# Sensor fusion with GPS and IMU

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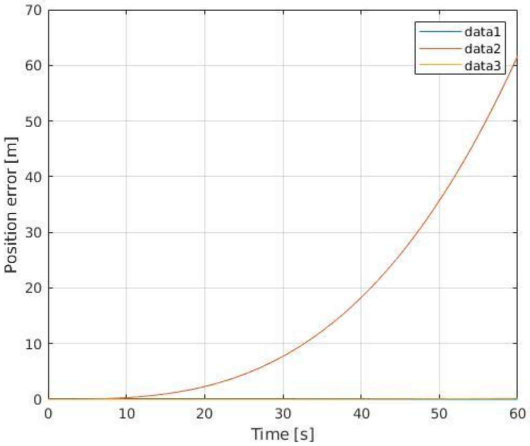
# Abstract

- The requirements of this assignment can be [read on this page]
- Our goal is to evaluate the effects of GPS signal outage on the navigation solution and use a Kalman filter to optimize the sensor fusion

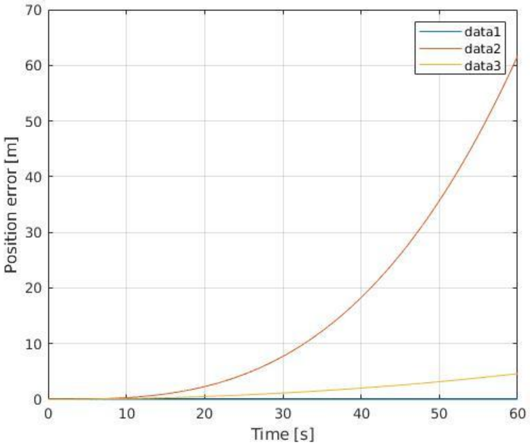
- Short introduction to the 4 tasks:
  - Task 1: Use the functions errorgrowth.m and Nav eq.m to evaluate how the position error grows with time
  - Task 2: Modify the code to simulate a GNSS-receiver outage from 200 seconds and onward
  - Task 3: Implement support for non-holonomic motion constraints
  - Task 4: Implement support for speedometer measurements

- The experiments codes with sufficient comments can be seen on [this GitHub repo]

# Task 1: How The Position Error Grows With




gyrobias = [0.01*pi/180;0;0]
gravity vector: Stockholm




gyrobias = [0.01*pi/180;0;0]
gravity vector: Lund

Since the position error grows cubically with time, for velocity errors (data2), we can get this formula to describe:

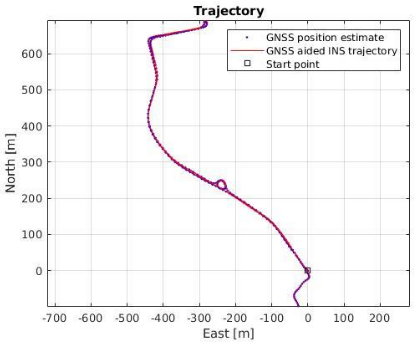
y = 1.0e-03 *

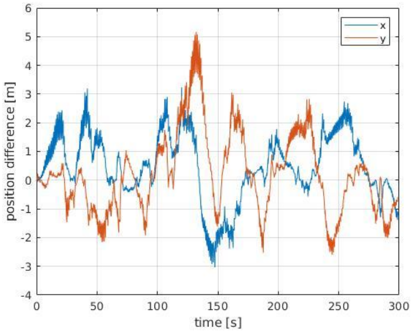
0.2855 x^3 - 0.0041 x^2 - 0.0033 x + 0.0107

By updating the parameter Latitude in function “gravity”, we can get different positions’ local gravity vector. These two charts are the comparison between Stockholm and Lund, both under a bias in the x-axis gyroscope with a magnitude of 0.01◦/s.

# Task 2: Simulating a GNSS-receiver outage

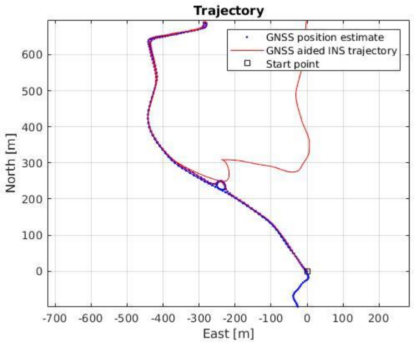
Default simulating (without GPS outage)

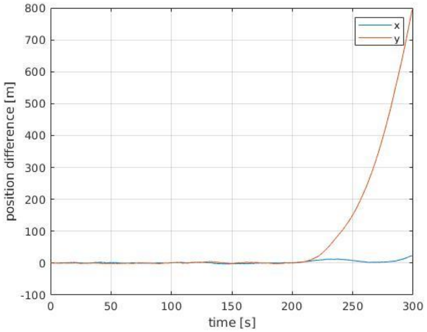



Position error RMS: 1.8606

A GNSS-receiver outage from 200 seconds and onward



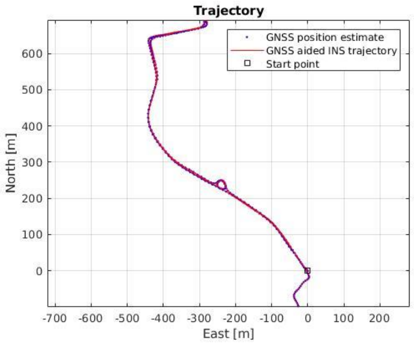



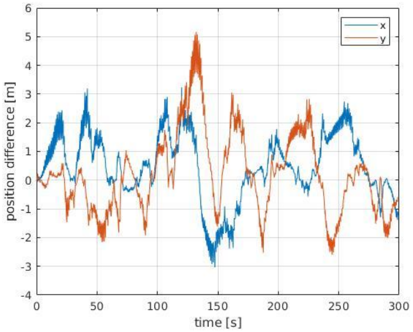

Position error RMS: 187.3696

According to the charts above, we can see that with a GPS outage, there are huge trajectory and position errors after t = 200.
For position difference, the errors mainly happened on direction x.

# Task 3: Support for non-holonomic motion constraints

Default simulating (without GPS outage)

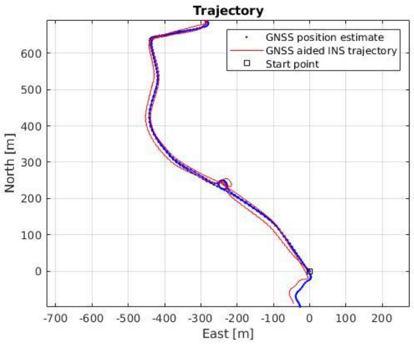


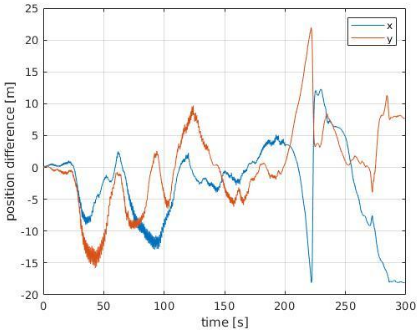




Position error RMS: 1.8606

GPS outage + non-holonomic constraints

settings.sigma_non_holonomic = 3




Position error RMS: 9.7721

Obviously, the car does not skid or fly, so we can add a set of motion constraints and enforce these constraints on the navigation solution using so called constrained filtering. In another word, the velocity in the y-axis and z-axis direction of the vehicle coordinate frame (p-frame) should therefore be equal to zero.

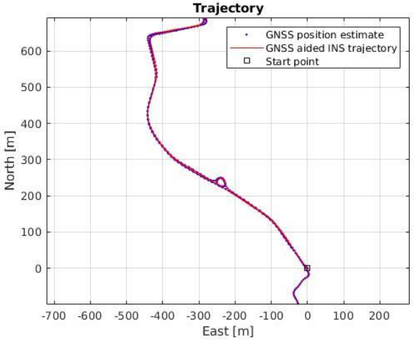
# UPDATE

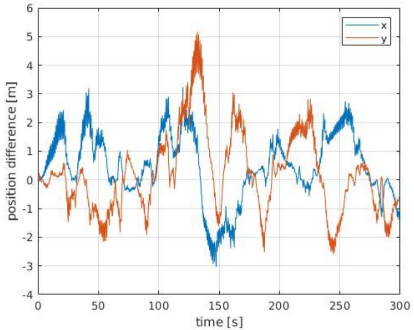
## Task 4: Implement support for speedometer measurements

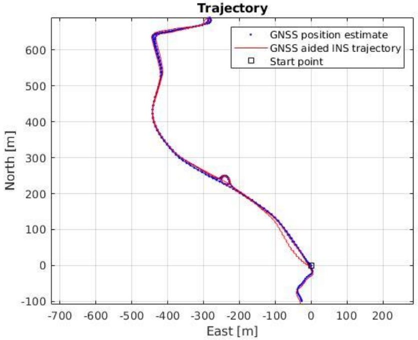
Default simulating (without GPS outage)

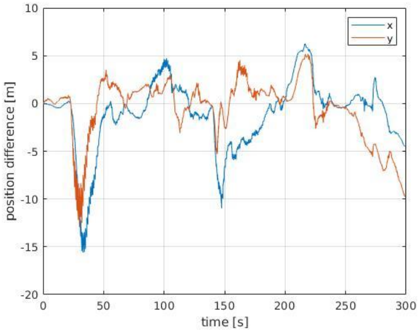
GPS outage + speedometer + non-holonomic constraints

settings.sigma_speed = 0.21; settings.sigma_non_holonomic = 7.47




Position error RMS: 1.8606

Position error RMS: 4.9728

The data included in the GNSSaidedINS.zip folder also include measurements from a speedometer. This time we use both the data of speedometer and the non-holonomic constraints to optimize the filter.

After tuning the parameters more carefully, including measurements from a speedometer indeed decreases the RMSE quite a lot.