Master Thesis - “Impact of Propulsion-Model Fidelity on Mission Analysis and Conceptual Aircraft-Engine Design”
(30 credits/20 weeks – 2 student[s])

About us

GKN Aerospace is the world’s leading multi-technology tier 1 aerospace supplier. With 33 manufacturing locations in 12 countries, we serve over 90% of the world’s aircraft and engine manufacturers. We design and manufacture innovative smart aerospace systems and components. Our technologies are used in aircraft ranging from the most used civil aircraft to the world’s advanced 5th generation fighter aircraft and the Ariane orbital rockets used by ESA.

Project Background

Aircraft mission analysis is conducted during the conceptual and preliminary design phases of aircraft development to estimate the aircraft take-off weight (W_{TO}) and fuel consumption for a given mission profile. Combined with aircraft performance requirements, engine performance characteristics, and preliminary sizing parameters such as thrust loading (T_{SL}/W_{TO}) and wing loading (W_{TO}/S), mission analysis predicts the evolution of aircraft weight throughout the mission and enables assessment of overall aircraft and propulsion system performance.

Accurate and efficient mission analysis is particularly important during early design studies, where multiple engine and aircraft concepts must be evaluated under varying mission requirements. Since mission characteristics directly influence propulsion system sizing and cycle selection, a tightly integrated aircraft-engine analysis capability is essential for informed design decisions.

GKN has developed a Python-based framework for performing aircraft constraint and mission analysis based on the methods presented by Mattingly [1]. The framework interfaces with NPSS (Numerical Propulsion System Simulation) [2] to evaluate engine performance at discrete mission points and retrieve the data required for aircraft performance calculations. While the current framework provides the necessary functionality, the generation of engine performance data relies on a largely iterative process that requires significant user interaction and preparation of input datasets.

To improve the efficiency and fidelity of the analysis process, there is a need to strengthen the coupling between aircraft mission analysis and engine performance simulation. Such an improvement would increase automation, enable more flexible mission definitions, and facilitate rapid evaluation of alternative propulsion concepts during early-stage design studies.

[1] J. D. Mattingly, W. H. Heiser, and D. T. Pratt, *Aircraft Engine Design*, 2nd ed. Reston, VA, USA: American Institute of Aeronautics and Astronautics, 2002.

[2] NPSS is an object-oriented, non-linear thermodynamic simulation environment widely used within the aerospace industry for the modelling of gas turbine engines, propulsion systems, control systems, and integrated aircraft-propulsion studies.

Assignment Description

The aim of this thesis is to develop a methodology for tightly integrating aircraft mission analysis and propulsion system simulation, and to evaluate how different levels of engine-model fidelity influence mission-level performance predictions and engine design decisions. The developed framework will be applied to a range of representative aircraft missions to assess the impact of mission requirements on optimal engine characteristics and establish guidelines for the appropriate level of propulsion-model fidelity during conceptual aircraft design. Particular focus will be placed on determining whether increased propulsion-model fidelity leads to different conclusions regarding preferred engine-cycle characteristics and propulsion-system design choices across different mission types.

Milestones and content

1) Development of an Integrated Aircraft-Engine Mission Analysis Framework

   Develop and enhance the existing mission analysis framework to support several propulsion-system integration approaches, including:

   a) Simplified engine representation (constant TSFC (thrust-specific fuel consumption) and fixed thrust lapse)
   b) Performance deck approach using NPSS-generated engine performance tables
   c) High-fidelity coupling through integrated NPSS models and/or FMU-based (Functional Mockup Unit) engine models
   d) Improved interfaces for aerodynamic data and mission definition

2) Assessment of Propulsion-Model Fidelity

   Evaluate the impact of propulsion-model fidelity on mission-level and engine-level predictions for a representative aircraft and mission. The study will compare effects on fuel burn, mission range, aircraft sizing, engine operating conditions, and computational effort.

3) Mission-Driven Engine Design Study

   Apply the developed methodology to a range of representative mission profiles and investigate how variations in engine-cycle design parameters influence mission performance, fuel consumption, and aircraft sizing. The study will assess how preferred engine characteristics vary between different mission types and operating requirements.

4) Documentation and Reporting

   Document the developed methodology, analysis results, conclusions, recommendations for future work, and all software tools developed during the project

Qualifications

- M.Sc. student in a relevant engineering discipline (e.g. Applied Mechanics, Engineering Physics, Mobility Engineering, Aerospace or Mechanical Engineering)
- Basic knowledge of gas turbine engines, aircraft performance, or aircraft propulsion is preferred
- Experience with object-oriented programming, preferably in Python
- Interest in simulation, numerical analysis, and propulsion systems
- Interest in aircraft performance and conceptual design methods

Apply by

Send your CV/resume, cover letter, and academic transcript to:

- Patrick Nilsson (Patrick.Nilsson@gknaerospace.com)
- Michael Crona (Michael.Crona@gknaerospace.com)