OST
Ostschweizer
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aris

Wireless Parachute Reefing System for Sounding Rockets

Requirements Specification

Luca Jost

Advisor: Prof. Andreas Breitenmoser
Co-advisor ARIS: Jonas Binz

May 10, 2022

Acronyms

ARM Advanced RISC Machines. 2

LED Light-emitting Diode. 5

PCB Printed Circuit Board. 5

RISC Reduced Instruction Set Computer. 2

USB Universal Serial Bus. 5, 6

Glossary

STM32 Is a family of 32-bit microcontrollers based on the ARM Cortex-M processors. 5, 6

1 Introduction

1.1 Association

The association Akademische Raumfahrt Initiative Schweiz (ARIS) brings together students from Swiss universities fascinated by space exploration. Formed around ETH Zurich, HSLU, ZHAW, UZH and OST the association engages it's members in engineering challenges by integrating theory and practice. ARIS is also offering a wide variety of Theses for parts and systems that can be integrated in their future rockets.

1.2 Background

In order to reduce the drift of a sounding rocket's descent a multi stage recovery system is needed. Normally, at apogee, a drogue chute is deployed, and the main chute is released at a lower altitude. If a parachute inflates too rapidly it can cause extreme shock to the overall parachute system and rigging causing it to malfunction. In order to keep the loads to a minimum, the descent speed needs to be reduced but at the same time the rocket needs to come down to earth as fast as possible to reduce its drift. As the rockets developed by ARIS get bigger and heavier new methods need to be developed to reduce these loads.
Reefing is something that prevents a parachute from opening too rapidly. With an active reefing system the main parachute can be deployed at apogee and slowly open at a low altitude. This would simplify and reduce the overall weight of the recovery system.

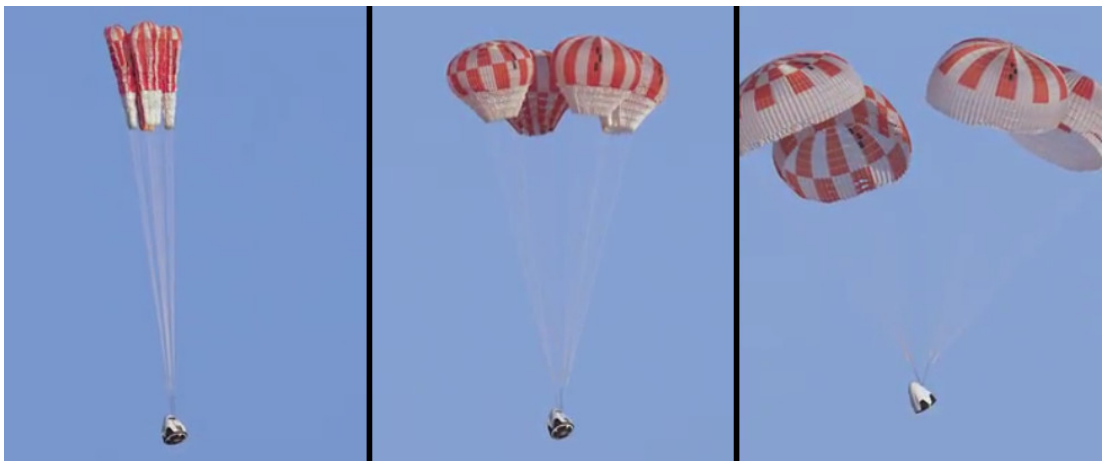

Figure 1.1: *Dragon Reefing System*

In the space industry reefing is often achieved by cutting lines inside the parachute. In the Figure 1.1 above two lines are cut inside the parachute. This is often done by using pyrotechnic line cutters, activated by an electric signal.

2 Task Definition

For this bachelor thesis methods for cutting a parachute line shall be investigated. A dedicated device has to be developed and manufactured to separate the parachute lines. The line cutter needs to be light and small enough to be placed inside the parachute as shown in Figure 2.1. Additionally the device needs to be durable to withstand forces acted on it during the deployment of the parachute.
The line cutter interfaces through a wireless link, from the body of the rocket, with the main recovery computer. The computer can then initiate the separation of the reefing line. As a backup method, independent operation should also be supported. In that case, air pressure data shall be used to deploy the reefing line at a set altitude.

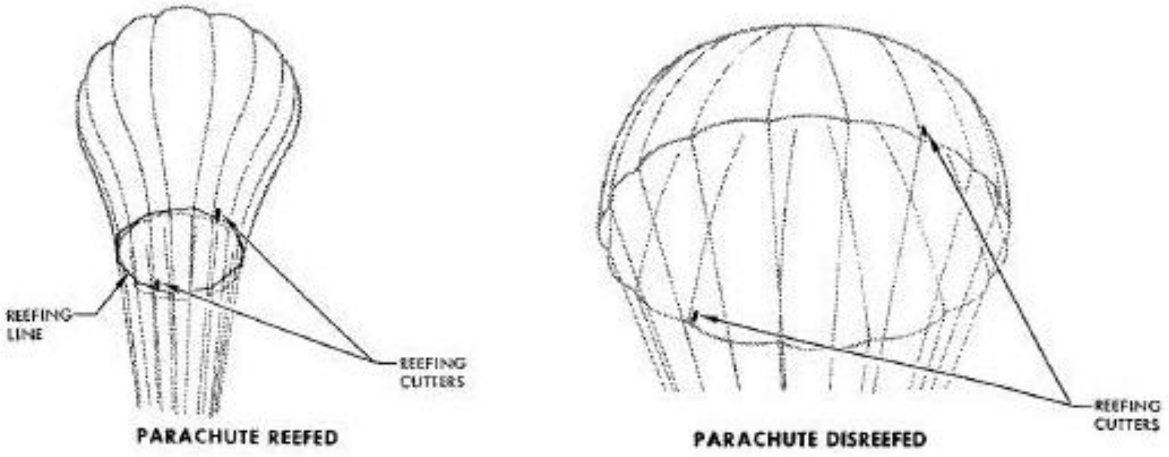

Figure 2.1: *Illustration of line cutter placement from NASA Gemini missions in 1963*

3 Product Requirements

3.1 Hardware

The custom built hardware contains all necessary components integrated on a single Printed Circuit Board (PCB). The hardware needs to comply with the following requirements:

- The hardware shall be based around an STM32 microcontroller.
- The hardware shall be able to do altitude measurements for independent operation.
- The hardware should use a wireless communication method to receive commands.
- The hardware should be able to do detect if the parachute was ejected (e.g. light sensor).
- The hardware should be able to detect liftoff (e.g. accelerometer).
- The hardware shall be battery operated.

  The battery shall last at least 6 hours.

  A battery management system should be added to charge and monitor the battery.
- The hardware shall be enclosed in order to minimize dust and moisture getting into the system.
- The hardware shall weigh less than 150g
- The hardware shall have dimensions no bigger than 80x50x30mm
- The hardware shall be able to indicate the current device status (e.g. LED, buzzer).
- The hardware shall have an USB interface for configuration.

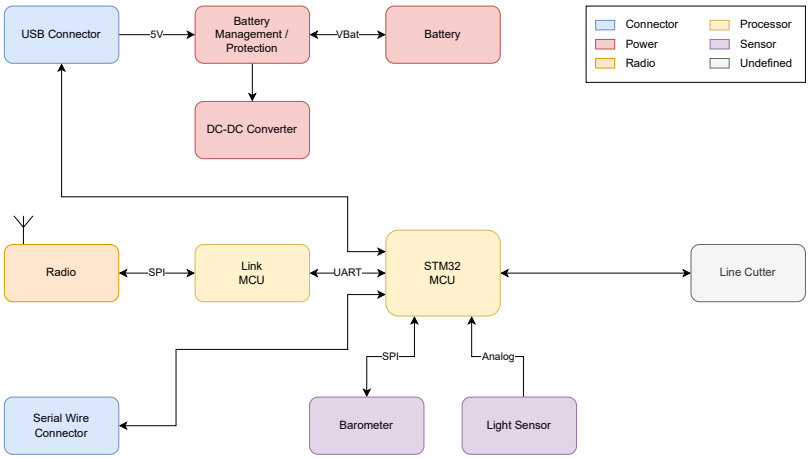

Figure 3.1: *Example Hardware Block Diagram*

3.2 Line cutting mechanism

The line cutting mechanism will be specifically developed for this application and needs to follow these requirements:

- The mechanism shall behave in a predictable manner.

  The mechanism shall separate the line with a standard deviation of less than 5s

- The mechanism shall be reliable.
- The mechanism shall withstand forces acted on it during the deployment of the parachute

3.3 Firmware

The embedded firmware will run on a STM32 and will be written in C. The requirements for the firmware are as follows:

- The firmware shall read air pressure data.
- The firmware shall be able to initiate the separation at a set altitude without a telemetry link.
- The firmware shall display the current device status to the user.
- The firmware should connect to a transmitter.

  The firmware should initiate the separation when commanded to.

- The firmware should offer an interface to configure the device through USB.
- The firmware should take light measurements to determine the ejection time.
- The firmware should take acceleration measurements to determine the liftoff time.

4 Project Schedule

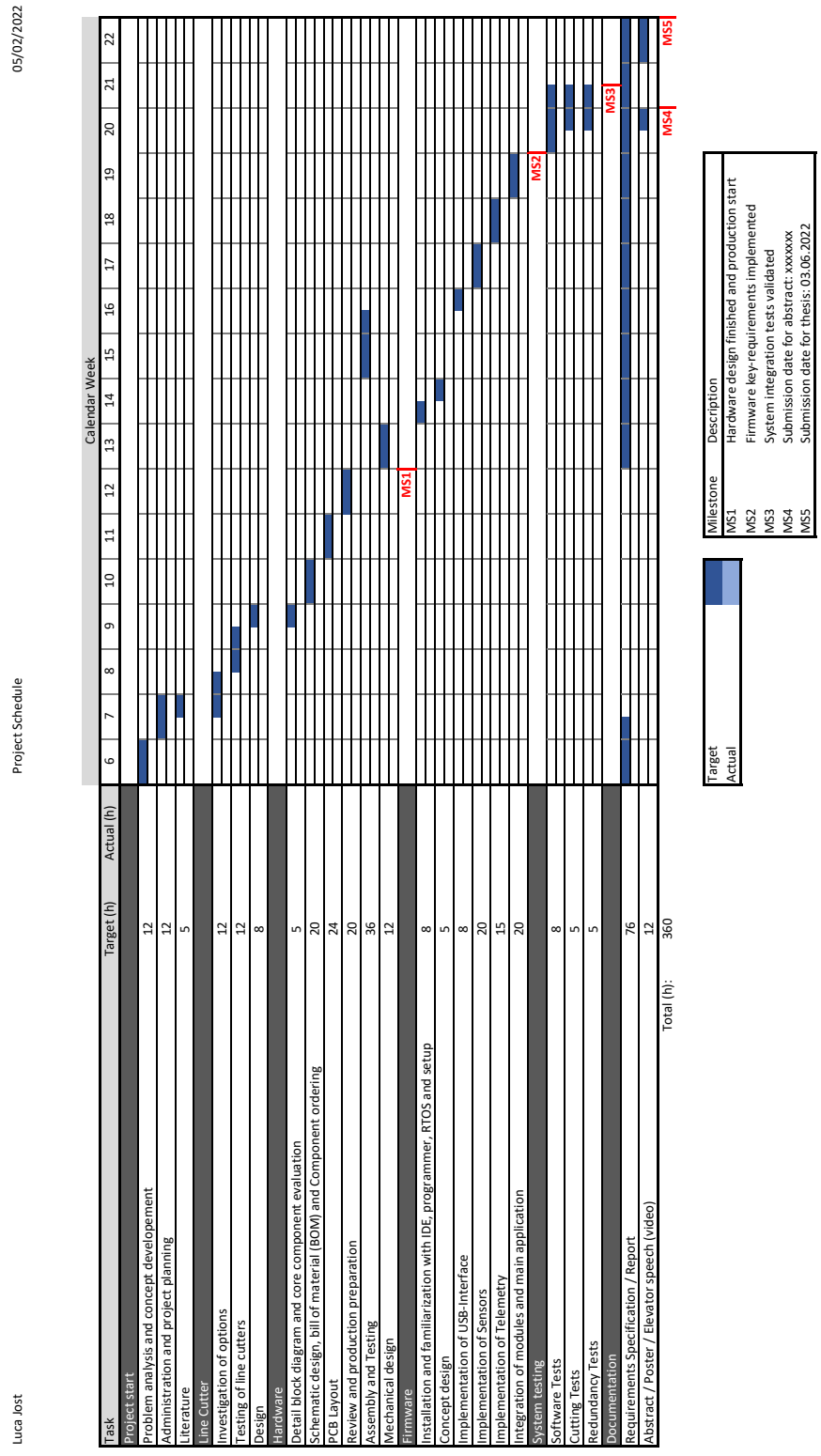

Figure 4.1: *Project Schedule*