miniATV goes WinterSIM
Test 1 – Alignment of the digital Rantavitikka map in WinterSIM with it’s physical twin

Objective:
The Rantavitikka map in WinterSIM (https://wintersim.fi/) has it’s own location coordinates relative to it’s origin. This origin’s coordinates are latitude = 66.4819458, longitude = 25.7216783 altitude = 0.0, acquired with map.transform_to_geolocation(carla.Location(0,0,0)) in the Rantavitikka map of WinterSIM and the surface of the map is made with a point cloud at around 78m of altitude.
The map is modeling the area around the Lapland UAS buildings at Jokiväylä 11 in 96300 Rovaniemi (https://goo.gl/maps/g2CBLdnEwiXPf5PH6).
Originally, the model of the area was not made for driving robots in it, only the area the two lidars were facing when collecting data on the influence of different weathers on typical sensors for autonomous driving (https://wintersim.fi/data/) is modeled in detail (see Illustration 2 down in the measurement points section). For that purpose, the relation of prominent structures to each other such as the buildings to each were modeled with a higher degree of accuracy and snow was covering the ground during the creation of the map, so finer details, such as different textures, lines on the ground and the borders between asphalt and grass patches were not visible and are not as accurately modeled in the Rantavitikka map.
The land surveying department of the Lapland UAS (https://www.lapinamk.fi/fi/Hakijalle/AMK-tutkinnot/Insinoori,-maanmittaustekniikka) has local reference coordinate points with known coordinates of different accuracy classifications all over the campus area.
Those reference points act as a ground truth for the height of the surface in the physical parking lot and allow measurements of how accurate those landmarks, such as grass patches or lanterns, are placed in the WinterSIM map and how much offset exists between the map coordinates and the coordinates of the physical parking lot.
Since the datasheet of the the antenna does not describe where the measurement origin of the GNSS data is to be placed in the antenna and at the time of this test a customer service inquiry was not yet successful, testing 3 antennas of the same type could clarify that point as well. Usually the measurement origin depends on the frequencies used and on the angle of the incoming signal, this cannot be determined perfectly for every measurement. The achievable vertical accuracy with RTK correction is almost the height of the antenna case (2.5 cm), therefore the it is not sure that this question can be sufficiently answered as a byproduct of testing the alignment between the physical parking space and the Rantavitikka digital twin.

Measurement Points:
There are several local reference coordinate points in the parking spaces and areas surrounding the Lapland UAS buildings at Jokiväylä 11 in 96300 Rovaniemi (see Illustration 1). Two reference points, ap3 and ap6, are in the more detailed region of the Rantavitikka map and are also on ground level and not close to high buildings, which improves the accuracy of the GNSS sensors. Those two points are unclassified for accuracy standards though (see Jokiväylä Campus Points 2023 below), so two classified points from the less detailed side of the campus are included:
AMK1 (classification E5) and 50502 (classification E6). Even the unclassified points are used so frequently by the land survey department of the Lapland UAS, that their information on those points can be considered accurate enough for this setup.

Illustration 1: Overview of the Lapland UAS buildings on the Rantavitikka campus showing the ground truth measurement points (Source: Aerial image from Rovaniemi municipality open data API https://paikkatietojentuottajat-koekaytto.maanmittauslaitos.fi/aineisto/49eaa723-3480-4f0e-a1a7-b1bbffc4f424/rovaniemen-wms-palvelu – The reference point information is from the land surveying department of the Lapland UAS - The map was created with QGIS – Markings are my own)

Illustration 2: Screenshot of the Rantavitikka map in WinterSIM (developed by FrostBit) – Only the right side facing south to the river Kemijoki and the Korvanranta street is modeled in detail

Measurement Devices:
Antenna: MagmaX2 Active Multiband GNSS Magnetic Mount Antenna - AA.200
https://www.sparkfun.com/products/17108
Carrier board: SparkFun MicroMod GNSS Carrier Board (ZED-F9P)
(https://www.sparkfun.com/products/17722)
Processor: SparkFun MicroMod ESP32 Processor (https://www.sparkfun.com/products/16781)

Note! The cable of GNSS #1 has a small damage in the cable covering (see red tape on the photo), which doesn’t influence it’s measurements in a noticeable way. Verifying that assumption is another byproduct of this test.

Illustration 3: The 3 similar GNSS sensors, the carrier board with the ESP32 processor and an USB-C cable to connect to the laptop

Other Necessary Tools and Devices:
- Laptop with ROS and rosserial installed
- USB-C cable between the carrier board and the Laptop
- A digital caliper displaying in mm with two decimals for placing the GNSS sensors central over the measurement points
- A ruler for drawing straight markings with the chalk
- Chalk to mark the positions for the GNSS sensors
- A compass to align the GNSS sensors
- 50 m measuring tape to measure the distance to nearby landmarks
- Phone hotspot for getting RTK correction data via WiFi
- RTK correction data from the National Land Survey of Finland (https://www.maanmittauslaitos.fi/en/finpos/rtk)

Test Procedure:
Switch on the phone hotspot for receiving the RTK correction data. Each sensor needs a few moments until the first navigation fix and for the accuracy to drop to expected levels. Meanwhile the distance of the measuring point to landmarks shared with the digital twin is measured with the measurement tape and noted down in the table at the end of this document, together with a distinctive name or description of the landmark.
Photos of the landmark relative to the measurement point are to be made.
One after each other, the 3 similar GNSS sensors get placed on the measuring point such that the measuring point is in the middle of the underside of the sensor.
The cables and the carrier board stay the same.
For that, the outline of the correct sensor placement is marked with chalk and the compass is used to align the outline such that the cable leaving the case of the GNSS sensor points south.
Photos of each sensor placement are made
The 1,5m antenna cable, the carrier board, the USB-C cable and the laptop are aligned such that maximum distance between the experimenter and the antenna is kept during the GNSS measurement, to keep the antennas view to the sky clear of disturbances for better accuracy. For the same reason, conduct the test in a cloudless clear weather if possible.
Each sensor is measuring at each point for 5 minutes (due to laptop battery constraints), the GNSS data is send via rosserial by the ESP32 to the laptop which is recording a rosbag for each test run.
The Arduino code in the ESP32 is pushing RTK correction data to the antenna, while getting GNSS and accuracy data from the antenna and sending that with rosserial to the laptop via USB-C cable.
The code in the ESP32 can be found here:
https://github.com/Lapland-Robotics/miniATV/tree/master's_thesis_cs/Arduino/ATV_GPS_w_RTK
The test is conducted in one go without interruptions, using the same tools and all measurements taken by the same person.
All manually acquired data and additional notes are collected in a full size version of the data collection table in Appendix A.
Later, a document with a scan of the filled out data collection table and the photos taken during the measurement is created. This document is uploaded into the Lapland Robotics GitHub (https://github.com/Lapland-Robotics/miniATV/tree/master's_thesis_cs/Testing) together with the test protocol, and the recorded rosbags.
The rosbags are automatically named with the start time and date of the recording, later the name of the reference point and the number of the GNSS sensor used is added like that: [name of reference point]-[GNSS#]-[previous title of rosbag].bag

ROS commands (open a new tab for each):

```
roscore

rosrun rosserial_python serial_node.py

rostopic echo -c /atv_gps

rosbag record –duration=5m /atv_gps
```

Note!

The test procedure instructs to conduct the test in one go without interruptions, but that turned out not to be feasible:
Due to maintaining the hotspot for getting the RTK correction data and taking photos, the phone battery ran out just after completing the measurements for the second reference point.

Then it was planned to conduct the rest of the tests with the other two reference points the next day, where similar weather was forcasted. Unfortuneately, on that day the permission to use the NLS RTK service ran out (renewing is not possible while the permission is still active).

The most important test runs in the more detailed area of the Rantavitikka map are complete, but since the accuracy is so important for this test setup, if the weather and accuracy are even better on the second test day, further measurements at ap3 and ap6 could be conducted, to also compare the influence of different weathers.

Such changes to a test procedure are not ideal, but will be documented in the data collection table and the documentation of each test run together with other comments and notes from the test process.

For further runs of this test, a power bank for the phone will be used.
The other planned tests take more time and processing power and are more strenuous for the phone and laptop batteries. They are also closer to electrical outlets on the outside of the building, so bringing an extension cable to charge phone and laptop is possible.

Data Collection Table

Measurement point	Time and date of measurement (= rosbag file name)			Distance to Landmark 1	Distance to Landmark 2	Distance to Landmark 3	Notes
	GNSS #1	GNSS #2	GNSS #3				

Jokiväylä Campus Points 2023

Source: Land surveying department of the Lapland UAS (https://www.lapinamk.fi/fi/Hakijalle/AMK-tutkinnot/Insinoori,-maanmittaustekniikka

Lapin AMK - Älykäs rakennettu ympäristö
Maanmittaustekniikan laboratorio

1(2)
15.03.2023

JOKIVÄYLÄN KAMPUKSEN PISTEET 2023

ETRS-TM35FIN / N2000

ETRS89-TM35FIN	X/P/N	Y/I/E	Z/K/H	Laji	Luokka
AMK1 *	7374119.809	443121.533	78.022	Tanko maassa	E5
AMK2 *	7374215.444	443135.384	77.679	Tanko maassa	E5
REDU1 *	7374088.661	443186.992	78.084	Tanko maassa	E5
AMKSP1	7374179.933	443111.993	78.490	Seinätappi (Leica) / M8	E6
AMKSP2	7374162.955	443114.193	78.480	Seinätappi (Leica) / M8	E6
AMKSP3	7374128.493	443105.417	80.655	Seinätappi (Leica) / M8	E6
AMKSP4	7374115.596	443128.939	89.295	Seinätappi (Leica) / M8	E6
AMKSP5	7374115.462	443128.473	79.273	Seinätappi (Leica) / M8	E6
AMKSP6	7374104.388	443140.675	78.988	Seinätappi (Leica) / M8	E6
AMKSP7	7374039.453	443143.784	78.982	Seinätappi (Leica) / M8	E6
AMKSP8	7374044.805	443128.856	78.961	Seinätappi (Leica) / M8	E6
AMKSP9	7374066.546	443073.009	78.649	Seinätappi (Leica) / M8	E6
AMKSP10	7374091.843	443120.886	79.439	Seinätappi (Leica) / M8	E6
50501 *	7374224.133	443143.664	77.746	Naula päällysteessä	E6
50502	7374124.571	443130.138	78.111	Naula päällysteessä	E6
ap1	7374142.441	443111.536	77.565	Naula päällysteessä	-
ap2	7374151.095	443134.478	77.934	Naula päällysteessä	-
ap3	7374059.532	443098.707	78.107	Naula päällysteessä	-
ap4	7374053.618	443124.500	78.026	Naula päällysteessä	-
ap6 *	7373996.847	443071.450	77.671	Naula päällysteessä	-
TEKU1	7374129	443101	79.211	Pultti perustuksessa	vaaittu
216	7374212	442978	77.954	Pultti perustuksessa	vaaittu
235 *	7374030	442969	79.297	Pultti perustuksessa	tuntematon

Koordinaatit ja korkeudet perustuvat RAMK:n aikaisiin mittauksiin, laskentoihin ja muunnoksiin sekä Karjalaisen & Kinnusen (2023) opinnäytetyöhön.

Tanko maassa -pisteiden korkeudet on määritetty tarkkavaaiten MML:n 1. luokan korkeuskiintopisteeltä. AMKSP-sarjan pisteiden korkeudet on määritetty trigonometrisesti näiltä pisteiltä. TEKU1 korkeus on tarkistettu samoissa tarkkavaaituksissa.

* Maapisteiden AMK1, AMK2 ja REDU1 routasuojauksesta ei ole varmuutta ennen seuraavan kesän tarkistusmittauksia.

* Monikulmiopisteen 5051 korkeus on jonovaaitusharjoituksissa eronnut toistuvasti noin senttimetrin, kun lähtö- ja sulkupisteinä TEKU1 & 216.

* Apupisteen ap6 korkeuden luotettavuus on kyseenalainen.

* Korkeuskiintopiste 235 sijaitsee yksityisellä asuinkiinteistöllä, vältä pisteen käyttöä ja tarpeetonta kulkua!

Illustration 4: "Jokiväylä Campus Points 2023" - The title of the last column ,“luokka”, means “classification”