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DEPARTMENT OF AUTOMOTIVE AND AEROSPACE ENGINEERING hamburg
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Aircraft Systems – Reliability, Mass, Power and Costs

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- Education in Aircraft Systems
  - Aeronautical Engineering at HAW Hamburg
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- Aircraft Systems – Reliabilty, Mass, Power and Costs
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  - Costs and Trade-Studies
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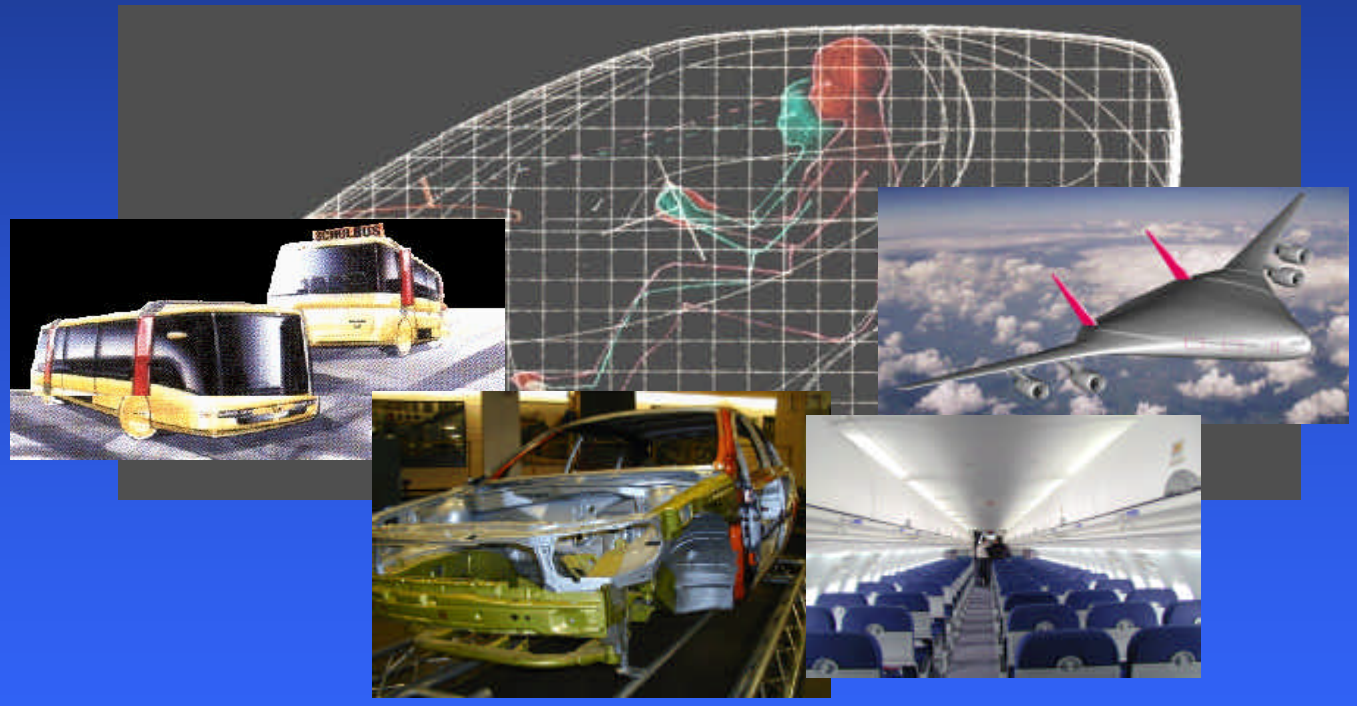
Education in Aircraft Systems



HAW Hamburg

Department of Automotive and Aerospace Engineering

HAW Hamburg

- University of Applied Sciences
  = „Hochschule für Angewandte Wissenschaften“ (HAW)
  = „Fachhochschule“ (FH)
- An alternative university system in Germany
- Practical approach
- Directly tuned to industry needs
- Integrated internship: one semester
- 4 years to degree (Dipl.-Ing.)
- HAW Hamburg: 13 departments, 14000 students

Departement of Automotive and Aerospace Engineering

- 1200 students
  - 800 students in Automotive Engineering
  - 400 students in Aeronautical Engineering
- ~ 29 professors
- ~ 20 part time lecturers from industry
- ~ 22 staff in laboratories and administration
- wind tunnel, structures lab, CAD lab, automotive lab

Degree Courses

- Dipl.-Ing.: Automotive Engineering 
- Dipl.-Ing.: Aeronautical Engineering 
- MEng: Lightweight Vehicle Structures 
- MEng: Lightweight Aeronautical Structures 
- MSc: International Automotive Engineering 

Aeronautical Engineering

- Internship as prerequisite to commence studies: 13 weeks

- Semester 1, 2, 3: Basic Studies
- Semester 4, 5, : Advanced Studies
- Semester 6: Internship - 20 weeks
- Semester 7: Advanced Studies
- Semester 8: Thesis

Advanced Studies: Aeronautical Subjects

- aerodynamics (with laboratory)
- flight mechanics (with flight testing),
- aircraft structures I (with laboratory)
- **aircraft design**
- FEM, manufacturing, ...
- propulsion I, **aircraft systems I**
- 3 electives chosen among:
  - gas dynamcis, stability and control,
  - structures II, vibration,
  - propulsion II, **aircraft systems II**, ...

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Aircraft Systems I (Descriptions)

Teaching Objectives

Students *know* …

- ... the technical German and English terms related to aircraft
- systems,
- ... the working principles of aircraft systems,
- ... the function of aircraft systems of selected aircraft,
- ... the dependencies among different aircraft systems.

Contents

- Description of aircraft system principles.
- Description of aircraft system functions of selected aircraft (currently: Airbus A321).

Aircraft systems considered: Air Conditioning ... Water/Waste

AIRBUS

Certificate of Recognition

JAR-147 APPROVED AIRCRAFT TYPE MAINTENANCE TRAINING
COURSE OR AIRCRAFT TYPE EXAMINATION

This Certificate of Recognition is issued to:

Name
Lars Potschies
Date of Birth
03.03.1976
Personal No. / Address

No. and Type of Licence

By **AIRBUS Deutschland** an organization approved to the requirements of JAR-147 by **Luftfahrt-Bundesamt (LBA)** a JAA full member authority under approval reference **LBA.004**
This Certificate confirms that the above named person either successfully passed the approved aircraft type training course or aircraft type examination stated below;

Type of Training
General Familiarization
Type of Aircraft and Engine
A319 / A320 / A321, CFM 56-5
Duration
24.09.2001–12.02.2002
with the result of
94 %

and in that respect has completed part of the requirement of JAR-66 to qualify as certifying staff for a JAR-145 approved maintenance organization.

This Certificate is recognized by all full members of Joint Aviation Authorities.

Signed:

Certificate No.: **1208**

For: **ATC Hamburg – Maintenance Training AIRBUS Deutschland** Date: **2002-02-13**

A319 / A320 / A321
General Familiarization
JAR-147 approved aircraft
type maintenance training

Optional test
at Airbus
based on HAW teaching

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Aircraft Systems II (Design)

Teaching Objectives

- Students *know* requirements and design principles of aircraft systems.
- Students have developed general *abilities* related to aircraft system design including systems engineering, simulation and reliability calculations.

Contents

- design requirements
- systems engineering
- simulation
- reliability calculation
- application of methods to the design of selected aircraft(sub)systems

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Aircraft Systems

Reliability, Mass, Power and Costs

Introduction

- aircraft = airframe + power plant + aircraft systems
- aircraft systems = „equipment“
- *aircraft system design* is part of *aircraft design*
- aircraft systems account for about 1/3 of
  - aircraft empty mass
  - development and production costs
  - Direct Maintenance Costs (DMC)
  - Direct Operating Costs (DOC)

Definition, Breakdown, Certification

Definition: *Aircraft System*:

A combination of inter-related items
arranged to perform a specific function
on an aircraft.

Breakdown:

1.) Airframe Systems - Avionic Systems
- General or utility systems

Power Plant Systems

2.) ATA-Breakdown: *ATA Spec 100*. Today: *ATA iSpec 2200*

ATA = Air Transport Association of America

identifier	name of system
21	air conditioning
22	auto flight
23	communications
24	electrical power
25	equipment / furnishings
26	fire protection
27	flight controls
28	fuel
29	hydraulic power
30	ice & rain protection
31	indicating / recording systems
32	landing gear
33	lights
34	navigation
35	oxygen
36	pneumatic
37	vacuum
38	water / waste
41	water ballast
44	cabin systems
45	central maintenance system (CMS)
46	information systems
49	airborne auxiliary power
50	cargo and accessory compartments

Breakdown of aircraft systems following ATA iSpec 2200

Certification of *Aircraft Systems.* JAR-25, FAR Part 25:

Subpart F "Equipment":

- § 1301 General
- § 1302 ... Instruments and Navigation
- § 1351 ... Electrical System
- § 1381 ... Lights
- § 1411 ... Safety Equipment
- § 1431 ... Miscellaneous Equipment

Subpart E "Power Plant" :

- § 951 ... Fuel System
- § 1195 ... Fire Protection

Subpart D "Design and Construction":

- § 651 ... Flight Control
- § 721 ... Landing Gear
- § 771 ... Equipment / Furnishings
- § 831 ... Air Conditioning
- § 851 ... Fire Protection

Safety and Reliability

- *Safety requirements*: § 1309

- *Reliability*: $R(t)=e^{-\lambda t}$ failure rate: λ
- *Probability of failure*: $F(t)=1 - e^{-\lambda t}$

- *Redundancy*: The existance of more means for accomplishing a given function

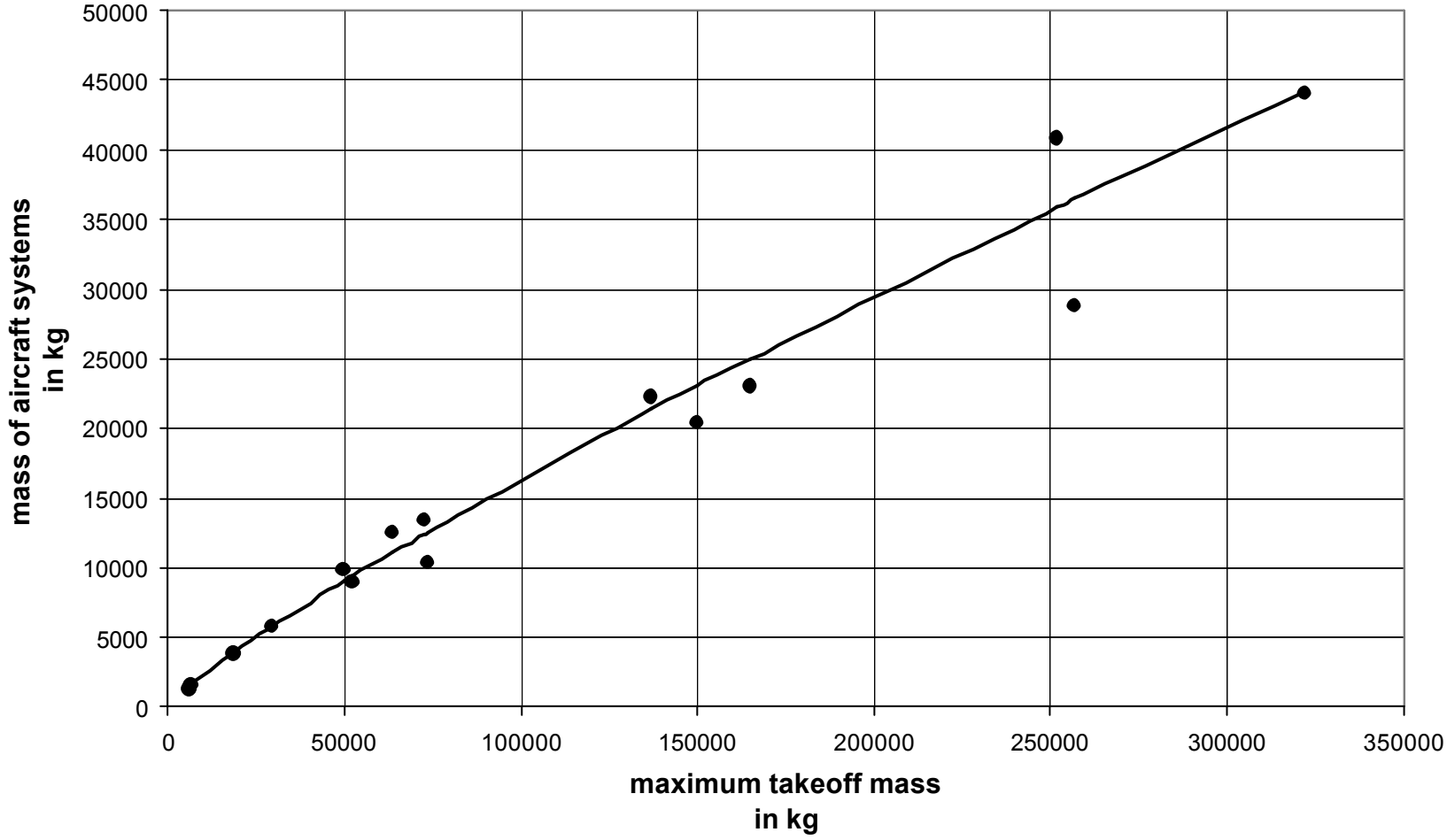
- *Steady state availability*: The probability that a system will be available when required
- Mean Time Between Failures: $MTBF = 1 / \lambda$

Safety requirements for large aeroplane's systems
ACJ No. 1 to 25.1309

effect on aircraft and occupants	normal	nuisance	operating limitations emergency procedures	significant reduction in safety margins difficult for crew to cope with adverse conditions passenger injuries	large reduction in safety margins crew extended because of workload or environmental conditions serious injury or death of small number of occupants	multiple deaths, usually with loss of aircraft
category of effect	minor	minor	minor	major	hazardous	catastrophe
probability of a failure according to JAR 25 (per flight hour)	frequent 10^{0} ... 10^{-2}	frequent 10^{-2} ... 10^{-3}	reasonably probable 10^{-3} ... 10^{-5}	remote 10^{-5} ... 10^{-7}	extremely remote 10^{-7} ... 10^{-9}	extremely improbable $< 10^{-9}$

Mass

$$m_{SYS} = 0.92\, m_{MTO}^{0.85}$$ (with *m* in kg)



Power

1.) propulsive power
2.) non-propulsive power = secondary power

Secondary power systems:

- hydraulic power, electrical power, pneumatic power

Secondary power sources:

- auxiliary power unit (APU), ram air turbine (RAT)
- aircraft batteries, ground power

Secondary power loads:

- *technical loads*:
  consumed by equipment required to operate the aircraft safely
- *commercial loads*:
  consumed by equipment required to increase passenger comfort and satisfaction, and the airlines needs to provide these services.

Power conversion

Simple Trade-Off Studies

- Calculation of a single figure of merit for an aircraft system based on:

  a subjectively defined weighted sum of individually defined parameters.

parameters:

  - mass
  - maintainability
  - reliability
  - system price
  - other specific criteria depending on the aircraft system in question.

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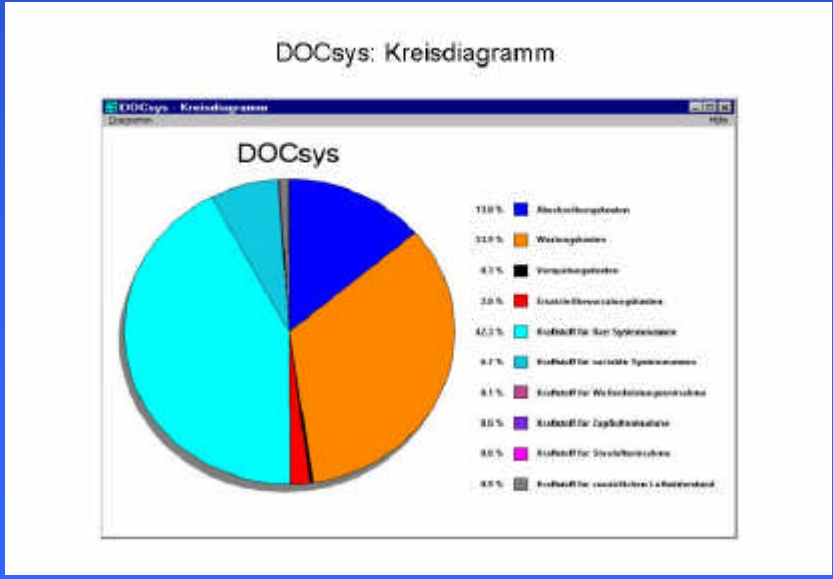
Cost Calculations

A DOC method for aircraft systems called DOC_{SYS}

$$C_{DOC,SYS} = C_{DEP} + C_F + C_M + C_{DEL} + C_{SH}$$



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Literature

THE STANDARD HANDBOOK FOR AERONAUTICAL AND ASTRONAUTICAL ENGINEERS

with section on *Aircraft Systems*

Editor in Chief:
Mark Davies
University of Limerick

Publisher:
McGraw-Hill, New York

Commissioning Editor:
Shelley Carr

To be published in 2002

Conclusion

- Aircraft system education at HAW:
  getting the most out of limited lecture hours
- Aircraft systems 1/3 of the total aircraft
- Focal points in aircraft system design:
  Reliability, Mass, Power and Costs
- Standard Handbook with aircraft systems section and more information.

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