ASTRID - aircraft on board systems sizing and trade-off analysis in initial design

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Need to include the on-board systems in the aircraft design process

The On-board systems should be designed starting from the conceptual design

Aircraft On-board systems represent:
• 15% (regional transport) ÷ 30% (fighter) of aircraft empty weight
• 30% ÷ 50% of aircraft cost

Figures for military aircraft
ASTRID – Conceptual design and On-board systems design module

Top level requirements

Sub-system level requirements

Layout definition

Weight and main dimensions

Aircraft feasibility and design optimization

Aircraft Conceptual design module

On-board system design module

Detailed mission profiles

Avionic System

FCS

LND Gear

Fuel System

ECS

Anti-Icing

Utility Systems

Power Distribution Systems

Electric system

Hydraulic system

Pneumatic system

Detailed On-board system dimensions estimation

Secondary power required

On-board system architectures

Detailed On-board system design tool
ASTRID – On-board systems design process

1° approach (only for avionics)

Selection from database

2° approach (for all other systems)

Users definition

Main equipment design

Main equipment definition

When is it used?

Equipment utilization within the mission profile

Power budget
Mass budget

Total power required

Design of power distribution systems

Global power required to the engine

When is it used?
Innovative On-board system architectures
- More electric aircraft

**STATE OF THE ART**

- ENGINE
  - BLEED Sys.
  - A.P.U.
  - ELECTRIC SYSTEM
    - ELECTRIC USERS
    - HYDRAULIC SYSTEM
      - HYDRAULIC USERS
    - PNEUMATIC SYSTEM
      - PNEUMATIC USERS

**NEW TRENDS**

- ENGINE
  - A.P.U.
  - ELECTRIC SYSTEM
  - ELECTRIC USERS

**EXTERNAL AIR**

**NEW TRENDS**

- All On-board power is electrical
- To power pneumatic and hydraulic users, electric motor driven hydraulic pump and air compressor are necessary
- Replace FCS and LNDG hydraulic actuators with electric ones
- New electric standards (230 VAC, 270 VDC)
An example – Environmental Control System

INPUT
- Fuselage wet area
- Windows area
- Fuselage material
- External air temperature
- Aircraft N.Mach
- Air density
- N. passengers and crew
- Avionics power required

Thermal loads estimation
- Heat flow through the fuselage
- Solar heating
- Physiological heating
- Cabin equipment heating

Conditioning Airflow estimation

Bleed from the engine

Airflow, cau weight, n. cau redundancy, minimum airflow

Dedicated compressors

Air cycle

Vapour cycle

CAU no Sub-freezing

CAU Sub-freezing
How ASTRID is connected with the other disciplines

- Mission profile (speed, altitude)
- Fuel quantity
- Aircraft weight (TO, LND, empty)
- Aircraft dimensions
- Number of passengers
- Engine position
- ......

- N. of redundancies
- ....

- Available volume for fuel
- Available volume for other main equipment
- Landing gear weight
- ......

- Flight control surface dimensions
- Flight control actuation time and speed
- Hinge moments
- Landing speed
- ......

- Engine main spec. (thrust, SFC, ...)
- Accessory gearbox shaft speed
- ......

- External air temperature, density
- ......

Global aircraft

Flight mechanics / Handling Qualities

Environment

Reliability/ safety

Structures

Propulsion
ASTRID output

- Navigation eq. (dimensions, weight, power)
- Flight ctrl eq. (dimensions, weight, power)
- Comm eq. (dimensions, weight, power)
- Equipment list
- Redundancy
- Electric voltage

Avionic System

- N. actuators
- Redundancy
- Actuators (dimensions, weight, power)
- Electric voltage
- Hydraulic pressure

FCS

- N. actuators
- Redundancy
- Retraction, steering, breaking
- Actuators (dimensions, weight, power)
- Electric voltage
- Hydraulic pressure

LND Gear

- N. feed, transfer pumps (dimensions, weight, power)
- Redundancy
- Pressure drops
- Fuel pipes diameter
- Tanks configuration
- Electric voltage

Fuel System

- CAU design (typology, dimensions, weight, power)

ECS

- Anti-ice design (typology, dimensions)
- Electric power/pneumatic airflow required

Anti-Icing

- Generator/pow er converter (typology, dimensions, weight, voltage)
- Hydraulic pumps (typology, dimensions, weight, pressure)
- Pneumatic airflow

Electric

Hydraulic

Pneumatic Systems
Thank you for your attention