RTK-GPS ISOBlue

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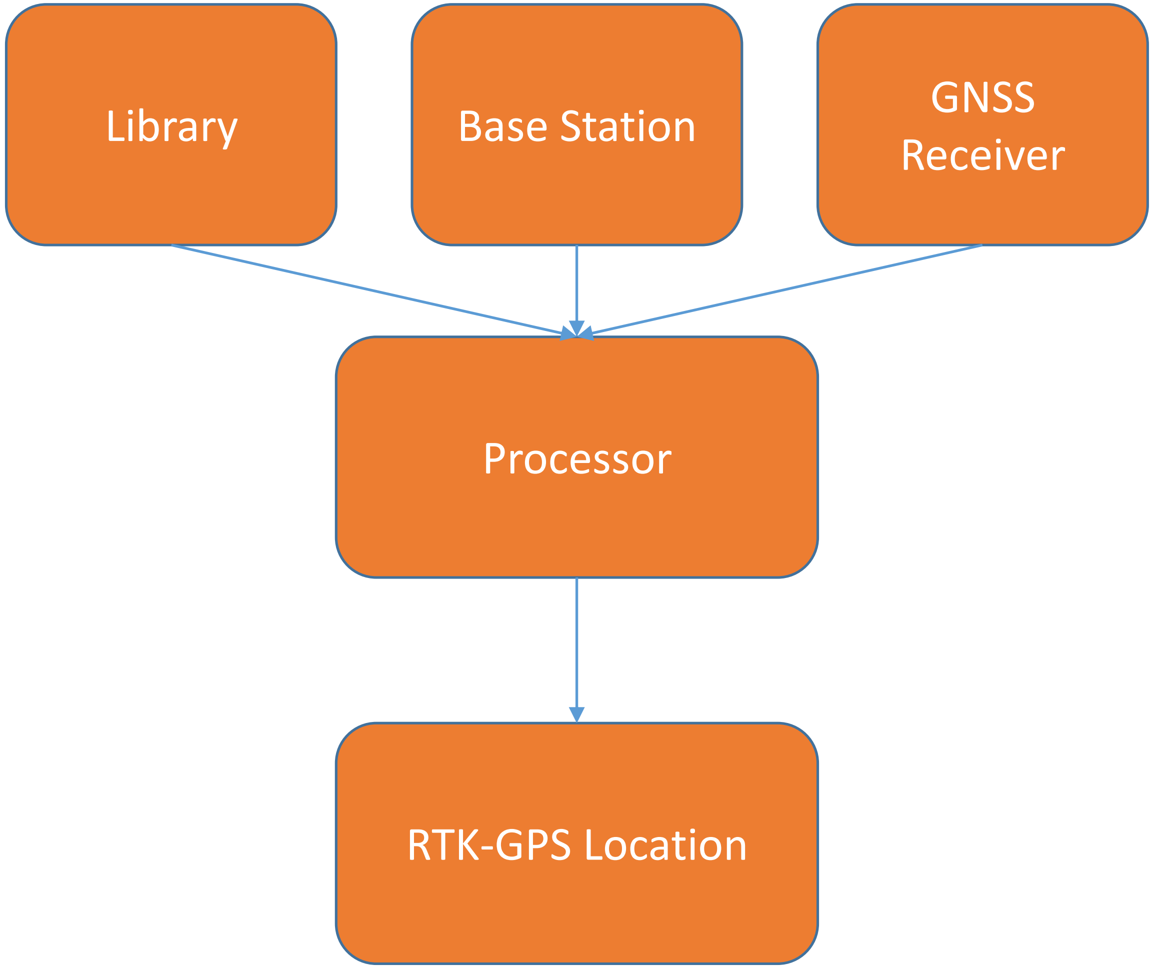
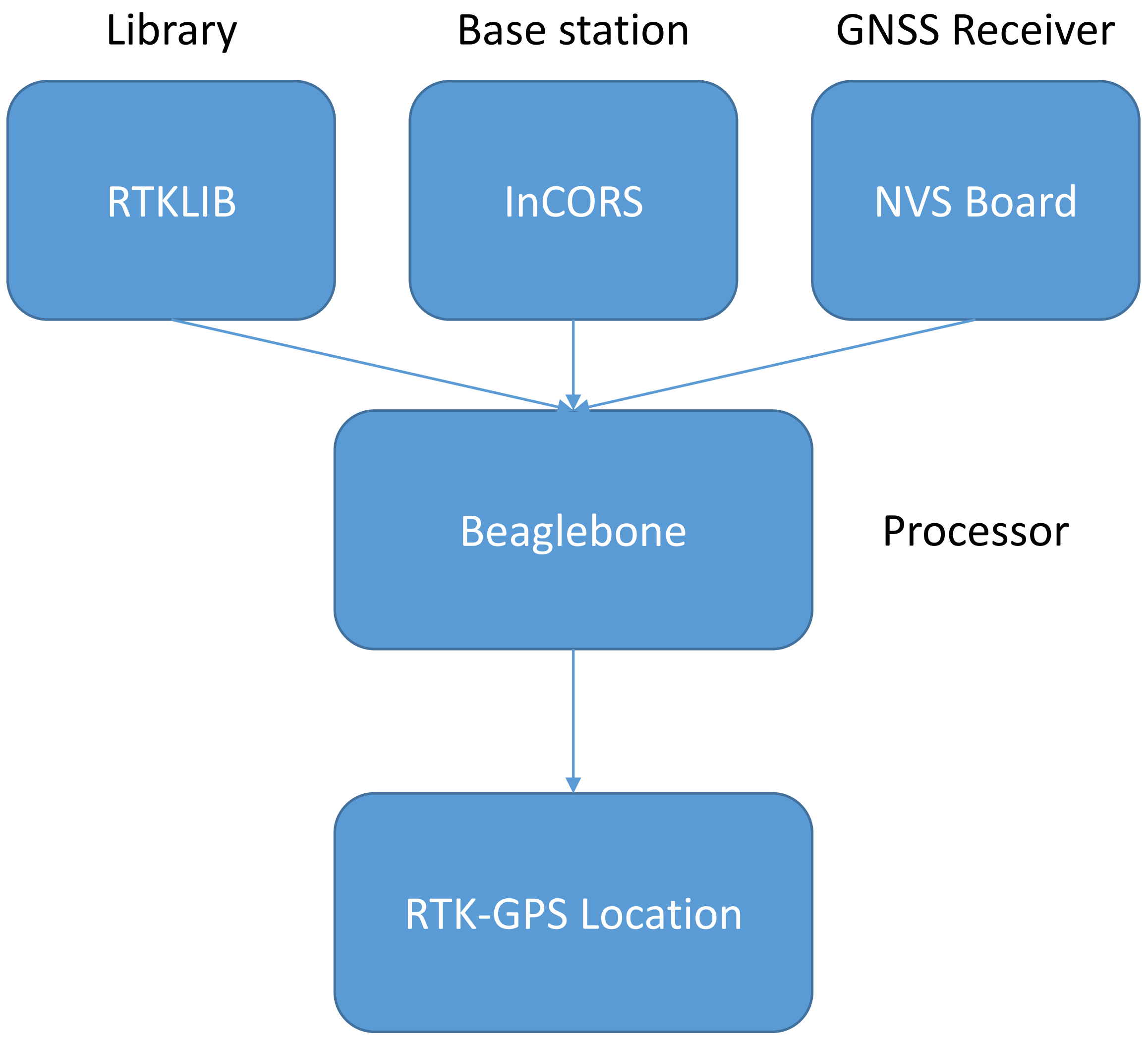
RTK-GPS

- RTK-GPS is an advanced technology that provides GPS location, accurate to the centimeter level.
- The problem is that the RTK-GPS devices currently used are very expensive.
- It would be a great advantage if we can build a similar device that is much cheaper.



RTK-GPS ISOBlue

- RTK-GPS ISOBlue is an RTK-GPS device that works with ISOBlue to provide high-precision location.
- RTK-GPS ISOBlue costs less than $200.
- It contains three main parts:
  - NVS Board (nv08c-csm-brd).
  - Beaglebone Black.
  - RTKLIB.

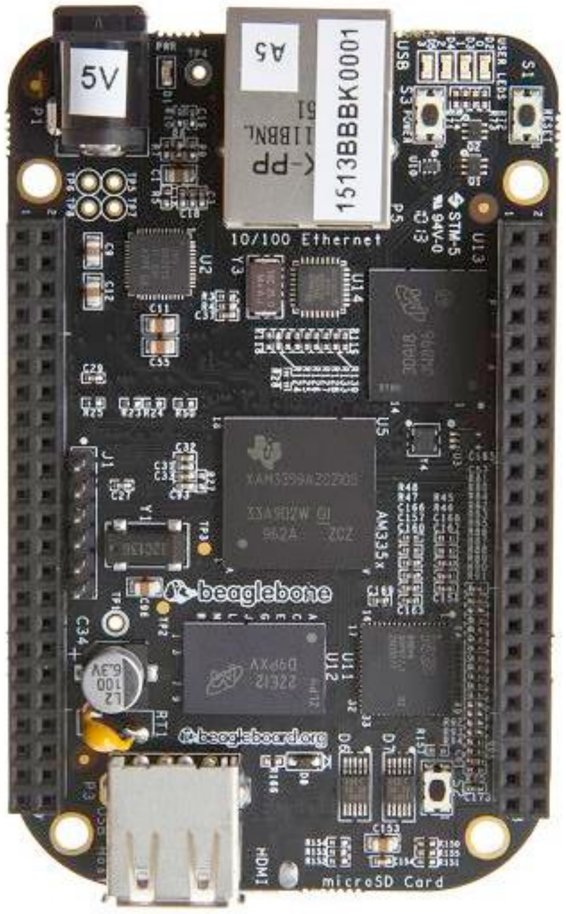


1. NVS Board

- NVS Board is a GNSS receiver.
- It receives GPS, GLONASS, and GALILEO signals.
- It measures the carrier phase of the satellites.
- It outputs raw data as BINR code to be used for more accurate location calculations, such as RTK-GPS.
- Cost: $64

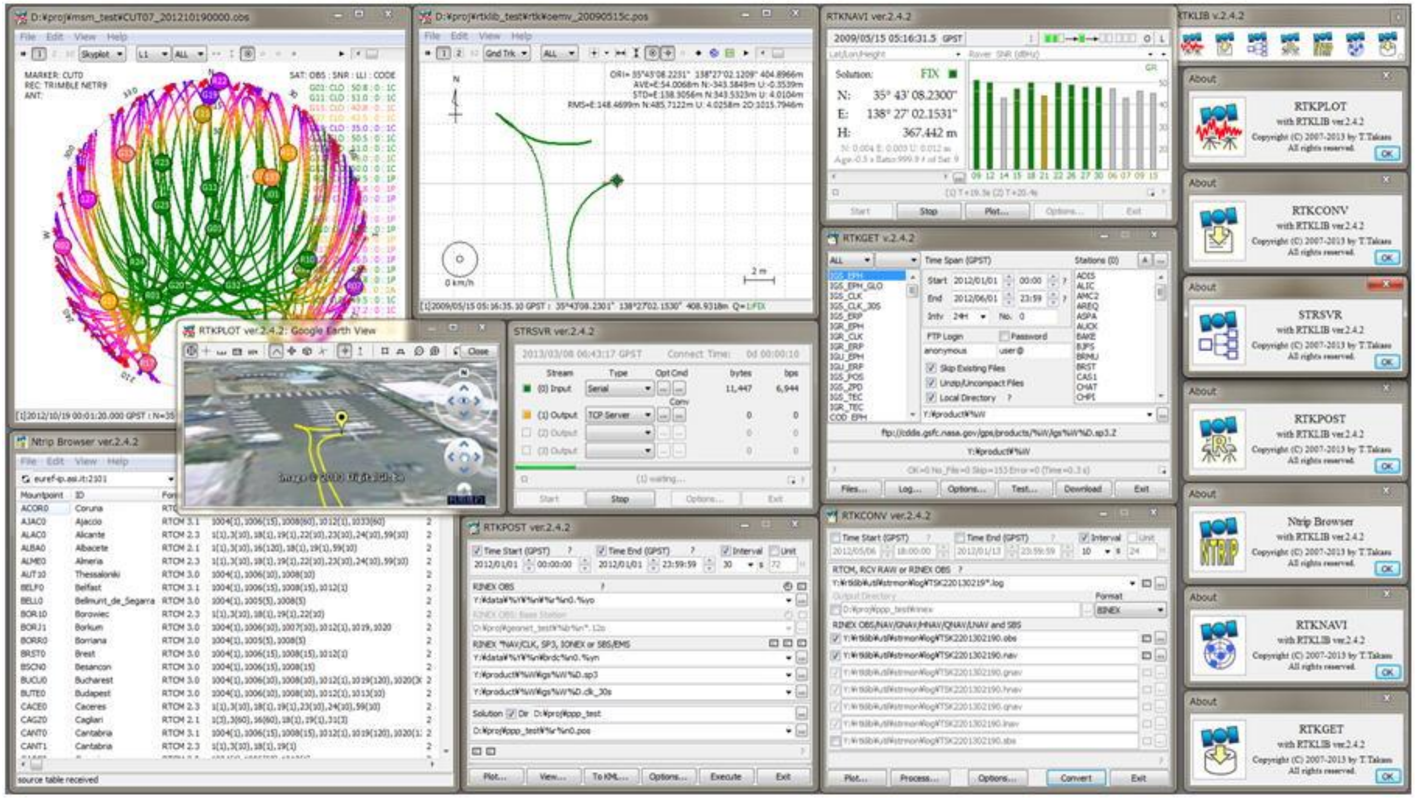
2. Beaglebone Black

- The Beaglebone Black is the processor that takes the BINR code from the NVS Board and generates the location using RTKLIB.
- Cost: $45

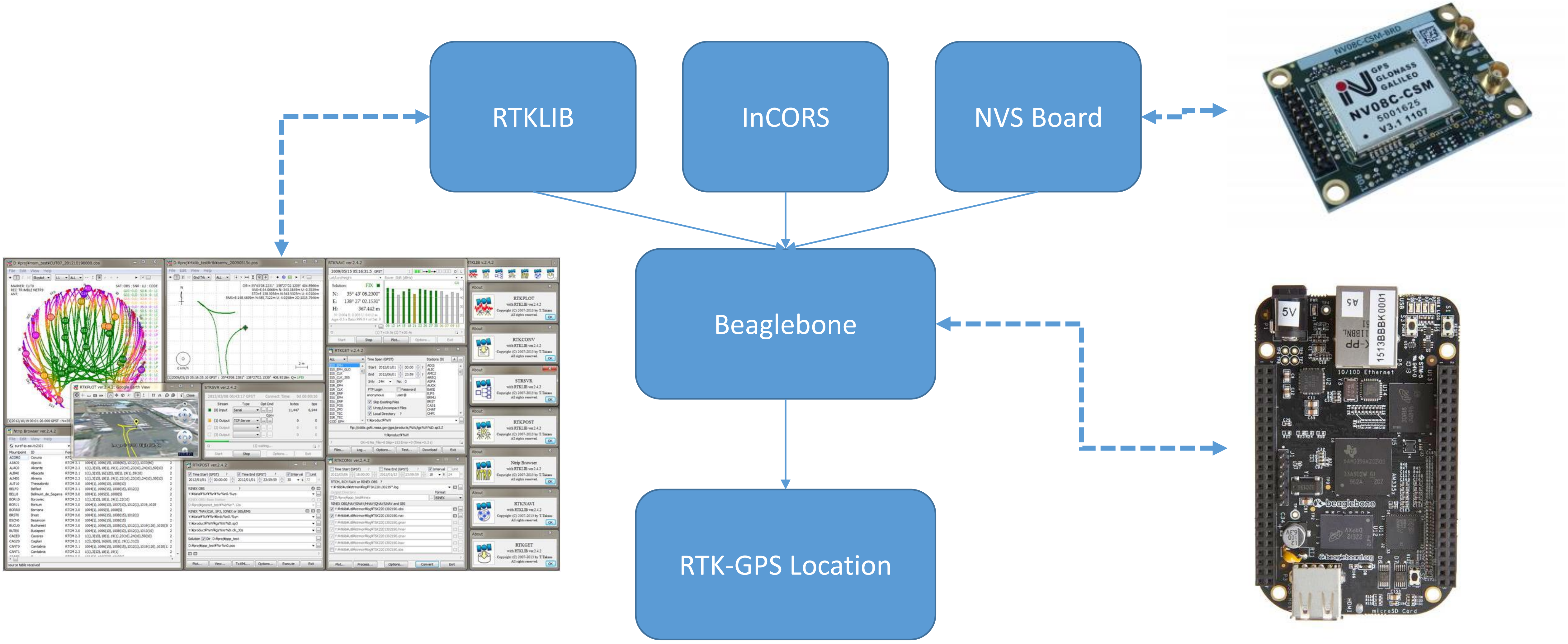


3. RTKLIB

- RTKLIB is an open-source library that contains all the necessary algorithms to generate RTK-GPS location.

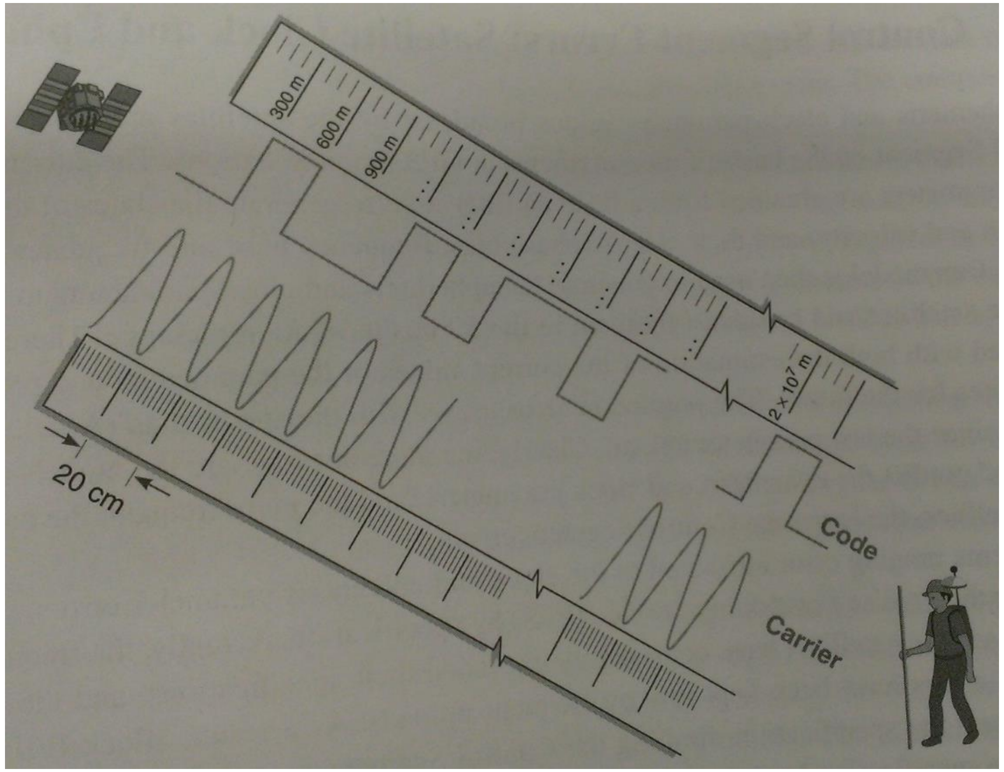


Diagram



How does RTK-GPS work?

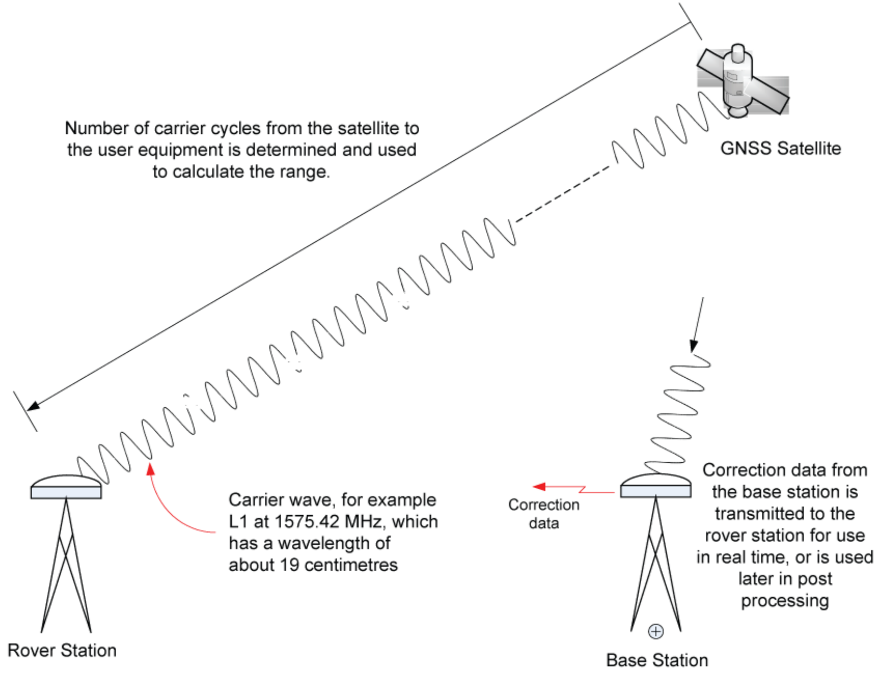
- The carrier signal has a wavelength of about 19 cm.
- The C/A-Code chip has a width of about 300 m.
- The receiver measures the phase of these two signals with an error of 1%.
- i.e. ±1.9 mm for the carrier and ±3 m for the C/A-Code.



C/A-Code = Meter stick with no millimeter marks
Carrier = Millimeter stick with no meter marks

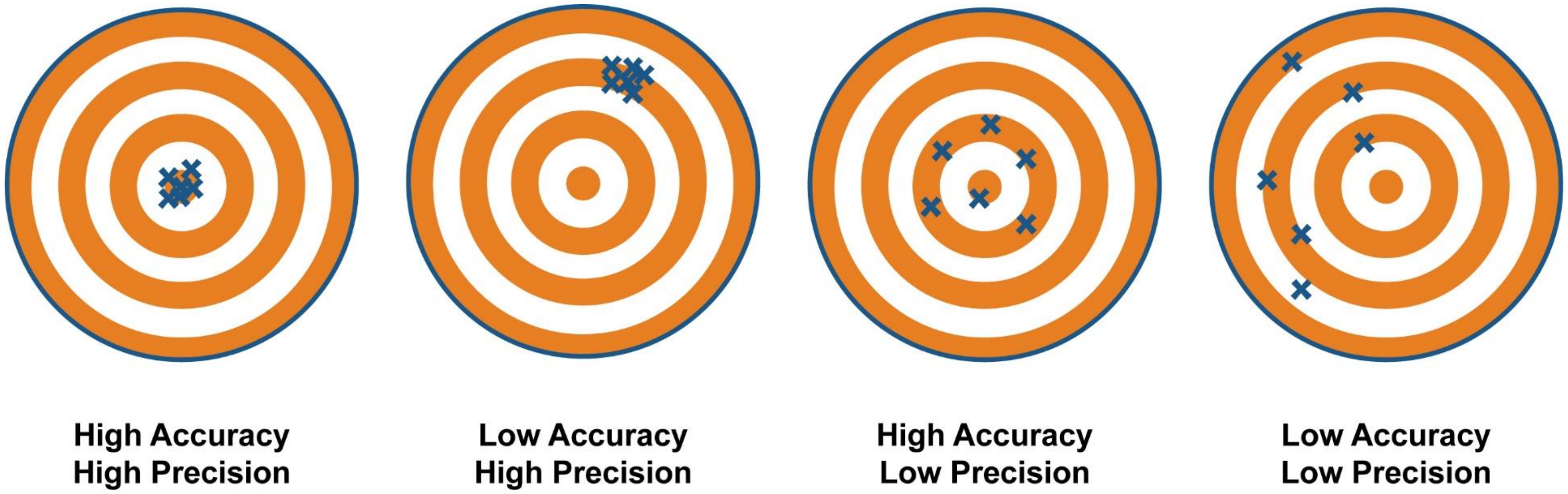
How does RTK-GPS work? (cont.)

- Because the base station knows its exact location, it can help the receiver solve this problem.
- The base station sends corrections to the receiver.
- The receiver uses these corrections to calculate the number of wavelengths between the satellite and the receiver.
- This number is called the ambiguity integer.
- The receiver calculates this integer using some estimation methods, such as Kalman filter, and generates the location.



Precision vs. Accuracy

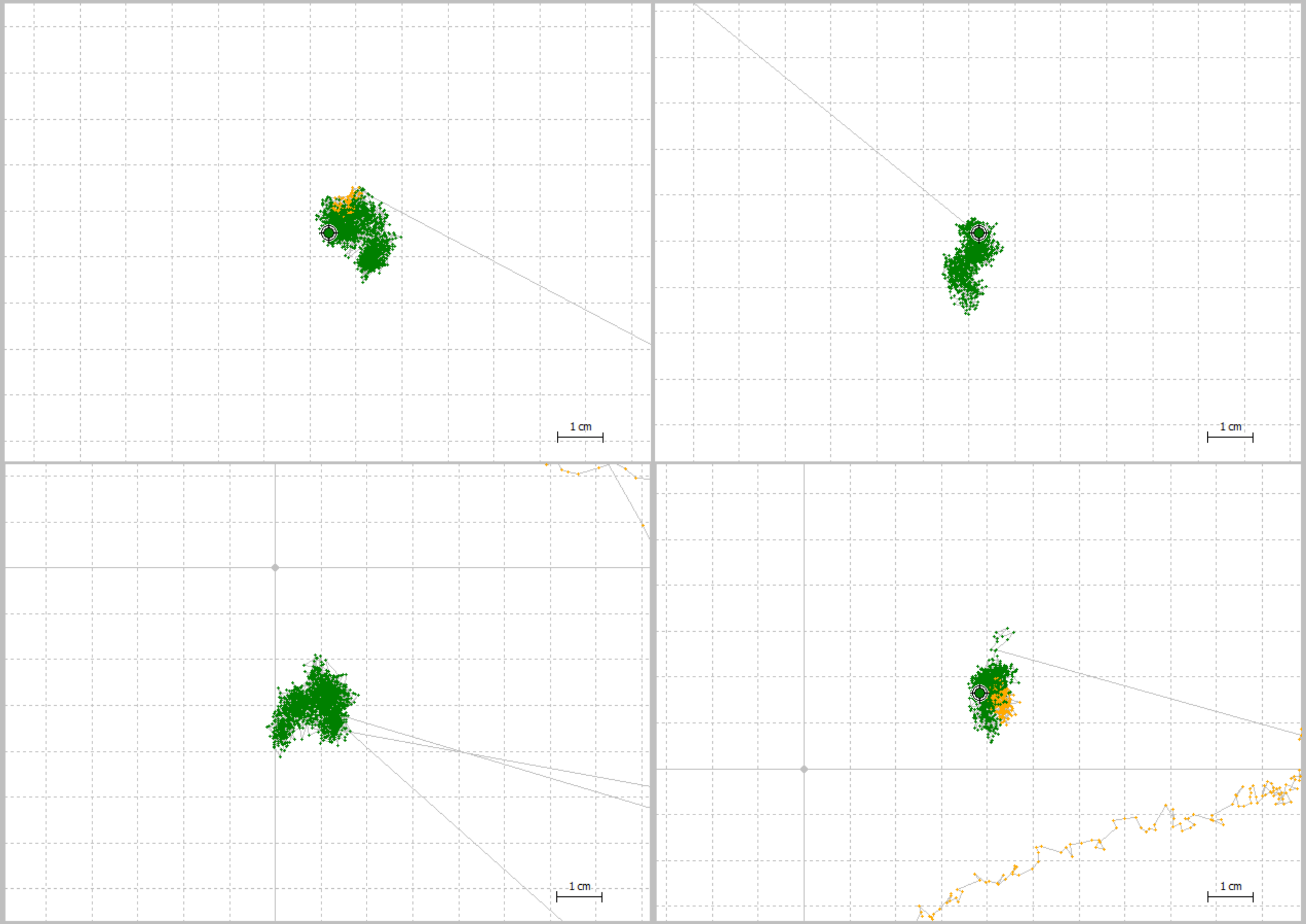
- Precision is how close the measured values are to each other.
- Accuracy is how close a measured value is to the true value.



How to test the precision of the device?

- We can test the precision by placing the device on a spot and observe.
- Then we run the same test on exactly the same spot over and over on a different time.
- Then we combine all observations and calculate the minimum radius that includes all observations.

A precision test on top of a parking garage.



Data 1
3/23
17:15

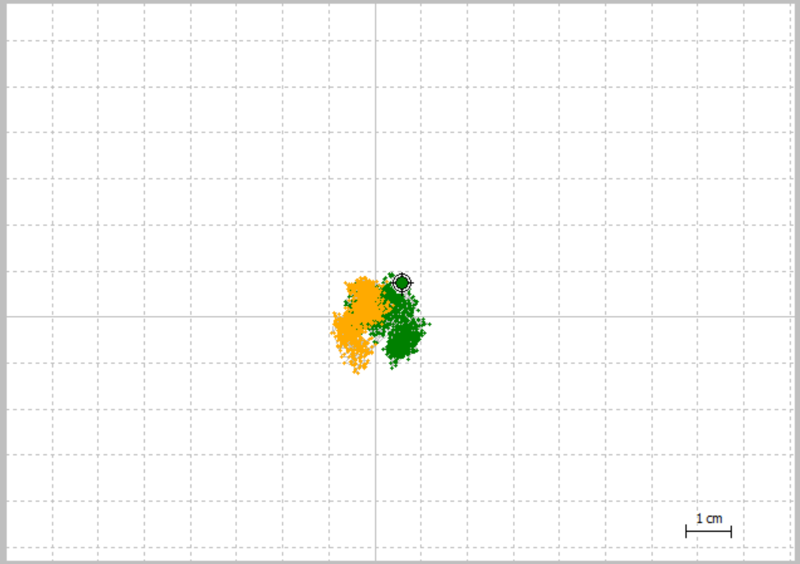
Data 2
3/23
23:11

Data 3
3/24
19:27

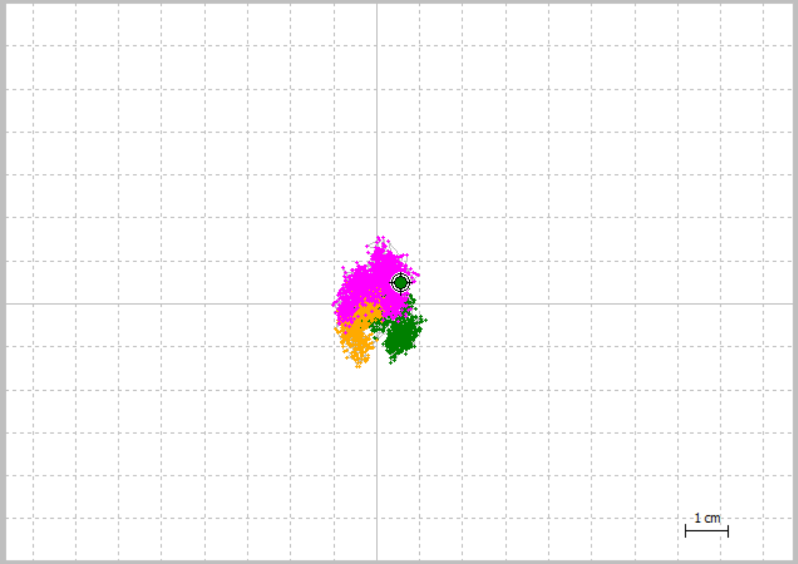
Data 4
3/25
02:01

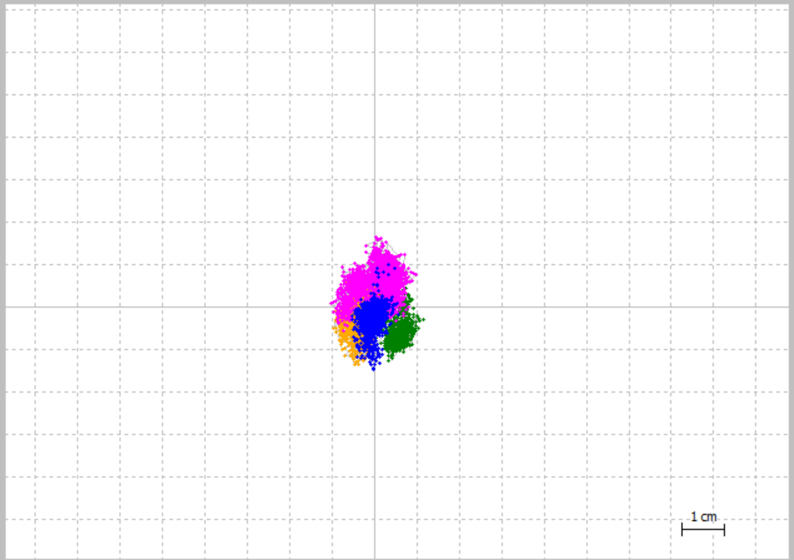
Combining all 4 tests data

Data 1 & 2



Data 1, 2, & 3



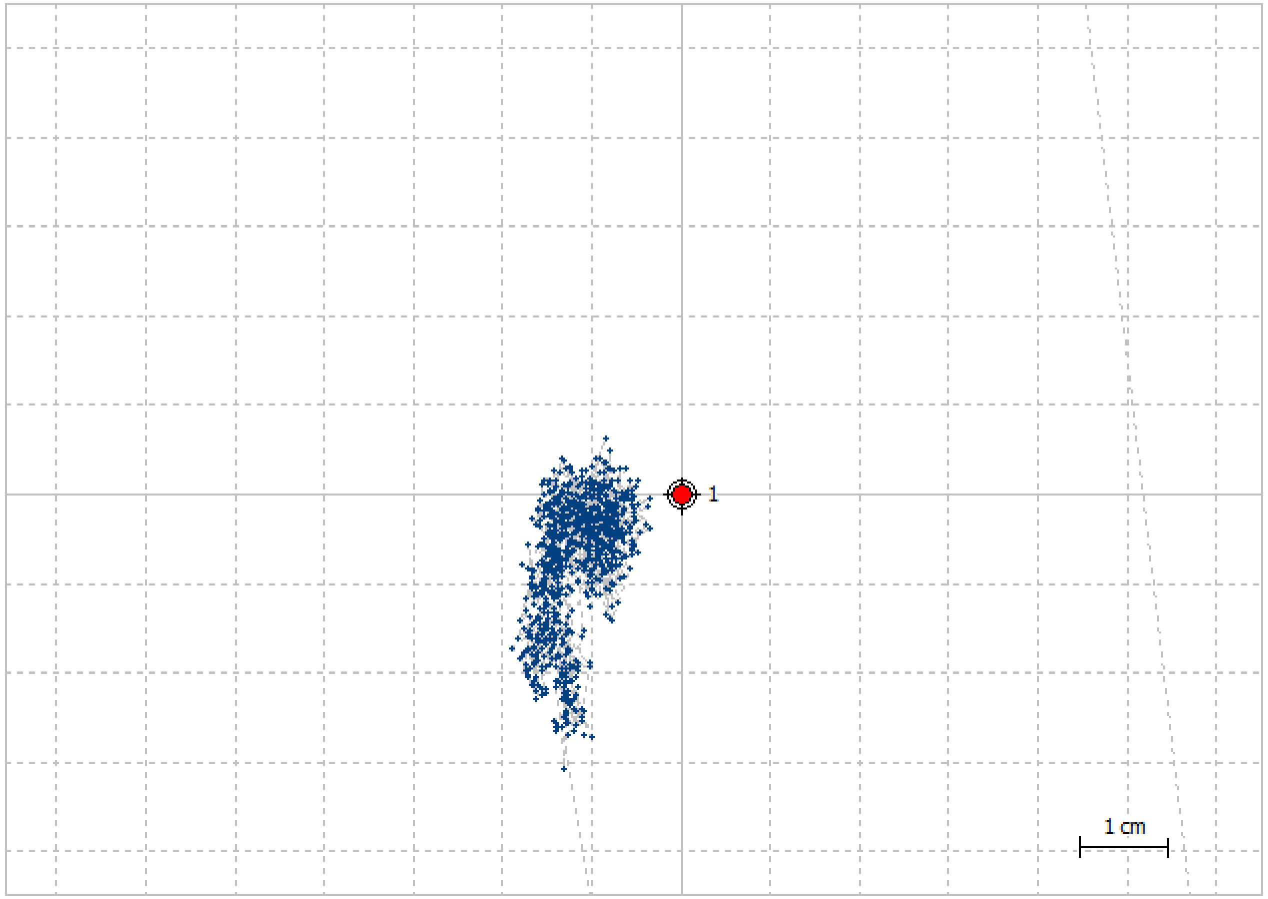


Data 1, 2, 3, & 4

How to test the accuracy of the device?

- We can test the accuracy by placing the device on a spot that we know exactly the location of.
- Then we calculate the distance between the exact location and the mean of the observed locations.

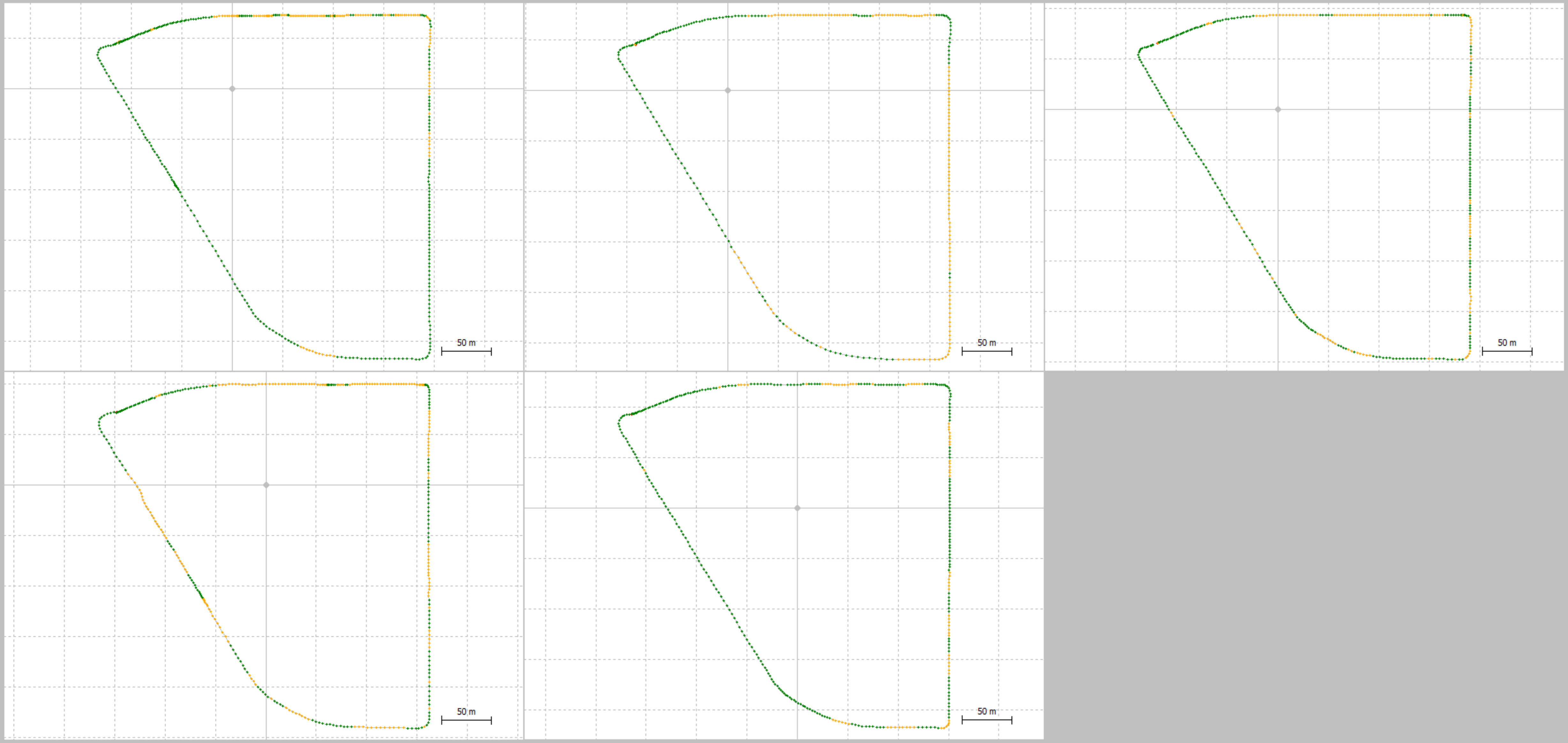
An Accuracy test near Purdue Airport



Motion test

- This test is performed to show how stable the device is while moving.
- We found out that motion affects the lock of the device.
- Many tests were performed to find out the reason behind this.

Motion test near W. Lafayette base station



The validation ratio

- $\check{N} = \underset{N \in Z}{\operatorname{argmin}}((N - \acute{N})^T \, Q_N^{-1}(N - \acute{N}))$

- $R = \dfrac{(\check{N}_2 - \acute{N})^T \, Q_N^{-1}(\check{N}_2 - \acute{N})}{(\check{N} - \acute{N})^T \, Q_N^{-1}(\check{N} - \acute{N})} > R_{Thres}$

Statistics made for the motion tests

	Motion data 1	Motion data 2	Motion data 3	Motion data 4	Motion data 5		Data 1	Data 2	Data 3	Data 4	airport
rounded total time (min)	9	5	10	10	7		36	24	37	35	18
number of lost locks	20	18	9	26	15		1	1	1	1	0
number of lost locks caused by increasing sat.	18	18	9	26	14		1	1	1	1	0
% of lost locks caused by increasing sat.	90	100	100	100	93.33333		100	100	100	100	?
% of ratio reduction caused by increasing sat.	80	92.3077	76.9231	95.8333	88.4615		66.6667	100	50	100	33.3333
% of fix after initialization	49.3827	75.0378	58.0282	68.5022	76.8116		94.9458	100	100	83.3438	100

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Issue

- Adding more satellites after locking is the main reason of losing the lock.
- We think this issue is a bug on the RTKLIB method of applying the Kalman Filter.
- This issue is fixable and it would take about one semester to fix.

Time of day test

- This test is performed to show if there are certain times where the device does not work properly.
- RTK-GPS ISOBlue usually takes about 2 min to lock and few seconds to relock.
- After performing this test, it turned out that sometimes it takes much longer than 2 min to lock, specially on the planting season.
- When we have this issue, it take from 20 to 30 min to lock and relocking is long.

Issue

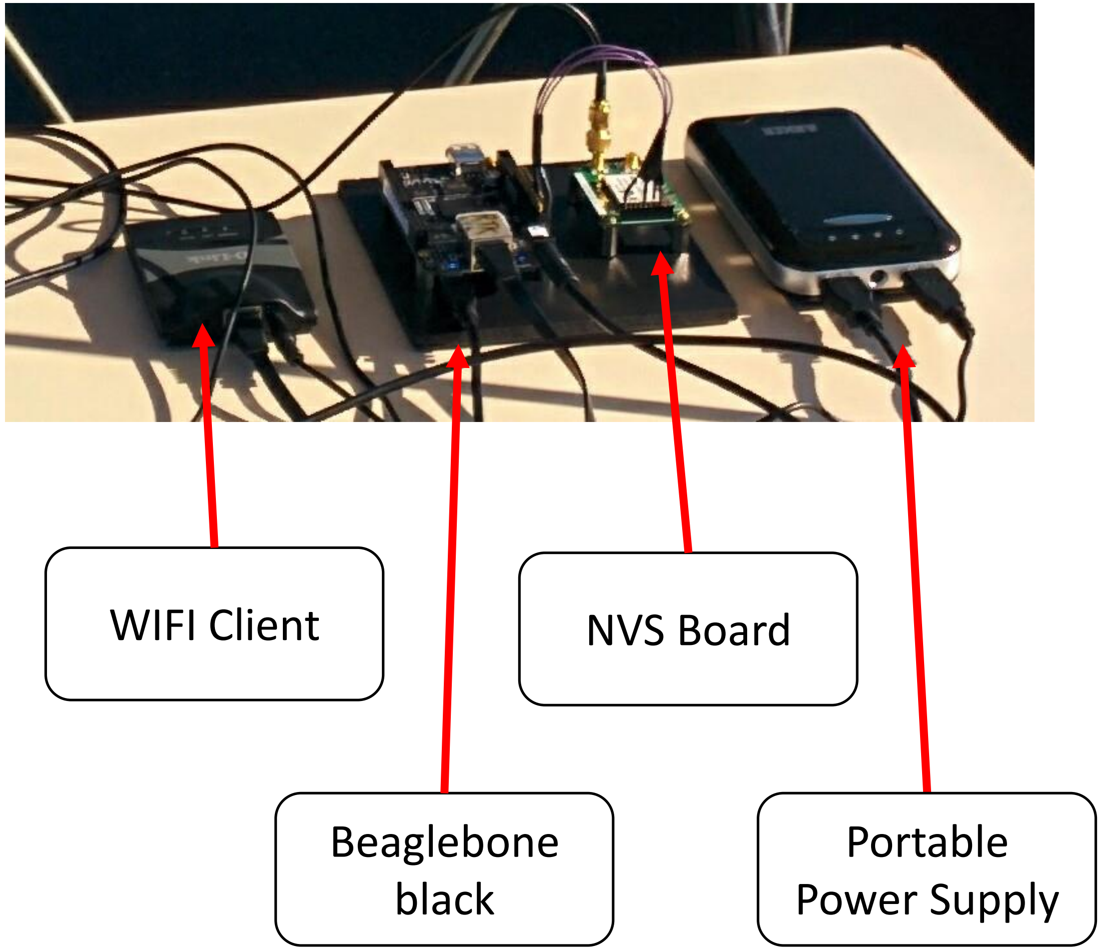
- We have a theory that when InCORS is busy, it fails to provide corrections to users.
- If this is true, then we cannot rely on InCORS all the time.
- We can subscribe to use a base station from a provider with an annual or monthly fee.
- OR we can build our own ISOBlue base station that will cost less than $200.

Plans for the future

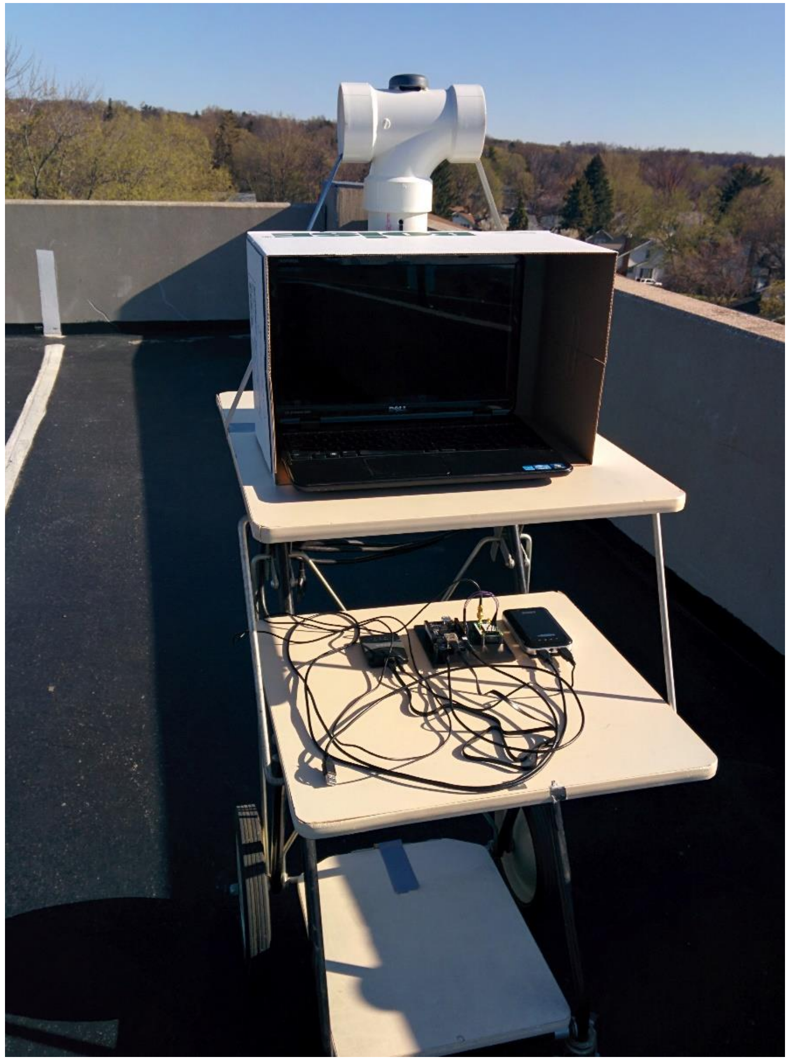
- Solving the bug of the implementation of the Kalman filter that causes the system to lose its lock. (one semester)
- Create an RTK-GPS ISOBlue base station. (two semesters)

Demo

- The RTK-GPS ISOBlue device was placed on a cart.
- The cart was taken to the parking garage in front of the EE building.
- It was pushed to follow a closed path.
- It went around this path many times.
- An Android device was plotting the location in real time.
- The data was post-processed for more detailed plots.



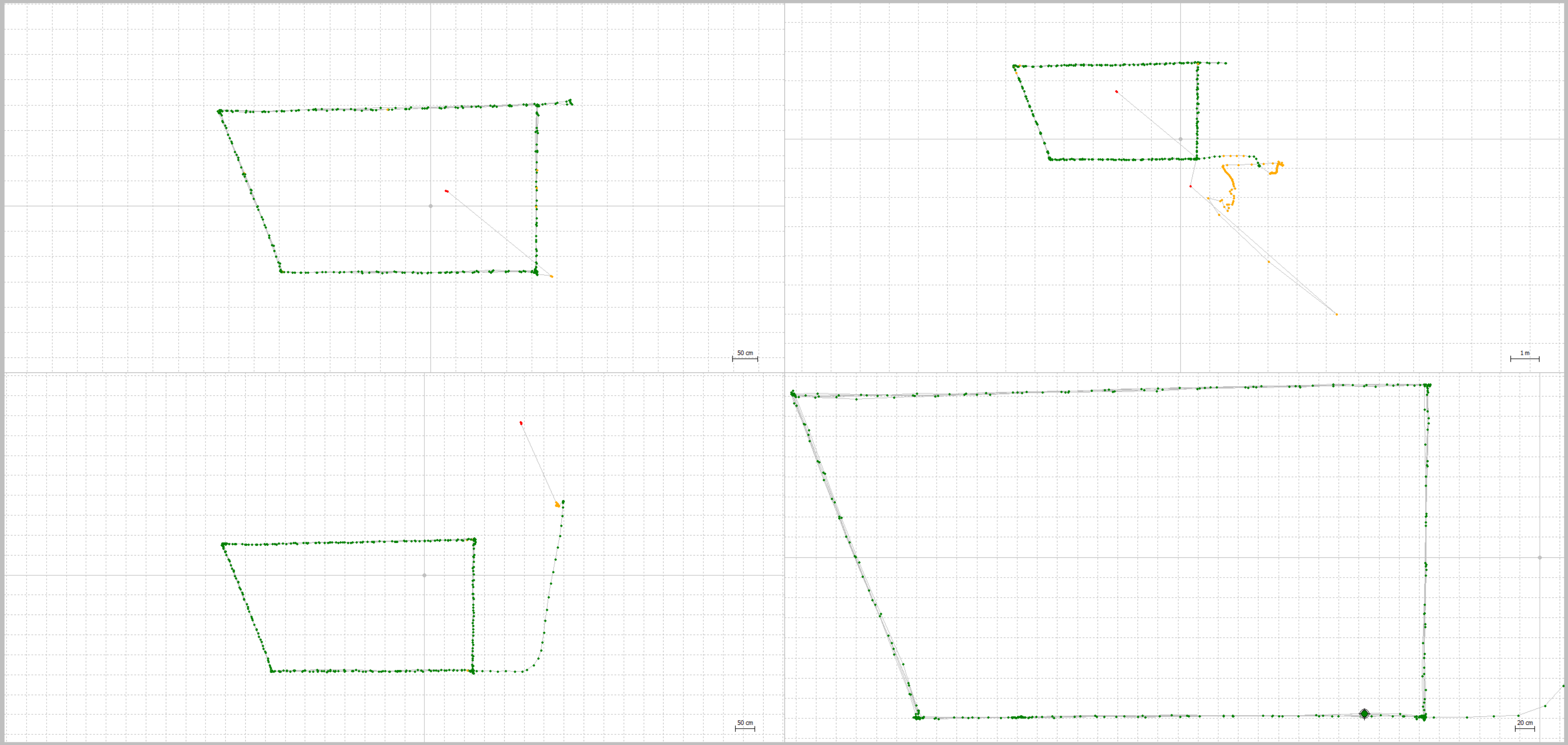
Pictures of the demo



Video of the demo

- https://www.youtube.com/watch?v=I-SMEfx-twc&feature=youtu.be

Plots of the preliminary Demo



Plot combining all data