



Hochschule Neubrandenburg  
University of applied science  
Faculty of Geodesy and Geoinformatics

# **„Development of an AD-HOC Monitoring System for Geodetic Sensors“**

**Master Thesis:**

for obtaining the academic degree of a Master of Engineering (M.Eng)

Presented by: Humaira Saifi

First Supervisor: Prof. Dr. –Ing. Karl Foppe

Second Supervisor: M.Eng. Philipp Engel

Submitted on: 11. 08. 2020

Urn: nbn: de: gbv: 519- thesis: 2020 - 0126 - 4

April 2020

## Table of Content

1	Acknowledgments .....	4
2	Abstract .....	4
3	Objectives .....	4
4	Introduction .....	5
4.1	Topology .....	6
4.2	Use case diagram .....	7
4.3	Motivation .....	9
4.4	Problem Area .....	10
5	Geodetic Measurements .....	10
5.1	Sensors .....	11
5.1.1	Geodetic sensors .....	13
5.2	Geotechnical sensors .....	18
5.2.1	DXL360 .....	18
5.3	Meteorological sensors .....	20
6	Hardware .....	20
6.1	Communication .....	20
6.1.1	RS-232 .....	22
6.1.2	USB .....	24
6.1.3	WLAN .....	26
6.1.4	Ethernet .....	27
6.1.5	Bluetooth .....	28
6.1.6	Supplying the power .....	28
7	Software .....	33
7.1	Operating System .....	36
7.2	Programmierung Language .....	36
7.2.1	Python .....	37
7.2.2	JavaScript .....	37
7.2.3	HTML .....	38
7.2.4	PostgreSQL .....	38
8	Data analyzation .....	39

9	Time Scheduling .....	40
10	Other type of monitoring system .....	41
10.1	Leica GeoMoS .....	42
10.2	MoSTUM Monitoring System .....	42
10.3	Trimble 4D Control.....	43
10.4	OpenADMS Monitoring System .....	44
11	Cost-based analysis of HAD-HOC Measurement system.....	46
12	Practical implementation .....	46
12.1	Hardware.....	46
12.1.1	Communication.....	47
12.2	Software .....	47
12.3	Implementation of the software .....	48
13	Monitoring functionality test .....	55
14	Conclusion and outlook.....	56
15	Attachments .....	57
16	Bibliography .....	61
17	List of Figure.....	66
18	List of Tables .....	67
19	Statutory Declaration: .....	68

## 1 Acknowledgments

At this point I would like to thank the following people who support me professionally and personally in the preparation of this work:

At first many thanks from Prof Karl Foppe, prof Andreas Wehrenpfinig for a good supervision of my work

A big thank you also goes to Mr. Phillip Engel, for the papering of the Sensors and always being there.

And my special thank from my small Deutsche family (Jan and Andrea) they were always here for supporting and motivate me to follow my dreams.

And also, a special thanks from all member of Neubrandenburg Hochschule, they support students with patience and energy.

## 2 Abstract

geodetic surveying is the main topic monitoring of structures and terrain sections which several geodetic sensors perform this task. This AD-Hoc monitoring station was developed at the University of Neubrandenburg, is designed as a free and manufacturer-independent. For using this monitoring system, you don't need for any specific hardware or software from specific manufacture this system shows the development of a Monitoring System which measure the target area, control the sensors and transfer measurement data to the cloud and Local databases. The block of sensors is included of: Dual Axis DXL360s, GNSS receiver, Sylvac and Disto which provide measurement data at a high measurement frequency.

## 3 Objectives

Objective of this project is to maintenance, providing of geodetic data from deferent sensor in real time in a scientific and reliable way, with a GUI interface with plotting the Data using Python to full fill real time requirement, design of the interface using HTML, CSS, JS, Python.

The data is always available and migratable in form of cloud and local, a reference field is considered in the Hochschule in Neubrandenburg.

This system works on IoT concept, which is Internet of Things, where all the physical devices will connect with digital systems. The further processing of the database (local and cloud) for storing the data.

## 4 Introduction

Even in the very earliest civilizations that there was not any improvements of needed technology for purposes agriculture, construction, and trade measurement, but accuracy measured always with basic innovation, like the innovation of Swedish Electronic Distance Measurement (EDM) which was light base and for measuring the time required a beam of light it could accurately determine the distance between the two points, another example is Lacoste- Romberg Gravimeter which was for land, ice and under water measurement (Canada 2017.02.22).

By progression the world, the need for the accurate measurement have been increased day by day and for many centuries, humans have strived and begin for making of method and developing of facilities to provide warning of nature for most violent and hazardous events. Some of these events—earthquakes, volcanic eruptions, and tsunamis—are caused by deformation of the Earth’s crust. Because human don’t have beforehand information about these events so the rapid detection of them can lead to early warning. Even a few seconds of warning can allow people to take action that can save lives and reduce the cost of an event” the national academies press, page 30, title early warning for natural hazard” (DAVID A. FEARY 2010) so by improving of monitoring investigation we can keep the information of building infrastructure, areas, and other geographical places up to date, that the smallest movements can be to damage or collapse (Engel August 2013).

there are some modern monitoring systems are offered by various manufacturers. you can not only control sensors and save measured values, but also process and analyze data and transfer them to other computer systems. In the event of danger, they automatically send alarm messages and warn the user (

Table 1) listed some example of such systems. In the 2008, general minimum requirements for a geodetic Monitoring system listed. The central component is always the measurement and evaluation software” (Alexander P. Karpik 14th – 15th April 2014).

Table 1: Geodetic monitoring systems Providers

Company name	System name
Trimble	4D Control Software
Solexperts	GeoMonitor-System
Leica Geosystems	GeoMoS (inkl. Spider)
Geodata	Eupalinos
Loxis	troggnos

## 4.1 Topology

The System physically is divided into three parts: USB-Hub dongle, several sensors and laptop. this system is usually controlled by central PC software, the correct interaction and integrity of these individual subsystems must be assumed. The geodetic measurement sensors used are also key components. The selection of the instruments used for geodetic monitoring results from the corresponding measurement task. GNSS, Disto, DXL360 and sylvas are receivers and motorized total stations. Below graphically shows a structure overview of this monitoring system with geodetic measurement sensors Figure 1 .

The interface is designed to receive characteristics of the sensors from the user and show the real time graph, the data will be saved in cloud and in the local host, the interface is hosted in Heroku, Heroku used GitHub as repository for storing the data.

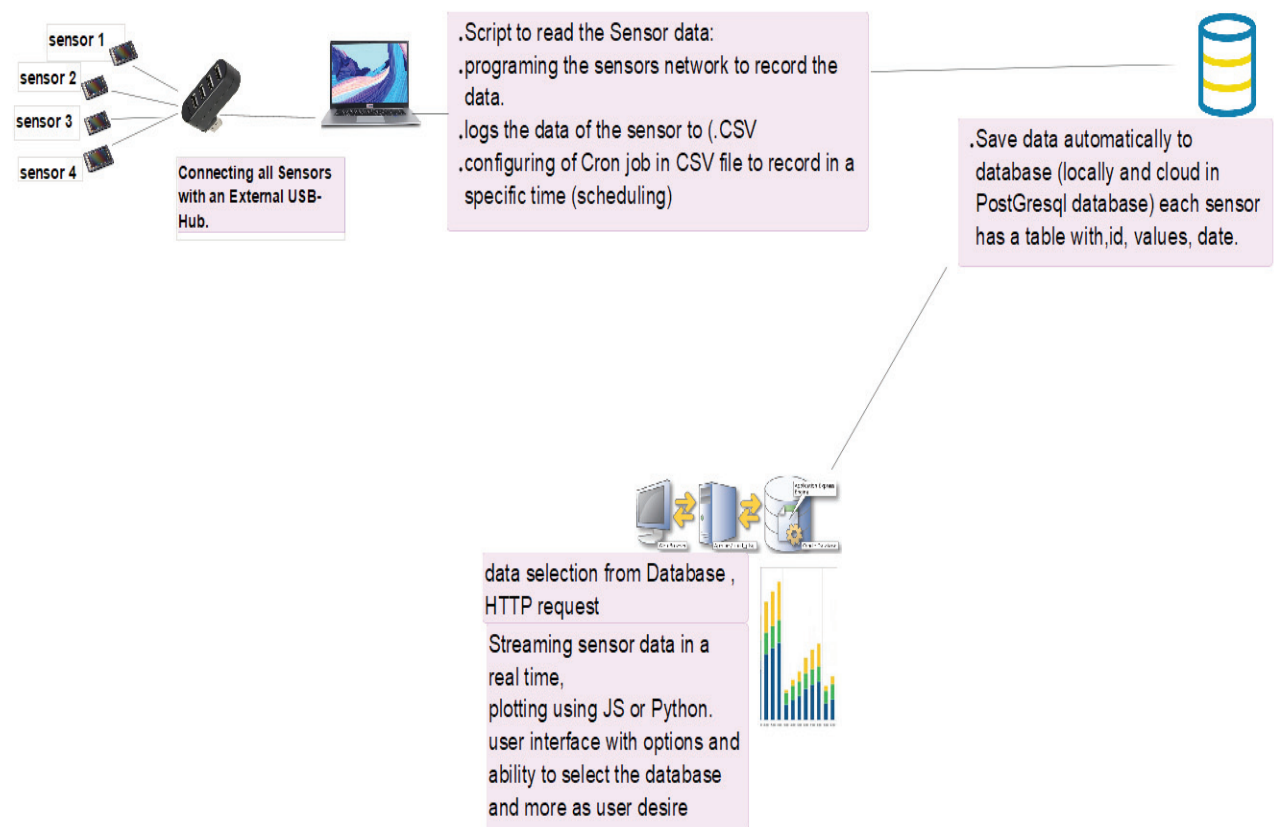


Figure 1: Structure of AD-HOC Monitoring System

## 4.2 Use case diagram

With the help of use case we can design end user system as desired by explaining all system behavior and it is the first form of a system requirements which is under work specify the exact expected behavior of the system like what is the system and how it will work and present the system in both textual and visualization. It is an effective technique for communicating system behavior in the user's terms by specifying all externally visible system behavior.

- defining user requirements.
- functional requirements of a system.
- Should be traceable.
- Use case can evolve at each iteration from a method of capturing requirements, to development guidelines to programmers, to a test case and finally into user documentation.
- Use case alternative paths capture additional behavior that can improve system robustness.
- It should be easily understandable by business users  
(Lynch Jul 16, 2019 ).

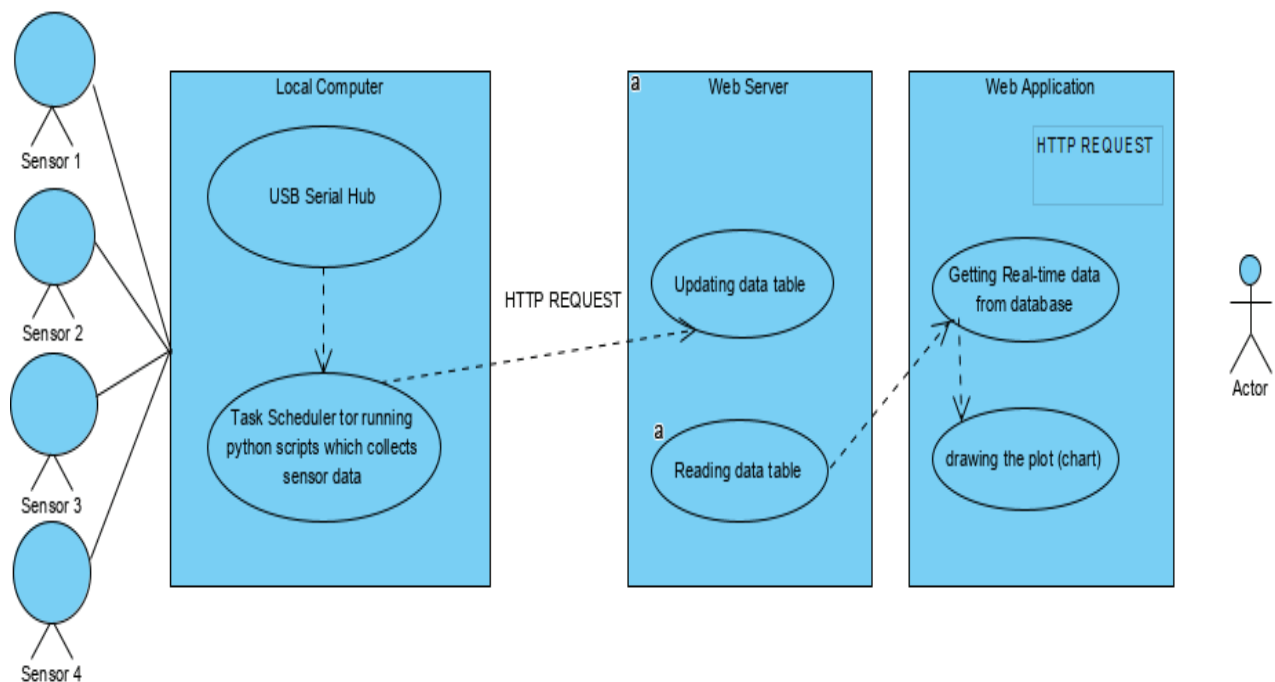


Figure 2: Use Case of Ad-Hoc Monitoring System

Figure 2 shows the behavior of the sensors, PC, interface, database and the way of communication to web application. The local computer is the main system that handle the sensor connectivity and task scheduling, the sensors sending information through USB-Hub to the system. Data is stored in database, When the browser requests it from

the web server and the web server responds with that page Figure 3 is a simple diagrammatic representation of this communication.

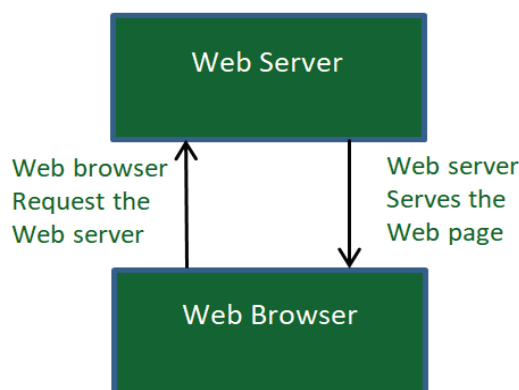


Figure 3: Web Server Request (Ujwala November 19, 2019)

### The Request process is consisting of 4 steps:

In Principle the web server communication is like, when two persons communicating with each other for sharing an information.

Acknowledgment, sending IP and receiving Ip, the steps are as follow

1. the web browser first obtains the IP address of the domain name (for e.g., for this page the domain name is (www.datatoolkit.herokuapp.com) resolves to. It can obtain the IP address in 2 ways-
  - By searching in its cache.
  - By requesting one or more DNS (Domain Name System) Servers.
 Note: Any website is assigned an IP address when it is first created on web server.
2. Browser requests the full URL: After knowing the IP Address, the browser now demands a full URL from the web server.
3. Web server responds to request: The web server responds to the browser by sending the desired pages, and in case, the pages do not exist, or some other error occurs, it will send the appropriate error message, there are 4 types of error message which server send according of the case.

For example:

Error 404, while trying request a page from server and the page is not exist so we receive this message.

Error 401 when access is denied to us due to incorrect credentials, like username or password, provided by us.



4. Browser displays the web page: The Browser finally gets the webpages and displays it or displays the error message (Brass 2006).

### 4.3 Motivation

A geodetic monitoring system consists of the following basic components: - power supply - user interface - Warning system (beeping or any other kind of notifications) - Geodetic measuring sensors - Geotechnical measuring sensors - data storage (e.g. SQL database) - visualization – Interfaces. The system is usually controlled by central PC software. The flawless interaction and integrity of these individual subsystems must be assumed.

The components which are used for this system are required sensors, USB-Hub, a PC, User Interface, Cloud for storing data, PostgreSQL. The first attempt was made to create a GNSS real-time monitoring system as an example or a part of the Network. It should be able to collect, visualize and evaluate NMEA data at the same time and save the measured data automatically to the Internet server and locally in the computer. All that was required for this were conventional GNSS receivers and a PC, as well as the interfaces for connection to one another and writing a python script. In the second step was the growing of the network with other 3 sensors and making the nice interface for all four sensors.

In this master thesis, a software system (AD-HOC Monitoring geodetic System) for notebook or PC is developed, which is made up of modules (storage, visualization and evaluation). It is designed to be expandable and communicates with a maximum of four different sensors.

The motivation of the master thesis is to have an easy-to-use software for small, fast surveillance measurements, quick monitoring measurements so that short, are easy to carry out. without having to install a complete and very complex monitoring system which is difficult to install or difficult to use.

The basic idea is a simple configuration of a low-cost computer and sensors to minimize the measurement, installation and operating. The system should offer the possibility to easily configure the relevant important parameters of the interfaces like (COM port, baud rate, Parity, Byte Size). (writing of this motivation is by reading of motivations topics from several sources and writing by my own words).

## 4.4 Problem Area

Data collection methods, viability of the data manipulation of the data and the Realtime displaying are an important consideration when planning a monitoring system. Analyzing survey of the data has become much more advanced with the advent of computer software programs (Rubertis n.d.).

Operators of earth-orbiting imaging satellites Human being environments, agriculture, building engineering, rehabilitation, require rapid and precise geolocation of their images in order to provide rapid service to their customers. The global nature of many of these applications requires the exact accuracy in order to serve as accurate as enough.

infrastructures are required to collect, analyze, and interpret the data and to communicate and manipulate with the data of the target object, so there is need for the highest real-time accuracy (DAVID A. FEARY 2010).

And in the past the system which were used need for need high level knowledge so it was difficult for common people to use systems For this reason, this measuring client specifically designed for the field of geodetic measurements which is easy to use, low price, easy maintenance, migratable and meet the standards requirements.

## 5 Geodetic Measurements

Geodesy is the knowledge about the Earth, accurately measuring of target area For example, by the using of the GPS, geodesists can measure the changes the points on the Earth's surface which is moved or not so today technology and scientist seriously thinking about the improving of the measurement science to have different possibilities and more accurate. By the geodesy science there is 3 main important properties which geodesists determine the changes of these properties during of the time.

- Geometric shape
- Orientation
- Space or gravity

During of the site surveying geodesist considering about the geometric information of the location under surveying, the orientation the site and the gravity (in some cases)



Figure 4: Test measurement in the lab (DABAMOS 20017)

There is a simple mathematical model of the earth which is named ellipsoid and it is the most basic model of the earth that is very simple of mathematical model and is completely smooth for any kind of information on the surface of the earth geodesists use the geoid, the geoid is the mean sea level which come over the surface of the ocean (NOAA 04/09/20). NASA has developed a system with the determination of 1-cm accuracy in three dimensions, with this high accuracy several geometric application become possible, including earthquake hazards assessment, precision surveying, plate tectonics and orbital determination (P. R. Escobal October 1972).

## 5.1 Sensors

Today by using high-precision sensors in automatic mode to control the daily behavior of points located on bridges, dams, buildings, landslides or subsidence area's it is possible to be warned early in advance of motions and deflections diverging from a normal state that could announce potential failures and to face the causes or at least to take actions that will mitigate the impact on the population.

We use the sensors in order to get data from different objects, measurement and selected topics related to measurement uncertainty and the adjustment calculation, terrestrial and global measurement methods have been available for such measurement tasks for around 20 years. Almost all measuring sensors can also be used in real time (dead or latency of a few hundred milliseconds). In addition to the classic post-processing methods, adapted real-time algorithms must be available for this.

Buildings, structures and structures have always been part of our lives, Geodetic sensors are understood to mean those instruments for measuring directions, angles, distances and height differences that are also used in other areas of geodetic practice, such as land surveying or property surveying (CRANENBROECK 2014) Some of them are

particularly suitable for periodic and vibration measurements Table 2 In the following some of them will be discussed in more detail.



Figure 5: Geodetic measurement sensors for monitoring tasks (Stempfhuber No Date)

These measuring sensors Figure 5 can be connected to the monitoring system by means of cable connections, radio data transmission, Bluetooth or via the Internet etc. (WLAN) connected. Almost all measuring instruments have a serial interface. The bi-directional communication protocols are available from some manufacturers (e.g. Leica GeoCOM or GSI).

In the research area Geodetic Measurement and Sensor Technology, measuring instruments and techniques are evaluated and developed for challenging measurement tasks for engineering and industry areas. To ensure a high standard of quality of the survey equipment, special attention is paid to the compliance with internationally recognized standards and norms. For this purpose, test methods are designed to account for the range of possible interference. Today, we are still unable to detect the effects of sensor refraction, which represents the major limiting factor to the accuracy of geodetic measurements.

Many geodetic, geotechnical and meteorological sensors are used to monitor buildings and sections of terrain. The sensors are increasingly being combined with one another. When recording building movements, both temporal and spatial changes are of interest.

The changes over time include vibrations and vibrations in the range of a few hundredths of a second to several seconds for bridge structures as well as long-term movements over months and years when the structure is being built. The spatial changes

measured by sensors range from small local areas (joints, cracks), to individual construction sections (walls, pillars) and entire structures (Hofmayer October 2018).

This chapter examines a selection of geodetic, geotechnical and meteorological sensors that are frequently used for monitoring measurements.

Generally, for a structural monitoring project, geotechnical sensors are placed to deliver physical information from inside a structure and around while geodetic sensors are monitoring the geometry of a structure from outside (Cranenbroeck 6-10 May 2012).

### 5.1.1 Geodetic sensors

Geodetic sensors are instruments and techniques which are designed for measurement tasks, they are using by geodesists engineer and industries to measure angles, height, distances and other characteristics of the Objects in different area like Agriculture, engineering, weather station and so on. in order to make the quality of the survey high and accurate so the geodetic sensors must meet the international recognized standards (Prof. Dr. rer. nat. Breunig 2011-01-19 ).

In the following are some geodetic sensors which are used in this project with description.

Table 2: Geodetic Sensors

Sensor	Measurement accuracy	Frequency	Connection
GPS	2 – 2.5 m CEP (Circular Error Probable)	>16 Hz	USB 2.0
Disto	±3 mm (Standard Deviation)	0.3	RS232 interface
Sylvac	0.1-0.001mm, ±6 µm (Maximum Error)		USB 2.0 + RS232
DXL360	±0.08° (Standard Deviation)	2.5Hz	USB 2.0 Type-A male + Bluetooth

#### 5.1.1.1 GNSS Receiver

GNSS receivers are electronic devices that receive and digitally process the signals from one or more GNSS satellite constellations in order to provide the user position, velocity and precise time (PVT).

The signal which are transmits by the GNSS/GPS satellite are included of carrier frequencies, digital codes and a navigation message, The carriers and the codes are then used to determine the distance from the receiver to the GNSS satellite, and the navigation message contains, among other information, the location of the satellites as a function of time (terrsgps online).

NMEA is the standard of the National Marine Electronics Association, The NMEA output Functionality will implemented on the GNSS receivers, this standard implemented in almost all receivers and is freely available.

This functionality made easy the task for developer to develop one software for all GPS receiver instead of developing a different interface for different GPS receiver. NMEA data can be transmitted via different types of communications interfaces such as RS-232, USB, Bluetooth, Wi-Fi, UHF, and many others (Gakstatter February 4, 2015).

The data which receive by the interface like NMEA0183 GGA is the most important NMEA data, which GGA is the current Fix data the RMC which provides the minimum GPS sentences information, and the GSA which provides the Satellite status data. GGA - essential fix data which provide 3D location and accuracy data. The GGA Format provides essential fix data which includes 3D location and accuracy data, Table 3, (Orolia 8-April-2020).

#### NMEA GGA Massage

\$GPGGA,123519.00,4807.038, N, 01131.000, E,1,08,0.9,545.4, M,-164.0, M, \*47

Table 3: Appropriate splitting of the NMEA-GGA data string (Orolia 8-April-2020)

Value	Meaning
GGA	Global Positioning System Fix Data
123519.00	Fix taken at 12:35:19 UTC
4807.038, N	Latitude 48 deg 07.038' N
N,01131.000, E	Longitude 11 deg 31.000' E
1	Fix quality: 0 = Invalid 1 = GNSS fix (SPS) 2 = DGPS fix 3 = PPS fix 4 = Real Time Kinematic 6 = estimated (dead reckoning) (2.3 feature) 7 = Manual input mode 8 = Simulation mode
08	Number of satellites being tracked
0,9	Horizontal Dilution of Position
545.4, M	Altitude, Meters, above mean sea level (geoid)
-164.0, M	Height of geoid (mean sea level) above WGS84 ellipsoid
(empty field)	(Field not provided in this setup)
*47	Checksum data, always begins with *



the GPSNN which used in this project is the NL-8022MU Figure 6 the NL-8022MU is a USB GNSS receiver with an internal antenna and a u-blox8 multi GNSS chipset. The USB port enables the connection with a notebook, UMPC, tablet / car, PC. The flanged thread enables safe and waterproof attachment e.g. on the vehicle roof.

The serial port dialogue is used to connect to Spatial. To connect the GNSS to HTerm there is need for serial port and baud rate. The default baud rate of Spatial is 115200. The connection indicator displays whether there is communication with a Spatial unit.

The NL-8022MU can be used as a USB GNSS receiver under Windows Vista/7/8. The corresponding Microsoft Windows driver is available on the CD-ROM (Documentation, NL-8022MU u-blox 8 multi GNSS USB roofmount receiver 4.50 m 08/2014).



Figure 6: GPSNN type of NL-8022MU

#### 5.1.1.2 Leica DISTOTMs

Leica DISTOTMs is comfortable measurement instrument for each situation. Automatically and in a second distances can measure at the touch of a button. It is not too expensive but accurate and reliable which provide the distances about millimetre. It has a variety of functions to set and configure for any measurement situation quickly and accurately. It came with a very strong and nice cover housing which protect the sensor against dust, water and other harmful things.

The laser makes it possible to have Precision measurement, Since the laser spot is clearly visible, you can always see exactly where you are measuring, even in hard-to-reach places. By this technology of the laser, distance measurements are precise even over longer distances.

For 20 years since Leica Geosystems is launched in the measurements industry as a surveying, this laser base measurement instrument is still under the development to make it more efficient.

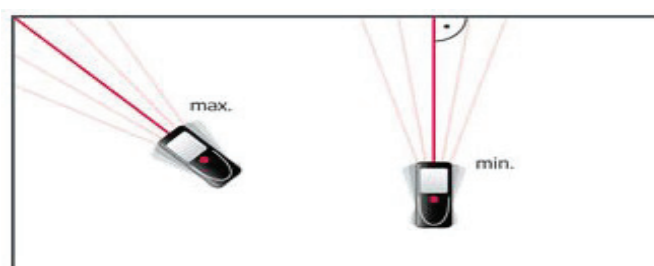
Leica Disto Laser Measurers are ideal for: Architects, Estimators, Contractors, Painters and Decorators, Fitters, Builders, Joiners, Electricians, Plumbers, Surveyors, Estate Agents, and more. The resulting products impress with their accuracy, reliability and robustness. That's why industry professionals trust Leica Geosystems. Satisfying the highest demands Meeting the customers' needs and fulfilling their expectations are top priorities at Leica Disto Sensor (Documentation, The original laser distance meter 2013).

The Leica DISTO™ range is ideal for quick, easy and precise measurements of distances such as length and volumes with the press of a button, even in inaccessible places, below is the communication character with Leica Disto Table 4, (Karl April, 2011).

Table 4: Communication character with Leica Disto (Karl April, 2011)

Orders to read Leica Disto	Operation	Interface parameter	Value
B	Disto on /off	Baudrate:	9600
G	Trigger distance Measurement	Datenbits:	8
H	Tracking on	Stopbits:	1
C	Tracking Stop	Parität:	even
K	Test		
C	Test Stop		
A	Reset		
A	Online-operation		

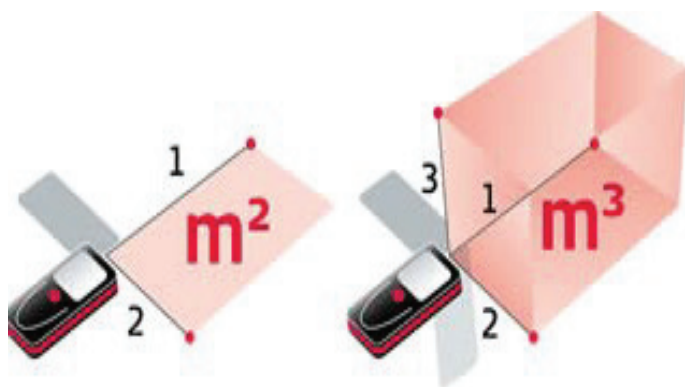
Following are some example of measurement method with laser Leica Disto sensor.



There is the functionality of the maximum measurement (e.g. for finding out the room diagonal) and minimum measurement (right angles to a wall) in the Leica laser sensor.

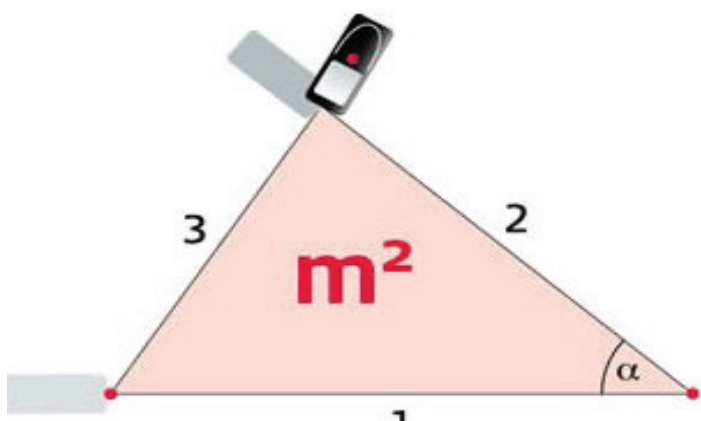
Figure 7: Right angles to a wall (Documentation, The original laser distance meter 2013)





For quickly and precisely measurement of the ceiling area, floor or the value of the room, the laser sensor can set to only 3 position and the result will automatically display on the screen.

Figure 8: The area of a ceiling,  
(Documentation, The original laser distance  
meter 2013)



The triangle function calculates quickly and efficiently the area of a multi cornered room. by using only three measurements Divide the room into imaginary triangles to determine the area of each triangle.

Figure 9: The area of a multi corner room  
(Documentation, The original laser distance  
meter 2013)

### 5.1.1.3 Sylvac

The electronic dial indicators are equipped with an engraved scale glued to the measuring spindle and a sensor which detects the Gears replaced. Instead of the analog display a digital display appears on the front panel. The range of Sylvac electronic dial indicators covers the entire range of standard dial indicators. With resolutions of 0.01 or 0.001 mm and measuring ranges up to 150 mm, they are perfect for mechanical dial indicators Measurement accuracy.

Inductive measuring system Sylvac (patented) Power supply: 3V lithium battery, type CR 2032 Operating temperature +5 to + 40 ° C Switching mm / inch Dial indicators (Documentaion n.d.).

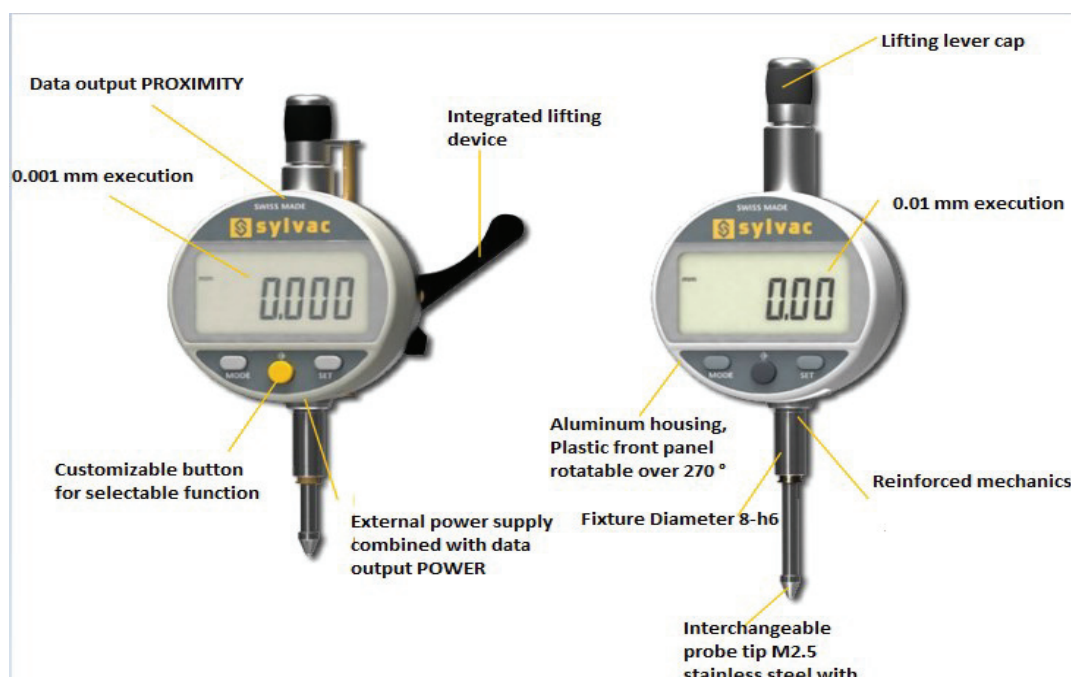


Figure 10: Sylvac View (Documentaion kein Datum)

## 5.2 Geotechnical sensors

Geotechnical sensors for measuring soil and structures. Wide range of sensors for monitoring concrete structures, measuring soil depressions and movements, pore water pressure and tilting of buildings and structures. Inclinoimeters are designed to measure lateral movement of soil. Extensometers are available for monitoring bedrock movements. Load Cell type force sensors are there for monitoring the anchorage forces of excavation support walls and finally strain gauge sensors for monitoring loads on concrete structures. Depending on the measurement size and the required accuracy, monitoring measurements use many geotechnical sensors in addition to the geodetic sensors. Geotechnical measurement methods include the direct detection of twists, deformations, strains, forces, tensions, water pressures, temperature, acceleration, vibrations and much more.

### 5.2.1 DXL360

The angle between two faces can be measure with this type of sensor which measure always the angle of the objects and the working procedure is with earth gravity direction , for measuring two object , first Press Angle key at the first face, and then rotate slowly and must keep the rotation axis to another testing face, it will then show the

angle once when not move the unit (Manual, DXL360/S V2 Digital Protractor User Guide 2013 July 29).

- Characteristics of the DXL369 are as bellow:
- High accuracy:  $\pm (0.08^\circ + 1\%)$ ,
- High resolution:  $0.01^\circ$
- Dual and Single axis angle
- LCD display
- Rechargeable (it means there is a battery inside which can be charged in case of need) V Shape metal case for easy use
- The angle range of the audible alarming is adjustable
- Level of Axis X and Y displayed on LCD by digits and pictures.
- Measurement with this sensor is easy.
- Absolute Level and Relative Level Modes are available for easier work.
- Auto adjust the display when turn the level box upside-down.
- Multi-function: this sensor works as multi-function it means it works as protractor, inclinometer, and level bar.
- external adapter is also used for data transmission, e.g. SVRS232 computer adapter or SV-BT wireless Bluetooth adapter (Manual 2013 July 29).

Figure 11 shows low-cost DXL360S two-axis inclination sensor with its attached Bluetooth-compatible.



Figure 11: DXL360S with Bluetooth dongle

### 5.3 Meteorological sensors

Meteorological sensors are used to understand and measure climate and weather. These sensors are typically deployed on a buoy or on shore nearby to record average lake conditions. Meteorology regulates many key characteristics of lakes and other water bodies, such as temperature, wave height, and dissolved oxygen. These sensors are usually physical sensors, and work on a variety of different principles and methods, often measuring internal voltage changes in response to changing meteorological parameters (Fonderiest.com online).

Example

Air temperature

Air humidity

Air pressure

Wind strength and direction

Amount of precipitation

Solar radiation

## 6 Hardware

The control of sensors and the management of their collected data do require not only software products and programming languages but also hardware appliances for data transmission, persistence, and inter-action. Until now, commercial personal computers with a windows10 operating system were used during the development and testing of AD-HOC. An uninterruptible power supply to protect against power failures must also be adapted to the high-power consumption of the computer. The hardware of the measurement client consists of individual components that are put together to form an overall system. These components include of PC, sensor, USB-Hub and another peripheral device and also software which will be need during the implementation of the project.

This chapter takes a closer look at them and presents specific products that are suitable for use in the measurement client.

### 6.1 Communication

The measuring software must be equipped with interfaces and adapters for communication with sensors and the connection to a network for data transmission (Engel August 2013). In communication, the process of sending data sequentially over a computer bus is called as serial communication, which means the data will be transmitted bit by bit see Figure 12, While in parallel communication the data is transmitted in a byte (8 bit) or character on several data lines or buses at a time see Figure 13, Serial communication is slower than parallel communication but used for long data transmission due to lower cost and practical reasons (Niyato 23 July 2012).

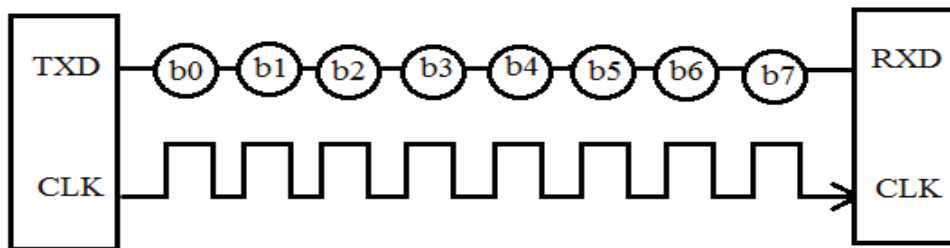


Figure 12: Serial communication (Sharma Jan 01, 2018)

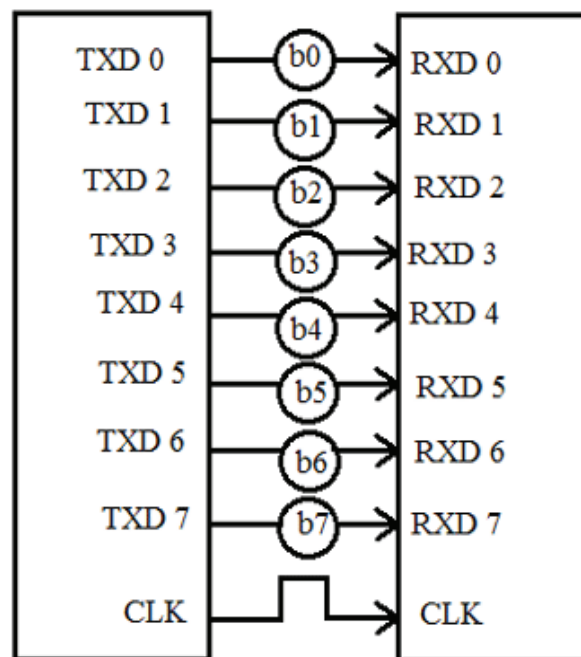


Figure 13:Serial communication (Sharma Jan 01, 2018)

Modes of Data Transfer in Serial Communication:

**Asynchronous Data Transfer:** The mode in which the bits of data are not synchronized by a clock pulse. Clock pulse is a signal used for synchronization of operation in an electronic system.

**Synchronous Data Transfer:** The mode in which the bits of data are synchronized by a clock pulse.

**Characteristics of Serial Communication:**

Baud rate is used to measure the speed of transmission. It is described as the number of bits passing in one second. For example, if the baud rate is 200 then 200 bits per Sec passed. In telephone lines, the baud rates will be 14400, 28800 and 33600. Stop Bits are used for a single packet to stop the transmission which is denoted as "T". Some

typical values are 1, 1.5 & 2 bits. Parity Bit is the simplest form of checking the errors. There are of four kinds, i.e., even odd, marked and spaced. For example, if 011 is a number the parity bit=0, i.e., even parity and the parity=1, i.e., odd parity (Sharma Jan 01, 2018).

Cables, radio waves or light waves are used as transmission media. Some interfaces serve both for sensor control and for network connection (e.g. Ethernet and Bluetooth). A closer look at the individual standards outlines the properties and fields of application for geodetic surveillance measurements. Communication with the sensor itself is a fundamental step in the development of this sensor. In order to be able to say anything about performance, data rates, calibration and applications, data must first be collected. It is therefore important to address the sensor and select the most ideal interface for communicating with the sensor. In this chapter, the interfaces used are presented and an overview of the first communication with the sensors is given.

### 6.1.1 RS-232

RS232C “Recommended Standard 232C” is the recent version of Standard 25 pin whereas, RS232D which is of 22 pins. In new PC’s male D-type which is of 9 pins. RS232 is a standard protocol used for serial communication, it is used for connecting computer and its peripheral devices to allow serial data exchange between them. As it obtains the voltage for the path used for the data exchange between the devices. It is used in serial communication up to 50 feet with the rate of 1.492kbps. As EIA defines, the RS232 is used for connecting Data Transmission Equipment (DTE) and Data Communication Equipment (DCE), see Figure 14 .

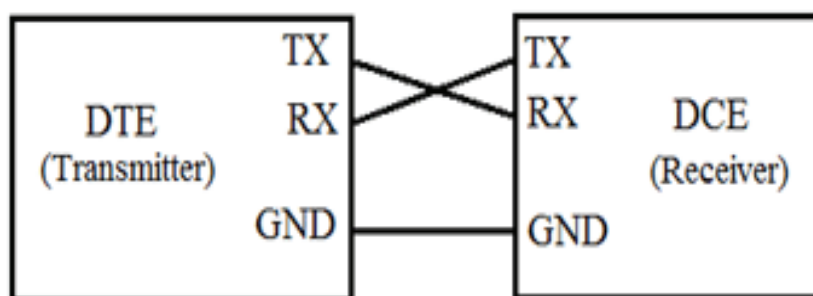


Figure 14: RS232 protocol (Sharma Jan 01, 2018)

Universal Asynchronous Data Receiver & Transmitter (UART) used in connection with RS232 for transferring data between printer and computer. The microcontrollers are not able to handle such kind of voltage levels, connectors are connected between RS232 signals. These connectors are known as the DB-9 Connector as a serial port and they are of two type's Male connector (DTE) & Female connector (DCE).

## RS232 Works procedure

RS232 works on the two-way communication that exchanges data to one another. There are two devices connected to each other, (DTE) Data Transmission Equipment & (DCE) Data Communication Equipment which has the pins like TXD, RXD, and RTS & CTS. Now, from DTE source, the RTS generates the request to send the data. Then from the other side DCE, the CTS, clears the path for receiving the data. After clearing a path, it will give a signal to RTS of the DTE source to send the signal. Then the bits are transmitted from DTE to DCE. Now again from DCE source, the request can be generated by RTS and CTS of DTE sources clears the path for receiving the data and gives a signal to send the data. This is the whole process through which data transmission takes place. See *Table 5*.

Table 5: Two-way communication (Sharma Jan 01, 2018)

TXD	Transmitter
RXD	Receiver
RTS	Request to Send
CTS	Clear to Send
GND	Ground

## Mechanical Specification:

There are two types of connectors that are DB-25 and DB-9. In DB-25, there are 25 pins available which are used for many of the applications, but some of the applications didn't use the whole 25 pins. So, the 9-pin connector is made for the convenience of the devices and equipment *Table 6*.

the DB-9 pin connector which is used for connection between microcontrollers and connector. Which has two types: Male Connector (DTE) *Figure 15* and Female Connector (DCE) *Figure 16*. There are 5 pins on the top row and 4 pins in the bottom row.



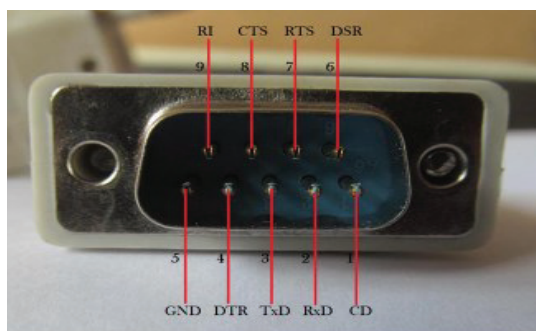


Figure 15:RS232 male connector

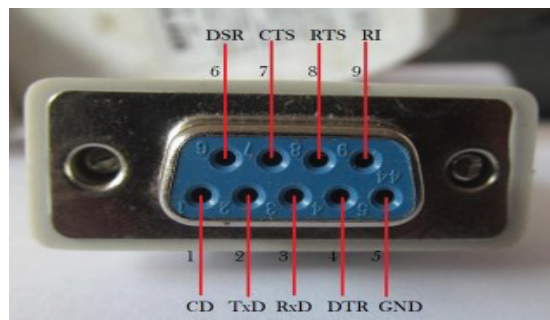


Figure 16:RS232 female connector

Table 6: Pin Description DB-9 Connector

PIN No.	Pin Name	Pin Description
1	CD (Carrier Detect)	Incoming signal from DCE
2	RD (Receive Data)	Receives incoming data from DTE
3	TD (Transmit Data)	Send outgoing data to DCE
4	DTR (Data Terminal Ready)	Outgoing handshaking signal
5	GND (Signal ground)	Common reference voltage
6	DSR (Data Set Ready)	Incoming handshaking signal
7	RTS (Request to Send)	Outgoing signal for controlling flow
8	CTS (Clear to Send)	Incoming signal for controlling flow
9	RI (Ring Indicator)	Incoming signal from DCE

Handshaking is the process that each two devices accomplishing for starting the communication, it is used for initiation of the communication, it means first receive the data and then transmit the data. Generally, in all networking IT the messaging between transmitter & receiver can be done by handshaking (Sharma Jan 01, 2018).

### 6.1.2 USB

USB or Universal Serial Bus make a simple and easy connection between computers and peripheral devices, like mice, keyboard, flash driver and other devices like sensor which have the USB connector Figure 17 (Computerhope 11/16/2019).

The RS232 interface is one of the most used interfaces in the electronics sector. it is because of a very simple data transmission. The interface works in series, which means that the data are transmitted one after the other in the form of individual bits.

each PC has at least two USB interface to connect some additional task to the computer when USB connect to the PC the device must response for PC connection request, then it will make enable the PC to learn about the connected device.



The characteristics of the USB are:

easy to use, fast, reliable, fixable, inexpensive, power conserving, support by the Operating system.

For a simple sensor to connect with a PC there is no need for power supply because the USB interface provides power supply facility for the sensor and also ground line which provide +5V power from the computer's via the USB-Hub a sensor which require normally 500 milliamperes can have it's all power via the USB controller instead of having its own power supply, as in this monitoring system almost all of the sensors have connected through the USB serial Port.

There are three type of speed for the USB

High speed (480 Megbps)

Full speed (12 Megbps)

Low speed (1.5 Megabps)

Almost all cables support the full and low, but high speed come with USB 2.0

USB 2.0 support much faster transformation, 20 times the speed is increased as before it means 480 Megabps, this made USB much attractive for other devices. To make the connection between USB and a device, there is needs for circuits connectors and a cable for host and device.

The host is PC which has two components, host controller and root hub these works together to enable Operating system to work with any other devices the host controller also manage the communication between devices, the root Hub has some connectors ports to detects the attached devices it receive the request from the host controller and pass this request to the other devices and vice versa these devices in this projects are the USB-Hub and other attached sensor to the USB hub.

And the USB-Hub has 4 connectors ports for connecting the sensors with host controller , and each sensor is already programed and has their own circuits to know how to communicate with host controller and also where to store the data, these sensors are connected through pre-defined cables connectors and form a network as a star topology which hub is the central device.

The exchange data between all devices which are connected to controller host is the host's main Job (Axelson June 2001).

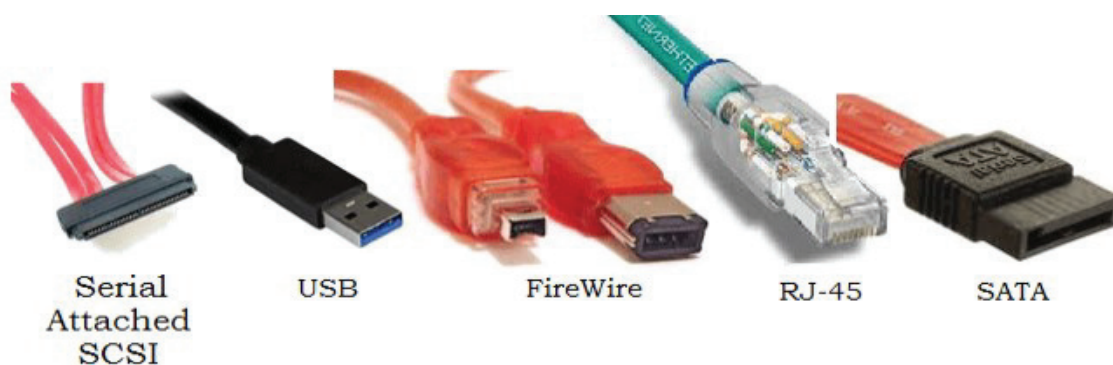


Figure 17: Devices using serial communication (electricalfundablog 2015)

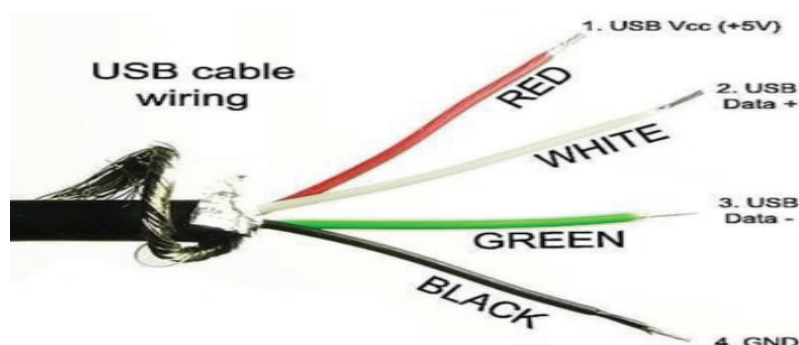


Figure 18: Wiring of every (Sunny May 20, 2019)

there are 4 different colored wires Inside of a USB cable the white a green are for data transformation the red and black which is 5V are for power transformation Figure 18.

these wires determine the charge speed for the USB , these 2 wires determine amount of the power which a USB can carry out (Sunny May 20, 2019).

### 6.1.3 WLAN

There are two type of network transmission, that include the cabled transmission and the wireless transmission, the LAN transmission is through the radio waves which used an access point on the internet.

WLAN can be either an extension to a current wired network or an alternative to it, the minimum transmission speed in WLAN is 1 to 54 Mbps, private companies offering up to 108Mbps but is expensive , the signal of the WLAN is broadcasting to the area under the use for using an access point the covered signal by the area will be up to 300 feet The people which are in one local area network using same range of network broadcasting and same standard with different devices the measurement system which use the radio-based connection the WLAN is best option for providing internet.

As today's world is as improved as enough that there is often internet connection available in each construction and the work of the WLAN is according of the specific Network Address translation (Ali November 8, 2017).

As the main task of a sensor is the measurement of the objects so it needs for a very fast and suitable data transfer mechanism to make the services of the applications and monitoring system always up to date and available, so this master thesis project also use the popular wireless mechanism 802.11 Wi-Fi standard which the most modern wireless LANs are base of this family.

The network of the sensor which works as a monitoring system also used this mechanism which is characterized by low operational power low cost low range, in the beginning of the Wi-Fi design as a transport mechanism 802.11, nobody had the sensor design in mind, but innovations in implementations have enabled the all requirements of the sensor in this design, this technology enables the sensors world to be use in any location very comfortable

Transmission over the wireless channel have one of these two mode.

- The first mode: the node associates an access point before transferring its data according of the Wi-Fi protocol.
- In second mode: sensor node is awake, it does not needs for any association procedure of the access point, in this case the controller need for customizing for how to receive the data, the dis advantage of this mode is battery life (redpinesignals 2017).

#### **6.1.4 Ethernet**

Ethernet is a computer networking technology which commonly used in local area networks (LAN), metropolitan area networks (MAN) and wide area networks (WAN), Ethernet uses coaxial cable as a shared medium, while the newer Ethernet variants use twisted pair and fiber optic links in conjunction with switches. Over the course of its history, Ethernet data transfer rates have been increased from the original 2.94 megabits per second (Mbit/s) to the latest 400 gigabits per second (Gbit/s). Systems communicating over Ethernet divide a stream of data into shorter pieces called frames. Each frame contains source and destination addresses, and error-checking data so that damaged frames can be detected and discarded; most often, higher-layer protocols trigger retransmission of lost frames. Ethernet is widely used in homes and industry and interworks well with Wi-Fi (Wikipedia 23 April 2020).

## Ethernet is part of the 802-standardization family

### IEEE 802 standardization:

802.1: LAN / MAN

802.2: Logical Link Control (LLC)

802.3: Ethernet (Basic Ethernet 10 Mbit/s Fast Ethernet 100 Mbit/s , Ethernet 1 Gbit/s or Ethernet 10 Gbit/s)

802.11: WLAN

802.16: WMAN

802.17: Resilient packet ring (Stiegler 2015)

### 6.1.5 Bluetooth

Bluetooth uses radio waves for data transformation with short range of wave technology, its functionality is like wi-fi wireless but wireless cover long distance and has unlimited usage but Bluetooth is limited and personal, Bluetooth uses the ultra-high frequency radio waves for data transmission and the frequency band of the Bluetooth is normally .4 and 2.485 GHz, if two devices use same Bluetooth range area so it will create problem. It is working unlike of wireless, wireless working with a single access point and multiple devices but Bluetooth connect only one device to another device.

Bluetooth don't use the cellular data package because Bluetooth is not transfer data over the airwaves, but WI-FI use the cellular data package. Bluetooth does not cover long distance maximum operate within 100- meter range so the sensor which has to use Bluetooth is normally attached with the sensor and does not use any external or long-distance area Bluetooth. Some company has the geodetic and geotechnical sensors with the integration of the Bluetooth, Recently the (IoF) also begun supporting of the Bluetooth technology, it can cover the weakness point of the power problem in electronic devices, by using of the Bluetooth the devices will keeping the connection with minimum-power consuming (Martindale October 11, 2019).

Examples of data transmission via Bluetooth in measurement technology is the DXL360S Figure 11 which is DXL 360 sensor system equipped with an appropriate Bluetooth interface, which is designed for remote control of the sensor not data exchange, Some of the sensor may consists of peripheral facilities like radio modem, data storage, and batteries and Bluetooth which this type of sensor are based on radio frequency communication, Bluetooth support point to point and point to multi-point connection, once a laptop enters to the range of some wireless devices the connection will be establish automatically.

### 6.1.6 Supplying the power

the power supply is the main factor for designing and installation of any geodetic monitoring system, so it is necessary to have a short overview about the power supply:

Power supply is a simple electronic design which has two side ( input side and output side which electrically isolated against each other) input of the AC output of DC, it means the AC input voltage must be converted into a DC voltage with the right value and degree of stabilization.

There is Electronic isolation between AC and DC it means this means that no electric connection exists between the input side and the output sides.

**Input voltage ranges:** power supply come with three type of voltage ranges

**Wide -range input:** In this range device can work with any voltage but with specific limitations, in this reason many modern power supplies work with AC voltages between 85 and 264 V and DC voltages between 100 and 350 V without any loss of power, power supplies with wide range input can be connected to any power supply system in the world so the cost will be reduce for stock keeping and logistics because this one can cover all requirements

**Auto range:** This type of power supplies which equipped with auto-range at first, they make an internal measurement for the applied voltage of the devices and automatically switch between the available input voltage ranges.

**Manual range selection:** in this kind of power supply the housing of the power supply has option switching for manual selection of the voltage range , but with some pre-defined voltage value like „110 V“ and „230 V“ , When selecting the 110V so the device will work with AC voltages between 85 and 132 V, but when selecting the 230V, then device start working with AC voltages and DC voltages.

new generation of surveying instruments and real time monitoring beside of the wire-less communication they are integrated with power supply as well and they should be uninterruptable because some instruction and objects have to under the survey 24 hours a days 365 days a year with high ,accurate and reliable measurements through any communication media under any weather conditions, this type of monitoring system are remotely controlled for any power fail error or any other forecast situation (Joël van Cranenbroeck 2012).

during of the site surveying the pc and the sensor network need to have a power supply, it depends on the software and in the projects that what kind of power supply do it used and which option will be the best, a pc which has installed the software of the monitoring system needs to have a permanent power supply so the external batteries can be also use for changing of the batteries over the time for reliabilities (Manual, Geodetic Monitoring System Equipment Lis 2005).

In this monitoring system the power provided through the USB connection with the cable adapter which converts the voltage of the 12 V DC into 5 V for the sensor, as above mentioned which some sensor has the integrated power supply like Disto sensor used Leica GEV189 Data Cable transfer USB cable in order to provide 5v power to the

sensor See Figure 19, but mainly all power source are provider via the PC power adapter.



Figure 19: Leica Serial Data Transfer Power cable (GEV189)

in some urgent and worse situations like no outlet or forgotten the charger there is some simple ideas to solve the power problem like car batteries, but before using the car battery there is need for an inverter to convert 12V car battery to 8V for laptop.

Another solution is to charge laptop from solar energy through the solar panels and battery kits and there is no need for converter (ATWELL OCTOBER 13, 2015).

### **Uninterruptible power supply (UPS):**

UPSs convert the incoming AC voltage to DC through a rectifies No delay between switching from the primary power source to the UPS The aim for the designing of the electricity supply utility is to provide up to date and always availability, sometime because of lack of power, may cause a significant fail in a company and loss of costumers, loss of data and cause other problems, any company which need for high availability factor for the providing of the facilities for the service so UPS is necessary to use,

The Ups is a device which works as a backup power and use in the case of main power fails, and may be use for long time until the task under process is finished or short time until the a power generator come again. (Mahendar Kumar Zubair .A Memon June 2018).

The main components of an UPS are

- transformer
- circuit boards
- Case or cover
- Relays
- Lead-acid battery some time included inside the ups
- Wires
- Switches
- Semi-conductors
- electrolytic capacitors (BONNEVILLE 2019).



UPSs have main three types in their design of Topology.

- Single Mode conversion
- Double Mode conversion
- Multi-Mode UPS

#### **single conversion system:**

this type of UPS normally provide AC power for the device , if the power falls out from pre-defined limits, at first UPS disconnect its input AC and then will draw it out from the battery with its inverter so it will prevent to not comeback from the inverter to the utility there are two type of single conversion system UPS.

**Standby UPS:** which device is not allowed to work until UPS detect the problem and solve it some UPSs have backup battery in this kind of situation to use in this time of checking interval. When the power supply is not there so the system will run on standby UPS

**Line- interactive UPSs:** the incoming voltage can be arranged as up or down as necessary, but this type also use the backup battery in the case of arrangements of the incoming voltage

#### **Double-conversion systems:**

dual or double conversion is Voltage and frequency independent (VFI), in this type of UPSs incoming AC is rectifies to DC to keep batteries charged and drive the inverter and the inverter will create AC power to keep running the equipment. As its name this type of UPSs converter the power twice it means first the input rectifier converts AC power into DC and transfer to the output inverter the output inverter process this power back to AC and then send it to the equipment, this type of the UPS manage the load of the power and provide clean reliable electricity for the equipment. As the double conversion ups operates double so if the input power falls out of predefined limit, the input rectifier will be off and output inverter begin the drawing power from battery.

#### **Multi-mode systems:**

It works more reliable and more efficient with the combination of the both single conversion system and Double conversion system UPS.

Below is the working procedure of this Multi-Mode UPS:

In normal condition it works in line-interactive mode it is a good mood for saving the energy and in same time taking care of the voltage in save tolerance.

If the input power falls pre-defined voltage in the line interactive mode so the system automatically switches to double conversion mode.

If the AC input fall out of the tolerance double conversion rectifier, so the UPS uses the Battery to keep the system running but when the main generator come back UPS switch to the double conversion mode until receiving of any input power. This multi-mode design has focus on the balance between efficiency and protection.

The UPS should always meet the needed requirements, so the following points should be considering, while choosing an UPS.

- 1- Which design of the UPS is suitable for the task, it come with how important the energy in the task is, or in the area in which priority is the power. Single conversion is efficient than double conversion, small task usually uses the single conversion, double conversion provides high protection with less efficiency, multi-conversion normally used by very big companies which are need for very high energy tolerance and 100% availability with more efficiency and protection.
- 2- The cost is depending on the voltage amperes the low rate is 300VA and high is 5.000.000 VA.
- 3- Consider the battery of the UPS, which is normally 15 minutes power backup, so there is possibility to use external battery for time efficiency as it is the most important part of the UPS.
- 4- There is some application for remote UPS monitoring to prevents failure during running of the system with the UPS the application control overheating battery even send a real-time notification as a warning.

There is no any efficiency if the UPS go down for long time and overheated, this software let the user to set up automatic options to be perform in urgent situations or power event cases, also can set for automatically being shut down the system after completing the task. Most UPSs came with software, today's IT technology made he possibility to enable communication between UPSs and servers through the Serial communication (RS232 and USB), so the UPS need to assign its IP address on the network and all networks can have access for this UPS, every server have access to monitor the UPS. The UPSs even can operate for 20 years long (Loeffler October 2011).

One of the advantage of the UPS is that before UPS loss the power try to notifies the user, so the user has time for saving the data, consumers can choose the type and size of UPS, depending on the amount of power they need to supply to a device. UPSs are silent. Maintenance of UPS systems is cheaper compared to generators,

Usually the main company of geodetic surveying using the UPS for measuring of the structure and important Objects, or not losing the data and always availability.

There are many IT equipment's like robots and geodetic monitoring systems, that all of them working efficiently and trustworthy, UPS system will be needed for its implementation for stable functionality.



## Power over ethernet

It is a technology which allows network cables to carry electrical power, for example, digital camera normally requires two connection power and network. Power over Ethernet (POE) is a networking feature that lets network cables carry electrical power over an existing data connection with a single Cat5e/Cat6 ethernet cable. PoE technology relies on the IEEE 802.3af and 802.3at standards, which are set by the Institute of Electrical and Electronics Engineers and govern how networking equipment should operate in order to promote interoperability between devices. PoE-capable devices can be power sourcing equipment (PSE), powered devices (PDs), or sometimes both. The device that transmits power is a PSE, while the device that is powered is a PD. Most PSEs are either network switches or PoE injectors intended for use with non-PoE switches. Common examples of PDs include VoIP phones, wireless access points, and IP cameras.

### What is the advantage of PoE?

Power over Ethernet (PoE) allows for installation of remote or outside equipment without having to connect to AC power. This allows power to be delivered to more areas without the need to install additional electrical infrastructure or to have power outlets at every endpoint. Equipment can be installed without the need for an electrician and because ethernet cable costs less and is often already installed in buildings, PoE-based systems are far more cost-effective and efficient.

### What are the benefits of PoE?

PoE benefits organizations in 5 primary ways reduced installation costs, installation safety, responsive deployments, data gathering capabilities, and productivity enhancements. End users can plug PoE capable devices into existing networks or start from scratch with ease (Cooney APR 6, 2020 8:10 PM PDT).

## 7 Software

GitHub is a website and cloud-based Git repository hosting service that helps developers store and manage their code, as well as track and control changes to their code, it is user-friendly enough so even novice coders can take advantage of Git.

- Version control: Version control helps developers track and manage changes to a software project's code.
- Git: Git is a distributed version control system, which means that the entire codebase and history is available on every developer's computer, which allows for easy branching and merging.

It is the Github repository for this Project which stored the project <https://github.com/Humi-Saifi/geodatatoolkit.git> Figure 20.

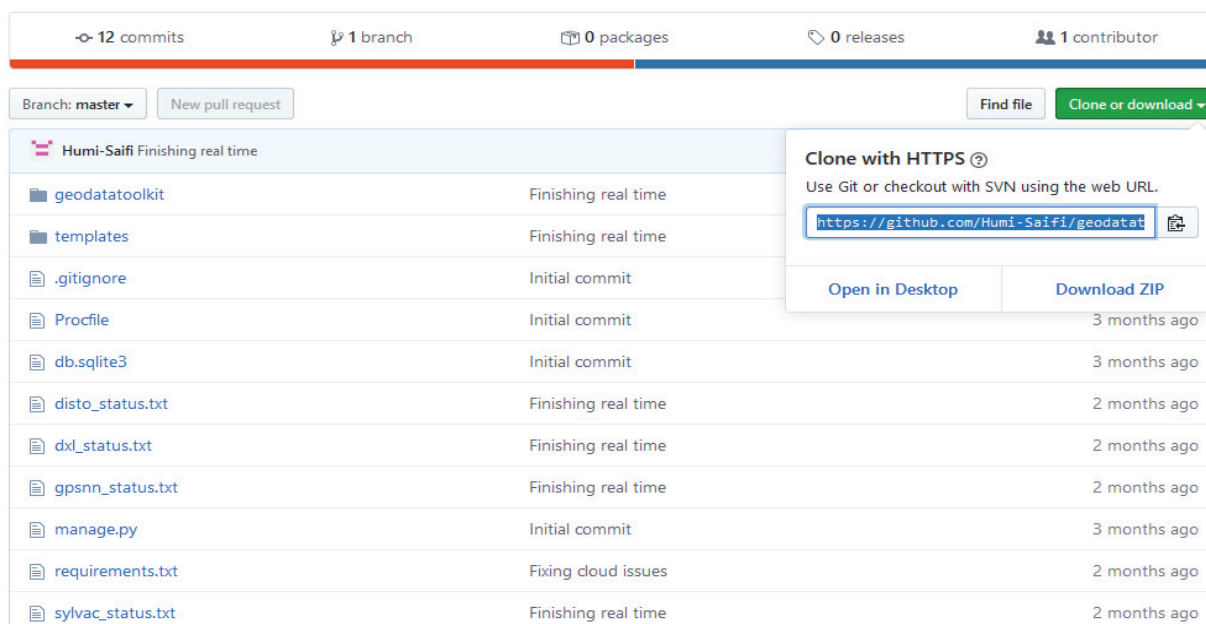


Figure 20: GitHub Repository

Heroku is known for running apps in dynos – which are just virtual computers that can be powered up or down based on how big your application is. Think of dynos as malleable building blocks for running your app.

If you want to process more data or run more complex tasks, you are going to need to add more blocks (what is called scaling horizontally) or increase the size of the blocks (what is called scaling vertically). Heroku then charges you a monthly fee based on the number of dynos that you have and the size of each dyno.

Although Heroku charges you by the dyno, they aren't hosting the app. In fact, the entire Heroku platform, as well as every app built on Heroku is deployed to Amazon Web Services (AWS). Heroku is open and extensible so developers can build in whichever language they choose. Whether that's Nodejs, Ruby, PHP, Python, Java, it doesn't matter.

Not only are developers able to build in whatever language you choose, but there is a huge network of Heroku Add-ons. Heroku Add-ons are powerful features and functionalities that can be deployed to the apps with the click of a button. Some of these applications are paid, and some are free, but they can shave hundreds of hours off your next project, this project is deployed on Heroku under <https://git.heroku.com/geodatatoolkit.git> and in local host used Django and Django used its default webserver which is Apache, Figure 21 shows the diagram of hosted project in Heroku (coutermarsh November 2014).

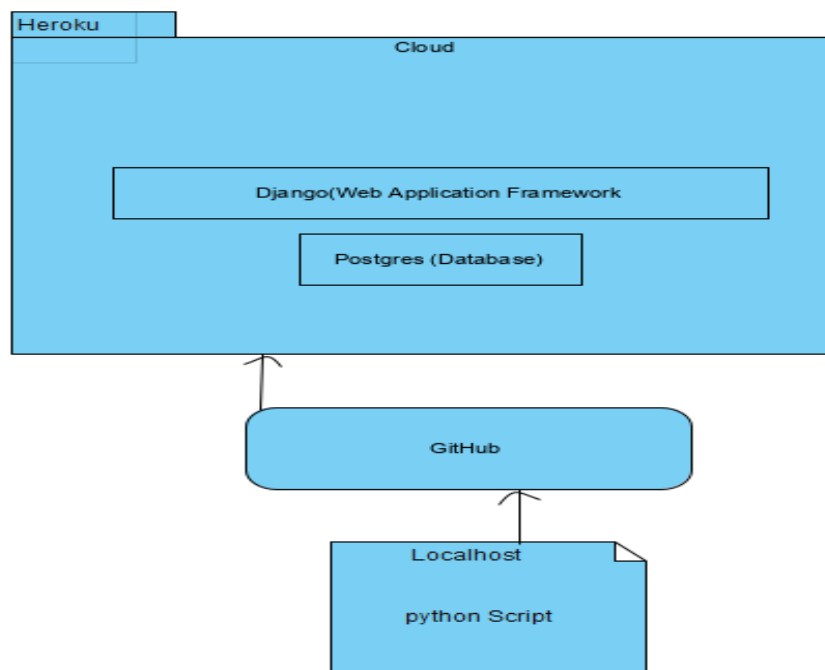


Figure 21: Hosted Project Diagram in Heroku

Django is a web framework which contains packages we use this for developing of web base application that that backend is by python, Figure 22 shows the communication of client with Heroku, which sent the Heroku repository address to the Heroku server and server response with HTML template.



Figure 22: Browser and Heroku Communication

**Apache:** is a software program that handles the web request, so the software program could be running on Heroku or local computer.

**web server:** web server processes incoming network requests over HTTP and several other related protocols. The primary function of a web server is to store, process and deliver web pages to clients. The communication between client and server takes place using the Hypertext Transfer Protocol (HTTP) (contributors Dec 10, 2019, by MDN contributors).

## Heroku

The Heroku is a container of the codes in cloud as server it is used for hosting the website, developers use it for deploying and managing the apps, these container called "dynos" dynos make the isolation of each activities, and execute the code when a user specify command is arrived, in order to work with Heroku and make the deploying process, we need to install Toolbelt of Heroku, CLI which is interface to the Heroku Platform API and Git This is used for version control and to deploy our applications (coutermarsh November 2014).

### 7.1 Operating System

An Operating System is a collection of software that manages the computer's memory and processes, as well as all its software and hardware. It also allows you to communicate with the computer without knowing how to speak the computer's language and provides services for programs, specifically, it hides hardware complexity, manages computational resources, and provides isolation and protection. Most importantly, it directly has privilege access to the underlying hardware, major components of an OS are the file system, scheduler, and device driver.

There are three key elements of an operating system, which are: (1) Abstractions (process, thread, file, socket, memory), (2) Mechanisms (create, schedule, open, write, allocate), and (3) Policies (LRU, EDF) (Le Jan 8, 2018) .

In this Project the windows 10 is used as OS, to use the windows 10 OS user have to login with a Microsoft user account or local user account, it is prefer for an online user account because many facilities will be activated and user can have full access for many app and software like OneDrive, OneNote and Appstore. To use a Windows 10 OS the computer should meet some requirements like 1GHz Processor, minimum 2 GB main memory 16 Gb free disk, graphic card from DirectX9.

Windows server also used for windows server for desktop, Notebooks (Operating System 2020-04-19).

### 7.2 Programmierung Language

A program is a set of instructions written in a language, understandable by the machine language or need to compile in order to run and execute by the computer to perform a specific task on the computer. A well written program could solve specific type of problem on the computer system with some specific type of programming language, Programming languages are artificial notational languages created or developed to be used in preparing coded instructions on the computer for later execution by the computer, e.g. Python which is used in this project like python is used as main programing language in this HAD\_HOC Monitoring system it perform the reading of data and connection on the database and other important tasks(Usman Opeyemi Lateef October 2016).

### 7.2.1 Python

Python is a powerful programming language, it can be use in different platforms a(Win-dows, Mac, Linux, Raspberry Pi, etc) and in different task and reasons. Python has a simple syntax and easy among of other languages that allows developers to write programs with fewer lines than some other programming languages. Python runs on an interpreter system, meaning that code can be executed as soon as it is written, this means that prototyping can be very quick. (w3schools Online).

It is used for:

- Web development (server-side)
- System Scripting.
- On a server to create web applications.
- Can connect to database systems, read and modify files.
- Python can be used to handle big data and perform complex mathematics.
- Python can be used for rapid prototyping, or for production-ready software development.

The python programming language has integrated function that enables communication via the serial interface. With is pySerial library, in this project Python is the main back-end language, which is used for:

- Django Framework which is based on the MVC (Model-View-Controller) paradigm.
- for handling HTTP requests, process the data and present the data back to the user.
- Communicating with the sensors through serial ports.
- Reading data from sensors.
- Saving data from sensors to the database.

### 7.2.2 JavaScript

JavaScript is a dynamic computer programming language. It is most commonly used as a part of web pages, the pages which is design by JS, allows client-side script to interact with the web page and make dynamic pages. It is an interpreted programming language with object-oriented capabilities. The general-purpose core of the language has been embedded in Netscape, Internet Explorer, and other web browsers (tutorialspoint 2020).

JavaScript is used in this project on HTML templates for interactivity and update the graph and data presented to the user in real-time. We are using an interval of time to send ajax requests and update the graph on the HTML page if there are any updates.

### 7.2.3 HTML

HTML or Hyper Text Markup Language structuring and presenting content for the World Wide Web, it is like creating a skeleton of a page, HyperText means text has a link within it and links pages with each other, to apply layout and formatting conventions to a text document. Markup language makes text more interactive and dynamic. It can turn text into images, tables, links, etc.

The main aim is to improve the language with support for the latest multimedia to keep it easy and readable by humans and understandable by computers and device. HTML5 improved the browser functionalities on client side it provides a great way to implement drag and drop functionality in modern browsers (WCGs (Web Code Geeks) 2015).

In this project HTML is used for front-end pages; the pages are the templates that they can use with Django as views for presenting or getting input from the user.

### 7.2.4 PostgreSQL

The PostgreSQL is used as Database of this Project in local and in cloud as the Database Server, PostgreSQL is one of the world's most popular relational database management systems. Millions of developers and companies rely on PostgreSQL as their transactional data store of choice to drive application health and decision-making. And developers with knowledge of Oracle or MySQL databases can use their SQL querying experience to quickly leverage PostgreSQL's capabilities as a fast, functional, and powerful data resource.

Heroku Postgres helps you maximize your data instead of spending time on database setup and maintenance. test new schema migrations manage database access levels and protect queries, scale horizontally, and allow your team to quickly access data. (heroku 2020).

- PostgreSQL hosted on Heroku (for cloud processing)

Heroku Add-ons are integrated into the Heroku platform experience, making it easy to install new services and manage billing, credentials, or configurations directly from the Heroku Dashboard or CLI.

- PostgreSQL installed on the local machine.

This installer includes the PostgreSQL server, pgAdmin; a graphical tool for managing and developing the databases, and Stack Builder; a package manager that can be used to download and install additional PostgreSQL tools and drivers. Stack builder includes management, integration, migration, replication, geospatial, connectors and other tools. This installer can run in graphical or silent install modes. The installer is designed to be a straightforward, fast way to get up and running with PostgreSQL on Windows (postgresql 21st May 2020).

## 8 Data analyzation

Statistics is for calculations and analysis to find the nature of a given data and the relation between the sets of data. In this age of growing and increasing information, data is increasing at a very fast rate making. There are two important statistical methods used in data analysis which are descriptive statistics, which simplifies data from dump of data using mean or standard deviation, and inferential statistics, which provides conclusions or results from data that are used in random variation. Descriptive statistics are most often used or performed with two sets of properties of a distribution which is sample and population. (Chapman November 9, 2018).

In this master thesis the median average and standard division are considerate to be implement on the data of the all sensor. The sample mean is the average and is computed as the sum of all the observed outcomes from the sensor NMEA divided by the total number of events. We use  $\bar{x}$  as the symbol for the sample mean. In math terms formula is as bellow, where  $n$  is the sample size and the  $x$  correspond to the observed valued.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x$$

**Median** is the middle score. If we have an even number of events, we take the average of the two middles. The median is better for describing the typical value. It is often used for income and home prices.

**Standard division:** is calculated as the square root of variance by figuring out the variation between each data point relative to the mean and looks at how far from the mean a group of numbers is. If the points are further from the mean, there is a higher deviation within the date; if they are closer to the mean, there is a lower deviation. So the more spread out the group of numbers are, the higher the standard deviation.

The standard deviation formula defined as bellow

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x - \bar{x})^2$$

The variance is the average of the squared differences from the mean. To figure out the variance, first calculate the difference between each point and the mean; then, square and average the results.

the variance formula is as bellow

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x - \bar{x})^2}$$



## 9 Time Scheduling

The nature is not constant that is why there is always the changing possibilities in constructions, and geodetic area. And the places where every engineers of geodesy are trying to make the high precision of measurements so the need to run the automatic job running in the area in any time any date. Task Scheduler allows the sensors' python scripts to run every particular day, time and automate the receiving and storing the data, it works by keeping tabs of the time and events on the computer and executes the task as soon as the condition is met. There is the best possibility in windows under the name of task scheduler application which can handle this problem. The basic options are triggers and actions.

the trigger causes the task to run after a well-determined schedule configured by the user. From the trigger settings the task repetition can be determine which is every 10 min it automatically run.

The action is the process or a part of the process that is performed when the task is running. A task can have up to 32 actions. Every action has some settings that determine how the task is performed. In the Settings menu of the Actions tab entered the name of the script or the program that hat is going to be start. (Dinita April 25, 2019). This setting is repeated for each sensor and there are other setting and configuration possibilities.

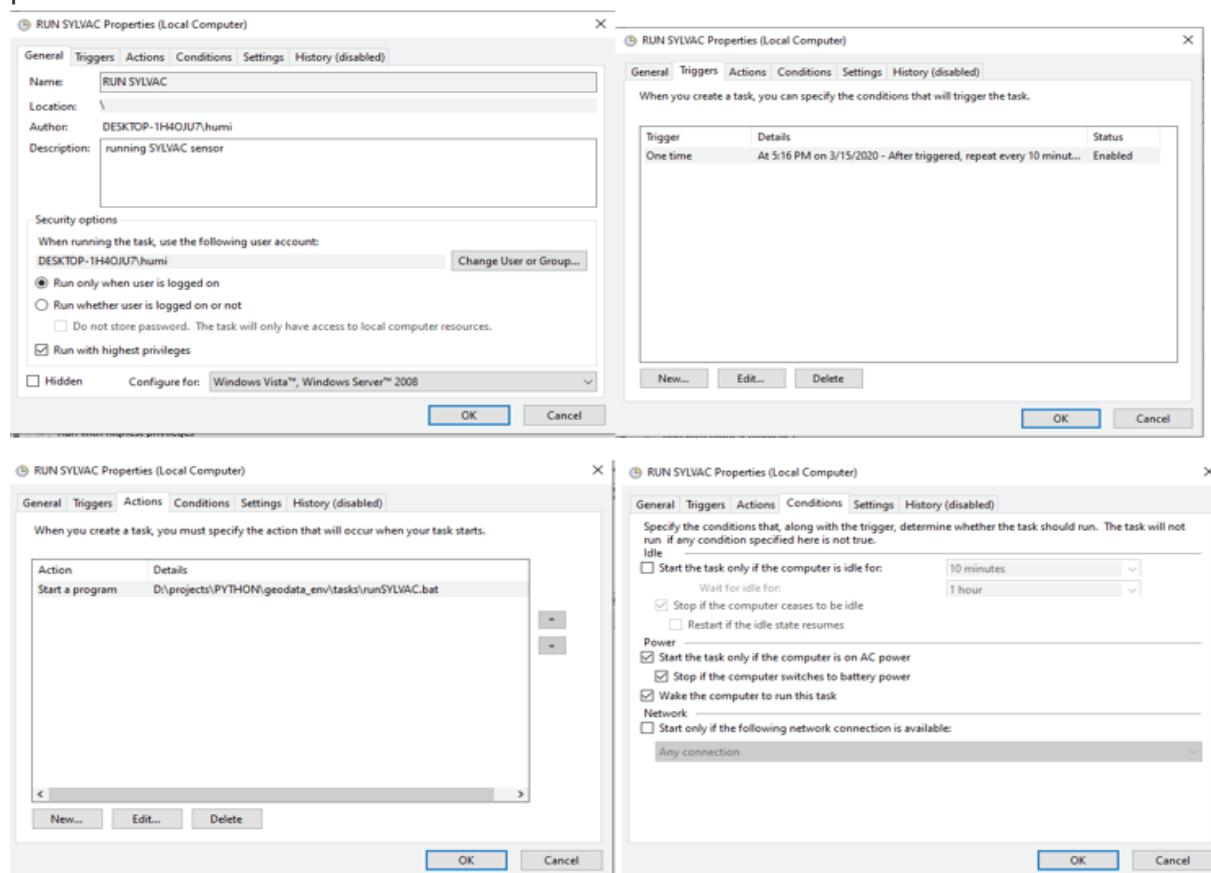


Figure 23: Task scheduling of the HDM System



## 10 Other type of monitoring system

There are two options in geodesy engineering for surveying one is classic and other one is applications in format of monitoring. The different is in the method of the measurements and in the application of automated measuring instruments from the area of Geodesy and geotechnics classic method for static objects monitoring is not in use anymore because there are no fair periods are required (Stempfhuber No Date).

The modern option or application and software for monitoring system is on the progressed very fast, some manufacture of high end geodetic offering various platforms like Leica Geosystems, Trimble and Topcon, and also some engineering companies and universities also providing some monitoring system with very advance functionalities and they upgrading the system always. An overview is summarized in Table 7. The developer always try to implement simple analysis tools for the integration of the geodetic measuring sensors in monitoring, like various alarm options, web-based systems enable remote monitoring and visualization, control and configuration via the Internet, Data storage is usually implemented using databases. There is currently no desired integration of the monitoring systems into geographic information systems (GIS).

Table 7: Some example of Real-time Monitoring Systems

Name	Own Hardware	Software	Preis	Usability	Installation	Sensors
Commercially:						
Leica GeoMoS	yes	yes	ex-pen-sive	easy	Difficult	(Leica)
Trimble 4D Control	yes	yes	ex-pen-sive	easy	Difficult	(Trimble)
Scientific:						
MoSTUM	Possible	yes	Free	Difficult	Difficult	All
OpenADMS	Possible	yes	Free	Difficult	Difficult	All
This work:						
<b>AHM „ad hoc monitoring“</b>	<b>No</b>	<b>yes</b>	<b>Free</b>	<b>easy</b>	<b>easy</b>	<b>All</b>

## 10.1 Leica GeoMoS

GeoMos is a simple monitoring system, it can automatically make the deformation measurements for one weeklong or even for one month from several and different object environment like.

Natural hazard  
Structural Monitoring  
Construction  
Minim

It can have any surveyor from object over time with any kind of operator and also management of the coordinates and heights, during of automatically observation the sensor detect the movement in points and in station , find the wrong monitoring points when there is a problem found it immediately inform there is possibility to save the task on the USB or SD card.

The webserver of the GeoMos is easy to use web portal and it is capable to work with smartphones, tablet computer it make possible to have a quick access at anytime and anywhere, each user can have their own account ,Figure 24 is a simple scenario of how the GeoMos is working (M. Rutschmann 11, October, 2016).

How does it work?



Figure 24: Leica GeoMoS functionality (M. Rutschmann 11, October, 2016)

## 10.2 MoSTUM Monitoring System

TUM monitoring system was developed in the university of TU-München in the year of 2003 an special monitoring system for the behavior of the building and instruction, the

sensor which was used for detection focused of the meteorological values, this monitoring system has the possibly of autonomous integration at arbitrary sites, It offers the possibility to check the state of the object from the office or even wireless from any other place in the world.

In critical cases the geodesist engineer receives a message to mobile phones as alarm, it works as a robot- tachometer standard so for the installation the choice of the position of the object points is free. Engineer can easily change the configuration of the object points during the of the observations, If there is no direct sightline between robot-tachometer and the retro prisms at important object points, an indirect line of sight can be realized by the use of plane mirrors.

Since this monitoring system is for measurement of the building and structure so it should meet the following requirements:

- Permanents and regular detection of the objects, like temperature value inside and outside of the building, pressure of the inside of the building, humidity of the inside.
- The concept of the system should be very clear and fixable to bring anytime changes, the expansion of the system should be easy with minimal costs.
- For each kind of movements there is the required accuracies.
- The system should deal with cultural meaning of the building (Dr. Karl Foppe October 8-13, 2006).

### **10.3 Trimble 4D Control**

Trimble 4D Control is a Universal all-inclusive monitoring system which hast the high level of compatibility and get information of the senor with a very high detail information and perform sensor management it means there is possibilities to add instruments, sensors, and customize them. Trimble 4D Control can perform complex monitoring measurements projects and has the capabilities of alerting.

The aim of this monitoring system is to detect the changes and movements of the structures and building and use in different area in natural disaster to cause for displacement and movements of the objects even shows the speed and direction of the disaster. Working with this monitoring system is not difficult.

This monitoring system used in the following areas:

Mining, Construction, engineering, transportation, Tunneling Geotechnical.

The Trimble 4D also work with web interface, which shows two possibilities for selection of the sensors in order to object observations, as automatic received and stored by the Trimble 4D Control Server and as manual entering configuration using Trimble 4D Control Web,

Below is a display of the Trimble 4D Control Web interface which shows different control areas, status bar, main menu, left panel (containing the project status), content panel (containing the Home Page content), and the notification right panel. Below we will present the areas used for navigation Figure 25.

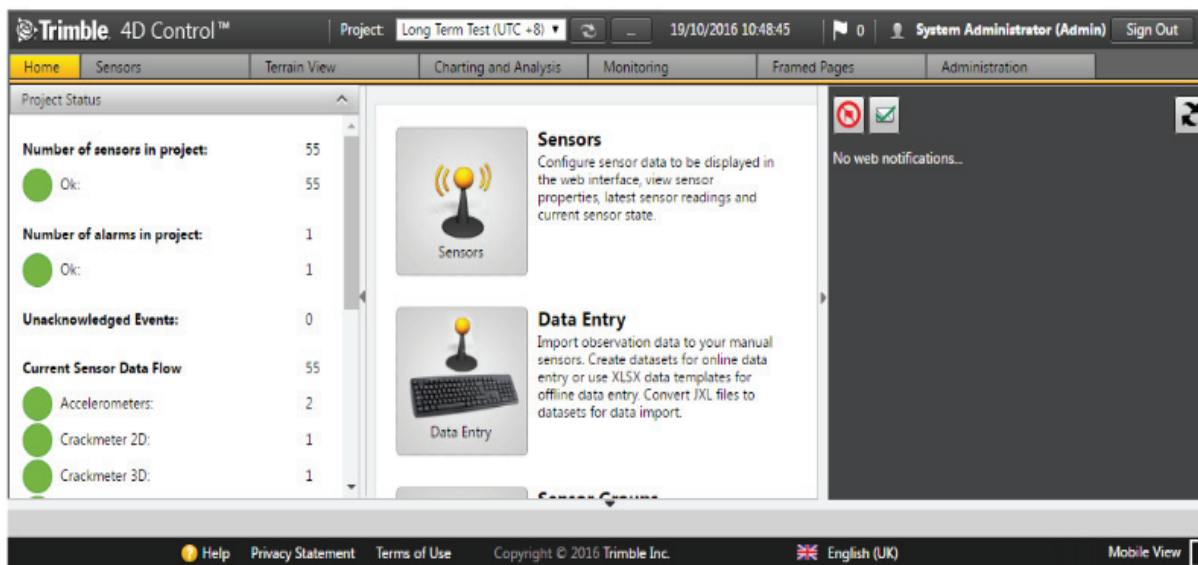


Figure 25: Web interface of the Trimble 4D (trimble Online, Manual)

There are some terminology of the Trimble 4D like map, web come and report.

the map is the kind of terminology of this system which shows sensors as icons on a geographic terrain either from standard map providers or from a particular geo-referenced terrain photo.

for monitoring of the remote area there is a webcam configuration possibility to receive a video feed from a video camera.

report generated automatically from a sensor, the report shows the information according of its configuration (trimble Online, Manual).

## 10.4 OpenADMS Monitoring System

OpenADMS is a monitoring system that control the system and observed data processing, it is developed in the system of (IoT) it has database server for storing the data,

it has multi-platform monitoring system for automated observations in engineering geodesy OpenADMS can be use in geodetical and geotechnical sensor networks within the Internet of Things Figure 26. For running of the OpenADMAS software run there is need for only a single sensor to measure the target object, the obtained data after the analyzation will be stored in the database or cloud services.

### Sensors:

The sensor which can be use in this system are, inclinometers, weather stations, GNSS receivers and supports many geodetical, geotechnical, and meteorological sensors. For adding a neu sensor there is no need for any Additional programming, only by modifying of configuration can be done. This monitoring system is platform independent and compatible to all modern computer architectures and all type of operating systems like Windows, macOS, FreeBSD, Linux, Android.

Python 3 and other languages modules are used for functionality of this system.

### Free & Open Source:

This software is for academic and commercial purposes and as this project used the open sources component, so all provided as free. The software is licensed under BSD-2-Clause (Prof. Dr.-Ing. Karl Foppe online).

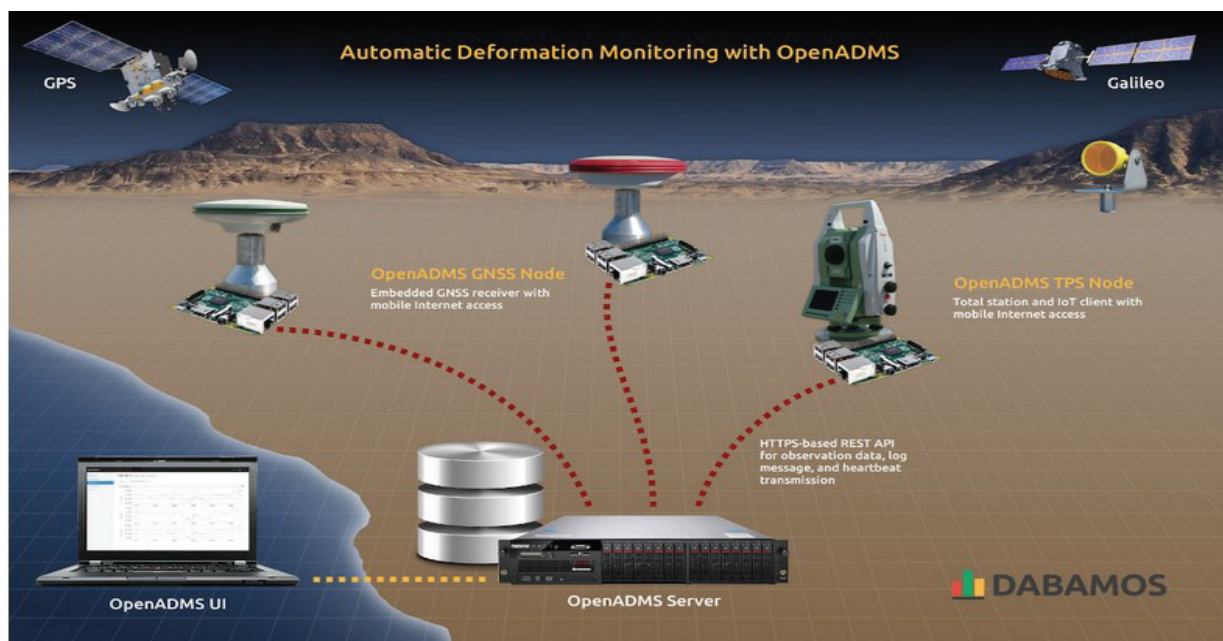


Figure 26: Schematic illustration of a sensor network based on OpenADMS (Prof. Dr.-Ing. Karl Foppe online)

## 11 Cost-based analysis of HAD-HOC Measurement system

The sensor and hardware are manufacture independent so there is no need for any depend hardware or software. The cost for individual components and for productions is low as possible so the system meets the requirements for a low -cost solution.

For this project all required components are provided from Hochschule NB, but any manufacture has its own product and price, prices normally are from 50\$ up to thousands of dolar.

The cost of the control computer of Lenovo with interruptible power supply (5hr Power capability) has its own market price, the software which is used the free trail and paid version available that free is used in this project.

The Heroku cloud domain is available as free trail and paid, there is limitation in free but in some cased will meet all projects requirements, when there is need for unlimited add-ones and stability so there will be need for cost

As the components of this system are all manufacture independent so for the maintenance and migration a, backup and also for transferring data no specific paid software or hardware needed.

## 12 Practical implementation

For practical implementation, there is two factor which are under the focus , the part of components or hardware of the system which are together to form the Network , the main component that we used are required sensors USB-Hub and a single board computer, and the second part is the development of the software with the target of control sensors and stores measured values in a cloud base database and local base database.

This version of HAD-HOC monitoring system has integrated a graphical user interface. This is completely web-based, the server component also uses the Java Server Faces framework for display. The JavaScript library flot (flot is a JavaScript plotting library for engineering and scientific applications derived from Flot) can also be used to display diagrams from the measurement data stored on the server on the web browser, there are all details about the implementation steps in this chapter.

This next version of this system will be added new functionalities with news libraries and the design with mobile and smartphones also will be under the consideration

### 12.1 Hardware

Hardware development deals with the integration of the Hub-with sensor and, the communication with sensors, single-board computer with the 1,80 GHz speed, 8



logical processor, Corei5, and it is suitable for the implementation environments and meets all requirements during of the implementation.

### **12.1.1 Communication**

Communication method implementation is equipped via the Hub-USB which with provides five USB ports to connect all four sensors to the Ethernet interface of the single-board computer. The Ethernet interface is primarily used for network connections, windows 10 is uses as operating system manages all the software and hardware on the computer.

## **12.2 Software**

The python programming language is used in developing of the measurement software to control the sensor and connection with PostgreSQL in order to store the data and also the web-based graphical user interface. Visual studio is installed used as compiler for development of interface and PyCharm for the test and backend coding, HTerm which is a terminal Program for the serial interface that runs under Windows.

The particularities of this Software are:

- Support of any (virtual) serial (RS232) ports
- Support of all baud rates available on the target hardware
- Input and output in ASCII, hex, binary and decimal
- Send and save files
- Parity for sending and receiving
- Copy any received formats to the clipboard
- Can be completely customized via config file
- Only a few settings need to be made for the configuration: only COM port, baud rate, parity as well as data and stop bits (9600 baud, 8N1).

Testing sensor and configuration of sensor are the first implementation of the prototype here is the details about the testing.

for the testing of sensor HTerm is a suitable software, the software ask for sensor characteristics, which are computer port, parity, Baud data in Bite, after stablishing the connection the sensor responds (e.g. GPSNN) with the following character string:

1588616975.0426 5333.27266, N,01314.82856, E,182936.00.

The inclinations in the X and Y directions are in milliradians, the first value is time in degrees Celsius. First attempt to connect Sensor USB to the Computer there will be



required a suitable windows driver to be first installed for the adapter cable, for the connection to the sensor Figure 27.

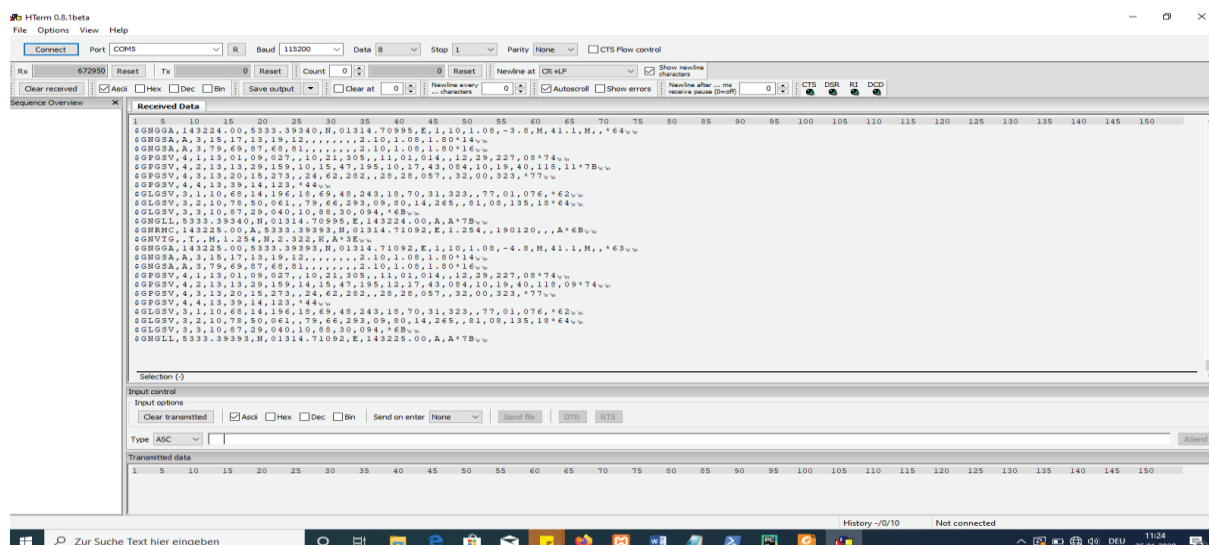


Figure 27: Sylvac HTerm Data Capture

## 12.3 Implementation of the software

The System backend is solely based on Python (version 3), the frontend is a combination of HTML, CSS and JavaScript, and visual studio code compiler to run, the System is built on top of the Django framework (version 3), the user interacts with the system by accessing web pages served through a browser. The database is created on PostgreSQL and each sensor has a table corresponding with it in the database Figure 28.

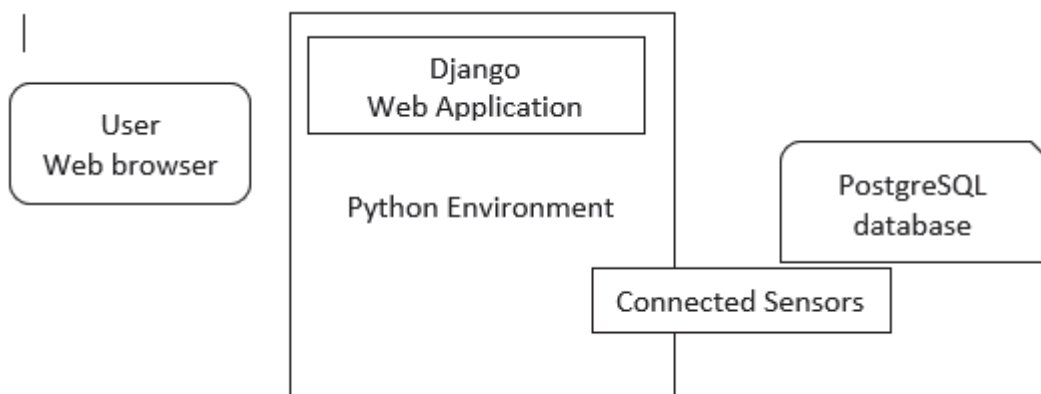


Figure 28: Practical implementation overview

The first step of implement is creating of the project under the Django platform, which you can then populate with site-specific settings, paths, models, views, and templates, which will discuss these in later.

For this task there is need for a virtual environment(where we can deploy our codes and isolate it from the rest of the computer data) in order to work on Virtual environment the `virtualenvwrapper-win` has to be installed and after applying of `mkvirtualenv` command the environment will be set up, when the command completes the new virtual environment will be active and start of the prompt in cmd will be the name of the environment in brackets, inside of this virtual environment the all requirements like python and Django have to be installed.

Following are the workflow summary for setting up the virtual environment.

- pip3 install virtualenvwrapper-win ---- Installing virtualenvwrapper
- mkvirtualenv Geodata\_env ---- Creating virtual environment
- deactivate — Exit out of the current Python virtual environment
- workon — List available virtual environments
- workon name\_of\_environment — Activate the specified Python virtual environment
- rmvirtualenv name\_of\_environment — Remove the specified environment
- mkdir projects ---creating a name in desired location
- python -m venv geodatatoolkit --- checking python in Venvirument
- cd geodatatoolkit
- cd Scripts
- activate.bat
- cd .. // --for returning to the environment home directory
- activate Scripts --- script activation
- pip3 install django~=2.2 ---nstaltion of Django
- pip3 install Python ---instaltion of Django
- pip freeze > requirements.txt ---find and set the requirements

django-admin startproject geodatatoolkit --- To start the django web application, This creates a django web application directory which contains directories and files:

/geodatatoolkit

```
__init__.py
asgi.py
settings.py
urls.py
views.py
wsgi.py
db.sqlite3
manage.py
```

This is the default folder structure of the Django web framework, /geodatatoolkit is python package that contains necessary basic files for running a django project. db.sqlite3, SQLite is the default database of the django web framework manage.py, is the manager of the application, adding apps (packages), running sql migrations (if any) and running the default server.

Run the development web server from within this folder using `manage.py` and the `runserver` command using `'python3 manage.py runserver'`.

### **Publication of the Software:**

Once the Ad hoc monitoring system it is needed to host it as public and accessible than personal development computer, to share the software to the local browser/network and running in public. The following task have to be applied.

### **Choosing a hosting provider:**

there are several hosting providers that works well with Django, these vendors provide different types of environments, IaaS (Infrastructure as a Service), PaaS (part of a Platform as a Service), and different levels of computing and network resources at different prices, Some of the things to consider when choosing a host:

- How busy the site likely to be, and the resource requirements
- Where the supplier has data centers, and hence where access is likely to be fastest.
- The tools which is providing for managing (e.g. SFTP vs FTP).
- The limitation of the host providers like, certain services (e.g. email).

There are some providers which offers the free environment and of course there is lots of resources limitation, like in this project as used PostgreSQL instead of SQL because SQL is not offered as free.

In this Master thesis the Heroku is used as a hosting provider as it is Free tier with some limitations, as a PaaS take care for lots of the web infrastructure and Heroku makes things easy to set up, (Jones 2013).

### **Getting a Heroku Account**

We need an account on Heroku and install Heroku client in order to start with it And then by run the following command the project will upload to the repository.

"Heroku create" it create repository

"git push Heroku master" it will push the project push to the Heroku repository

After setting up the database we have to migrate the project into the Heroku DB.

"run python manage.py migrate"

Working procedure of the Heroku is like, the HAD-HOC project run within "Dynos" which make the isolation of each parts, there are "add-ons" which can be install and use, in order to execute the project, Heroku needs to set up the environment and dependencies, so for Django we provide this information in a number of text files

- runtime.txt: introduce the programming language.
- requirements.txt: The Python component dependencies, including Django.

- Procfile: a list of processes to be executed to start the web application. For Django this will usually be the Gunicorn web application server (with a .wsgi script).
- wsgi.py: WSGI configuration to call our Django application in the Heroku environment.

In order to get the application to work on Heroku the project should put into a git repository, add the files above, integrate with a database add-on, and make changes to properly handle static files. After these all steps the Heroku can be setup and we can use Heroku client for interacting with Heroku. (MDN Dec 10, 2019).

### **Production Environment:**

Before making public version of the project there is need for production environment which is the server computer or the repository of the Heroku where the project will be public, for that reason we need for some requirements:

- The local computer or the hardware, where we have the Project.
- The framework libraries of the programing language which we used for the project.
- The web server which is used for the project like Apache.
- Application server that passes "dynamic" requests between Django website and the webserver.
- The database of which is dependent of the Projects.

The server computer is assumed like a computer in the cloud, and meant like the code is running on the on a remote computer (virtual computer) and used some resources like RAM and CPU of the cloud for certain price, this kind of resource called Infrastructure as Service (IaaS). Or the support some Platform Like Django, so it means Platform as a Service (PaaS) offering, in this type hosting we don't need to take care about the resources like web server, application server (MDN Dec 10, 2019).

### **Creating the repository in Github**

Git is version control that developer can track the source code during of the development and it is integrated with Heroku, git is a repository on the Heroku on the cloud, we can upload and changes of the code to this repository, for this reason first there is need for an account on GitHub and then create repository there and named Geotada-toolkit, and then sync it locally or clone repository on local computer using URL <https://github.com/Humi-Saifi/geodatatoolkit.git> Figure 29.

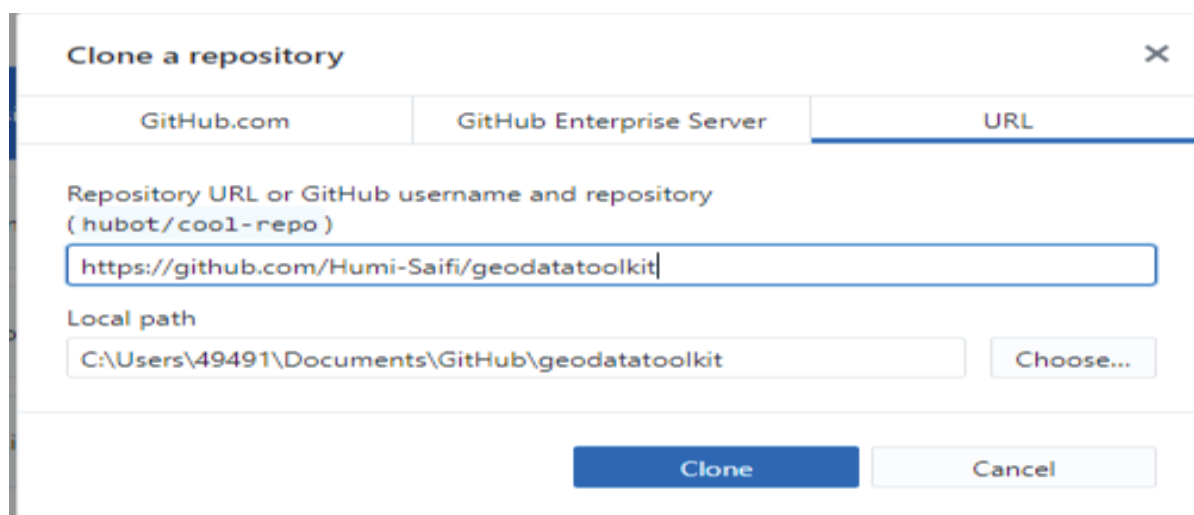


Figure 29: Project Repository

## Database configuration

for handling database Heroku has the database add-ons, there are quite a lot of database options, but The Ad-HOC MS stores the sensor data in a Heroku PostgreSQL database as this is free, in order to the project use the database the database connection information should be configure using DATABASE\_URL and Django needs psycopg2 to work with Postgres database and it needs to add this information also to the requirements.txt .

Commands to active Database in Heroku

```
heroku-postgresql      ----Command the database will be under the use.
pip3 install dj-database-url  ---Installing of dj-database-url
pip3 install psycopg2      ---Installing of dj-database-url
```

For running of the web server “python3 manage.py runserver” command should be run each time and then to push the changes to GitHub repository these steps should be done

1. navigate to the local repository
2. git status ----- Checking the status
3. git add . -----Copying of Django application
4. git commit -m ----After satisfying commit the files to local repository
5. git push origin master ----Pushing local repository to the remote Github repository (MDN Dec 10, 2019).

There are Views and Functions for each sensor in this monitoring system, below is the explanation of each sensor view with details.

## Views.index

This view function renders the Home Page

### **Views.sensorDataCloud**

This view function renders the page where the user can see the historical time series in the form of graph of all the sensors data that were collected in the cloud database.

### **Views.sensorDataLocal**

This view function renders the page where the user can see the historical time series in the form of graph of all the sensors data that were collected in the local database.

### **Views.ApiSensor1**

This view function is a RESTful API GET endpoint that fetches the real-time data saved on the `disto_realtime` table for the sensor 1 (`disto`) and returns the response as a json object containing the data.

### **Views.ApiSensor2**

This view function is a RESTful API GET endpoint that fetches the real-time data saved on the `gpsnn_realtime` table for the sensor 2 (`gpsnn`) and returns the response as a json object containing the data.

### **Views.ApiSensor3**

This view function is a RESTful API GET endpoint that fetches the real-time data saved on the `sensordata_realtime` table for sensor 3 (`sylvac`) and returns the response as a json object containing the data.

### **Views.ApiSensor4**

This view function is a RESTful API GET endpoint that fetches the real-time data saved on the `dxl_realtime` table for the sensor 4 (`dxl`) and returns the response as a json object containing the data.

### **Views.ApiRemoteSensor1**

This view function is a RESTful API GET endpoint that fetches the data saved on the cloud database table (`disto`) for sensor 1 (`disto`) and returns the response as a json object containing the data.

### **Views.ApiRemoteSensor2**

This view function is a RESTful API GET endpoint that fetches the data saved on the cloud database table (`gpsnn`) for sensor 2 (`gpsnn`) and returns the response as a json object containing the data.

### **Views.ApiRemoteSensor3**

This view function is a RESTful API GET endpoint that fetches the data saved on the cloud database table (sensordata) for the sensor 3 (sylvac) and returns the response as a json object containing the data.

#### **Views.ApiRemoteSensor4**

This view function is a RESTful API GET endpoint that fetches the data saved on the cloud database table (dxl) for the sensor 4 (dxl) and returns the response as a json object containing the data.

#### **Views.ApiLocalSensor1**

This view function is a RESTful API GET endpoint that fetches the data saved on the local database table (disto) for sensor 1 (disto) and returns the response as a json object containing the data.

#### **Views.ApiLocalSensor2**

This view function is a RESTful API GET endpoint that fetches the data saved on the local database table (gpsnn) for sensor 2 (gpsnn) and returns the response as a json object containing the data.

#### **Views.ApiLocalSensor3**

This view function is a RESTful API GET endpoint that fetches the data saved on the local database table sensordata (name of sylvac sensor) for the sensor 3 (sylvac) and returns the response as a json object containing the data.

#### **Views.ApiLocalSensor4**

This view function is a RESTful API GET endpoint that fetches the data saved on the local database table (dxl) for the sensor 4 (dxl) and returns the response as a json object containing the data.

#### **Views.runComPort**

This view function is a RESTful API POST endpoint that triggers the chosen sensor to start getting data through serial PORT where the sensor is connected, the user need to submit the sensor type [ disto, gpsnn, sylvac, dxl ], according to the type the appropriate function will run runGPSNN, runDISTO, runSYLVAC, runDXL.

#### **Views.disconnect**

This view function is a RESTful API GET endpoint that stops the serial PORT to get the data from the sensor which was currently transferring.



### 13 Monitoring functionality test

After the implementation we put the Monitoring system under the test and this measurement client has to be checked for functionality, if the hardware and software is working as expected

After connecting the sensor to the USB port, server should be run with python manage.py runserver, and the form of the interface should be fill out with the proper parameters, after the press connect the data will be read from the serial port.

For example, to test the Disto sensor: The Disto sensor is equipped with an RS-232 interface, which is used for communication with a connected computer the parameters are required to fill out the interface and query the measurement values in order to read the data.

The parameters are:

Baudrate = 9600

Bytesize = 8

Parity = None

Port = 12

The Disto sensor mesure 0.0001 milisecond, The resolution of the inclination measurement is 0.001 mrad, that of the temperature 0.1°C. A measuring cycle takes 300 ms. The Nivel220 and Sylvac and GPS are the sensors with the same metrological specifications, but with the difference of the boudrade. After initial attempts the sensore measured distance of a Room in section 4 student living building. The sensor records the distance of the room over a period of 2 hours.

## 14 Conclusion and outlook

Geodetic monitoring systems have achieved a high degree of automation in recent years through the integration of evaluation methods and, adapted measuring sensors. The task of the monitoring system and geosciences is very ideal can be efficiently analyzed in the future and improve, in this master thesis the sensor block could professionally deliver the result for the object under the test.

The first version of topology focused on as simple as possible system for quick access and which successfully achieved.

The system still has capacity for optimization and improving in different methods, and It is my personal desire to expand this program in the future. Here is an example scenario:

This Monitoring system could be able to monitor from remote with a very high-level User interface, it means more requirements will be implemented, providing user accounts for each user so each user can have his own user account space for managing, controlling the desired target area with calculation of his own data and possibility to calculate this data in form of 3D deformations and printing report as PDF for each final result.

Another future idea is the control of additional sensors, for example, a combined acceleration and rotation, temperature, rate, sound racemization and other height technology sensor to detect the natural disaster and recognize any kind of natural or environmental hazard,

Another idea base of this system could be to Expansion with Raspberry pi, because with the Raspberry Pi we can have a low-cost measurement network with sufficient computing power, the final target is to develop this system as mobile application to install and use at anytime and anywhere.

## 15 Attachments

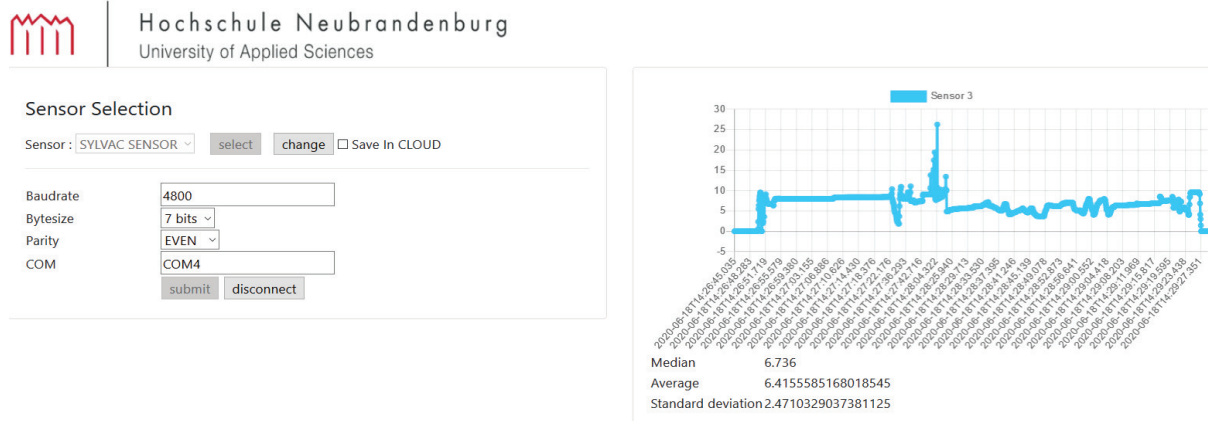


Figure 30: sylvac realtime measurements

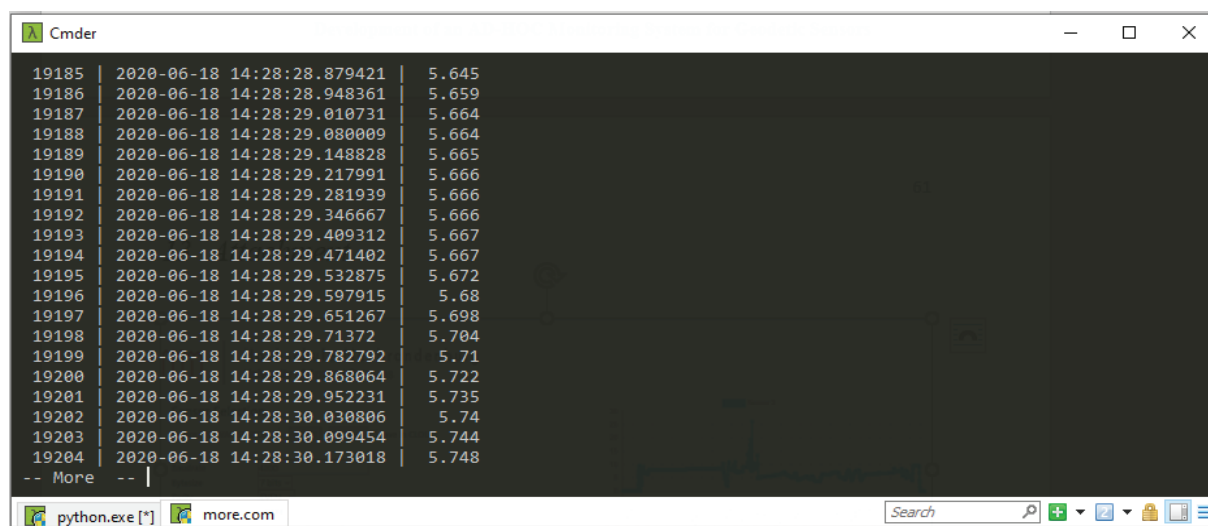


Figure 31: Local table of SYLVAC

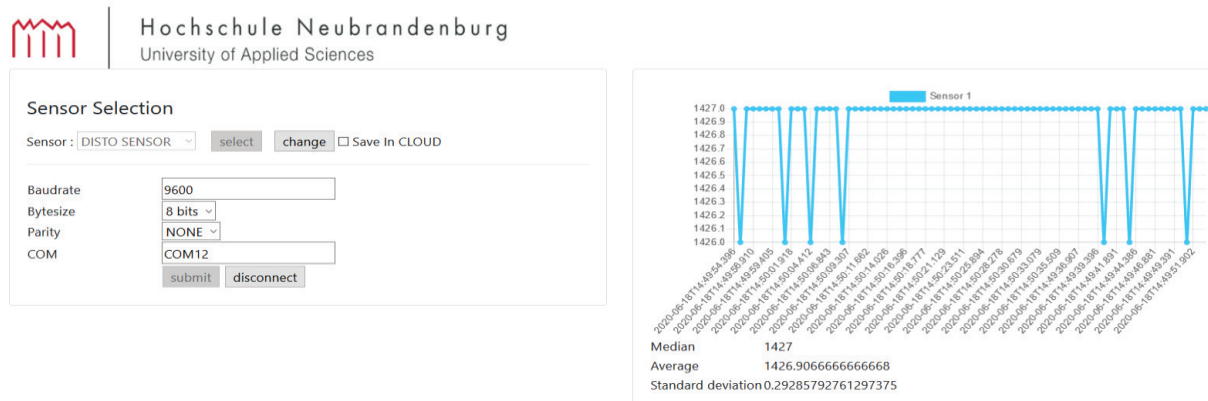


Figure 32: Disto realtime measurements

832	2020-06-18 14:49:43.554124	1426
833	2020-06-18 14:49:44.386676	1427
834	2020-06-18 14:49:45.217834	1427
835	2020-06-18 14:49:46.049343	1427
836	2020-06-18 14:49:46.881391	1427
837	2020-06-18 14:49:47.712714	1427
838	2020-06-18 14:49:48.544729	1427
839	2020-06-18 14:49:49.391442	1427
840	2020-06-18 14:49:50.238803	1427
841	2020-06-18 14:49:51.071677	1426
842	2020-06-18 14:49:51.902683	1427
843	2020-06-18 14:49:52.734262	1427
844	2020-06-18 14:49:53.567478	1427
845	2020-06-18 14:49:54.396763	1427
846	2020-06-18 14:49:55.230354	1426
847	2020-06-18 14:49:56.077674	1427
848	2020-06-18 14:49:56.909993	1427
849	2020-06-18 14:49:57.741402	1427
850	2020-06-18 14:49:58.576764	1427
851	2020-06-18 14:49:59.405441	1427
852	2020-06-18 14:50:00.24032	1427

Figure 33: Disto Local Table

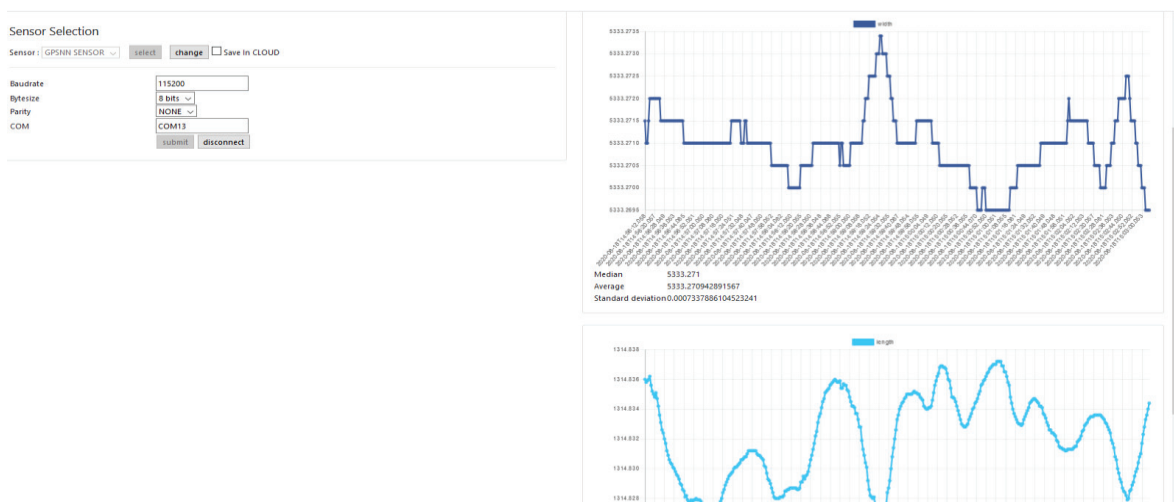


Figure 34:GPSNN realtime measurments

7080	2020-06-18 15:03:45.070079	5333.2705	1314.8348	130345
7081	2020-06-18 15:03:46.051392	5333.271	1314.8347	130346
7082	2020-06-18 15:03:47.049723	5333.271	1314.8347	130347
7083	2020-06-18 15:03:48.049577	5333.271	1314.8347	130348
7084	2020-06-18 15:03:49.0509	5333.271	1314.8347	130349
7085	2020-06-18 15:03:50.052215	5333.271	1314.835	130350
7086	2020-06-18 15:03:51.055874	5333.271	1314.8351	130351
7087	2020-06-18 15:03:52.050178	5333.2715	1314.8356	130352
7088	2020-06-18 15:03:53.059706	5333.2715	1314.8358	130353
7089	2020-06-18 15:03:54.052257	5333.272	1314.8367	130354
7090	2020-06-18 15:03:55.048679	5333.2715	1314.8367	130355
7091	2020-06-18 15:03:56.049491	5333.2715	1314.8374	130356
7092	2020-06-18 15:03:57.05193	5333.272	1314.8374	130357
7093	2020-06-18 15:03:58.049831	5333.272	1314.8376	130358
7094	2020-06-18 15:03:59.049369	5333.272	1314.838	130359
7095	2020-06-18 15:04:00.058219	5333.272	1314.838	130400
7096	2020-06-18 15:04:01.050284	5333.272	1314.8386	130401
7097	2020-06-18 15:04:02.058844	5333.272	1314.8391	130402
7008	2020-06-18 15:02:33.050769	5333.2705	1314.8326	130233
7009	2020-06-18 15:02:34.050187	5333.2705	1314.8324	130234
7010	2020-06-18 15:02:35.046363	5333.271	1314.8319	130235

Figure 35: GPSNN local Table

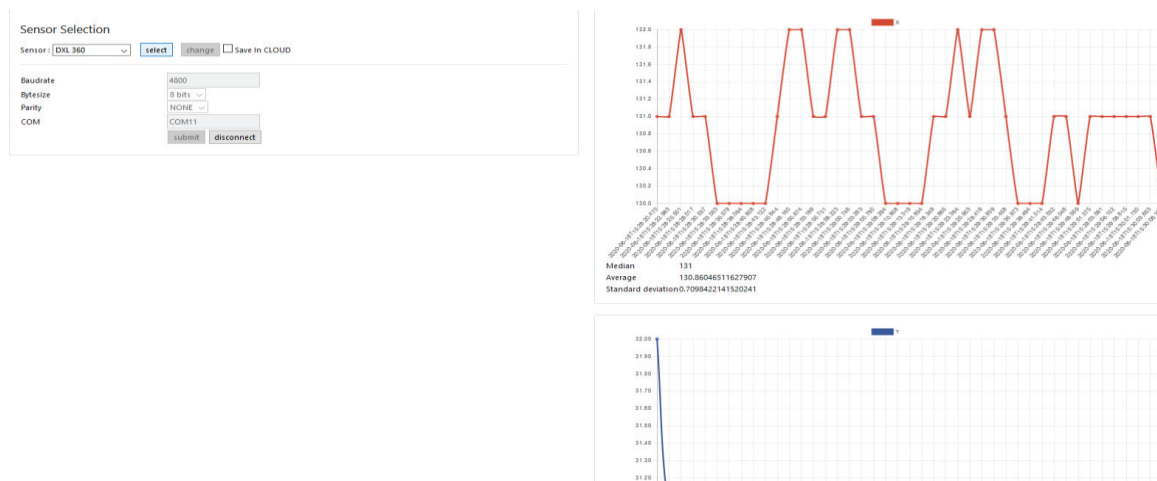


Figure 36: DXL 360 realtime measurements

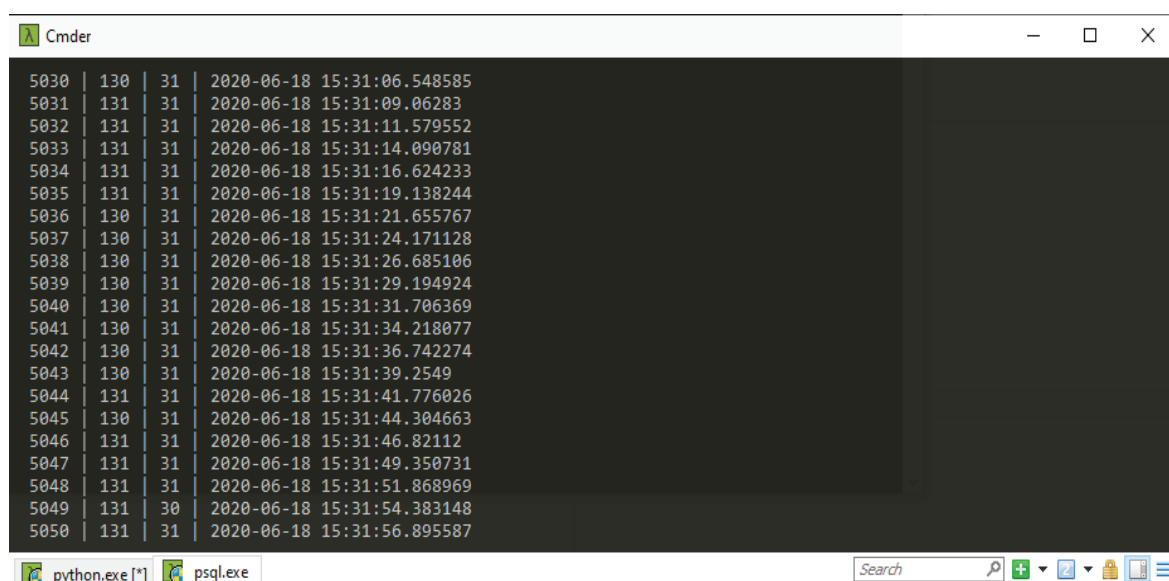


Figure 37: GPSNN local Table

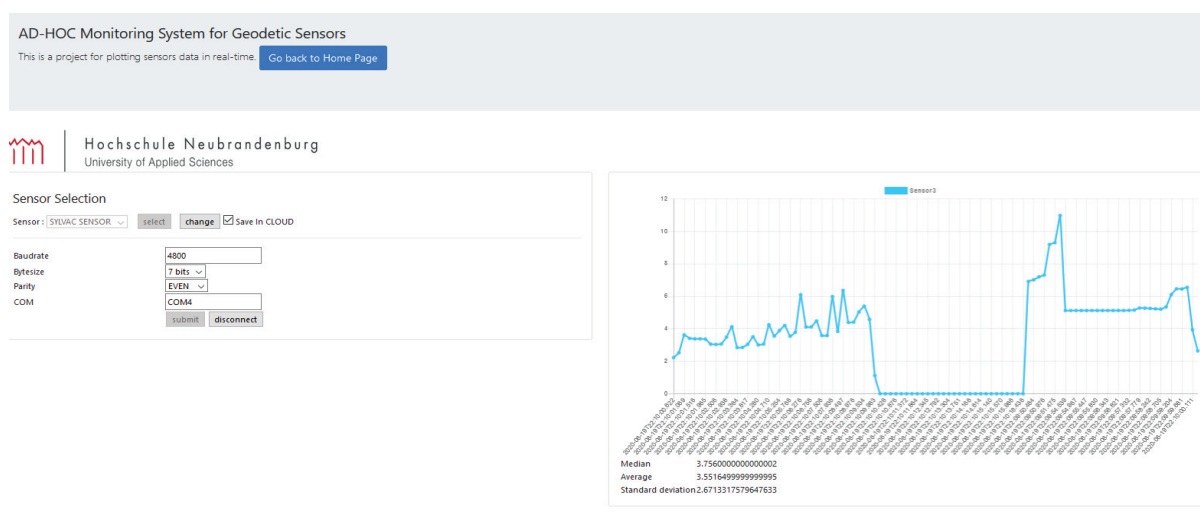


Figure 38: Sylvc Data is storing on the cloud

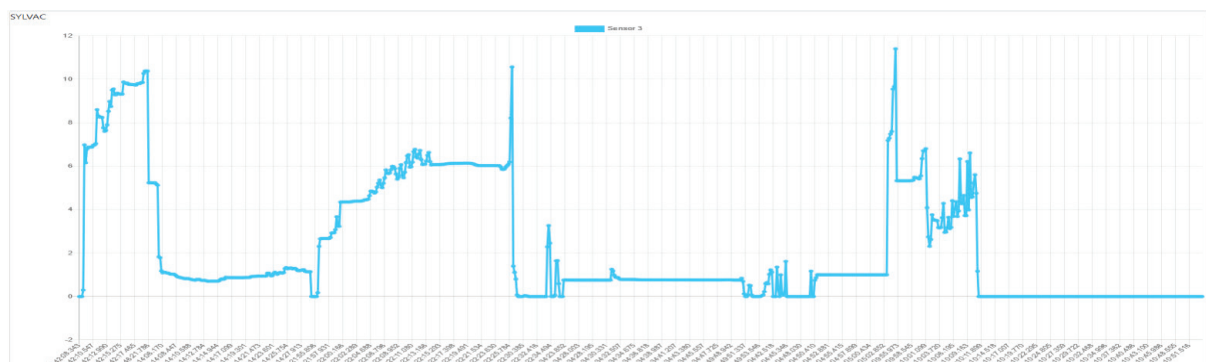


Figure 39: Showing Sylvac graph on the cloud

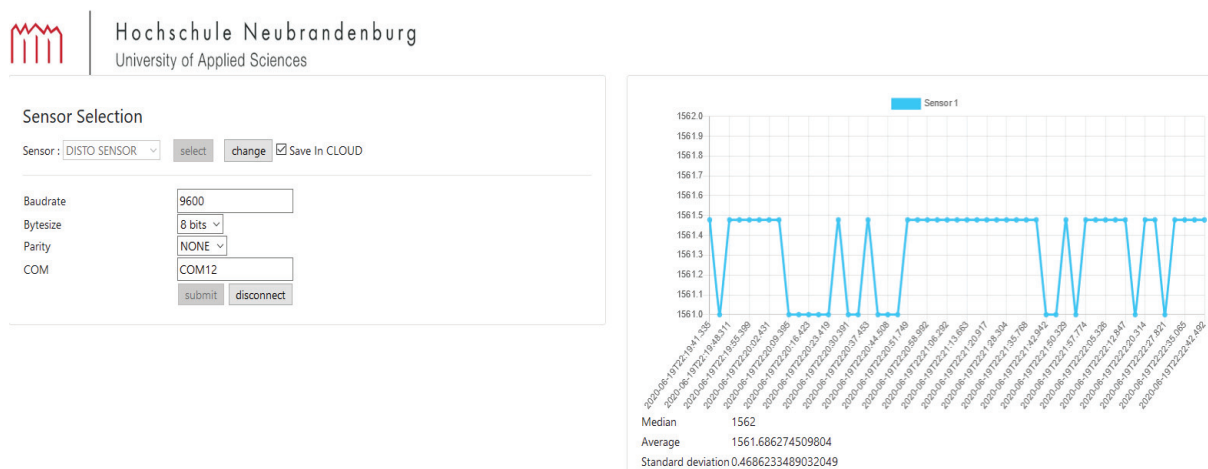


Figure 40: Disto real time on the cloud

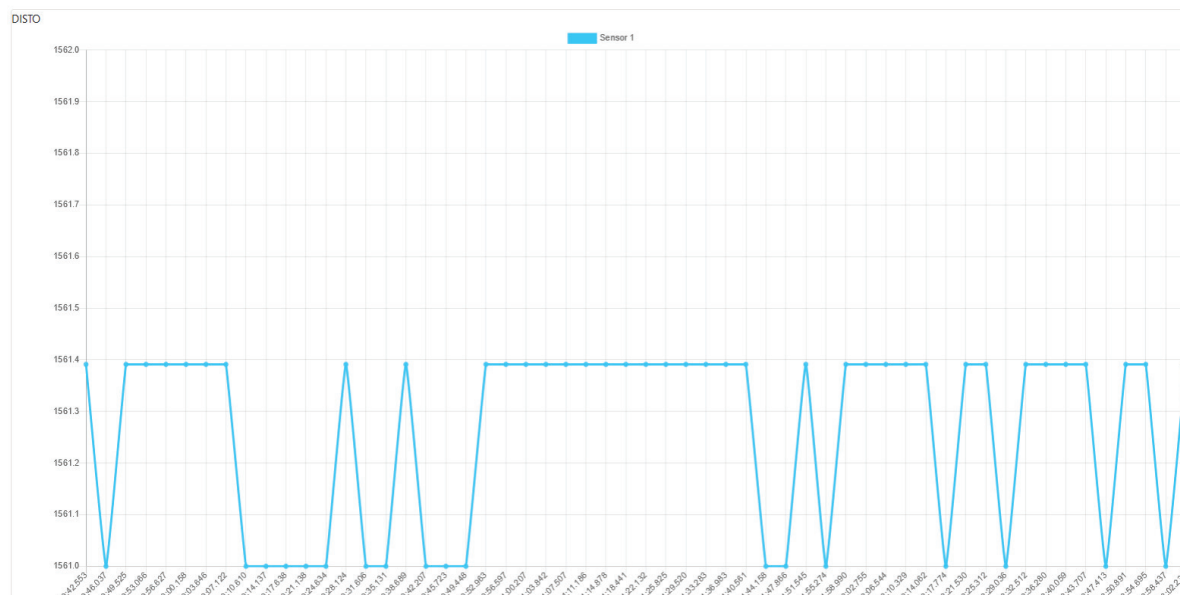


Figure 41: Disto data graph on the cloud



## 16 Bibliography

- Alexander P. Karpik, Volker Schwieger, Argina Novitskaya, Otto Lerke. International Workshop. 14th – 15th April 2014.
- Ali, Mustafa. What is Wireless LAN? What is WLAN? November 8, 2017. <https://www.fieldengineer.com/blogs/what-is-wireless-lan>.
- ATWELL, CABE. 8 alternative ways to power a laptop. OCTOBER 13, 2015. <https://www.edn.com/8-alternative-ways-to-power-a-laptop/>.
- Axelson, Jan. USB Complete Introduction. USA: <https://www.mobt3ath.com/uplode/book/book-50420.pdf>, June 2001.
- BONNEVILLE, Eric. PRODUCT ENVIRONMENTAL FOOTPRINT CATEGORY RULES, Uninterruptible Power Supply (UPS). 8TEC –37 quai Paul Louis Merlin –38000 Grenoble –France : February15th2019, 2019.
- Brass, Stefan. Grundlagen des World Wide Web. Universität Halle,, 2006.
- Canada, Government of. 100 Years of Geodetic Surveys in Canada . 2017.02.22. [www.nrcan.gc.ca](http://www.nrcan.gc.ca).
- Chapman, By Rachael. limeproxies. November 9, 2018. <https://limeproxies.com/blog/top-5-widely-used-statistical-data-analysis-techniques-in-2018/>.
- Computerhope. USB. 11/16/2019. <https://www.computerhope.com/jargon/u/usb.htm>.
- contributors, MDN. Deploying Django to production. Dec 10, 2019, by MDN contributors. <https://developer.mozilla.org/en-US/docs/Learn/Server-side/Django/Deployment>.
- Cooney, Michael. What is power over Ethernet (PoE)? APR 6, 2020 8:10 PM PDT. <https://www.networkworld.com/article/2328615/the-power-over-ethernet.html>.
- coutermarsh, Mike. Heroku CookBook. Birmingham, UK: Packt Publishing Ltd, November 2014.
- CRANENBROECK, Joel VAN. Introducing Geosensing as also the Integration of Geodetic. Belgium: FIG Congress 2014, 2014.
- Cranenbroeck, Marco Di Mauro and Joel van. Geodetic and Geotechnical Combined Monitoring Concept. Rom, Italy : TS01F - Dam and Reservoir Engineering Surveying, 5505, 6-10 May 2012.
- DABAMOS. Research. 20017. <https://www.dabamos.de/research/>.



DAVID A. FEARY, LEA A. SHANLEY, NICHOLAS D. ROGERS, COURTNEY R. GIBBS. THE NATIONAL ACADEMIES PRESS, Page 30. Washington, D.C., 2010.

Dinita, Madalina. windowsreport. April 25, 2019. <https://windowsreport.com/schedule-tasks-windows-10/>.

Documentaion. „MESSUHREN S\_Dial.“ kein Datum.

Documentation. NL-8022MU u-blox 8 multi GNSS USB roofmount receiver 4.50 m. 14167 Berlin, Germany: 13/15, 08/2014.

—. „The original laser distance meter.“ 2013. [http://www.icp-leica.com/downloads/Disto\\_family\\_en.pdf](http://www.icp-leica.com/downloads/Disto_family_en.pdf).

Dr. Karl Foppe, Dr. Wolf Barth, and Sebastian Preis. Autonomous Permanent Automatic Monitoring System with Robot-Tacheometers. Munich, Germany,, October 8-13, 2006.

electricalfundablog. „Serial Communication – Protocols, Standards and Advantages.“ 2015. <https://electricalfundablog.com/serial-communication-protocols-standards/>.

Engel, Philipp. Entwicklung eines autonomen Low-Cost-Messclients für geodätische Überwachungsmessungen. Neubrandenburg Hochschule: 2017, August 2013.

Fonderiest.com. „Meteorological Sensors.“ website lakescientist. online. <https://www.lakescientist.com/meteorological-sensors/>.

Gakstatter, By Eric. What Exactly Is GPS NMEA Data? February 4, 2015. <https://www.gpsworld.com/what-exactly-is-gps-nmea-data/>.

heroku. Heroku Postgres. 2020. <https://www.heroku.com/postgres#>.

Hofmayer, Dr. Ijad Madisch and Dr. Sören. Geodetic and Remote-Sensing Sensors for Dam Deformation Monitoring. Beijing, October 2018.

Javatpoint. What is HTML. 2020. <https://www.javatpoint.com/what-is-html>.

Joël van Cranenbroeck, Andrey Balan, Marco Di Mauro. A New Geodetic Network Design for Hydro Power Plant. Rome, Italy: 6-10 May 2012, 2012.

Jones, Darren. Jump start Sintara, . 48 Cambridge Street Collingwood, Australia 3066: SitePoint Pty, 2013.

Karl, Prof. Dr. –Ing. „characteristics.“ Document, hochschule NB, April, 2011.

Le, James. How Operating Systems Work: 10 Concepts you Should Know as a Developer. Jan 8, 2018. <https://medium.com/cracking-the-data-science-interview/how-operating-systems-work-10-concepts-you-should-know-as-a-developer-8d63bb38331f>.

- Loeffler, Chris. UPS Basics. Raleigh, North Carolina: WP153005EN, October 2011.
- Lynch, Warren. What is Use Case Diagram? Jul 16, 2019 .  
<https://medium.com/@warren2lynch/use-case-modeling-e314b9eee0ba>.
- M. Rutschmann, Senior Product Manager. The latest innovations from. 11, October, 2016.
- Mahendar Kumar Zubair .A Memon, M .Aslam Uqaili and Mazhar H. Baloch. „An Overview of Uninterruptible Power Supply System w i t h To t a lHarmonic Analysis& Mitigation:An Experimental Investigation for Renewable Energy Applications.“ Manual, eapartment of Electrical Engineering, Mehran University of Engineering & Technology, Pakistan, June 2018.
- Manual. „DXL360/S V2 Digital Protractor User Guide .“ Manual . 2013 July 29.  
<http://spot-on.net/images/DXL360S%20v2-Dual%20Axis%20Digital%20Protractors.pdf>.
- . „Geodetic Monitoring System Equipment Lis.“ gefos-leica. 2005.  
[https://www.gefos-leica.cz/ftp/GPS/Prospekty/Monitoring/GeoMoS%20Equipment%20List\\_en.pdf](https://www.gefos-leica.cz/ftp/GPS/Prospekty/Monitoring/GeoMoS%20Equipment%20List_en.pdf).
- Martindale, By Jon. Why Bluetooth is named after this famous king . October 11, 2019.  
<https://www.digitaltrends.com/computing/what-is-bluetooth/>.
- MDN. Deploying Django to production. Dec 10, 2019.  
<https://developer.mozilla.org/en-US/docs/Learn/Server-side/Django/Deployment>.
- Niyato, Nipendra Kayastha Dusit. Smart grid sensor data collection, communication, and networking: a tutorial. 23 July 2012.  
<https://onlinelibrary.wiley.com/doi/epdf/10.1002/wcm.2258>.
- NOAA. What is geodesy? 04/09/20.  
<https://oceanservice.noaa.gov/facts/geodesy.html>.
- Operating System, Microsoft. Windows 10. 2020-04-19. [https://www.operating-system.org/betriebssystem/\\_english/bs-windows10.htm](https://www.operating-system.org/betriebssystem/_english/bs-windows10.htm) .
- Orolia. NMEA GGA Message. 8-April-2020.  
[http://manuals.spectracom.com/VSP/Content/NC\\_and\\_SS/Com/Topics/APPE NDIX/NMEA\\_GGAmess.htm](http://manuals.spectracom.com/VSP/Content/NC_and_SS/Com/Topics/APPE NDIX/NMEA_GGAmess.htm).
- P. R. Escobal, H. F. Fliegel, R. M. Jaffe, P. M. Muller, K. M. Ong, O. H. von Roos, and M. S. Shumate. J PL Quarterly Technical Review. Jet Propulsion Laboratory/California Institute of Technology: Jet Propulsion Laboratory, October 1972.

- postgresql. Interactive installer by EDB. 21st May 2020.  
<https://www.postgresql.org/download/windows/>.
- Prof. Dr. rer. nat. Breunig, Martin, Prof. Dr.-Ing. Hennes, Maria, Prof. Dr.-Ing. habil. Kutterer, Hansjörg. Karlsruhe Institute of Technology . 2011-01-19 .  
<https://www.gik.kit.edu/english/staff.php>.
- Prof. Dr.-Ing. Karl Foppe, M. Eng. Philipp Engel. Deformation Monitoring System. online. <https://www.dabamos.de/>.
- redpinesignals. „Wi-Fi in Sensor Applications .“ PDF,  
<https://www.redpinesignals.com/pdfs/White-Paper-Sensor-Networks.pdf>,  
 North First Street, Suite 680, San Jose CA 95131, 2017.
- Rouse, Margaret. uninterruptible power supply. 2020.  
<https://searchdatacenter.techtarget.com>.
- Rubertis, Kim de. „Abstract.“ In Geodetic Monitoring, Abstract. June 28, 2018, kein Datum.
- Sharma, Tamanna. „RS232 Serial Communication Protocol: Basics, Working & Specifications.“ circuitdigest., Jan 01, 2018.
- Staiger, Deumlich u. 2002.
- Stempfhuber, Prof. Dr.-Ing. Werner. „GRUNDLAGEN ZUR ENTWICKLUNG VON MONITORINGSYSTEMEN FÜR GEODÄTISCHE ANWENDUNGEN “. Beuth Hochschule für Technik Berlin , No Date.
- Stiegler, Dr. Leonhard. Rechnernetkommunikation und Vernetzung, Teil 1: Ethernet Protokoll. Stuttgart, 2015.
- Sunny, By. Your cable could be slowing down your charging speed. May 20, 2019.  
<https://blog.banggood.com/your-cable-could-be-slowing-down-your-charging-speed-31493.html>.
- terrsgps. How GNSS Receivers Work. online. <http://www.terrsgps.com/how-gnss-receivers-work/>.
- trimble, Manual. „Introduction.“ T4D Control Web User Manual. Online, Manual.  
[http://help.web.t4d.trimble.com/version4.6/web/Trimble\\_4D\\_Control\\_Web\\_User\\_Manual.pdf](http://help.web.t4d.trimble.com/version4.6/web/Trimble_4D_Control_Web_User_Manual.pdf).
- tutorialspoint. JavaScript- Overview . 2020.  
[https://www.tutorialspoint.com/javascript/javascript\\_overview.htm](https://www.tutorialspoint.com/javascript/javascript_overview.htm).
- Ujwala. web server web browser. November 19, 2019.  
<https://www.milesweb.com/hosting-faqs/what-is-a-web-server-how-do-web-servers-work/web-server-web-browser/>.

Usman Opeyemi Lateef, Akeem Owoade, Gbenga Ogunsanwo. „INTRODUCTION TO COMPUTER PROGRAMMING (BASIC).“ ResearchGate. October 2016. <https://www.researchgate.net/publication/317182495>.

w3schools. Python Introduction . Online. [https://www.w3schools.com/python/python\\_intro.asp](https://www.w3schools.com/python/python_intro.asp).

WCGs (Web Code Geeks) . HTML5 Programming Cookbook. 2015.

Wikipedia. Ethernet. 23 April 2020. <https://en.wikipedia.org/wiki/Ethernet>.

## 17 List of Figure

Figure 1: Structure of AD-HOC Monitoring System.....	6
Figure 2: Use Case of Ad-Hoc Monitoring System .....	7
Figure 3: Web Server Request (Ujwala November 19, 2019) .....	8
Figure 4: Test measurement in the lab (DABAMOS 20017) .....	11
Figure 5: Geodetic measurement sensors for monitoring tasks (Stempfhuber No Date) .....	12
Figure 6: GPSNN type of NL-8022MU .....	15
Figure 7: Right angles to a wall (Documentation, The original laser distance meter 2013) .....	16
Figure 8: The area of a ceiling, (Documentation, The original laser distance meter 2013) .....	17
Figure 9: The area of a multi corner room (Documentation, The original laser distance meter 2013) .....	17
Figure 10: Sylvac View (Documentaion kein Datum) .....	18
Figure 11: DXL360S with Bluetooth dongle .....	19
Figure 12: Serial communication (Sharma Jan 01, 2018) .....	21
Figure 13: Serial communication (Sharma Jan 01, 2018) .....	21
Figure 14: RS232 protocol (Sharma Jan 01, 2018) .....	22
Figure 15: RS232 male connector.....	24
Figure 16: RS232 female connector .....	24
Figure 17: Devices using serial communication (electricalfundablog 2015) .....	26
Figure 18: Wiring of every (Sunny May 20, 2019).....	26
Figure 19: Leica Serial Data Transfer Power cable (GEV189) .....	30
Figure 20: GitHub Repository .....	34
Figure 21: Hosted Project Diagram in Heroku .....	35
Figure 22: Browser and Heroku Communication .....	35
Figure 23: Task scheduling of the HDM System .....	40
Figure 24: Leica GeoMoS functionality (M. Rutschmann 11, October, 2016).....	42
Figure 25: Web interface of the Trimble 4D (trimble Online, Manual).....	44
Figure 26: Schematic illustration of a sensor network based on OpenADMS (Prof. Dr.- Ing. Karl Foppe online) .....	45
Figure 27: Sylvac HTerm Data Capture .....	48
Figure 28: Practical implementation overview .....	48
Figure 29: Project Repository .....	52
Figure 30: sylvac realtime measurments .....	57
Figure 31: Local table of Sylvac .....	57
Figure 32: Disto realtime measurments .....	57
Figure 33: Disto Local Table .....	58
Figure 34: GPSNN realtime measurments .....	58
Figure 35: GPSNN local Table .....	58

Figure 36: DXL 360 realtime measurments.....	59
Figure 37: GPSNN local Table .....	59
Figure 38: Sylvc Data is storing on the cloud .....	59
Figure 39: Showing Sylvac graph on the cloud.....	60
Figure 40: Disto real time on the cloud .....	60
Figure 41: Disto data graph on the cloud .....	60

## 18 List of Tables

Table 1: Geodetic monitoring systems Providers.....	5
Table 2: Geodetic Sensors .....	13
Table 3: Appropriate splitting of the NMEA-GGA data string (Orolia 8-April-2020) ....	14
Table 4: Communication character with Leica Disto (Karl April, 2011) .....	16
Table 5:Two-way communication (Sharma Jan 01, 2018).....	23
Table 6: Pin Description DB-9 Connector.....	24
Table 7: Some example of Real-time Monitoring Systems.....	41

## 19 Statutory Declaration:

I herewith formally declare that I have written the submitted dissertation independently. I did not use any outside support except for the quoted literature and other sources mentioned in the paper, it is prepared under the term and conditions of the examination regulations of the geoinformatics and Geodesy Master's course at the Neubrandenburg Hochschule, University of applied science.

I am aware that the violation of this regulation will lead to failure of the thesis.

_____	_____
name	signature

_____	_____
Matriculation number	Neubrandenburg date