FACHHOCHSCHULE
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ENGINEERING

Research Proposal for a Master Thesis

in Aerospace Engineering

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Table of Contents

I.	**Working Title**	**3**
II.	**Research Question and Task**	**4**
III.	**Research Context**	**5**
IV.	**Proposed Thesis Outline**	**7**
V.	**Advisor**	**8**
VI.	**Literature Sources**	**9**

I. Working Title

"Basic Comparison of Three Aircraft Concepts: Classic Jet Propulsion, Turbo-Electric Propulsion and Turbo-Hydraulic Propulsion"

Keywords (at least 5): aeronautics, airplanes, aircraft, aircraft design, flight mechanics, aircraft performance, engines, turbofan engines, electric propulsion, hybrid propulsion, hybrid propulsion, distributed propulsion, hydraulics, certification, evaluation, DOC, environment, Airbus, A320

II. Research Question and Task

Research Question:

In light of today's propulsion options for passenger aircraft: What is the superior propulsion principle with respect to Direct Operating Costs and environmental impact? Turbo-electric propulsion, turbo-hydraulic propulsion or the established reference, the turbofan engine?

Task:

- Literature review of electric respectively hybrid propulsion, distributed propulsion as well as the characteristics of turbofan engines, electric engines and hydraulic engines.
- Prepare a very short summary about methods and steps in aircraft design.
- Analyze and compare the three engines in terms of overall aircraft design by integrating them in a short-medium range passenger aircraft using the Preliminary Sizing Tool (PreSTo) for aircraft design based on the Top Level Aircraft Requirements (TLARs) of the Airbus A320 used as reference aircraft in this study. Consider also various option of distributed propulsion for the turbo-electric and turbo-hydraulic concepts.
- Evaluate the three concepts with respect to their fuel burn, Direct Operating Costs (DOC) and environmental impact.
- Discuss your findings and make recommendations based on your results.

III. Research Context

The target to reduce carbon emissions while maintaining the drastic growth in air transport increases the need of improving the existing propulsion systems. With a regular increase in oil price, the operating costs for airlines tend to go up and airlines take the effort to reduce them. Extensive research into advanced propulsion technologies and advanced aircraft configurations can lead to fuel savings, cost reductions and less environmental impact. A sustainable aviation transport system is the final goal. This thesis is a continuation to the work of Prof. Scholz who has worked on the evaluation of electric and hybrid propulsion, aircraft design and simple turbofan models for aircraft design optimization. This thesis is one in a string of student contributions to evaluate new propulsion concepts in aircraft design.

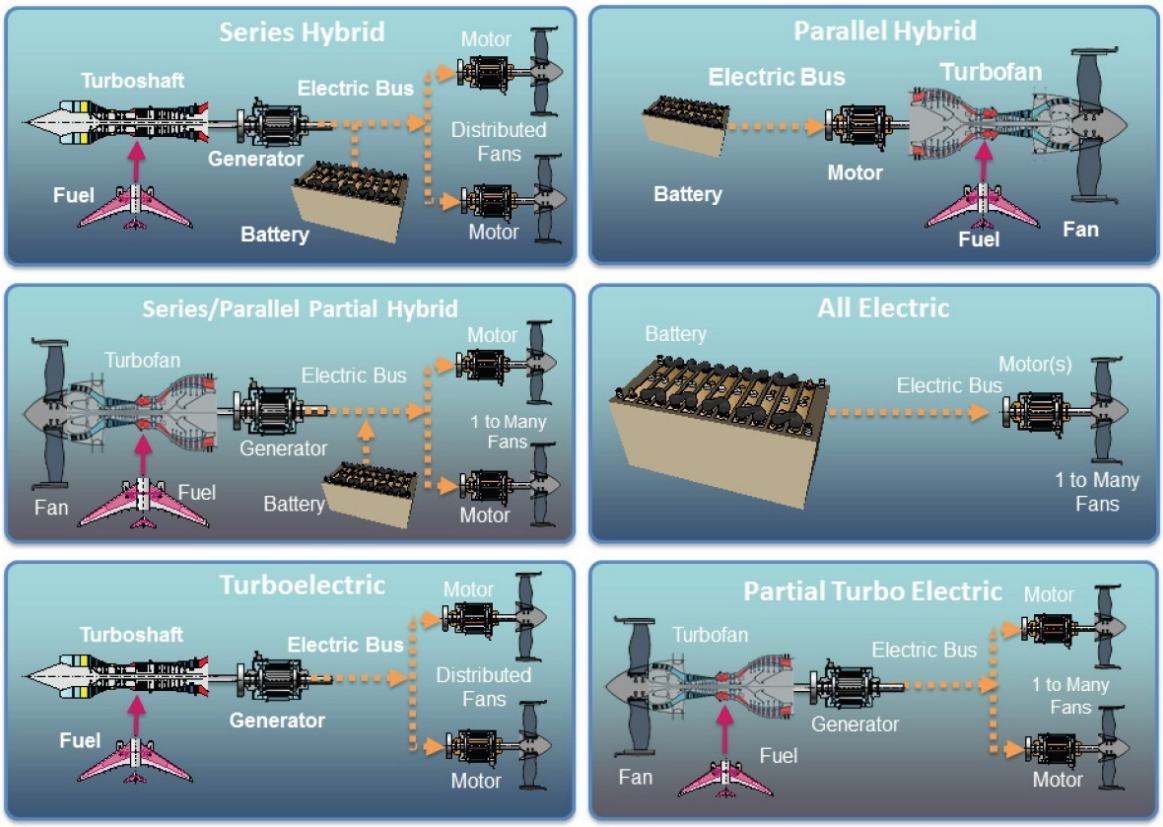

Figure 1 Different hybrid and turbo-electric engine concepts (NAS 2016)

The turbo-electric concept (Figure 1) seems to lead the discussion about new electric propulsion concepts for passenger aircraft. This is due to the fact that batteries would be too heavy for any reasonable range of passenger aircraft – now and in the future. After all, the specific energy (measured in Wh/kg) of kerosene is orders of magnitude higher than that of batteries and hydraulic accumulators.

A hybrid electric system only attenuates the problem of the heavy batteries, but does not solve it. As can easily be seen, a turbo-electric propulsion concepts will have a mass of the propulsion system three times the reference mass of the turbofan engine. Here a turbo-hydraulic concept may show some mass advantages. Also the partial turbo-electric (or turbo-hydraulic) concept may attenuate the problem, but again, is only a blend towards the original turbofan engine.

In a turbo-electric respectively turbo-hydraulic concepts, the energy generated by the gas turbine engine is converted by a generator or a pump into electric current respectively hydraulic volume flow. This energy can be utilized by several fans or propellers that are driven by an electric motor respectively a hydraulic motor. The separation between power generation and thrust generation is called distributed propulsion and is said to bring advantages to the overall system design.

Simple models for engine mass, price and energy efficiency are required for the electric and hydraulic machines. The thesis will contribute to these models with a literature review. The models can then be used in the tested aircraft design environment at the Aircraft Design and Systems Group (AERO) at HAW Hamburg. PreSTo is one aircraft design tool that can be applied. Various methods to calculate the Direct Operating Costs (DOC) for passenger aircraft are in use at AERO. The environmental impact can be calculated with a Life Cycle Analysis (LCA) that was developed especially for evaluations in aircraft design.

IV. Proposed Thesis Outline

Activity	Estimated time *
Performing a literature review	continuously
Studying propulsion system concepts	4 weeks
Defining engine parameters for preliminary sizing and aircraft design	2 weeks
Integrating the propulsion systems into the new aircraft	
Setting up the PreSTo tool for preliminary sizing and aircraft design	4 weeks
Analyzing initial results from the tool to obtain optimum results	
Comparing results from the three propulsion system options	2 weeks
Defining and optimizing possible partial turbo-electric or turbo-hydraulic concepts	4 weeks
Evaluating results from the three propulsion system options. Thesis writing takes place in parallel to all activities.	4 weeks
Discussing results and making recommendations. Finalizing thesis writing.	2 weeks
Total	**22 weeks**

(*) those time estimations are considered as a guideline,

but might be changing during preparation time of the thesis.

V. Advisor

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Signature of external supervisor: 

VI. Literature Sources

NAS 2016

NATIONAL ACADEMIES OF SCIENCES, ENGINEERING, AND MEDICINE: *Commercial Aircraft Propulsion and Energy Systems Research – Reducing Global Carbon Emissions*. Washington, DC : The National Academies Press, 2016. – URL: http://doi.org/10.17226/23490

Scholz 2018a

SCHOLZ, Dieter: *Aircraft Design*. Hamburg Open Online University (HOOU), Hamburg University of Applied Science (HAW Hamburg), Department of Automotive and Aeronautical Engineering, Lecture Notes, 2018. – URL: http://HOOU.ProfScholz.de

Scholz 2018b

SCHOLZ, Dieter: *Evaluating Aircraft with Electric and Hybrid Propulsion*. In: UKIP Media & Events: Conference Proceedings : Electric & Hybrid Aerospace Symposium 2018 (Cologne, 08 -09 November 2018), 2018. – URL: http://doi.org/10.15488/3986 and URL: https://www.ElectricAndHybridAerospaceTechnology.com

This last reference contains many more suitable references to get started with the thesis. Further help can be found also in http://library.ProfScholz.de. Help on thesis writing (German, English) here: http://ArbeitenHinweise.ProfScholz.de and http://buch.ProfScholz.de (English text on request).