http://ewade2013.AircraftDesign.org
http://dx.doi.org/10.5281/zenodo.546423

Eike Stumpf

Institute of Aerospace Systems (ILR)
RWTH Aachen University, Germany

Aircraft Design Lectures at RWTH Aachen University, Germany

11th European Workshop on Aircraft Design Education
Linköping, 17.-19.09.2013

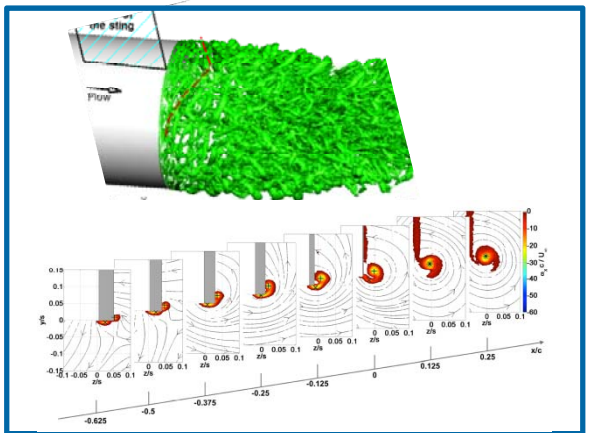
1. **Institute of Aerospace Systems at RWTH Aachen University**

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

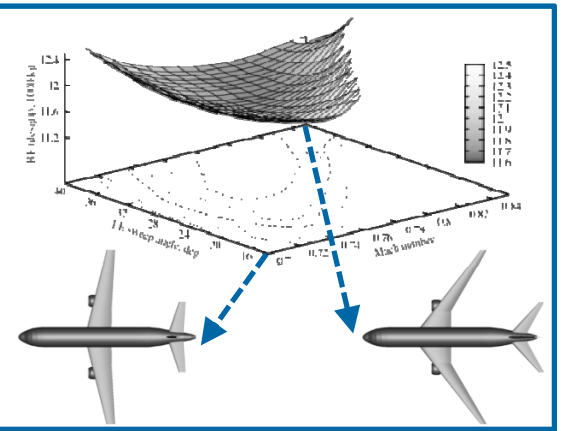
3. **Computer-Aided Aircraft Design: Familiarization with MICADO**

4. **Template for MICADO C++ Tool Development**

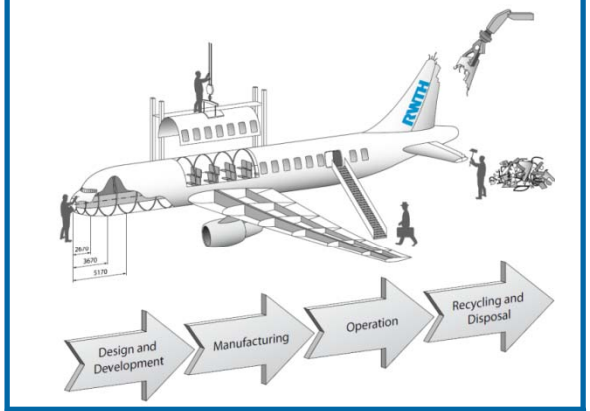
5. **Summary**



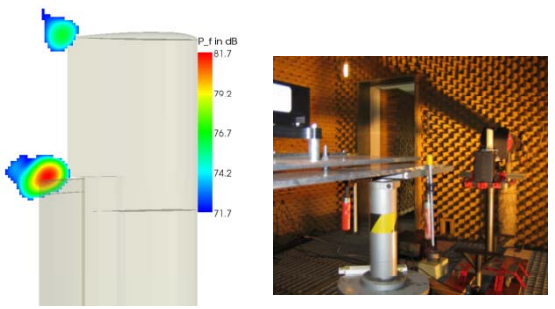
Vortex Dynamics/ Aeroacoustics

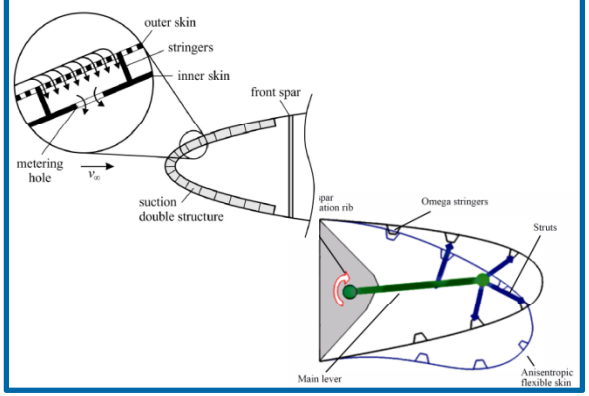


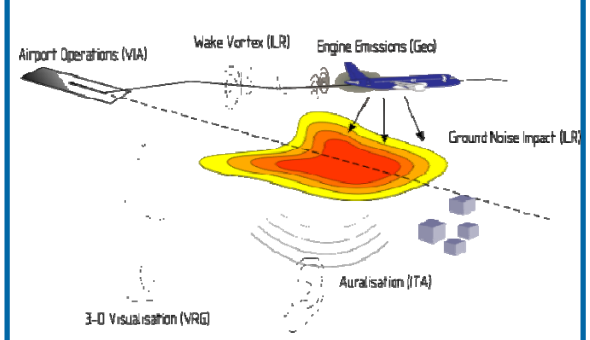
Aircraft Design/ Technology Integration and Assessment



Air Transport System/ Life Cycle Analysis

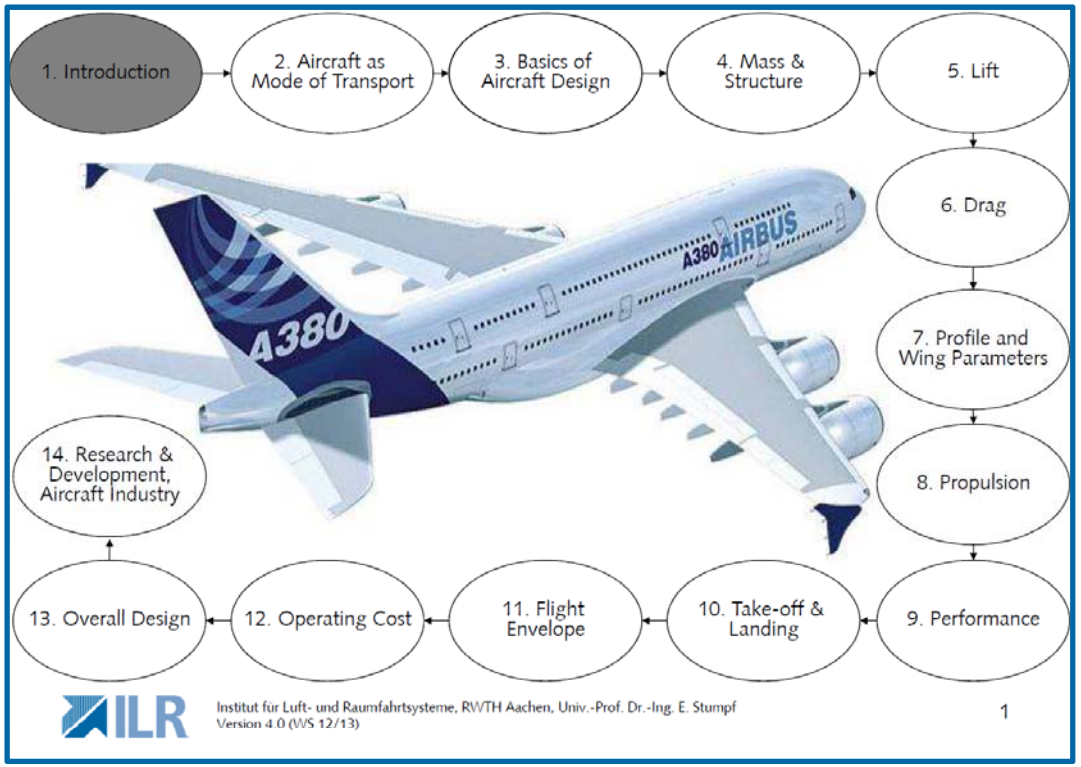


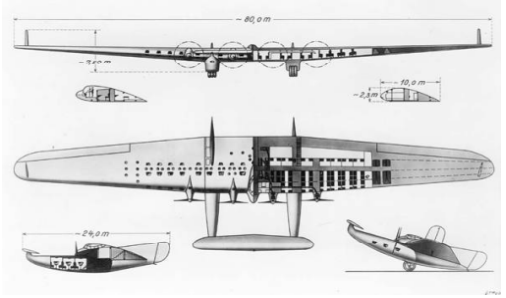




Fixed Wing Aircraft I	Fixed Wing Aircraft II	Short Course: Computer-Aided Aircraft Design
Aircraft Acoustics	Air Transportation System	Short Course: Aircraft Testing
Helicopters	Selected Current Research Topics in Aeronautics	Short Course: Windtunnel Testing
Aerospace Systems	Spacecraft I & II	Short Course: Delta Wings

- Fixed Wing Aircraft I is attended by Bachelor students with various study backgrounds → goal is to teach fundamentals , e.g.:
  - 3. Basics of A/C Design: AC decomposition, standard atmosphere, forces & moments, coefficients & dimensionless characteristic quantities
  - 9. Performance: Gliding flight, air speed stability, specific air range, climb performance
  - 13. Overall Design: Configurational decision, fuselage & empenage layout, engine installation, options for undercarriage, industrial design process
- Lecture provides basic knowledge and design-“language“ resp. design-“philosophy“ → practical aspects given in exercises





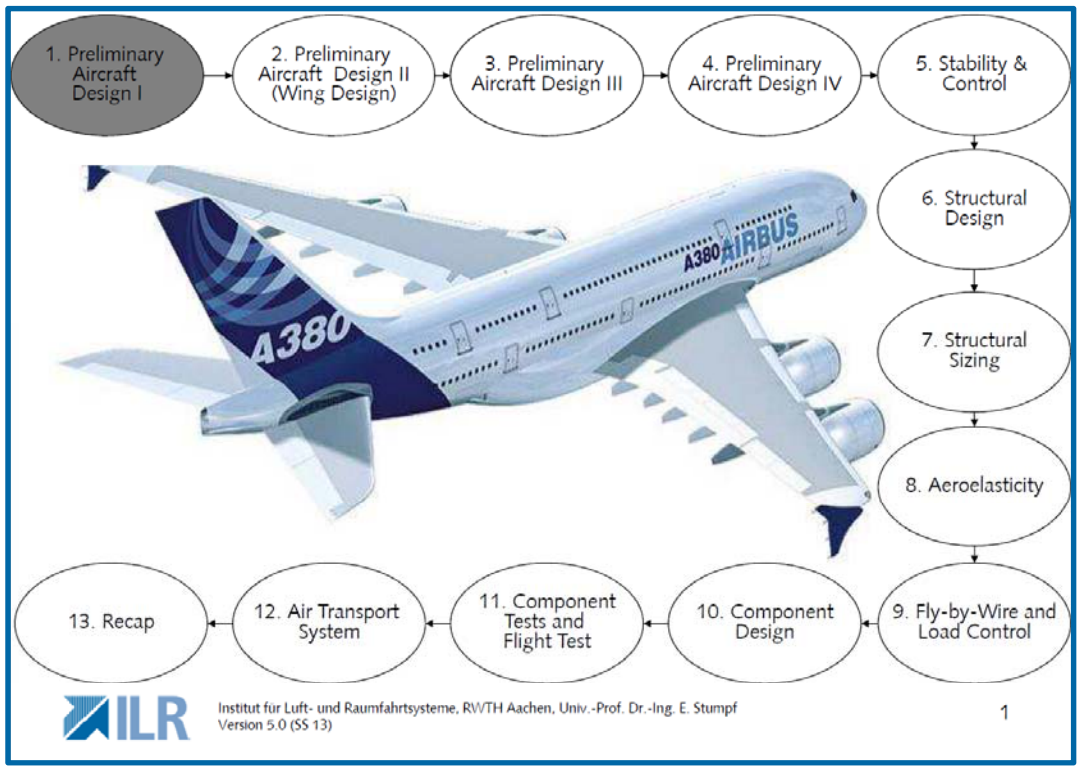
- Excercises contain calculations of separate aspects e.g.:
  - Range
  - Take-off and Landings Distances
  - DOC
- No continuous design process is run through here

- 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

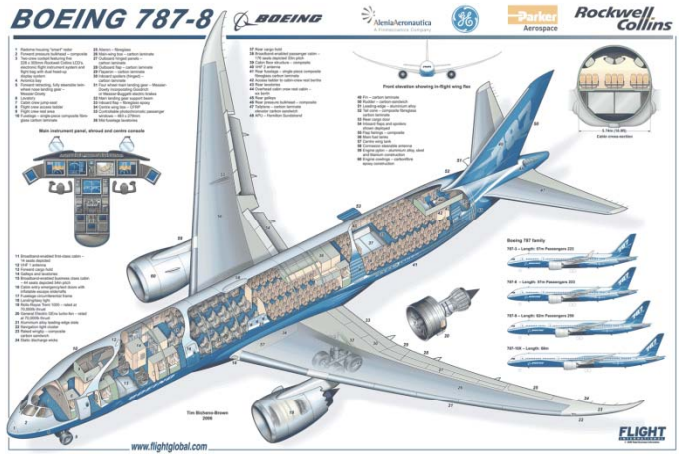
  which feature currently re-visited aspects, e.g.
  - Blended Wing Body/Flying Wing → Junkers 1000
  - Isogrid Structure → Vickers Wellington
  - Fan Wing Lift Concept → Ryan 5a
  - Counter-Rotating Prop → AN70
- Work is done in groups of 5 students as homework, all on different topics → Open administrative issues

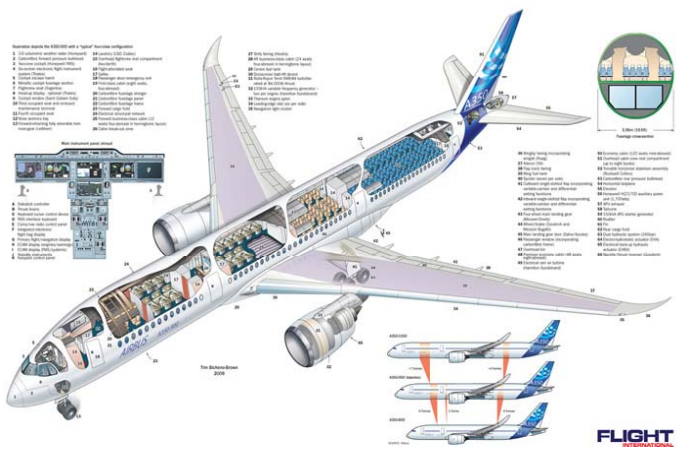
- Fixed Wing Aircraft II is attended by Master students with background knowledge → goal is to teach advanced aspects , e.g.:
  - 1. -4. Preliminary A/C Design: Top level aircraft requirements, initial sizing, layout of fuselage, cabin, wing, engine, undercarriage, empennage, mass estimation, aero estimation, 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

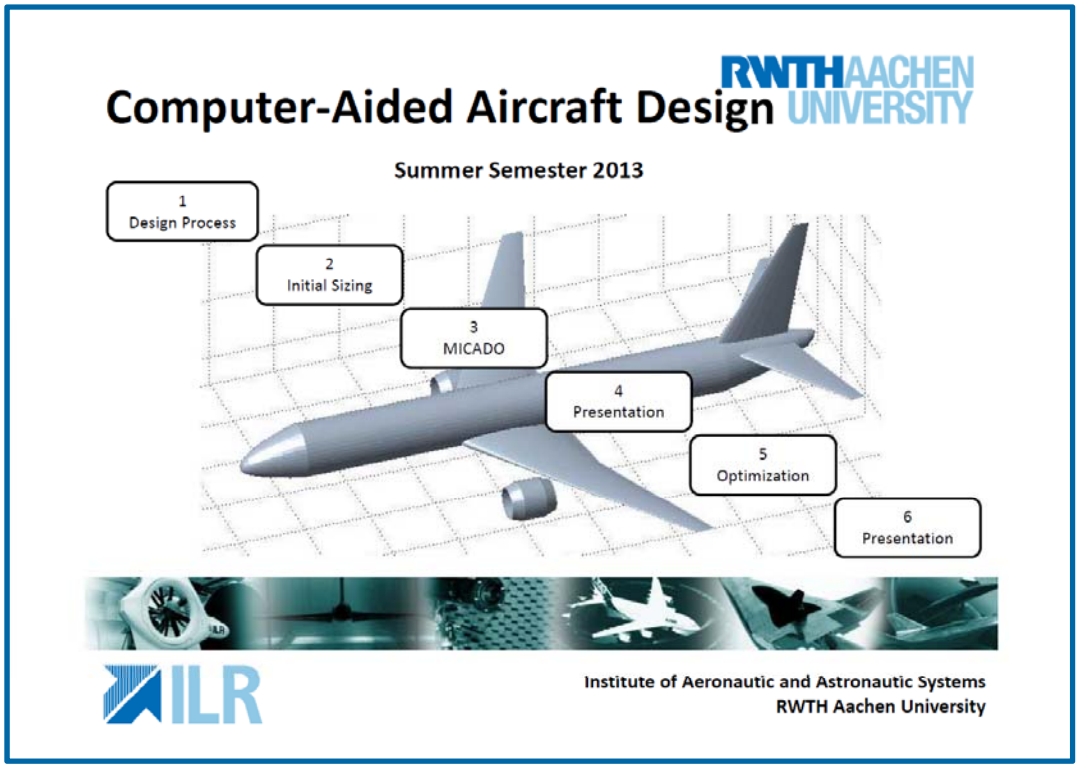
  we let them re-design current aircraft configurations on paper & pencil-basis, e.g.
  - Boeing 787
  - Airbus A350
  - Sukhoi Superjet





- 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 → 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 → perfect double-use option resp. win-win situation

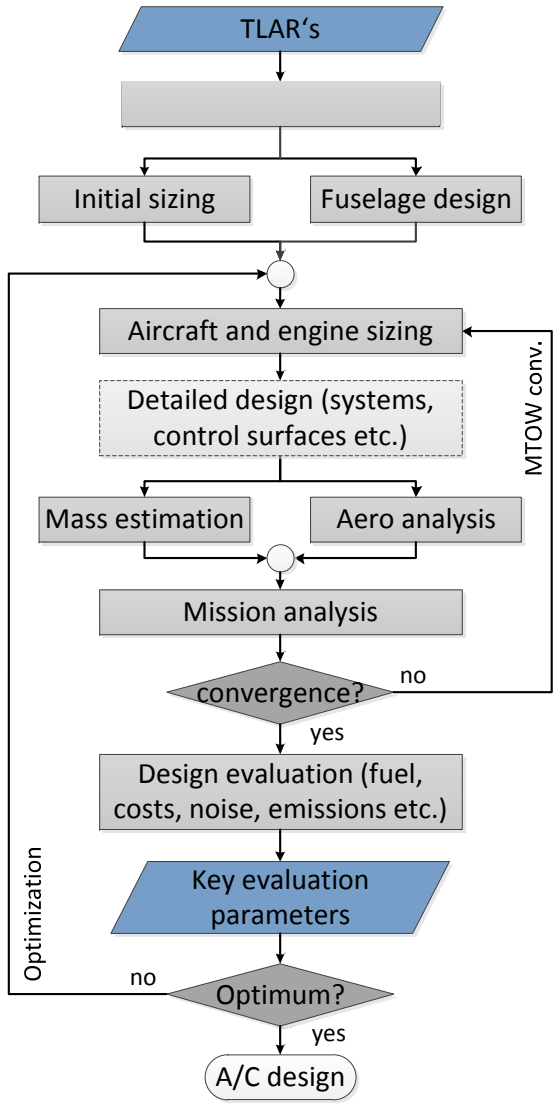


MICADO Design Methodology – Process Overview

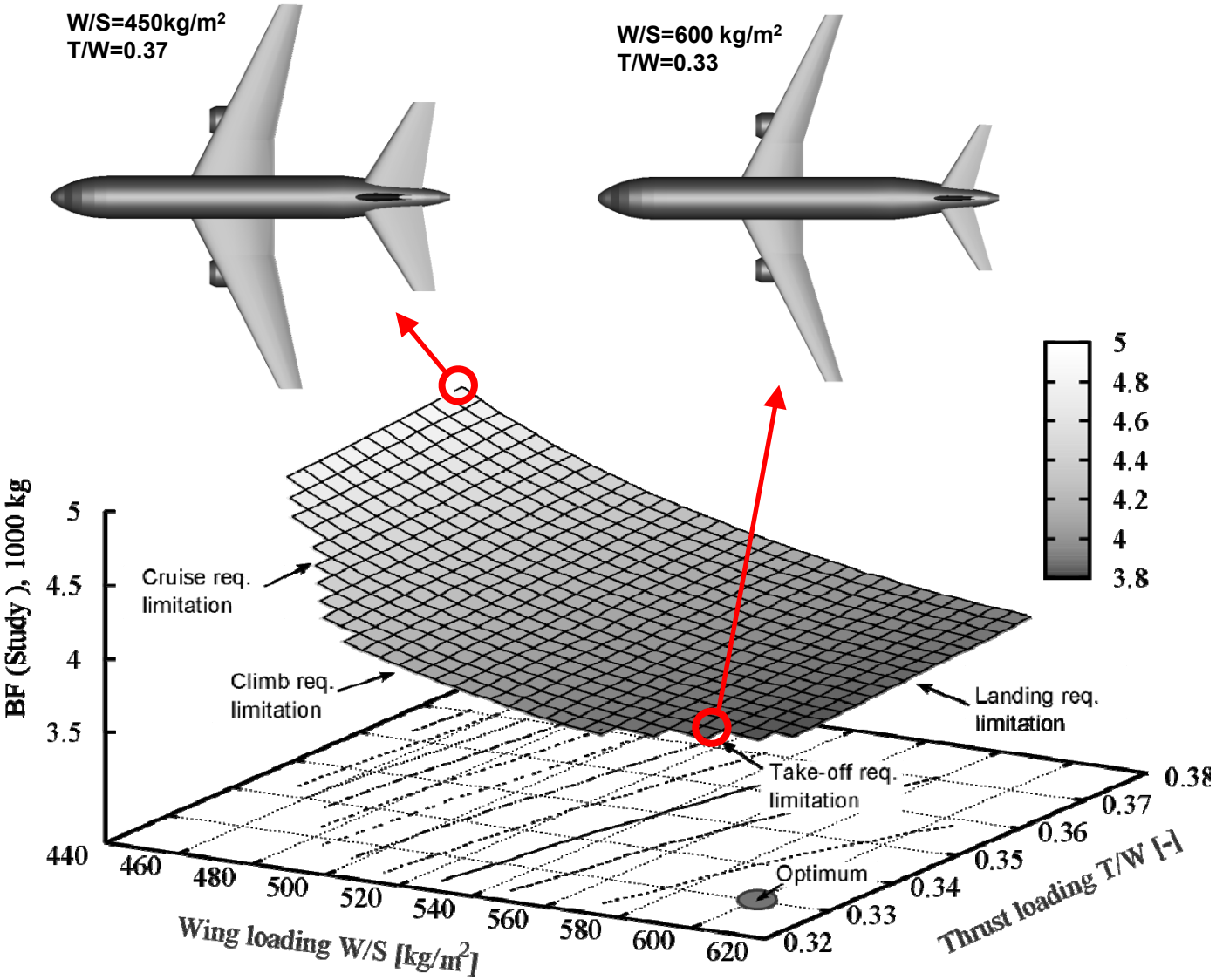
- White sheet design approach starting from a set of top-level req's (TLARs)
- Aircraft design programs size geometry components → general arrangement
- Optionally, more detailed design programs
- Design undergoes performance analysis (masses, aerodynamics, mission)
- Full a/c design iteration
- Assessment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

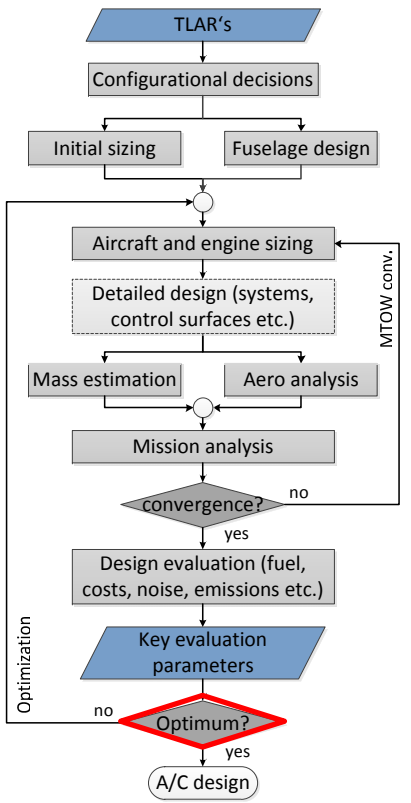
→ Capturing of particular design changes or system integration on overall aircraft level due to component resizing and snowball effects

→ A full initial design synthesis (w/o optimization) takes about 15 min. on a normal desktop PC



MICADO Short Range Design – Block Fuel Optimization





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:

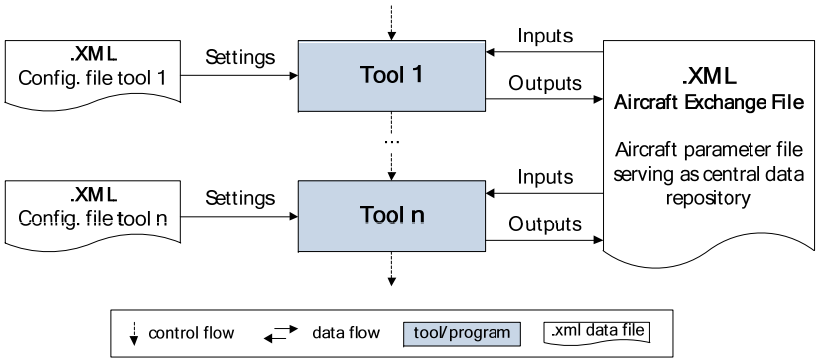
A template has been created (already at the beginning of the MICADO developent phase) that already includes all C++ software features and templates, e.g.

- Geometry classes
- XML parsers → access to Aircraft and Settings XML files
- Engines, Aerodynamic, ISA etc. libraries
- Automatic plot generation

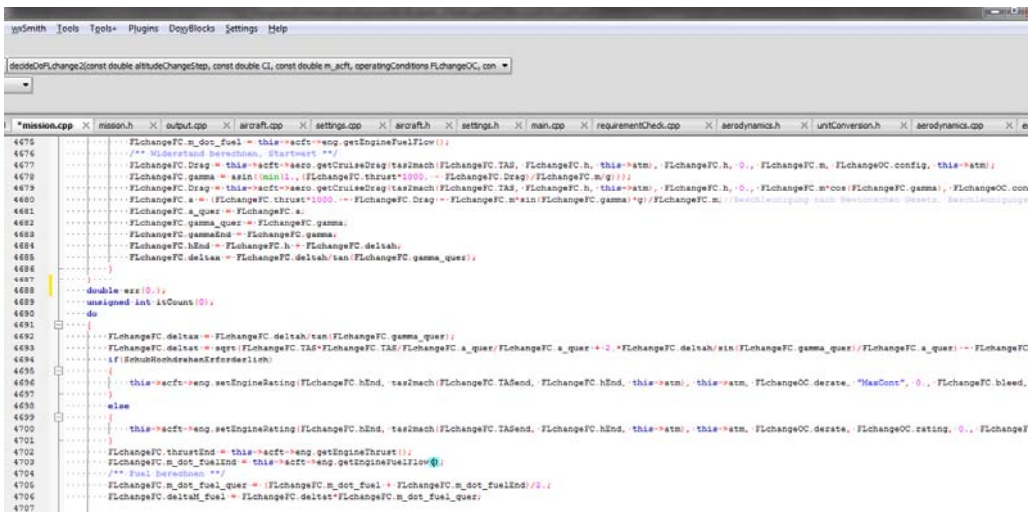
→ Completely working program package

→ Students only have to insert their methods and have a stand-alone program

MICADO control and data flow



MICADO mission classes code snippet



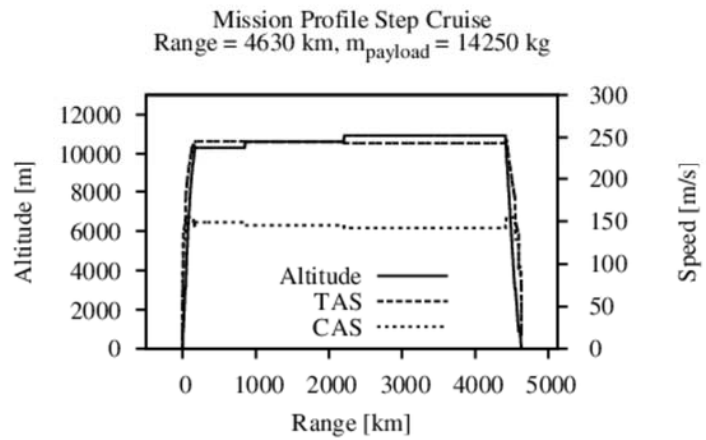
Automatic generated html report

Report Missionsanalyse Airbus-A320-200

Leermasse (OWE)	42567.6	kg	
Reichweite (gefordert)	2500	NM	
Nutzlast	14250	kg	
Passagiere	150		
Frachtmasse	645	kg	
Startmasse (TOW)	77097.4	kg	= OWE + PL + Loaded Fuel - Taxi Fuel (T/O)
Getankte Kraftstoffmenge (loaded fuel)	20520.4	kg	= Block Fuel + Reserve Fuel
Blockfuel	16234	kg	= Trip Fuel + Taxi Fuel (T/O + Ldg)
Trip Fuel	15772.8	kg	
Restkraftstoff	4266.38	kg	
Taxi-Fuel Start	240.6	kg	
Taxi-Fuel Landung	240.6	kg	
Landemasse	61324.6	kg	
Missionsstrecke (berechnet)	2501.24	NM	
Gesamte Flugzeit	5.47	h	
Blockzeit	5.81	h	

Ermitteltes optimales Cruise-Profil:

Cruise Step	Flight Level [100 ft]	Rel. Cruise Step Length [%]
1	338.7	16
2	348.7	47.9
3	358.7	100



- 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!