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Project Pelican

Construction, building and testing of a barometric rocket flight simulator

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Supervision

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I want to express my gratitude to Pfeiffer Vacuum for generously supporting our team and specifically this project, providing both materials and knowledge. We are immensely thankful for your contribution, without which this project would not have been possible.

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I declare that I have authored this thesis independently, that I have not used other than the declared sources / resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

Graz 1. September 2023 Georg Kurzmann

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1 Introduction

The AeroSpaceTeam Graz (ASTG) is currently working on the development of rockets for the European Rocketry Challenge (EuRoC). These rockets are specifically designed to transport payloads to precise altitudes. Barometric pressure is utilized for altitude measurement, particularly in the lower atmosphere. To ensure accurate measurements and optimal performance, thorough testing of the rockets is crucial. However, due to the high costs associated with real rocket tests, there is a demand for a ground-based simulation method that can replicate the rocket's flight.

The objective of the Pelican project is to simulate the rocket's flight by manipulating barometric pressure. To accomplish this, specific equipment is necessary. A suitably sized chamber is required to house either the entire rocket or, at least, the flight computer. Additionally, the chamber should be equipped with a vacuum pump, valves, and electronic components to control the pressure inside. [1]

1.1 Requirements

By considering both the official rules of the EuRoC and the unique requirements outlined by ASTG, the following set of requirements has been derived.

- The system must be able to simulate flights up to 3000 m altitude. It should be able to simulate flights up to 10 000 m and it should be determined whether flights up to 30 000 m are possible.
- The maximum dimensions of the test object will be 30 cm diameter and 1.5 m long. The chamber shall be able to handle this.
- The chamber shall be radio transparend.
- The barometric curve shall be provided to the valve controller as csv file on an SD card.
- The closing of the recipient shall be done without causeing pressure spikes.
- The pressure in the recipient shall be measured to allow the pressure tobe controlled.
- The valve controll shall be done via Arduino C.
- The system shall be able to operate standing alone, only connected to 230 V AC.

1.2 Intended Use

Currently, there are two rockets prepared for testing: AVES II and HALCYON. Each rocket has its own unique dimensions and flight characteristics. The barometric height simulator must be capable of accommodating both rockets.

1.2.1 AVES II

AVES II is equipped with a solid motor for initial acceleration and an air brake to reach the target apogee of 3000 m. Once the rocket reaches apogee, it deploys a drogue chute, followed by the deployment of the main parachute after descending for some time. This procedure is showen in figure 1.

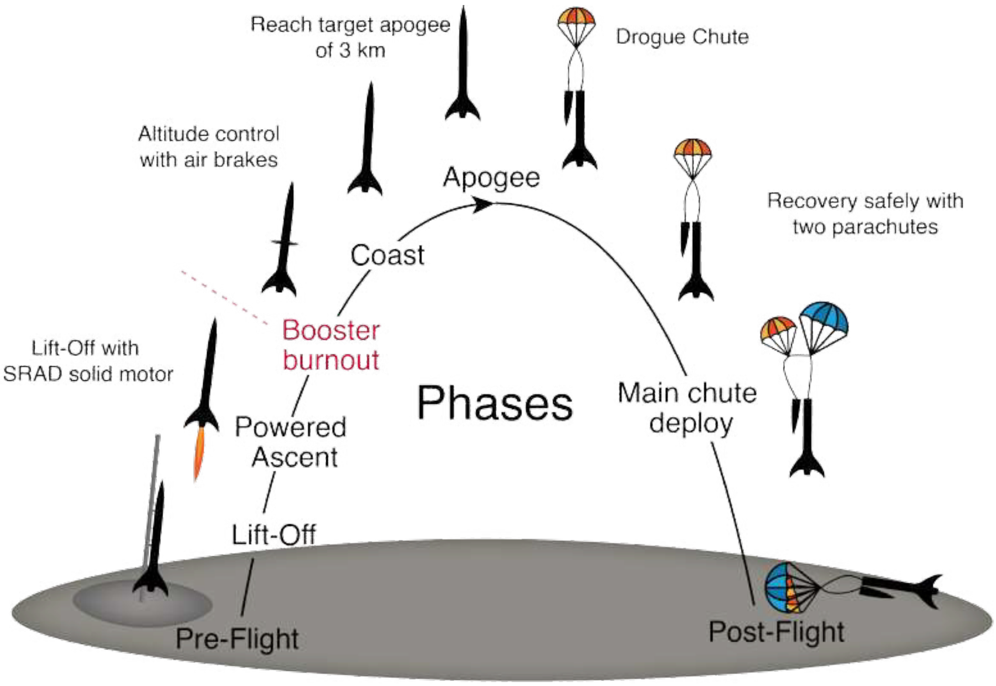

Fig. 1: Phases of the flight of AVES II[1]

1.2.2 Halcyon

Halcyon utilizes a hybrid rocket motor powered by a combination of Nitrous oxide and paraffin. This fuel mixture enables the rocket's acceleration. To achieve the precise target apogee of 3000 m, the flow of Nitrous oxide can be adjusted. The parachute system operates in a similar manner to AVES II. The overall flight cycle can be visualized as showen in figure 2.

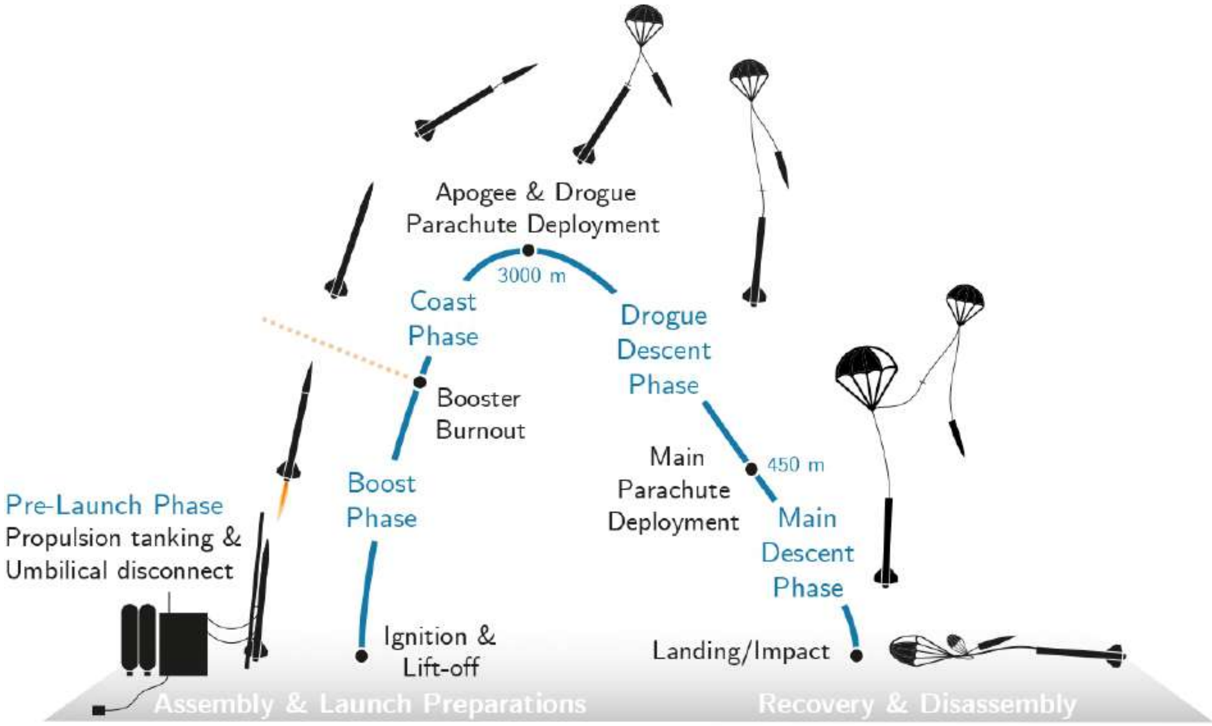

Fig. 2: Phases of the flight of Halcyon

[1]

The flight was simulated with RocketPy and this simulation leads to a pressure-to-time function which is shown in figure 3.

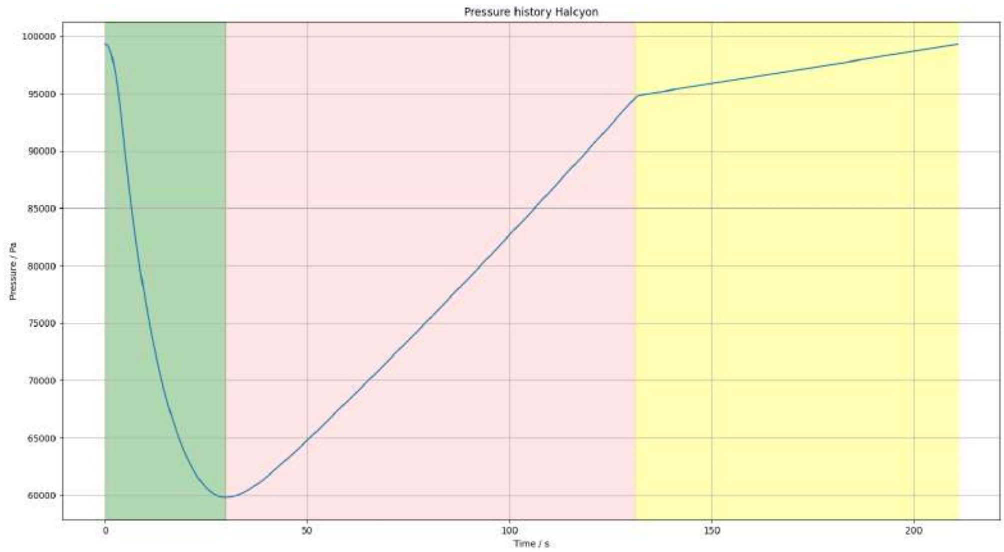

Fig. 3: Halcyon Pressure History
green . . . ascent
red . . . descent with drogue
yellow . . . descent with main chute