Lucerne University of
Applied Sciences and Arts

ARIS - Localization of a Sounding Rocket via GPS

Bachelor Thesis

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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 April 13, 2018

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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% less points (3.5 points) $\widehat{=}$ 9m deviation

Chapter 2

GPS Concept and Error Sources

Along with earlier navigation systems, this chapter explains the positioning concept of GPS and modern Global Navigation Satellite Systems(GNSS) in general. The error sources that impact the accuracy of GPS are listed and split into categories that determine in which segment those errors occur.

2.1 Predecessors

Before there was GPS, other systems that were mostly ground based and limited to a certan area were used to navigate.

2.2 Global Navigation Satellite Systems

2.3 Error Sources

Chapter 3

Accuracy enhancement systems

3.1 Carrier-Phase Measurements

3.2 Differential GPS

3.3 Real Time Kinematic

3.4 Satellite-Based Augmentation Systems (SBAS)

3.5 Summary

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 correntions 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.
- RTCM 2.3 meassage 1 and 3 are created with the pseudorenge corrections.
- The RTCM messages are sent to the rocket over the RF-link. The update rate of the corrections could be about 1Hz.

- On the rocket, the messages are fed into the UART interface of the GPS receiver which includes them in the position estimation.
- Tropospheric corrections could be added to the pseudorange corrections at the ground station or in the rocket.
- 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 position estimations 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

6.1 Testing Setup

Two receivers, with and without correction message input. Both can log data. Reference station with antenna pole, GPS receiver, laptop and XBee module. Software to visualize data.

6.2 Static Accuracy Test

Compare GPS positioning accuracy with and without correction messages to see if the accuracy is improved. The reference receiver measures the reference position over some hours. The rover is at a fixed and though Google Maps known location. The variance and bias are observed in both cases.

Is the bias improved? Is the variance improved?

6.3 Mobile Accuracy Test

Two receivers test while the rover is moving. A route is walked which was predetermined with Google Maps.

How accurate is the system when the rover is moving?

6.4 Distance Test

Two receiver test with a horizontal distance of about 3km between rover and reference station.

Does DGPS still improve the accuracy if the rover is 3km away from the reference station?

6.5 Height Difference Test

Two receiver test with the rover on a mountain which is about 3km higher than the reference station in the valley.

How much impact does the tropospheric height effect have on the DGPS accuracy?

6.6 Telemetry Antenna Interference Calculation

6.7 Antenna Rotation

6.8 Correction Message Interruption

6.9 Rocket Test

Chapter 7

Conclusion

Bibliography

Appendices