Green Freighter

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Content

• Project partners
• Basic facts about the GF-Project
• Aim of the project
• Why freighter aircraft?
• Methods and tools
  – Aircraft preliminary sizing
  – PrADO
  – Aim
• Current state
Project partners

- Hamburg University of Applied Sciences (HAW) (Project leader)
- Airbus Deutschland GmbH, Future Projects Office (FPO)
- Institute of Aircraft Design and Lightweight Structures (IFL) of the Technical University of Braunschweig
- Bishop GmbH
Basic facts about the GF-Project

• Partly funded by the German Federal Ministry of Education and Research (243,000 €)

• Initial time schedule: Sep. 2006 – Aug. 2009

• Kick-off: Dec. 2006

• Total volume: 646,000 €

• Tentative entry-into-service: 2025
Aim of the project

• Investigations on **environmentally friendly** and cost effective freighter aircraft configurations

• “Environmentally friendly” due to:
  – Low fuel consumption
  – Low emissions (CO₂, NOₓ)
  – Future fuels (Liquid hydrogen – LH₂, Synfuel, Biofuel)
  – Low noise level
Aim of the project

- Investigations on environmentally friendly and cost effective freighter aircraft configurations

- “Cost effective” = low operating costs due to:
  - Low fuel consumption
  - Low emissions (emissions related taxes)
  - Low noise level (nighttime operation)
  - Zero-pilot operation (crew costs, no / reduced environmental control system)
Why freighter aircraft?

- Greater freedom in design
  - Greater psychological acceptance of zero-pilot operation
  - No or at least largely reduced environmental control system (ECS)
  - Less problems with flying wing and blended wing-body configurations (cabin pressurization, accelerations during flight maneuvers, no outside-view, evacuation, ...)
Methods and tools

• Aircraft preliminary sizing:
  – Excel spreadsheets from HAW and the University of Linköping, Sweden
  – Only conventional aircraft configurations possible
  – Fast and easy but rough, many estimations
Methods and tools

• Detailed design, analysis and optimization:
  – PrADO (Preliminary Aircraft Design and Optimization program) from IFL
  – Today, only jet propulsion and kerosene possible
    ➢ Task: modification for propeller and LH$_2$-powered aircraft
  – Very sophisticated (including aerodynamics and finite elements analysis) but bulky
Aircraft preliminary sizing

- Basic design process

Requirements → Trade-off studies → Aircraft configuration → Propulsion system → Sizing → Cabin / fuselage → ... → Operating costs → Three-view drawing

Constraint diagramm

- Design point

Wing loading [kg/m²] → Thrust/weight ratio [-]
PrADO

(Analysis and synthesis models of particular discipline)

Input
Mission
Aircraft concept
Regulations

Design analysis
(Feasibility study)

Parameter variation

Optimization

Output

Optimized Version
Performance data
Economic efficiency

Convergence check of related Design parameters
okay ?

Database system DMS

PrADO
PrADO

Structural breakdown

Design analysis
(incl. ground handling)

Design analysis
No crew
(UAV-operation)
Fuel tanks
with liquid hydrogen
kerosene in
wing tanks
Cargo on two decks
(no passengers)
Unpressurized fuselage

Jet engine model

FE analysis

Unpressurized fuselage
Cargo on two decks
(no passengers)
Kerosene in wing tanks
Fuel tanks with liquid hydrogen
No crew (UAV-operation)

Jet engine model

FE analysis
Methods and tools

Aim: Combination of Excel spreadsheet and PrADO

- ‘Feeding’ PrADO with Excel-generated design parameters
  → Reduced effort to run PrADO
Current state

- Two reference aircraft of different size
  - ATR-72 and B-777F

- Top level aircraft requirements (TLARs) being defined, e.g.:
  - Payload: 108 t (B-777F)
  - Configurations to be compared:
    - Conventional jet: $M_{cr} = 0.84$
    - Blended wing-body: propeller vs. jet driven
      - LH$_2$ vs. kerosene powered
      - $M_{cr}$ as a result
  - Cargo compartment large enough for cross section of standard ship container (TEU)
Current state

• **HAW**
  – Use and structure of PrADO
  – Cargo chain, cargo handling
  – Environmental effects of air transport
  – Propeller efficiency, engine data
  – Adaptation of HAW preliminary sizing tool

• **IFL: modification of PrADO**
  – New databases for different fuel tank geometries
  – New engine characteristics
  – New mass estimations
Current state

- Bishop
  - Benefits / penalties resulting from no / reduced environmental control system (ECS)
  - Hydrogen handling issues
  - Propeller efficiency
Current state
Current state
Current state