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Hybrid-Electric Flight Demonstrator

This project is created with the aim to research and investigate the hybrid-electric propulsion system for the next generation of aviation, and finally build a hybrid-electric flight demonstrator based on Rolls-Royce hybrid M250 propulsion system. The involved industrial companies are Rolls-Royce Germany and the aerospace development company APUS. The Power Electronics and Drives (LEA) of Brandenburg University of Technology (BTU) Cottbus will participant in this project with the following tasks:

- Modelling the hybrid-electric propulsion system including generators, motors, battery, converters, as well as the control system and Energy Management System (EMS), in MATLAB Simulink
- Failure mode and effects analysis (FMEA) of the hybrid-electric flight
- Researching and making the safety standard for the hybrid-electric flight
- Assisting the iron-bird testing of the hybrid-electric flight demonstrator

The project is being supported by the Brandenburg Government under ProFIT Brandenburg, managed by the Investment Bank of the State Brandenburg (ILB), and is scheduled for a duration of three years[1].

Fig.1[1]: Rolls-Royce Hybrid-Electric Flight Demonstrator (Concept Image)

According to research, the aviation industry produces more than 900 million metric tons of CO_2 each year, which constitutes about 2% of all human-induced CO_2 emission. However, due to the limited specific energy of the current battery, the pure electrified airplanes are not in high efficiency[2]. This project focuses on the hybrid-electric system, with the Rolls-Royce M250 turboshaft engine as the main energy source.

To investigate this hybrid-electric propulsion system, the system model will be built in MATLAB Simulink to do simulation at first. This simulation will have the basic function to do the analysis of dynamic response, such as variable operation points of the generators, the motors, and the battery. As the fundamental of other tasks, the model will also include the function of fault dynamic response, as well as the protection concept.

As the hybrid-electric system is a highly complex system with many components, assemblies, and subsystems, the FMEA is aimed to analyze potential failure modes, their causes, and the effects. The method of Fault Tree Analysis (FTA) will be used in the FMEA and finally gives the risk factors of different system failures. The FMEA can help to give the probability of various safety accidents and the best ways to reduce the risk.

With the research of FMEA, to improve the safety of the hybrid-electric propulsion system, making requirements relating to the quality and safety design will become the next stage. Differ with the conventional flight, the hybrid-electric flight has electrical system. The new safety standard should satisfy the existing standard of aerospace, as well as taking the electrical part into consideration.

The final stage of the project is to assist iron-bird testing. Iron-bird is a full-scale hardware simulation of the flight on the ground, which will include all the machinal, electrical, and control systems. BTU will attend and assist the test. If successful, the Simulink simulation and FMEA result can be checked by the iron-bird testing.

[1]. https://www.rolls-royce.com/media/press-releases/2019/06-11-19-rr-announces-new-hybrid-electric-flight-demonstrator-to-be-built-with-brandenburg-partners.aspx

[2]. Philip J. Ansell, Kiruba S.Haran, *Electrified Airplanes-A path to zero emission air travel*, IEEE Electrification, June 2020, Volume 8 Number 2, Page 18.