01 - Design of a Weather Balloon Alternative

Meteorological prediction and modelling requires data from all around the world at a range of altitudes. Currently, the KNMI launches a weather balloon every night at 00:00 UTC to collect this data. Along with measurements from ground-based sensors, aircraft, and remote-sensing satellites, the collected meteorological data is fed into numerical weather forecasts and climate models. The balloons burst at altitudes of around 33 km and the measurement instruments, called radiosondes, return to the ground on a parachute without control. With approximately 900 launch sites worldwide launching weather balloons multiple times a day, the lost electronics from radiosondes cause a large amount of waste which ends up scattered over the land and sea. Thus, the current method of collecting weather data poses a significant threat to the environment, resulting in the need for a suitable alternative.

Mission Objective

Project BRAVO (Balloon-Released Aerial Vehicle for weather Observation) involves the design of a reusable and controllable alternative to weather balloons. The vehicle must conduct at least the same measurements as conventional weather balloons, which also necessitates the need to reach altitudes with pressures of 10 hPa. The mission is to provide our primary stakeholder, KNMI, and potentially other customers, with a system that can easily replace conventional weather balloons while showcasing superior controllability and reusability characteristics. In addition, two driving goals are to reduce the cost per launch and mitigate the environmental impact. The chosen mission involves an ascent phase with a balloon and a controlled descent phase with an autonomous glider.

System Design

To accommodate different payloads in the most optimal way, it was decided to design two gliders: BRAVO Mini, a smaller model optimised for a radiosonde payload and BRAVO Max, a larger model for ozone sensing and custom payloads up to 2 kg. Both gliders are designed to have a range of 150 km, enabling them to return to the main launch site even in adverse wind conditions. With a weight of only 0.75 kg, the Mini can be launched with a 1 kg balloon, while the Max, with a weight of up to 4 kg, can be launched with 2-3 kg balloons, depending on the payload mass. The custom payload of the Max can include greenhouse gas sensors or even a 3U CubeSat, as the high altitudes can serve as a testing environment. The core of the gliders will be made of EPP foam, while aramid fibres will be used for the skin, providing both a strong and lightweight structure. To provide sufficient lift at every altitude and at low Reynolds numbers, the Dillner 20-32C was chosen as the airfoil. Once the glider is released from the balloon, the onboard path-planning software and autopilot will guide the glider back to the main landing site. In unforeseen scenarios, such as during extreme winds, the glider will divert to the next closest landing site. The design of the electronics and radiosonde package allows for an extremely compact structure for the Mini, which will be the most frequently operated glider. The coming days will involve an analysis of the costs and risks and the development of a production plan for the BRAVO family.