Green Freighter
Green Systems

The Economic Performance of the Green Freighter

Final Thesis Task

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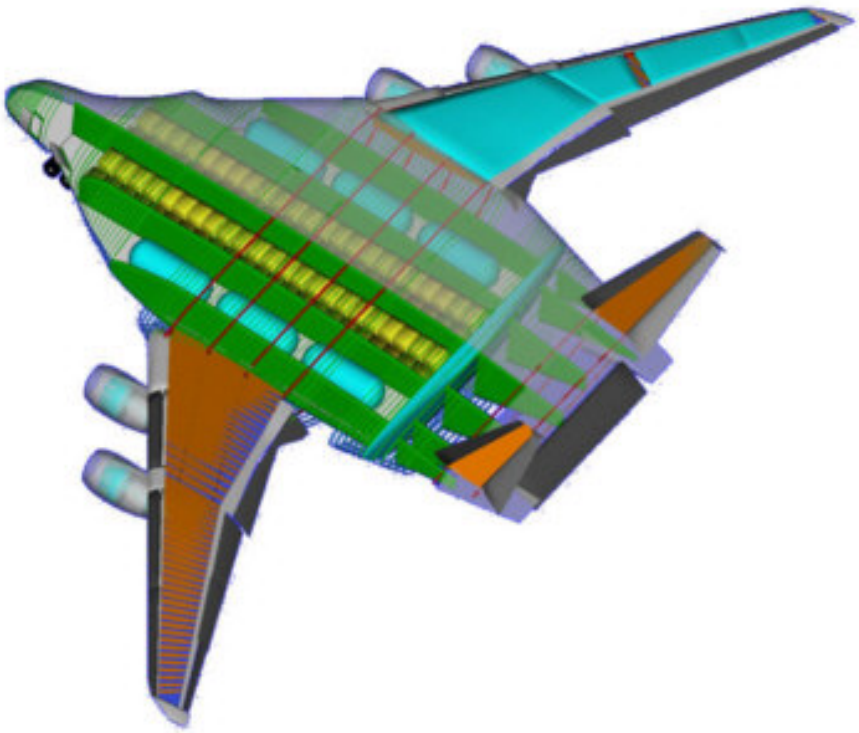

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Final Thesis Task: Green Freighter Subsystems

The herein described final thesis will be part of the Green Freighter project. This project aims to research conventional and unconventional cargo aircraft configurations to allow for environmentally friendly and economic aircraft operation by the year 2025. It is envisioned that this can be accomplished by focussing on low fuel consumption, new fuels like LH2, LPG and synthetic fuels, low noise (night) operation and reducing crew (including zero pilot operation).

Within this project multiple partners are involved, including The Hamburg University of Applied Sciences (HAW), acting as project leader, The Institute of Aircraft Design and Lightweight Structures (IFL) at the Technical University of Braunschweig, Airbus GmbH with its Hamburg based Future Project Office (FPO) and Bishop GmbH.

Literature Research

The final thesis started with a literature research of about 10 weeks, as required by the TU-Delft Aerospace Engineering program and is then followed by the actual final thesis of another 30 weeks.

During the literature research, a better view on what the green freighter project is all about was acquired by reading up on the following subjects:

- The Green Freighter project itself, its requirements and its goals
- The current and forecasted air freight and freighter market
- Current and next-generation aircraft systems technology
- Current and next-generation fuel cell technology
- Integrated Aircraft systems
- The hydrogen Aircraft

This has been combined into a global description of the Green Freighter project, with special attention to the green freighter's subsystems, as they will change significantly with respect to conventional aircraft subsystem layout, due to the fact that there are no pilots (and obviously no passengers) onboard. Furthermore, a preliminary comparison has been made between a next generation A320 passenger aircraft and a Green Freighter based on the A320. The method by which the analysis was conducted can be seen in figure 1.

The results of the analysis allowed for a more detailed evaluation of the benefits of the (partial) removal of a number of aircraft systems in terms of direct operating cost (DOC), as well as the consequences of removing these systems for the Green Freighter operation.

It was found that the market demand was also influenced by the choice of systems aboard the aircraft. This has been taken into account by using the DOC calculation to do an economic analysis, such that the market demand could be taken into account.

The most important conclusion of the literature research is that the ECS-less Green Freighter is not economic. Furthermore, the Green Freighter fitted with a conventional ECS performs somewhat better than a green freighter fitted with a temperature control system, while both perform significantly better than a conventional new freighter aircraft. Therefore, it is recommended that further research during the final thesis will concern a detailed evaluation of the Green Freighter with a conventional ECS and a heating system. No further attention should be paid to the ECS-less variant.

Final Thesis

The final thesis can build further on the results obtained during the literature research, even though the decision was made that the Green Freighter project should focus on large/long-range transport aircraft. This is especially the case for the results from the market analysis. With respect to the preliminary DOC analysis more detail and accuracy should be acquired for the new reference aircraft, the B777F. Furthermore, more insight in typical DOC's for freighter aircraft operation could also significantly increase the reliability of the DOC analysis. It is noted that a schematic representation of the analysis during the final thesis is shown in figure 1.

When accurate DOC estimates have been established for the B777F, scaling factors will be applied, to take into account efficiency gains due to the higher standard of technology in 2025. Furthermore, the DOC for the unconventional blended-wing-body configuration could be estimated, using the B777F as a reference as well.

The second part of the assignment is to model and optimize the Green Freighter's systems. Especially the conventional environmental control system (ECS) and power generation, distribution and (emergency) backup systems, as well as APU should be redesigned and optimized for zero-pilot operation and freight transport only. In this respect different aircraft subsystem layouts arising from the following six system design concepts will be evaluated:

- Cargo Bay ECS (Temperature and Pressure Control)
- Cargo Bay Temperature Control System
- Cargo Bay Pressure Control System (No oxygen partial pressure control)
- Container Temperature Control System
- Container ECS (Temperature and Pressure Control)
- Container Pressure Control (No oxygen partial pressure control)

In the last three configuration concepts the cabin should be redesigned, as cabin pressurization is no longer a design factor. Furthermore, increased efficiency of the gas turbines should be taken into account, as lower power off-takes will result in better engine performance. Finally, other snowball effects should also be identified and taken into account in the final trade-off.

The results of the system analysis should include the scenarios, of a blended-wing-body configuration, when the Green Freighter is fueled by liquid hydrogen fuel, as well as more conventional designs. This will help to get an accurate picture of how the aircraft system design concept interrelates with other design choices within the Green Freighter project.

At this point the weight and fuel savings can be calculated, which subsequently allows for the calculation of the DOC reductions, using the brequet-Range equation. Other DOC can be estimated similarly to the estimations in the literature research, where possible in somewhat more detail, such that the total DOC reduction is known for all configurations. In this way the deliverables shown in table 1 should be acquired.

Table 1: Deliverables Matrix

	Cargo bay ECS	Cargo bay Heating	Container heating	Cargo bay Pressure	Container ECS	Container Pressure
Short-Range GF based on conventional A320	Literature Research	Literature Research	-	-	-	-
Long-Range GF based on B777F scaled to 2025 tech lvl	Step 1	Step 2	Step 3	Step 4	Step 7	Step 9
Long-Range Green Freighter with BWB configuration	-	Step 5	Step 6	-	Step 8	Step 10

It is noted that the steps 2-3 and 5-6 are quite similar. Therefore, it is expected that time can be saved by making smart use of computer programs for the calculations. Furthermore, steps 7-10 are proposed to be optional depending on the time spent on the other steps in combination with the deadline in November. Finally, it is noted that the "Cargo bay ECS" and "Cargo bay pressure control system" will not be investigated for the Blended-Wing-Body configuration, as these would conflict with the unpressurized cabin requirement for this configuration, in conjunction with the latest Green Freighter project decisions

In the end the final thesis work should lead to a trade-off for the different design concepts for the aircraft subsystems, which should be based mainly on environmental friendliness and economic operation, in conjunction with the consequences of interrelated choices for the Green Freighter's overall design.

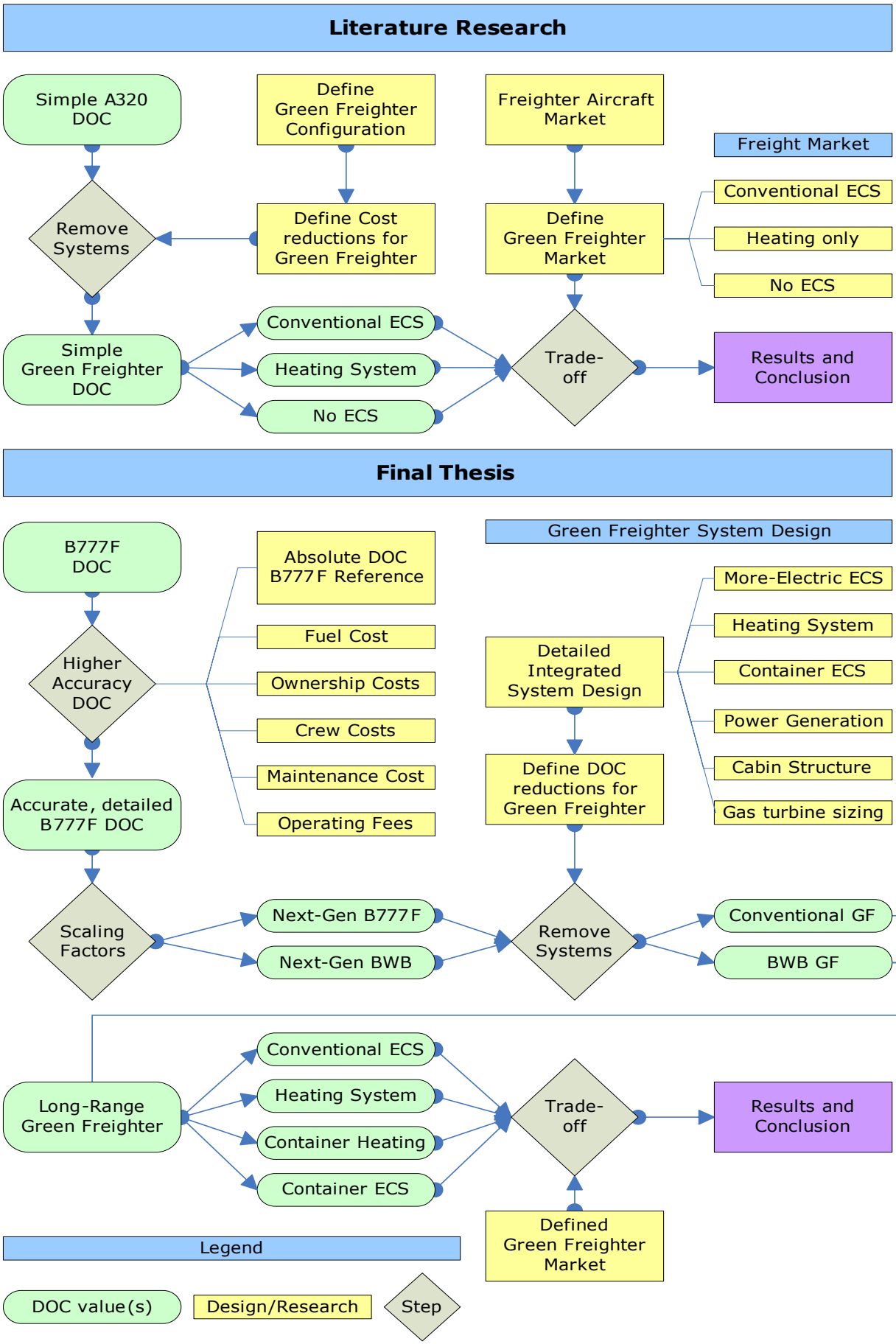

Figure 1: Schematic representation of the Literature Research and the Final Thesis Proposal