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Ministry of Labor and Skills

Rural Land Administration

Level-III

Based on March 2022, Version II Occupational Standard

Module Title: Demarcating Land Parcel Boundary Using GNSS/GPS

LG Code: AGR RLA3 M06 LO (1-3) LG (14-16)

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Table of Contents

Introduction to the Module

This module covers the competence required to collect data using basic Global Positioning System (GPS) or Global Navigation Satellite System (GNSS) equipment and to be able to use suitable software to communicate with a GPS/GNSS receiver in demarcating land parcel boundary. It requires the ability to combine technical application in a team environment with sound communication skills. Functions would be carried out under limited supervision and within organizational guidelines.

LG #14	LO #1- Preparation for data collection

Instruction sheet-1

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Safety requirements and site safety plan
- Adjusting equipment for data collection

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Apply safety requirements and site safety plan
- Adjust equipment for data collection

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the "LAP test"

Information Sheet – 1

1.1. Safety requirements and site safety plan

The safety requirements are those requirements that are defined for the purpose of risk reduction. GNSS/GPS survey is a method of measuring and mapping the position and elevation of points on the earth's surface using signals from global navigation satellite systems (GNSS) such as GPS, GLONASS, Galileo and BeiDou. GNSS/GPS survey can be used for various purposes such as land surveying, geodesy, mapping, navigation, construction, engineering and environmental monitoring. GNSS/GPS survey involves the use of GNSS/GPS receivers, antennas, cables, batteries, tripods and other equipment that are deployed in the field.

GNSS/GPS survey can pose various hazards and risks to the surveyors and the public, such as:

- Exposure to traffic, pedestrians, animals and other environmental factors
- Exposure to electromagnetic radiation from GNSS/GPS signals and equipment
- Exposure to electric shock from cables and batteries
- Exposure to physical injury from falling objects, slips, trips and falls
- Exposure to theft, vandalism or sabotage of equipment
- Exposure to interference or spoofing of GNSS/GPS signals

To ensure the safety of the surveyors and the public, and to protect the equipment and data quality, it is essential to follow some safety requirements and to prepare a site safety plan before conducting a GNSS/GPS survey. Some of the safety requirements and site safety plan elements are:

- Conduct a risk assessment of the survey site and identify the potential hazards and mitigation measures
- Obtain the necessary permits, approvals and permissions from the landowners, authorities and stakeholders
- Inform the relevant parties of the survey objectives, schedule and contact details

- Wear appropriate personal protective equipment (PPE) such as high-visibility clothing, hard hats, gloves and boots
- Use appropriate signs, cones, barriers and flags to mark the survey area and warn the public
- Follow the traffic rules and regulations when working near roads or vehicles
- Maintain a safe distance from power lines, pipelines, railways and other sources of interference or danger
- Secure the equipment against theft, vandalism or sabotage using locks, alarms or guards
- Check the equipment for proper functioning, calibration and battery level before and after each survey session.

1.2. Adjusting equipment for data collection

GPS receivers are devices that use signals from satellites to determine your location, speed, and time. They are widely used for navigation, mapping, surveying, and other applications that require accurate positioning. However, to ensure the reliability and accuracy of GPS data, you need to adjust the settings and parameters of your GPS receiver to match the current conditions and reduce errors.

Several factors affect the accuracy and quality of GPS data, such as the number and quality of satellite signals, the type and configuration of the receiver, the presence of obstructions or interference, and the method of data correction. To improve the accuracy and reliability of GPS data collection, some best practices are:

I. **Choose a suitable receiver:** There are many types of GPS receivers available, but not all of them work with every application. Some receivers can only use GPS signals, while others can use multiple GNSS systems. Some receivers can only receive signals on one frequency, while others can receive signals on multiple frequencies. Some receivers can support differential corrections, while others cannot. Generally, the more signals and frequencies a receiver can use, and the more correction methods it supports, the more accurate it is. However, these receivers may also be more expensive and difficult to carry in the field. Therefore, it is important to choose a receiver that meets the project needs and budget.

II. **Configure the receiver correctly:** Before using a GPS receiver in the field, it is necessary to configure it correctly according to the project specifications and the receiver's manual. Some common settings that need to be adjusted are the coordinate system and datum, the output format and rate of NMEA sentences (the standard protocol for GPS data), the antenna height and offset, the differential correction source and mode (if applicable), and the quality control parameters (such as minimum number of satellites, minimum signal-to-noise ratio, maximum dilution of precision).

III. **Connect the receiver to a device:** To collect GPS data in the field, a GPS receiver needs to be connected to a device that can store and display the data. This device can be a smartphone, a tablet, a laptop, or a dedicated data collector. The connection can be done through Bluetooth, USB, or serial port. The device should have an application that can communicate with the receiver and record GPS metadata (such as accuracy, fix type, number of satellites).

IV. **Test the receiver before collecting data:** Before starting data collection in the field, it is advisable to test the receiver's performance and accuracy in different locations and conditions. This can help identify any potential issues or errors with the receiver's configuration or operation. Some common tests are: checking the number and quality of satellite signals in different environments (such as open sky, urban areas, forested areas), comparing the receiver's position with a known point or benchmark (such as a survey marker or a map feature), measuring the distance and direction between two points with the receiver.

V. **Follow best practices during data collection:** During data collection in the field, some best practices are:

- Avoiding obstructions or interference that may block or degrade satellite signals (such as buildings, trees, power lines),

- holding or mounting the receiver in a stable position with a clear view of the sky (such as on a pole or tripod),
- waiting for enough satellites and good signal quality before recording a point or vertex (such as at least four satellites with high signal-to-noise ratio),
- using GPS averaging to reduce random errors by collecting multiple points and calculating their mean
- Checking the accuracy and quality indicators on the device's screen (such as horizontal accuracy, vertical accuracy, confidence level).

Self-check 1	Written test

Name………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

I. Choose the correct answer from the given alternatives

1. Which one of the following is site safety plan element
   A. Conduct a risk assessment of the survey site
   B. Obtain permissions from the landowners, authorities and stakeholders
   C. Inform the relevant parties of the survey objectives, schedule and contact details
   D. Wear appropriate personal protective equipment
   E. All are correct
2. Which of the following is not best practices during data collection:
   A. Avoiding obstructions or interference that may block or degrade satellite signals
   B. mounting the receiver in a stable position with a clear view of the sky
   C. waiting for enough satellites and good signal quality after recording a point
   D. reduce random errors by collecting multiple points and calculating their mean
   E. Checking the accuracy and quality indicators on the device's screen

3. Which one is true about GNSS/GPS receivers?

A. Some receivers can only use GPS signals

B. Some receivers can only receive signals on one frequency

C. Others can receive signals on multiple frequencies

D. The more signals & frequencies a receiver can use, the more correction methods it supports, the less accurate it is

II. **Answer the following Questions**

1. what are the best practices used to improve the accuracy and reliability of GPS data collection?

……

……..

2. What are best practices we should follow during data collection?

……

……..

LG #15	LO #2- Carryout data collection procedures

Instruction sheet-2

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Planning data collection
- Testing GNSS/GPS equipment
- Methods of data collection
- Collecting point positional data
- Methods of improving accuracy of GNSS/GPS
- Validation and recording of GNSS/GPS measurements
- Identification of plan scale and contour interval

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Plan data collection
- Check fulfilment of organizational GNSS/GPS survey requirements
- Prepare Equipment for surveying
- Attain designated responsibilities of data collector
- Determine and operationalize GNSS/GPS equipment
- Manage collecting point positional data
- Apply methodologies of data collection
- Determine operational conditions for obtaining optimum GNSS/GPS positions
- Apply basic methods to improve the accuracy of GNSS/GPS point positioning

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 2

2. Introduction

GPS/GNSS surveying is the use of GPS and GNSS signals via a GPS/GNSS receiver and antenna to determine the form, boundary, position of objects or points in space relative to other forms, boundaries or points. The difference between GNSS and GPS is that, GPS is a specific satellite navigation system developed by the United States government. GNSS is a general term encompassing all navigation systems using satellite signals to calculate the position of a receiver. While GPS is widely available and affordable, GNSS offers more robust coverage and accuracy using multiple systems.

GNSS is consisting of the following segments

- **Space segment:** having a constellation of satellites in Medium Earth Orbit (MEO) at the height of nearly 20,000 km,
- **Control segment:** having monitoring and control stations to monitor/control/update the constellation of satellites. consists of master control center along with some monitoring stations and telemetry tele command antennas spread all over the globe to perform the following main tasks.
  - ✓ Measures the position of each satellite and controls its attitude and orbit;
  - ✓ Monitors the signals broadcast by satellites
  - ✓ Sends information to satellites for a proper clock alignment
  - ✓ Sends information to satellites for the navigation message
- **User segment:** consisting of receivers to give position, velocity and time (PVT) of the static and mobile user all over the globe at all times using at least four satellites of the constellation in view.

Carrier-phase and pseudo range measurements in GNSS/GPS

Carrier-phase measurements and pseudo range measurements are two types of GNSS/GPS measurements that are used to determine the position of a receiver. Pseudo range measurements: are based on range measurements that have been distorted by factors such as the ionosphere, troposphere, and satellite clocks, while carrier-phase measurements are based on the measurement of the phase of the GPS carrier wave. Pseudo range measurements are less accurate than carrier-phase measurements because they are affected by various error sources. However, they are easier and faster to calculate than carrier-phase measurements. Carrier-phase measurements are more accurate than pseudo range measurements but require precise equipment and software processing. They can be used to calculate centimeter-level accuracy in positioning.

2.1 Planning data collection

GNSS/GPS data collection planning follow the below listed practices:

1. **Define the project objectives and specifications:** Before starting the data collection, it is necessary to define the project objectives and specifications clearly. This includes: the purpose and scope of the data collection, the expected deliverables and outputs, the required accuracy and precision levels, the coordinate system and datum to use, the GPS metadata to record (such as accuracy, fix type, number of satellites), the quality control procedures to follow.
2. **Choose a suitable receiver:** There are many types of GNSS/GPS receivers available, but not all of them work with every application.
3. **Check the satellite availability and conditions:** Before going to the field, it is advisable to check the satellite availability and conditions for the planned date and time of data collection. This can help avoid situations where there are not enough satellites or good signal quality to collect accurate data. There are various tools that can provide satellite

information and predictions such as: Trimble Planning, ArcGIS Field Maps, or NOAA Online Positioning User Service (OPUS).

- Some factors to consider are:

✓ The number of visible satellites from different GNSS systems (such as GPS, GLONASS, Galileo), the elevation angle and azimuth of each satellite (the higher and more spread out they are, the better),

✓ The dilution of precision (DOP) values (the lower they are, the better),

✓ The presence of interference or multipath effects (such as from buildings, trees, power lines)

4. **Prepare the receiver and device:** Before using a GNSS/GPS receiver in the field, it is necessary to prepare it correctly according to the project specifications and the receiver's manual. Some common steps are:

✓ charging or replacing the batteries of both receiver and device

✓ Updating or installing any software or firmware updates for both receiver and device

✓ Configuring any settings or parameters for both receiver and device

✓ Antenna height and offset, differential correction source and mode (if applicable).

✓ quality control parameters (such as minimum number of satellites, minimum signal-to-noise ratio, maximum dilution of precision)

5. **Test the receiver before collecting data**

Before beginning any project that will incorporate GPS data, planning is essential. It is important to coordinate equipment purchases and arrange for training and personnel needs. The specifics of the project will determine how some decisions will be made; however, there are some things that will be common to all projects.

2.1.1 Required Equipment

Project managers should make equipment purchases as soon as the contract is signed. The following equipment is required:

I. **GPS receivers:** One receiver per team, plus two backup receivers for the survey.

II. **Power supply**: Four times the number of batteries required per GPS receiver or sufficient quantities of chargers should be ordered.

III. **GPS/PC connector cables**: At least two per survey should be ordered because cables are easily misplaced. Most GPS receivers are sold with their own cable which is usually a USB connection.

IV. **GPS utility software**: GPS utility software is used to download data from the GPS receivers onto a computer.

V. **Paper record:** In addition to recording the location in the GPS receivers, field teams must record the data on a paper form.

2.1.2 Personnel Needs

GPS data collection can almost always be done without hiring additional personnel. The details and number of people will vary according to the projects. There should be a field team which will collect GPS data and a GPS coordinator. The project manager must identify a local staff person to serve as the GPS coordinator and must decide which field staff will be charged with the responsibility of actually collecting the GPS data.

The main responsibilities of the GPS coordinator are to ensure that:

- Field staff are well-trained in the use of GPS receivers
- GPS data are collected for all locations in the survey
- Technical and protocol questions raised by the GPS data collection team are resolved
- Team members are following the established GPS data collection protocols
- GPS data are regularly downloaded from the GPS receivers and verified
- GPS data from the paper forms are entered into a computer and verified
- All necessary GPS data are collected
- Copies of the GPS data are provided to the managing institutions

2.1.3 Training of GPS Coordinator and Field Team

Adequate training of personnel is crucial to promote an understanding of and proper use of the GPS receivers and to troubleshoot problems that may occur in the field. The GPS coordinator should be someone who has existing knowledge and/or experience with GPS data or the willingness and ability to learn quickly. Because of the advanced tasks the GPS coordinator must perform, s/he will need additional training beyond what is provided to the collection teams. This training will include how to transfer locations from the GPS receiver to a computer as well as some more advanced training with the GPS receivers. At a minimum the GPS coordinator should understand the basic operation of the GPS receiver and how to reset and modify the system settings (e.g. coordinate system, datum, measurement units). The field team must be trained in the basics of the GPS receiver, the data collection protocols, and simple troubleshooting techniques. In order to prevent a "black-box" syndrome where the team does not understand how the GPS receivers work, it is helpful to cover the basics of how GPS works. Lastly, the team should be given time to practice collecting GPS data. This training can last from a half to a full-day depending on the number of people and the specifics of the project.

2.2 Testing GNSS/GPS equipment

To ensure that the product performs, as it should, it is important to test the device's positioning performance at a number of stages from development to production and an accurate test plan for any given GNSS application is imperative. Evaluating and selecting the right GNSS receiver for a given application is crucial, as GNSS signals are highly vulnerable to atmospheric conditions, multipath effects, RF interference and sometimes intentional threats, like; spoofing and signal jamming, which may cause significant impact on mission critical applications.

- The most common and well-accepted basic tests where the GNSS solutions are validated include:
  - ✓ Time to First Fix (TTFF)
  - ✓ Static and Dynamic Position, Navigation and Time Accuracy
  - ✓ Acquisition and Tracking Sensitivity

- ✓ Reacquisition Time
- ✓ Susceptibility to Radio Frequency Interference
- ✓ Antenna characteristics
- ✓ Multipath and obscurations
- ✓ Robustness against GNSS vulnerabilities: GNSS impairments, Jamming, Spoofing.

- Standard certification equipment includes:
  - ✓ multi-channel high end simulator such as we used in our tests
  - ✓ Geodetic reference point
  - ✓ Multi-GNSS high-end reference receiver
  - ✓ Timing receiver
- **Spatial reference systems**

A spatial reference system is a framework that defines a set of rules for identifying locations on the earth's surface. In GNSS/GPS, spatial reference systems are used to convert collected data into meaningful positional information. Specifically, spatial reference systems define the coordinate system and datum used to establish a reference point for georeferencing data. This ensures that all collected data is aligned and can be accurately compared and analyzed. There are many different spatial reference systems in use, depending on the location and application of the data being collected.

2.3 Methods of data collection

Various methods are used to collect high precision differential GPS data. The particular method used depends on several factors, including survey objectives, desired precision, available equipment, and field logistics. Higher precision typically requires a more rigorous field methodology and longer occupation times.

The following table shows the features of the most common GPS survey methods:

- **Continuous:** stations are continuously operating long-term or permanent GNSS station installations involving immobile documentation and sustainable power, and often involving data telemetry. They can be used as pre-existing base stations in campaign surveys (static, rapid static and kinematic).
- **Static surveys:** are regional, sub-cm precision GNSS surveys with portable equipment and are the standard campaign data collection method for crustal deformation surveys. They typically involve occupying each point for several days to get the highest possible accuracy. Collect at least 6 hours of simultaneous data per day for processing and repeat benchmark occupations if possible.
- **Rapid static surveys:** are static surveys with just enough survey time at each point to be able to resolve the carrier phase integer ambiguity. A rule of thumb is to collect data for a minimum of 10 minutes per point, and add one minute of occupation time per kilometer of baseline length over 10 kilometers. For example, on an eight-kilometer baseline collect at least 10 minutes of data and on a 28-kilometer baseline collect at least 28 minutes of data.
- ***Real-time kinematic (RTK):*** refers to surveys in which the base and rover receivers communicate corrections in real-time via a radio link. RTK is a positioning technique to achieve more accurate GPS solutions, typically on the order of centimeters. The RTK system has three main components: 1) base station, 2) rover, and 3) radio. The GNSS orbits at approximately 20,000 km above the Earth, its signals travel through space and the atmosphere developing small errors. The base station listens to the GNSS signals and has algorithms to detect these small errors to calculate Real-Time Correction Messages (RTCM). The base then sends the RTCM packets over the radio to the rover. The rover uses the RTCM packets and adjusts its solution to get a more accurate geo-location. For more explanation look the following link: https://www.youtube.com/watch?v=257WX_agvtg

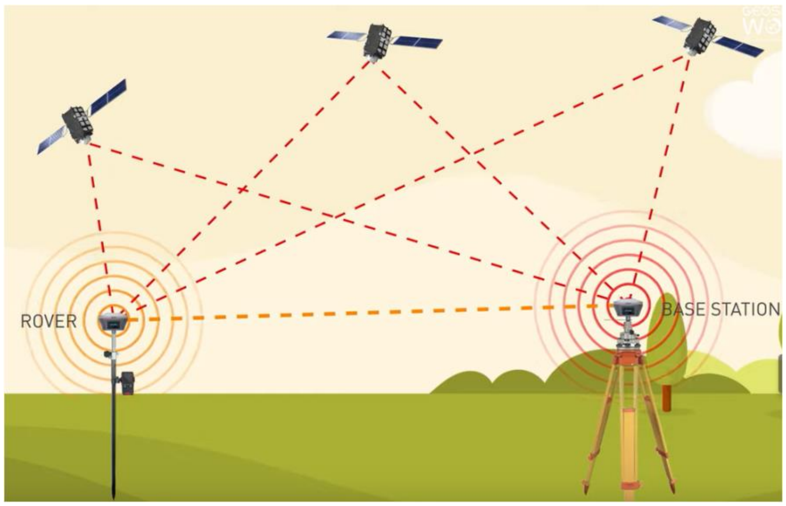

Fig 2.1. ***Real-time kinematic*** (Geospatial World, 2021)

GPS Positioning Modes

Positioning with GPS/GNSS can be performed in the two ways:

1. **Point (absolute) positioning**

Point positioning employs one GPS receiver that uses the measured code pseudo ranges and the broadcast ephemeris to determine the user's position instantaneously, as long as four or more satellites are visible at the receiver. This includes recreation applications and low-accuracy navigation. Recently, PPP was introduced, which uses ionosphere-free linear combinations of carrier-phase and pseudo range measurements along with precise ephemeris and clock products. PPP provides positioning accuracy comparable to that of relative positioning (i.e., centimeter to decimeter accuracy).

2. **Relative positioning**

Relative positioning, on the other hand, employs two GPS receivers simultaneously tracking the same satellites. If both receivers track at least four common satellites, a positioning accuracy level about a few meters to millimeters can be obtained. Carrier-phase and pseudo range measurements can be used in GPS relative positioning, depending on the accuracy requirements. The former provides the highest possible accuracy. GPS relative positioning can be made in either real-time or post-mission.

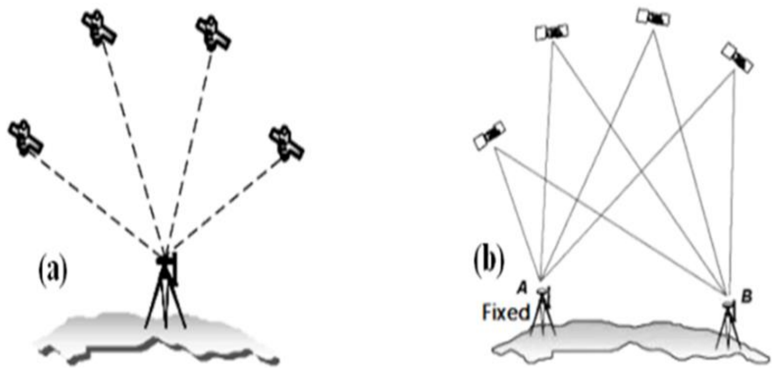

Fig 2.2. Point positioning (a) and relative positioning (b) modes of GNSS measurements

TABLE 2.1: Common GPS/GNSS survey methods

	Survey style	Typical accuracy	Occupation time	Typical applications
	Continuous	< 0.5 cm	Months or more	Crustal deformation, geophysics, reference stations
	Static	0.5cm–2.5cm	Hours to days	Crustal deformation, geodetic control, very long baseline surveys, geophysics
	Rapid Static	1cm – 3cm	Minutes	Short baseline surveys, glaciology
	*Real-time kinematic (RTK)*	+/- 2 cm		For cadastral surveying and topographic survey

2.4 Collecting point positional data

Collecting point positional data involves obtaining accurate location information for specific points on the Earth's surface. This data is used in a variety of applications, including in scientific research, surveying, and mapping. The following discusses some common methods for collecting point positional data. Collecting point positional data can be done using various methods such as GPS, GNSS, and other surveying techniques. The collected data can then be used for various applications such as mapping, construction, and navigation.

The process of collecting point positional data using GPS involves several steps such as setting up the GPS receiver, collecting data at the point of interest, and post-processing the data to obtain accurate coordinates.

Global Navigation Satellite System (GNSS), which includes the Global Positioning System (GPS), is a widely used method for collecting point positional data. GPS receivers can be used to obtain geographic coordinates of an object or location with high accuracy. This method relies on signals from GNSS satellites in orbit around the Earth that are received by the GPS receiver and used to calculate the exact location of the receiver. For more explanation open and learn by op https://youtu.be/6EllxBhZb6E , https://youtu.be/qXrDCuJscoc

Another method for collecting point positional data is through the use of geographic information systems (GIS). GIS software allows users to create digital maps that can be used to collect location information for specific points on the map. This is done by using various tools within the software, such as a cursor or drawing tool, to pinpoint locations on the map and extract their geographic coordinates.

Fig Leica GNSS/GPS for collecting positional data

- **GNSS/GPS data formats**

  GNSS/GPS data formats are the ways that GNSS/GPS data are encoded and transmitted by satellites and receivers. There are different formats for different purposes and applications. Some of the common GNSS/GPS data formats are:

  ✓ **NMEA**: National Marine Electronics Association. A standard format for serial communication between GNSS receivers and other devices. It consists of sentences that start with a $ sign and end with a checksum. Each sentence has a specific type and structure that contains information such as time, position, speed, course, etc. for example, $GPGGA is a sentence that provides time, latitude, longitude, altitude, and quality of fix.

- ✓**RINEX**: Receiver Independent Exchange Format. A standard format for storing and exchanging GNSS observation data between different receivers and software. It consists of header records and data records that contain information such as station name, antenna type, observation types, satellite codes, pseudo ranges, carrier phases, etc. RINEX files usually have extensions such as .obs (observation), .nav (navigation), or .met (meteorological).
- ✓**RTCM**: Radio Technical Commission for Maritime Services. A standard format for transmitting GNSS correction data from reference stations to roving receivers. It consists of messages that contain information such as station ID, differential corrections, integrity flags, network information, etc. RTCM messages are usually transmitted via radio or internet protocols.
- ✓**SP3**: Standard Product 3. A standard format for providing precise GNSS satellite orbit and clock information. It consists of header records and data records that contain information such as epoch time, satellite ID, position coordinates, clock correction, etc. SP3 files usually have extensions such as .sp3 or .eph

2.5 Methods of improving accuracy of GNSS/GPS

The accuracy of GNSS data depends on many factors. For example, the quality of the GNSS receiver, the position of the GNSS satellites at the time the data was recorded, the characteristics of the surroundings (buildings, tree cover, valleys, etc) and even the weather. This page gives a basic introduction as to how GNSS works and describes some of the key issues related to accuracy. While GPS has made navigation easier for many of us, we often assume that the location data received is very accurate and will always be there. In many circumstances, accuracy can still be an issue when satellite systems are obstructed or signals are blocked all together.

To improve accuracy and signaling, a new technique that depends on ground-based systems has been developed.

- You can improve GPS/GNSS accuracy by using techniques such as:

- ✓ Differential GPS
- ✓ GPS augmentation systems and
- ✓ Upgrading to high-quality GPS receivers

- **Multiple GNSS bands:** With respect to improving position accuracy, to have multiple signals at different frequencies transmitted from the satellite.
- **Terrestrial accuracy assistance:** Beyond that, there is a system whereby corrections can be generated and transmitted. This is done using reference stations around the globe whose position is known to millimeter levels. While such systems have been in place for some time, they continue to evolve, trading off deployment cost and positioning accuracy. An earlier example of these was the real-time kinetics (RTK) system.

2.6 Validation and recording of GNSS/GPS measurements

GNSS/GPS measurement data validation methods are techniques for detecting and correcting errors in the satellite-based positioning data. Some of the methods are:

- **RAIM (Receiver Autonomous Integrity Monitoring)**: This method checks the consistency of solutions from different combinations of satellite data.
- **DIA (Detection-Identification-Adaptation)**: This method uses statistical testing of the observation residuals
- **Linear combinations or time differences**: This method uses linear combinations of observations or their time differences to estimate cycle slips
- **High-rate kinematic positioning**: This method uses high-rate GNSS observations to detect short-term crustal deformations caused by seismic events.

2.6.1 Validation Test

The area of measured parcel should be determined “by any means proven to assure measurement of quality at least equivalent to that required by applicable technical standard, as drawn up at Community level.

I. Selection of optimal test site

- Landscape: mixed conditions (open horizon, trees, etc.)
- Location: ensure pegs will remain in the ground for the duration of the test
- Comfort of walking: no bulls, no slimy grounds, no wetlands, no obstacles to jump over, etc.

II. Mark the borders

- pegs every 15-20m (max 30m)
- pegs visibility: 9 bright colors, if parcels are overlapping – different colors for different parcels

III. Before data collection

- Operators are familiar with the test site,
- verify the settings of the receivers,
- verify the protocol of the measurements,
- first run – learning process... Be careful!

2.7 Identification of plan scale and contour interval

The contour interval is determined by the scale of the map and the degree of relief of the terrain being represented. On large-scale maps with a lot of topographical detail, the contour interval is usually smaller, while on small-scale maps with less detail, the contour interval is larger. To determine the elevation of each contour line you must first know the contour interval for the map. By using the values of two adjacent index contours, one can easily calculate the contour interval between each line. A contour line is a line drawn on a topographic map to indicate ground elevation or depression. A contour interval is the vertical distance or difference in elevation between contour lines. Index contours are bold or thicker lines that appear at every fifth contour line

Self-Check – 2	Written test

Name………………………………………… ID……………………… Date…….

Directions: Answer all the questions listed below.

I. Matching

	A	B
-----	1. Detection-Identification-Adaptation (DIA)	A. This method uses linear combinations of observations or their time differences to estimate cycle slips
-----	2. Receiver Autonomous Integrity Monitoring (RAIM)	B. uses statistical testing of the observation residuals to identify and remove outliers
-----	3. High-rate kinematic positioning	C. checks the consistency of solutions from different combinations of satellite data
-----	4. Linear combinations or time differences	D. uses high-rate GNSS observations to detect short-term crustal deformations

III. Choose the correct answer from the given alternatives

1. ---- is A standard format for storing and exchanging GNSS observation data between different receivers and software.

   A. NMEA B. RINEX C. RTCM D. SP3

2. Which one is false from the following statement ?
   A. On small-scale maps with less detail, the contour interval is small
   B. On large-scale maps with a lot of topographical detail, the contour interval is small
   C. on small-scale maps with less detail, the contour interval is larger
   D. all

IV. Short Answer Questions

1. What is the difference between static and RTK ?

………………………………………………………………………………………………
………………………………………………………………………………………………

2. What is static survey?

………………………………………………………………………………………………
………………………………………………………………………………………………

3. What are factors affect accuracy of GNSS data?

………………………………………………………………………………………………
…………………………………………………………………………………………

Operation Sheet – 2

2.1. Procedures to Set up of a GPS/GNSS and equipments

A. Tools and Equipments

- GPS/GNSS recievers
- controler
- Tripode
- Pole
- Permanent marker
- Tape

B. Procedures to Set up of GPS/GNSS reciever

1. Assemble and erect the equipment.

At the base:

i. Set the antenna over the ground mark using a tripod, a tribrach, and a tribrach adaptor.
ii. Use the tripod clip to hang the receiver on the tripod.
iii. Alternatively, place the receiver in its base case. Run the antenna cable out of the portal in the side of the base case to the antenna so that the case can stay
iv. closed while the receiver is running.
v. Assemble and erect the radio antenna.

At the rover:

i. Mount the receiver onto a range pole. Power for the receiver is supplied by the
ii. internal battery in the receiver.
iii. Attach the controller to the holder.Connect the controller holder to the range pole.
iv. Connect the controller and the receiver using the appropriate cable to Bluetooth.
v. If you are using an RTK radio survey, connect the controller, receiver, radio

2.2.Procedures to operate GNSS/GPS instruments:

A. Tools and Equipment's

i. GNSS receiver
ii. Battery
iii. Tripod
iv. Pole
v. Software package
vi. Controller device
vii. USB cable

B. Procedures to operate GNSS/GPS instruments

1. Choose a suitable GNSS/GPS receiver and antenna that can receive signals from multiple satellite constellations and frequencies.
2. Choose a suitable controller device that can communicate with the receiver and run the software application for data collection and processing
3. Install the antenna on a stable and secure mount that can provide a clear view of the sky. Avoid any obstructions or sources of interference that may block or degrade the signals.
4. Connect the antenna to the receiver using a coaxial cable. The cable should be as short as possible and shielded from any noise or damage.
5. Turn on the receiver and the controller device and launch the software application
6. Configure the settings according to your needs and preferences. i.e. select the mode of operation, such as single-point positioning, differential positioning, real-time kinematic (RTK), etc.
7. Connect the controller device and the receiver using the appropriate cable or Bluetooth. You may need to pair the devices using a PIN code or scan a QR code.

8. Track the satellite signals and check the status of the signals on the display screen or using a software application on your controller device. You may need to wait for a few minutes until the receiver achieves a sufficient number of satellites and accuracy level.
9. Start collecting GNSS/GPS data for your intended purpose.

LAP Tes-2	**Performance Test**

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 5 hours.

Task 1: Set up GPS/GNSS receivers

Task 2: Operate GNSS/GPS instruments and data collection

LG #16	LO#3- Data collection process
Instruction shee-3	

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Procedures of communicating basic GNSS/GPS software
- Determination of information using GNSS/GPS software
- Designing and measuring data using GNSS/GPS
- Software for data processing

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify procedures of communicating basic GNSS/GPS software
- Recognize determination of information using GNSS/GPS software
- Design and evaluate measurement of data using GNSS/GPS
- Check against organizational requirements
- Complete all the required documentations
- Utilize appropriate software for proper data processing

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet-3

3.1.Procedures of communicating basic GNSS/GPS software

To communicate basic GNSS/GPS software, you can follow these procedures:

A. Ensure that you have all the necessary hardware and software. This includes a GPS receiver, a computer, and a software program that is compatible with your receiver. Make sure that your software is up to date and that you have the latest version.
B. Connect your GPS receiver to your computer using a USB cable or Bluetooth connection. Follow the manufacturer's instructions for connecting your receiver to your computer.
C. Launch your GPS software on your computer. The software will automatically detect your GPS receiver and establish a connection.
D. Configure the software settings. Enter information such as the latitude and longitude of your location, the date and time, and any other relevant parameters.
E. Begin tracking satellites. Once you have established a connection, the software will start tracking satellites and receiving signals. Display GPS data. The software will display basic information such as your latitude and longitude coordinates, speed, heading, and altitude. You can also view maps, charts, and graphs that show your location in real-time or over time.
F. Analyze and export data. Use the software's analysis tools to study your GPS data and identify patterns or trends. You can also export data to other programs for further analysis or presentation.

These steps should help you communicate basic GNSS/GPS software and get started using GPS technology for a variety of applications.

3.2. Determination of information using GNSS/GPS software

Global Navigation Satellite System (GNSS) software is a crucial tool for determining location information using signals from a network of satellites in orbit around the Earth. The most widely used GNSS system is the Global Positioning System (GPS), which provides accurate location data for a variety of applications, including navigation, surveying, and mapping. The determination of location information using GNSS/GPS software involves complex calculations that take into account the movement of the satellites, their positions in space, and the time it takes for signals to travel from the satellites to the receiver. Specialized software is required to process the raw satellite data and generate accurate position information. The use of GNSS/GPS software has become increasingly essential in a variety of industries, including agriculture, construction, transportation, and surveying. By providing accurate and reliable location information, these tools help businesses and organizations make informed decisions that can lead to increased efficiency and productivity. There are a variety of different types of GNSS/GPS software available, each with its own set of features and capabilities. Some common examples include mapping software, surveying software, and software for tracking and monitoring movement. One important thing to keep in mind when using GNSS/GPS software is that accuracy can be affected by a variety of factors, including the strength of the GPS signal, the number of satellites being used, and any interference from nearby objects or sources of radio noise.

3.3. Designing and measuring data using GNSS/GPS

Designing and measuring data using GNSS/GPS involves the collection and analysis of location-based data to create accurate maps and survey information that can be used in a wide variety of applications. The use of GNSS/GPS technology has revolutionized the way we gather and analyze data, making it easier and more efficient to collect and process location-based information.

One important aspect of designing and measuring data using GNSS/GPS is ensuring that the raw data collected is accurate and reliable. This is accomplished by using specialized equipment and software that is designed to process the signals received from GNSS/GPS satellites.

Measuring data using GNSS/GPS involves the use of survey-grade equipment such as receivers, data collectors, antennas, and other accessories that are designed to provide highly accurate data. During the survey process, measurements are taken at various points in the area being surveyed, and these measurements are used to create a digital map or other representation of the area. Once the data has been collected, it can be processed and analyzed using specialized software that is specifically designed for GNSS/GPS analysis. This software can be used to analyze the quality of the data collected, as well as to create 3D models or other representations of the area being surveyed.

3.4.Software for data processing

Advanced GNSS data processing software are programs that allow you to perform complex and precise analysis of GNSS data, such as GNSS/INS integration, multi-GNSS and multi-frequency positioning, and error modeling. Some examples of advanced GNSS data processing software are:

1. **Leica Infinity**: The Bridge between field and office. It is designed to manage, process, analyze and quality check all field survey measure data, including total stations, digital levels, GNSS and UAVs[1].
2. **Leica Captivate**: Immersive 3D field software to capture and manage data[1].
3. **Leica SmartWorx Viva**: Field software for any application[1].
4. **Spark Fun Learn**: A tutorial that teaches you the basics of GPS and how to use a GPS module with a computer.
5. **Trimble TDC650**: A high-performance GNSS handheld receiver for GIS professionals and surveyors

6. **GINav**: A MATLAB-based software for the data processing and analysis of a GNSS/INS integrated navigation system. It provides a user-friendly graphical user interface (GUI) and a visualization tool for solution presentation and error analysis[1].
7. **GIPSY-OASIS II**: A software package developed by Jet Propulsion Laboratory (JPL) that supports precise point positioning (PPP) using data from multiple GNSS constellations and frequencies[2].
8. **RTKLIB**: An open-source software package for real-time and post-processing of RTK and PPP using standard and precise GNSS products[2].
9. **Bernese**: A commercial software package developed by the Astronomical Institute of the University of Bern (AIUB) that supports high-precision GNSS data processing with various models and algorithms[2].

https://youtu.be/Hj6SOqwHCmo

Self-Check – 3	**Written test**

Name…………………………………………… ID………………………… Date…….

Directions: Answer all the questions listed below.

II. Short Answer Questions

1. List and describe advanced GNSS data processing softwares

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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2. What is GNSS?

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………………………………………………………………………………………………

3. What are the equipment involving to Measure data using GNSS/GPS

………………………………………………………………………………………………………
………………………………………………………………………………………………………
…….

Operation Sheet -3

3.1 Procedures to communicate basic GNSS/GPS software:

E. Tools and Equipments

I. GNSS Reciever
II. Tripod
III. Software package
IV. Data collector / tablet
V. USB cable

F. Procedures to communicate basic GNSS/GPS software

1. **Choose a suitable software package** that meets your needs and supports your hardware and operating system. Some examples of open-source GNSS/GPS software and libraries are RTKLIB**,** GNSS-SDR**,** and GINav etc.
2. Download and install the software according to the instructions provided
3. Connect your GNSS/GPS receiver to your computer and configure the software to access the data stream from the receiver.
4. Run the software and start processing the GNSS/GPS data. Depending on the software, you may be able to perform different types of positioning methods, such as single-point positioning, differential positioning, precise point positioning, etc. You may also be able to visualize the results or save them to a file for further analysis.

3.2 Procedures to Process GNSS/GPS data using Bernese

A. Tools and Equipment's

I. Software package (bernese)
II. GNSS/GPS raw data file
III. USB cable
IV. Computer

B. Procedures to Process GNSS/GPS data using Bernese

I. Prepare the data: Ensure that the raw GNSS/GPS data files are in the correct format and include all required information such as receiver and antenna information, observation types, and station coordinates.
II. Convert the raw data files into RINEX format: This format can be read by most GNSS processing software, including Bernese.
III. Determine the reference frame: Select the reference frame or datum for your data based on your regional location and requirements.
IV. Set up Bernese configuration files: Using the included Bernese Configuration File Editor, set up the configuration files to match your specific GNSS receiver and data parameters.
V. Run preprocessing and quality control: Run the preprocessing program to ensure the data free from errors or abnormalities.
VI. Run Bernese processing: Run the Bernese-processing program to generate position solutions and other relevant data outputs based on your specific requirements.

VII. Analyze results: Use specialized software to analyze the output files generated through the processing stage. This will often include maps, plots, accuracy assessments, and other data visualizations.

https://youtu.be/pxLtkbwFHdw

LAP Tes-3	Performance Test

Name………………………………. ID……………………………..

Date…………………………………….

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **10** hours.

Task 1: Communicate basic GPS receivers with computer by using Basic GNSS/*GPS software*.

Task 2: Process GNSS/GPS data using Bernese

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