Lucerne University of
Applied Sciences and Arts

ARIS - Localization of a Sounding Rocket via GPS

Bachelor Thesis

Simon Herzog

Department
Electrical engineering and information technology

Supervisor
Prof. M. Joss

Expert
W. Scheidegger

Industry Partner
O. Kirchhoff
CEO ARIS

Classification: Access

March 12, 2018

Declaration

I hereby declare and confirm that this thesis is entirely the result of my own original work. Where other sources of information have been used, they have been indicated as such and properly acknowledged. I further declare that this or similar work has not been submitted for credit elsewhere.

Horw March 12, 2018

Simon Herzog

Abstract

Contents

Chapter 1

Introduction

1.1 Requirements

Scoring (1000 points possible)

- Delivery of Entry Form: 60 points - 6%
- Technical Report: 200 points - 20%
- Design Implementation: 240 points - 24%
- Flight Performance: 500 points - 50%

Flight performance is split into apogee relative to the target apogee(350 points) and successful recovery(150 points).

Calculation of apogee points:

$$Points = 350 - \left(\frac{350}{0.3 \times Apogee_{Target}}\right) \times |Apogee_{Target} - Apogee_{Actual}|$$

$Apogee_{Target} = 3000m$
1% points $\widehat{=}$ 9m deviation

Chapter 2

GPS concept and error sources

Chapter 3

Accuracy enhancement systems

3.1 Code-Phase Differential GPS

3.2 Carrier-Phase Differential GPS

3.3 Carrier-Smoothed-Code Differential GPS

3.4 Satellite-Based Augmentation Systems (SBAS)

Chapter 4

Differential GPS concept for a sounding rocket

Setup:

- Two M8T modules in the nosecone and one at the ground station.
- RF-uplink from ground station to rocket.

Procedure:

- Ground station averages position measurements over a longer time to get reference position. This might not be the exact position, but this only results in a constant bias in the rockets absolute position. Reference position stays fixed when sending of differential corrent ions starts.
- Ground station calculates distance to each visible GPS satellite from reference position and ephemeris data.
- The differnce between the calculated distance and the measuren pseudorange is calculated for each satellite.
- The range differnces are sent to the rocket over the RF-link. The update rate of the corrections could be about 1Hz.

- On the rocket, the pseudorenge measurements are corrected with the latest differential corrections and a tropospheric model. The tropospheric corrections are zero at the launchpad and get bigger with altitude.

- The rocket position is then calculated with the corrected pseudoranges.

- The first correction is sent when the rocket is still on the launch pad. One or more corrected measurements at the launch pad serve as the zero point of the trajectory.

- The calculated position measurements during the flight can be differnced with the launch pad zero point to get the relative position to the launch pad. With this the reference position bias cancels out. For the rocket controll and the post processing, the relative position to the launchpad is more relevant. The absolute position, where the reference positon bias is still present, is only needed for the recovery of the rocket where accuracy is not as important.

Chapter 5

Implementation

Chapter 6

Testing and Validaton

Chapter 7

Conclusion

Bibliography

Appendices