>
<tr>
<th>Fixed Wing Aircraft I</th>
<th>Fixed Wing Aircraft II</th>
<th>Short Course: Computer-Aided Aircraft Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft Acoustics</td>
<td>Air Transportation System</td>
<td>Short Course: Aircraft Testing</td>
</tr>
<tr>
<td>Helicopters</td>
<td>Selected Current Research Topics in Aeronautics</td>
<td>Short Course: Windtunnel Testing</td>
</tr>
<tr>
<td>Aerospace Systems</td>
<td>Spacecraft I &amp; II</td>
<td>Short Course: Delta Wings</td>
</tr>
</tbody>
</table>
Fixed Wing Aircraft I is attended by Bachelor students with various study backgrounds → goal is to teach fundamentals, e.g.:

- 9. Performance: Gliding flight, airspeed stability, specific air range, climb performance
- 13. Overall Design: Configurational decision, fuselage & empennage layout, engine installation, options for undercarriage, industrial design process

Lecture provides basic knowledge and design-“language” resp. design-“philosophy“ → practical aspects given in exercises
Exercises contain calculations of separate aspects e.g.:
- Range
- Take-off and Landings Distances
- DOC

No continuous design process is run through here

Since this year: In order to teach the students that
- It is needed to see the bigger picture
- It helps to analyze and learn from the past
we let them investigate on past configurations
which feature currently re-visited aspects, e.g.
- Blended Wing Body/Flying Wing → Junkers 1000
- Isogrid Structure → Vickers Wellington
- Fan Wing Lift Concept → Ryan 5a
- Counter-Rotating Prop → AN70

Work is done in groups of 5 students as homework, all on different topics → Open administrative issues
- Fixed Wing Aircraft II is attended by Master students with background knowledge → goal is to teach advanced aspects, e.g.:
  - 1-4. Preliminary A/C Design: Top level aircraft requirements, initial sizing, layout of fuselage, cabin, wing, engine, undercarriage, empennage, mass estimation, aero estimation, performance, assessment based on general and specific criteria
  - 9. Fly-by-Wire/Load Control: FBW architecture, laws, protections, mechanical backup, load control options
- Lecture provides basic introduction into aircraft design process, but mainly advanced insight on system level → practical aspects given in exercises
Excercises contain calculations of separate aspects e.g.:
- TLARs
- Initial sizing
- Undercarriage layout
- Performance

No complete design cycle is done yet

Since this year: In order to teach the students
- A „feeling“ for dimensions
- A knowledge of interdependencies

we let them re-design current aircraft configurations on paper & pencil-basis, e.g.
- Boeing 787
- Airbus A350
- Sukhoi Superjet

Work is done in groups of 5-8 students as homework, all on the same configuration, statistics and complementary infos are provided
Computer-Aided Aircraft Design is attended by Master students with background knowledge. The goal is to:

- Teach execution of complete aircraft design cycle with advanced conceptual aircraft design tool.
- Understanding and usage of ILR design tool MICADO:
  - For preparation to use MICADO for bachelor/master thesis.
  - For qualification of students as student assistants or to pursue a PhD at ILR.

Lecture provides insight into aircraft design process, but fully aligned with ILR-MICADO tool, creating a perfect double-use option, resp. a win-win situation.
MICADO Design Methodology – Process Overview

- White sheet design approach starting from a set of top-level req’s (TLARs)
- Aircraft design programs size geometry components → general arrangement
- Optionally, more detailed design programs
- Design undergoes performance analysis (masses, aerodynamics, mission)
- Full a/c design iteration
- Assessment against evaluation criteria
- Evaluation parameters can be used for overall aircraft design optimizations

→ Capturing of particular design changes or system integration on overall aircraft level due to component resizing and snowball effects

→ A full initial design synthesis (w/o optimization) takes about 15 min. on a normal desktop PC
MICADO Short Range Design – Block Fuel Optimization

W/S=450 kg/m²
T/W=0.37

W/S=600 kg/m²
T/W=0.33

TLAR’s

Initial sizing
Fuselage design

Configurational decisions

Aircraft and engine sizing
Detailed design (systems, control surfaces etc.)

Mass estimation
Aero analysis

Mission analysis

Convergence? yes

Design evaluation (fuel, costs, noise, emissions etc.)

Optimum?

Key evaluation parameters

Optimum?

A/C design

16.09.2013
E. Stumpf - A/C Design Lectures at RWTH
Slide 10
Motivation:
Contribution of Student Theses to MICADO software development

Problem:
MICADO is based on object-oriented class structure (C++)
Many Students have no or limited programming skills

Approach:
A template has been created (already at the beginning of the MICADO development phase) that already includes all C++ software features and templates, e.g.
- Geometry classes
- XML parsers → access to Aircraft and Settings XML files
- Engines, Aerodynamic, ISA etc. libraries
- Automatic plot generation
→ Completely working program package
→ Students only have to insert their methods and have a stand-alone program
MICADO control and data flow

XML Config file tool 1

Settings

Tool 1

Inputs

Outputs

XML Aircraft Exchange File
Aircraft parameter file serving as central data repository

MICADO mission classes code snippet

Automatic generated html report

Report Missionsanalyse Airbus A320


description of data

Mission Profile Step Cruise

Range = 4630 km, m_{payload} = 14250 kg

Altitude [m]

0 12000

Speed [m/s]

0 300

Altitude

TAS

CAS

Range [km]
- Aircraft design /technology integration and assessment represents main research field at ILR

- In ILR lecture Fixed Wing Aircraft I: students will work on old aircraft concepts to build up „system thinking“

- In ILR lecture Fixed Wing Aircraft II: students will execute a full design cycle to build up „system knowledge“

- In ILR lecture Computer-Aided Aircraft Design: students get familiarized with current conceptual aircraft design tool

- C++ tool templates enable to motivate students to do tool development (which otherwise would refuse)
Thank you for your attention!