Sustainability is one of the biggest challenges for the aviation industry in the twenty-first century. To understand how aviation impacts the environment, being able to measure aviation’s environmental footprint is key in improving the scientific understanding on how the long term effects of aircraft emissions affect human health. Although monitoring systems do exist, they are unable to quantify the emissions of aircraft types as they cannot distinguish between different sources and existing computational models do not reflect reality in many cases as they rely on assumptions. Stakeholders such as the airports, local communities or policymakers therefore demand for better ways of monitoring the environmental impact of aircraft to enable a constructive discussion on regulatory and other mitigation strategies.

Mission Objective

The objective of this project is to design an autonomous, flying environmental sensing system. The system shall measure both noise and air pollution, distinguish between different emission sources and create aircraft type specific emission metrics in near-real time. It must be designed using off-the-shelf components of which at least 70% can be downcycled and have a maximum hardware cost of €25000.

System Design

For the environmental sensing system, a coaxial octocopter was designed to perform the mission. This multirotor design maximises the operational flexibility to move closer to an operating aircraft than existing ground-level monitoring systems. By using state-of-the-art lithium-polymer batteries and minimising the structural mass through light and sustainable materials, the operational time is being maximised. Full autonomy is achieved using a combination of radar, GPS-RTK and stereo vision for take-off, landing and automatic charging of the system.

To perform the actual mission, an operation concept was developed which will minimise the time required to obtain the necessary data for the emission metrics. Emphasis was put on using geo-caging of active runways and flight directories to avoid interference with the daily airport operations. For each mission, a three-dimensional measurement grid will be generated by the system and the required operating time will be minimised using path planning optimisation algorithms. Based on this operational concept, the emission metrics were defined and shown how the four-dimensional emission metrics will be generated based on the distinct spatial and temporal measurement points using advanced interpolation techniques.

To generate these emission metrics, air pollution sensors were chosen based on the data analysis of existing air quality measurements and atmospheric dispersion modelling. Next to the frequently used sensors, the unique addition of an ultra-fine particle sensor on a mobile monitoring system will measure the continuously increasing concentrations of particulate matter on nanoscale size. To measure noise emissions, modern MEMS microphones were selected to distinguish between different noise sources around the system and measure low frequencies at different altitudes.

During the final phase of the project, it will be further investigated how the measurement accuracy of the system can be increased using calibration procedures and how computational models can be improved through machine learning and cloud computing based on the raw emission metrics.