TRAINING MODULE

FOR

CADASTRAL SURVEYING AND MAPPING

LEVEL IV

BASED ON TVET OCCUPATIONAL STANDARDS



Ministry of Urban and Infrastructure, Urban Revenue Reform Project Office (URRPO)
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List of Abbreviations

2D	Two Dimension
3D	Three Dimension
4M1E	Man, Machine, Method, Material and Environment
5S	Sort, Set in Order, Shine, Standardize, Sustain
5W1H	What, Why, When, Where, Who and How
ADR	Alternative Dispute Resolution
AS	Antispoofing
BoM	Bill Of Material
C/A	Coarse Acquisition
CAD	Computer-Aided Design
CCP	Critical Control Points
CCTV	Closed-Circuit Television
CIRS	Celestial Intermediate Reference System
CRPRS	Cadastre and Real Property Registration System
DEM	Digital Elevation Model
DGPS	Differential Global Positioning System
DMD	Double Meridian Distances
DoD	Department of Defense
DOP	Dilution of precision
DRMS	Distance Root Mean Square
EDM	Electronic Distance Measurement
EFQM	European Foundation for Quality Management
ESSGII	Ethiopian Space Science Geospatial Information Institute
ELADM	Ethiopian Land Administration Domain Model
EMA	Ethiopian Mapping Agency
ERDAS	Earth Resources Data Analysis System
ESD	Electro-Static Sensitive Device
ESRI	Environmental Systems Research Institute
FDRE	Federal Democratic Republic of Ethiopia
FIG	International Association of Geodesists
FOC	Full Operational Capability
GAAP	Generally Accepted Accounting Principles

GCP	Ground Control Point
GDOP	Geometric Dilution of Precision
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GLONASS	GLObal NAvigation Satellite System
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HDOP	Horizontal Dilution of Precision
HRM	Human Resource Management
HW	Hardware
INSA	Information Network Security Agency
IOV	In-Orbit Validation
IS	Information System
ISO	International Organization for Standardization
ISS	Inertial Surveying Systems
KPT	Kaizen Promotion Team
LAGT	Landholding Adjudication Grievance Handling Tribunal
LIS	Land Information Systems
MD	Meridian Distances
MoUDC	Ministry of Urban Development and Construction
MSE	Micro And Small Business
NAVSTAR	Navigation System using Timing And ranging
NGO	Non-Governmental Organizations
OHS	Occupational Health and Safety
OTF	On The Fly
P	Precision
PDCA	Plan, Do, Check, Act
PDOP	Position Dilution of Precision
PMB	Performance Measurement Baseline
POM	Production/Operations Management
PPP	Precise Point Positioning
PR	Public Relation
PRN	Pseudorandom Noise

PVT	Position, Velocity and Time
QAP	Quality Assurance Plan
QC	Quality Control
QCC	Quality Control Circles
RCA	Root Cause Analysis
RINEX	Receiver Independent Exchange
RTK	Real Time Kinematics
SA	Selective Availability
SAR	Systematic Adjudication and Registration
SGO	South Geomatics Office
SMART	Specific, Measurable, Achievable, Realistic and Time-Bounded
SOP	Standard Operation Procedure
SW	Software
TDOP	Time Dilution of Precision
ULRIA	Urban Land Registration and Information Agency
UNECE	United Nation Economic Commission for Europe
UTM	Universal Transverse Mercator
VDOP	Vertical Dilution of Precision
WBS	Work Breakdown Structure
WCB	Whole Circle Bearing

Preface

The overall objective of TVET is to create a competent, motivated, adaptable, and innovative workforce in Ethiopia contributing to poverty reduction and social and economic development through facilitating demand-driven and outcome based, high quality technical and vocational education and training, relevant to all sectors of the economy, at all levels and to all people.

The reformed TVET-System is an outcome-based system. It utilizes the needs of the labor market and occupational requirements from the world of work as the benchmark and standard for TVET delivery. The requirements from the world of work are analyzed and documented – taking into account international benchmarking – as Occupational Standards (OS).

In the reformed TVET-System, Curriculum and Learning Material play an important role with regard to quality driven TVET-Delivery. Curriculum and Learning Material help to facilitate the learning process in a way, that trainees acquire the set of occupational competences (skills, knowledge, and attitude) required at the working place and defined in the Occupational Standards (OS) and Curriculum.

This Learning Material is designed to equip the trainees with the necessary knowledge, skills, and attitude of the learners to the standard required by the occupation. The contents of this Learning Material are in line with the Occupational Standard (OS) and Curriculum. This training material is prepared in accordance with the TVET Occupational Standard (OS) and curriculum for Level **IV** on **Cadastral Surveying and Mapping** occupation in land and land related fields.

The prime objective of these training materials is to facilitate the learners with the identified competences specified in the OS. It comprises of **12** competencies which includes the following areas: Conduct GNSS Data Collection, Computation and Set-out Survey, Manage Control Survey Works, Perform Adjudication for Legal Cadaster, Conduct Cadastral Survey project, Develop Subdivision Survey Design, Produce Block Diagram, Perform Aerial Triangulation and DTM Generation, Produce Ortho-photo Maps, Perform 2D and 3D Feature Extraction Undertake Field Verification and Completion, Assess Applications for Legislative Compliance, and Undertake Cadastral Surveying Work Improvement.

CHAPTER ONE: CONDUCTING ADVANCED GNSS DATA COLLECTION, COMPUTATION AND SET-OUT SURVEY

1.1 Introduction

Dear trainee! This chapter deals with the concept of conducting and performing Global Navigation Satellite System (GNSS) computations. GNSS is constellations of satellites orbiting over the earth's surface and continuously transmitting signals that enable users to determine their position. Satellite navigation is a system that uses satellites to provide autonomous geo-spatial positioning. GNSS data can produce high-accuracy, high-resolution measurements in common reference frames. Positioning with GNSS can be conducted in point and relative modes. The most important of using GNSS is that inter-visibility between the points is not required and it provides user defined coordinates in a digital format. This means that extensive traversing is eliminated, clear-cutting is not required, and intervening private properties is avoided.

The accuracy obtained with GNSS is consistent over the entire network; such accuracy is lacked by conventional surveying methods. Likewise, with GNSS, one reference station can support an unlimited number of rover receivers. A number of governmental and private organizations have reported that the use of GNSS in cadastral surveying is cost-effective. It requires the ability to interpret and analyze information and apply technical skills, in a team environment, often in the lead role. Besides, positioning with static GNSS method does not give the result on real-time mode. It generally collects and stores the raw GNSS data in a proprietary format, which may need to be translated into a different format for data post-processing or data sharing. This gives an opportunity to be flexible if the surveyor misses or commit mistake in the field.

1.2 Learning Objectives

After completing this chapter, you will be able to:

- Explain the importance of GPS Mission Planning,
- Describe the preparation phase and how to conduct GNSS measurement,
- Establish control networks using GNSS and collect detail data,
- Identify and Describe positioning modes,
- Discuss the concepts of GNSS data processing and computation,



Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts of GNSS and GNSS data processing.

_____

_____

_____

_____

1.3 Plan and Prepare for Global Navigation Satellite System (GNSS)

GNSS stands for Global Navigation Satellite System, and is the standard generic term for satellite navigation systems that provide autonomous geo-spatial positioning with global coverage. Examples of GNSS include Europe's Galileo, the USA's Navigation. Signal Timing And Ranging (NAVSTAR) Global Positioning System (GPS), Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) and China's BeiDou Navigation Satellite System.

The performance of GNSS is assessed using four criteria:

- **Accuracy**: the difference between a receiver's measured and real position, speed, or time;
- **Integrity**: a system's capacity to provide a threshold of confidence and, in the event of an anomaly in the positioning data, an alarm;
- **Continuity**: a system's ability to function without interruption;
- **Availability**: the percentage of time a signal fulfils the above accuracy, integrity, and continuity criteria.

1.3.1 GPS Mission Planning

GPS mission planning has great importance to monitor a survey campaign. It answers questions like:

- When the PDOPs for a station < 8 and > 4 satellites visible?
- When are the best conditions for all of them?
- How many satellites will be visible?

A computed GPS position can vary in accuracy depending on how many and which satellites are used for measurements. The more satellites the GPS receiver can see, the better your accuracy. That is why having 8 visible satellites will usually result in a more accurate

position than only viewing 5. Calculations are needed from at least 4 visible satellites (above a 15-degree elevation mask) for a single point, 3D measurement (latitude, longitude, and height) with time.

Satellite visibility problem is expected more at high altitudes (higher than about 55°) because of satellites constellation. The receiver's free sky window is reduced as a result of the obstruction caused by the high-rise buildings and the trees. Because the satellite geometry varies with time, visibility problem may be taken care by selecting suitable observation time, which is by considering minimum number of visible satellites and maximum DOP value.

There is mission planning software used to identify suitable observation time by providing different types of plots. Sky plot is a diagram that represents the user's sky window by a serious of concentric circles.

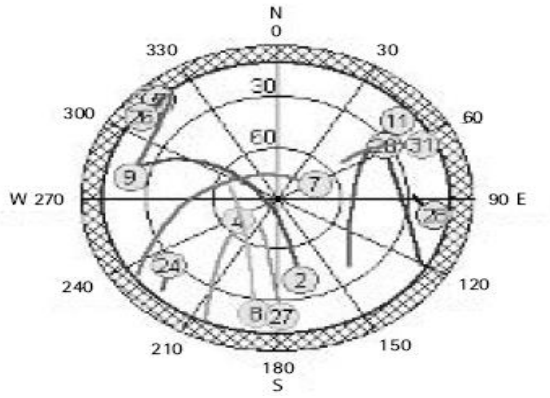


Figure 1: Sky Plot Diagram for Mission Planning

The numbers at the outer circle denote the azimuth; zero means north, 90° is east, 180° is south, 270° is west. Centre of the circles is the zenith (elevation angle 90°) and the outer circle shows elevation 0° (i.e., the horizon). The tracks of all selected visible satellites for the given time span are projected onto this map. Another important plot is the satellite availability plot, which shows the total number of the visible satellites above the user specified mask angle and the satellite geometry plot.

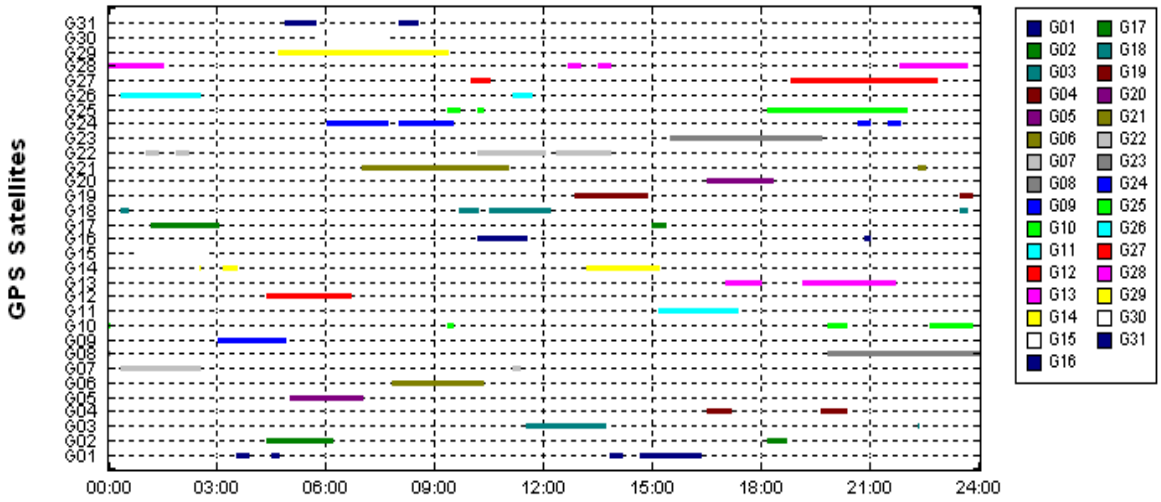


Figure 2: Satellite Visibility Diagram

DOP (Dilution of Precision) is an indicator of the quality of a GPS position. It takes account of each satellite's location relative to the other satellites in the constellation, and their geometry in relation to the GPS receiver. Standard DOPs for GPS applications are PDOP, HDOP, GDOP, VDOP, and TDOP. The most useful DOP is the GDOP, since this a combination of all the factors, vertical, horizontal, 3D and time. The lower the DOP value, the better the satellite geometry.

The satellite orbits used in the planning is based on previously collected GPS data, which must not be too old. Planning also includes the decisions on type and number of personnel and equipment. Mission planning also helps ensure the safety and security of personnel by being aware of hazardous weather, satellite obstacles and etc.

1.3.2 GNSS Applications

The initial purpose of the first GNSS systems (GPS and GLONASS) was military. The first non-military applications of GNSS technology were in surveying and mapping. Today, GNSS is being used for:

Different types of civil applications are:

- **Cadastral Surveying Application**
- **Personal Applications**
- **Road Applications**
- **Aviation Applications**
- **Rail Applications**
- **Maritime Applications**
- **Industry Applications**

In addition to position, GNSS receivers can provide users with very accurate time, by "synchronizing" their local clock with the high-precision clocks onboard the satellites. This

has enabled technologies and applications such as the synchronization of power grids, cellular systems, the Internet and financial networks.

1.4 Conduct the GNSS survey

1.4.1 GNSS Reference System

GNSS (Global Navigation Satellite System) utilizes a reference system to provide accurate positioning information. The reference system used in GNSS is typically based on a geodetic datum, which serves as a framework for defining the Earth's shape, size, and orientation. Two commonly used reference systems in GNSS are:

World Geodetic System (WGS): WGS is a standardized geodetic reference system developed and maintained by the United States Department of Defense. The latest version is called WGS84, which is widely used as the basis for GNSS positioning. WGS84 defines the Earth's shape as an ellipsoid and includes precise models for the Earth's gravity field and geoid.

International Terrestrial Reference Frame (ITRF): The ITRF is a global reference frame developed and maintained by the International Earth Rotation and Reference Systems Service (IERS). It provides a consistent reference system for various geodetic applications, including GNSS. The ITRF is periodically updated to account for changes in the Earth's dynamic behavior and aligns with WGS84.

It's important to note that GNSS receivers use reference stations with known coordinates to calculate accurate positions. These reference stations, equipped with high-precision receivers, continuously monitor signals from multiple GNSS satellites and determine their precise location. The coordinates and timing information from reference stations are used to establish the reference frame and provide corrections or adjustments to improve positioning accuracy for GNSS users.

The recent practice of geospatial data collection, management, and analysis in Ethiopia is in geocentric coordinates of a point defined based on a global datum (WGS84). However, the Adindan clack 1880 datum is the locally known datum for Ethiopia.These systems may be tied to the global reference systems like WGS or ITRF but provide localized or regional coordinate systems based on specific mapping requirements or projections.

1.4.2 GNSS Surveying Parameters

When using GNSS for surveying purposes, several important parameters and considerations come into play. These parameters affect the accuracy and reliability of the surveying results. Here are some key GNSS surveying parameters:

Datum and Map Projection System

Based on the national standard adopted by ESSGI, coordinates shall be calculated in reference to the Grid on UTM projection and zones 36, 37, or 38 depending on the geographic location.

- Projection – Universal Transverse Mercator
- Spheroid/Reference Ellipsoid – Clarke1880 modified
- Local Geodetic Datum – Adindan
- Unit – Meter

Projection Parameters

- UTM Grid Zone – 36, 37, 38 depending up on the geographic location
- Central Meridian – 33°E for zone 36; 39° E for zone 37; and 45° E for zone 38
- False Easting – 500,000 m E
- 4) False Northing – 0 m N
- 5) Scale Factor - 0.9996

Coordinate Transformation Parameters and Coordinate System

The datum transformation parameters provided by ESSGI shall be used for transforming the geodetic coordinates from WGS84 to Adindan geodetic datum. In cadastral surveying and mapping activities the transformed coordinates shall be stated in Cartesian coordinate system; The parameters to be used are:-

Semi-major axis (a): 6378249.145metre

Semi-minor axis (b): 6356514.9667metre

Ellipsoidal flattening (f):1/293.466307656

Translational transformation parameters are:-

$\Delta x = -162$ $\Delta y = -12$ $\Delta z = 206$

1.4.3 GPS Positioning Modes

Positioning with GPS can be performed by either of two ways: point positioning or relative positioning. GPS point positioning employs one GPS receiver that measures the code pseudoranges to determine the user's position instantaneously, as long as four or more satellites are visible at the receiver. The expected horizontal positioning accuracy from the civilian C/A-code receivers has gone down from about 100m (2 drms) when selective availability was on, to about 22m (2 drms) in the absence of selective availability. GPS point positioning is used mainly when a relatively low accuracy is required. This includes recreation applications and low accuracy navigation.

GPS relative positioning, however, employs two GPS receivers simultaneously tracking the same satellites. If both receivers track at least four common satellites, a positioning accuracy level of the order of a sub-centimeter to a few meters can be obtained. Carrier-phase or/and pseudorange 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 modes. GPS relative positioning is used for high-accuracy applications such as surveying and mapping, GIS, and precise navigation.

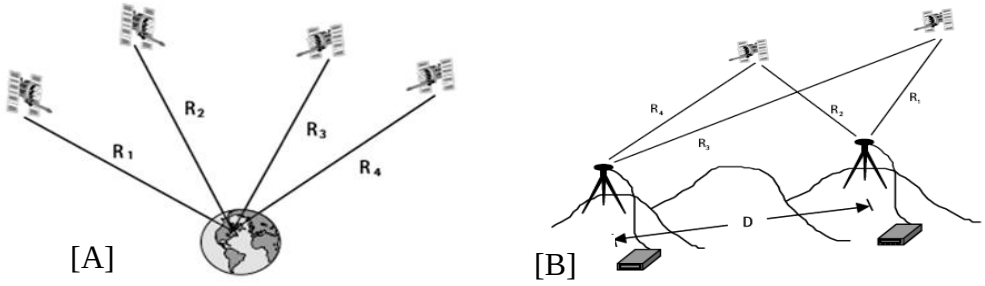


Figure 3: Point Positioning (A), Principle of Relative Positioning(B)

A) Static GPS Surveying

Static GPS surveying is a relative positioning technique that depends on the carrier phase measurements. The process begins with one receiver called the base receiver being located on an existing control station, while the remaining receivers called the roving receivers occupy stations with unknown coordinates. The base receiver can support any number of as long as a minimum of four common satellites are visible at both the base and the remote sites.

In principle, this method is based on collecting simultaneous measurements at both the base and remote receiver for certain period of time, which, after post processing yield the coordinate of the unknown point. The observation, or occupation, time varies from 20 min to few hours depending on the distance between the receivers (the baseline length), the number of satellites, and the satellite geometry. The measurements are usually taken at recording interval of 15 or 20 seconds, or one sample measurements every 15 or 20 seconds.

After completing the field measurements, the collected data is downloaded into computers for processing. Different processing methods can be adopted depending on user requirements, the baseline length, or other factors. For example, for baseline length of, say, 15 or 20 km, resolving the ambiguity parameters would be a key issue to ensure a high-precision positioning. In contrast if the baseline is relatively long, the option of ionosphere free linear combination may be selected to remove the majority of the ionosphere errors.

Static GPS surveying with carrier phase measurement is the most accurate positioning technique. This is mainly due to the significant change in satellite geometry over the long observation time span. Although both single and dual frequency receivers can be used for static positioning, the latter is often used especially for baselines exceeding 20km. The expected accuracy of geodetic quality receiver is typically 5mm+1ppm (rms) that is for 10 km baseline, for example, the expected accuracy is 1.5cm.

B) Rapid Static GPS Surveying

This procedure is similar to static survey, except that one receiver always remains on a control station while the others are moved progressively from one unknown point to the next during the entire observation session. The observation time or the occupation time for rapid static surveying is relatively small. The rover receiver remains stationary over the unknown point only for short period of time then moves to another unknown point whose coordinates are sought. Similar to static GPS surveying, the base receiver can support any number of rover receivers.

This method is suitable when the survey involves a number of points in the vicinity which are within a distance of about 15 km. The survey starts by setting the base receiver over a known point and setting the rover receivers over unknown points. The base receiver remains stationary and collects data continuously. The rover receiver collects data for about 2 to 10min depending on the distance to the base receivers and the satellite geometry. Once the rover collects the rover receiver has collected data, the user moves to the other unknown

point and repeats the procedures. It can be noted that rover receiver may be turned off while moving to the other unknown point. As the occupation time for the rover receiver is relatively shorter, the recording interval for the data is reduced to 5 seconds.

After collecting and downloading the field data from both receivers to computers, the GPS data is processed. Depending on whether enough data is collected, the processing may yield fixed solution which indicates that the ambiguity is fixed to integers. Otherwise float solution is obtained which means that the processing is unable to fix ambiguity parameters to integer values (only real valued ambiguity parameters are obtained). This problem occurs when the collected data is insufficient.

C) Stop and Go GPS Surveying

Stop and Go is another carrier phase based relative positioning technique. In this method, the antenna is mounted for a short time (seconds to minutes) on the survey marker that is to be coordinated. The required stop-time comes rather from the need to identify the station and to mount the antenna pod vertically than from the need to gather sufficient GPS data at the station. The trajectory between stations is usually of no interest in this type of surveying.

It employs two or more receivers, one base receiver that remains stationary over the known point and one or more rovers. The rover receiver travels between the unknown points, makes a brief stop at each point to collect the GPS data. The data is usually collected at one to two seconds recording rate for a period of 30 seconds per each stop. Similar to the previous method, the base receiver can support any number of rover receivers. This method is suitable when the survey involves large number of unknown points located in vicinity (within up to 10-15km) of known point.

The survey starts by first determining the initial integer ambiguity parameters, a process known as receiver initialization. Once the initialization is performed successfully, centimeter-level positioning accuracy can be obtained instantaneously. This is true as long as a minimum of four common satellites simultaneously tracked by both the base and the rover receivers at all the time. If this condition is not fulfilled at any moment during the survey, the initialization processes must be repeated to ensure centimeter level accuracy.

Following receiver initialization, the rover moves to the first unknown point and after collecting data for about 30seconds, the rover moves, without being switched off, to the

second unknown point and the procedures are repeated. It is important that at least four satellites are tracked even while the rover is moving.

A special case of Stop and Go GPS surveying is known as kinematic GPS surveying. Both methods are the same in principle. However; the latter one requires no stop at unknown stations. The positional accuracy of Stop and Go GPS surveying is higher than kinematic GPS surveying.

D) RTK GPS Surveying

RTK GPS is a carrier phase-based relative positioning technique. However, this method yields the coordinates of the unknown points in real time. It employs two or more receivers, one base receiver that remains stationary over the known point and one or more remote receivers (rovers), simultaneously tracking same satellites. This method is suitable when the survey involves large number of points located in the vicinity and the coordinates of the unknown points are required in real time, hence the name Real Time Kinematics (RTK) GPS surveying. This is method also requires the line of sight, propagation path, to be unobstructed. As the ease of use and it real time solution, this method is preferred to other methods by many users.

In RTK method, the base receiver remains stationary over the known point and is attached to the radio transmitter. The rover receiver is also attached to the radio receiver. Similar to the conventional kinematics GPS survey, the data recording interval is 1Hz. The base receiver measurement and coordinates are transmitted to the rover receivers through communication link (radio). The built-in software at the receiver combines and processes the measurements at both the base and rover receiver to obtain the rover coordinates.

The initial integer ambiguity parameters are resolved using a method known as On The Fly (OTF) ambiguity resolution technique. Once the ambiguity parameters are fixed to integer values, the receiver will display the receiver coordinates right in the field, no post-processing is required. The expected positional accuracy is 2-5cm (rms). This can be improved by increasing the occupation time for short period of time.

Under same condition the positional accuracy of kinematics GPS surveying is higher than real time kinematics as the time stamp in base and rover receiver match perfectly for conventional kinematics surveying while for real time kinematics there is a latency or delay.

E) Real Time DGPS

Real time differential GPS is a code based relative positioning technique that employs two or more receivers simultaneously tracking same satellites. This method is used when a real time meter level accuracy is required. The method is based on the fact that the GPS errors in the measured pseudorange are essentially similar for baseline length of few hundred kilometers.

As before the base receiver remain stationary over the known point. The built-in software in the base receiver uses the precise coordinate of the base receiver and the coordinates of the satellites, derived from navigation messages, to compute the ranges to each satellite in view. The software further takes the difference between the computed pseudoranges and the measured code pseudorange to obtain the pseudorange error (DGPS correction). These corrections are transmitted, in standard format, to rover receivers through communication links. The rover is then applying the DGPS correction to correct the measured pseudoranges at the rover. Finally, the corrected pseudoranges are used to obtain the rover coordinate.

The accuracy obtained using this method varies between a sub meter and 5meters, depending on the base rover distance, the transmission rate of the DGPS correction, and the performance of C/A code receiver. High accuracy is obtained for short base rover distance.

	Discuss the general types of GPS receivers.

1.5 Other Satellite Navigation Systems

1.5.1 GLONASS

The GLONASS (GLObal NAvigation Satellite System) is nearly identical to GPS. GLONASS satellite-based radio navigation system provides the positioning and timing information to users. It is operated by the Ministry of Defense of the Russian Federation.

GPS and GLONASS systems may be integrated to improve geometry and positioning accuracy, particularly under poor satellite visibility, such as in urban areas. There are, however, two problems with GPS/GLONASS integration. The first one is that both GPS and GLONASS systems use different coordinate frames to express the position of their satellites. GPS uses the WGS 84 system, while GLONASS uses the Earth Parameter System 1990 (PZ-90) system. The second problem with the GPS/GLONASS integration is that both systems use different reference times. The offset between the two-time systems changes slowly and

reaches several tens of microseconds. One way of determining the time offset is by treating it as an additional variable in the receiver solution.

1.5.2 Chinese Regional Satellite Navigation System (BeiDou or Compass System)

The BeiDou Navigation Satellite System is developed to provide two kinds of service: an open service, which is designed to provide positioning accuracy within 10 meters, velocity accuracy within 0.2 meters per second and timing accuracy within 50 nanoseconds; and an "Authorized Service," which will offer "safer" positioning, velocity, timing communication services, and integrity information for authorized users.

The system has followed the development roadmap of starting with regional services first and expanding to global services later. A three-step development strategy has been taken. Phase I is BeiDou Navigation Satellite Demonstration System, which was been established in 2000. Phase II is BeiDou Navigation Satellite (regional) System to provide service for areas in China and its surrounding areas from 2012. Phase III is BeiDou Navigation Satellite System to be established completely and provide global service by 2020. The system Service coverage area is from 84°E to 160°E; and from 55°S to 55°N with positioning accuracy of 25 meters horizontally and 30 meters vertically, accuracy of velocity 0.4m/s and timing accuracy of 50 ns.

1.5.3 Galileo

Galileo is Europe's initiative for a state-of-the-art global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. Galileo will be not too different from the other GNSS parts, i.e., modernized GPS and GLONASS. It will provide autonomous navigation and positioning services, but at the same time will be interoperable with the two other global satellite navigation systems; the GPS and GLONASS.

A user will be able to take a position with the same receiver from any of the satellites in any combination. By providing dual frequencies as standard, however, GALILEO will deliver real-time positioning accuracy down to the meter range. It will guarantee availability of the service under all, but the most extreme circumstances and will inform users within seconds of a failure of any satellite. This will make it appropriate for applications where safety is vital, such as running trains, guiding cars, and landing aircraft. The combined use of GALILEO

and other GNSS systems can offer much improved performance for all kinds of users worldwide.

Galileo's first launch was made on 21 October 2011 by launching the first two of four operational satellites designed to validate the Galileo concept in both space and on Earth. Two more followed on 12 October 2012. This In-Orbit Validation (IOV) phase has been followed by additional Full Operational Capability (FOC) satellite launches. Four pairs of FOC satellites have so far been launched by Soyuz from French Guiana, on 22 August 2014, 27 March 2015, 11 September 2015, and 17 December 2015. The coordinate reference frame used for Galileo is the Celestial Intermediate Reference System (CIRS).

1.6 GNSS Data Processing

For many applications, such as airborne survey, corrected GNSS positions are not required in real-time. For these applications, raw GNSS satellite measurements are collected and stored for processing post-mission.

During post-processing, base station data can be used from one or more GNSS receivers. Multi-base processing helps preserve high accuracy over large project areas, which is a common occurrence for aerial applications. Depending on the project's proximity to a permanently operating GNSS network, base station data can often be freely downloaded, eliminating the need for establishing your own base station(s). Moreover, it is possible to process without any base station data through PPP, which utilizes downloaded precise clock and ephemeris data.

Post-processing applications offer a great deal of flexibility. Applications can involve stationary or moving base stations, and some support integration with customer or third-party software modules. Post-processing applications may be designed to run on personal computers that are accessible through simple-to-use graphical user interfaces.

	Discuss GNSS Data Processing.

1.7 Main Processing

In main processing procedures, it will now be assumed that all the data is clean, and free of cycle slips. The next step is the phase data processing in single baseline mode. The main steps of a baseline solution using phase data are:

A) Set Up

The set-up step includes the following tasks:

- **Preparation:** a priori coordinates, ephemeris file to be used, baseline to be processed (if more than one observed in a session), data file names, antenna height and offsets, etc.
- **Selection of parameters:** this is dependent on the baseline to be processed, the ambiguity model used in the software, differencing scheme adopted, etc.
- **Selection of options:** a priori standard deviation of parameters and observations, criteria for data rejection, data reduction methods, whether correlations are to be considered, elevation cutoff, satellites to be excluded from solution, differencing strategy to be used, etc.

B) Processing the data and get solution

In such case, there are three types of phase solutions:

- Triple Difference Solution.
- Double Difference Solution (Ambiguity-free)
- Double Difference Solution (Ambiguity-fixed)

There are two types of double-difference phase data solutions:

- **Ambiguity-free solution (Ambiguity- float solution):** in which the parameters to be estimated are the non-reference coordinates and the ambiguity parameters. It is generally the first step, after this solution the values of the ambiguity parameters (which theoretically should be integers) may be close to integer values (but not exactly due to the presence of residual biases such as atmospheric refraction, orbit error, or multipath.
- **Ambiguity-fixed solution:** in which some or all the ambiguity parameters have been, resolved to their integer values. Such a solution is very strong as it only contains the station coordinating parameters (hence it is equivalent to processing unambiguous and precise ranges)**.** Note that it may not always be possible to attempt the ambiguity fixed solution.

C) Outputs

The main processing gives the following outputs. These outputs used for reporting the work and the supervisors to evaluate the overall data collection and processing works.

- Coordinate parameters as Cartesian (x, y, z) or geodetic (ϕ, λ, h) values in the WGS84 datum, baseline components, for ground mark and antenna centers.
- Estimated standard deviation and correlation matrix or variance covariance matrix of parameters.

South Geomatics Office (SGO), Leica Geo Office and Spectrum survey are the widely known and used GNSS data processing software. It is recommended to convert the data in to RINEX format to process the data in any given software.

1.8 Real Time vs. Post-processing

Table 1: Real Time Vs Post-Processing

Real time	**Post processing**
• Results are almost instantaneously • Accuracy measures (or quality control) are also obtained in the field • Higher productivity and Important for RTK • Only enough GPS data to obtain a fixed solution is collected. • Also saves the time spent in data processing • In some cases, input parameters may contain some errors and this results in erroneous computed rover coordinates which cannot be completely corrected	• Results are processed not in the field • More flexibility in editing and cleaning of the collected GPS data • More accurate results • No accuracy degradation due to data latency • Relatively unobstructed line-of-sight requirement, are avoided • In some cases, input parameters may contain some errors and this results in erroneous computed rover coordinates which can be corrected

1.9 Summary

Dear trainee! GNSS are the global satellite-based navigation and positioning systems which including the GPS, GLONASS, Galileo, Beidou and other systems. Its primary mission is to provide passive, real-time, 3-D positioning, navigation, timing and velocity data for land, air, and sea-based strategic and tactical forces operating anywhere in the world.

Positioning with GPS requires some understanding of the GPS signal structure and how the measurements can be made. The basic principle behind how GPS determines a position of point on the earth using the distances from a point on the Earth (a GPS receiver) to three GPS satellites and the satellite locations by simply applying the well-known concept of resection. Positioning with GPS can be performed by either point positioning or relative positioning.

The GNSS positioning for receiver's position is derived through the calculation steps or algorithm. In essence, a GNSS receiver measures the transmitting time of GNSS signals emitted from four or more GNSS satellites (giving the pseudo-range) and these measurements are used to obtain its position (i.e., spatial coordinates) and reception time. For many applications, such as airborne survey, corrected GNSS positions are not required in real-time. For these applications, raw GNSS satellite measurements are collected and stored for processing post-mission. Post-processing applications offer a great deal of flexibility. Applications can involve stationary or moving base stations, and some support integration with customer or third-party software modules.

After the field tasks completed, post-processing shall be conducted to get precise positions of the points especially for static positioning techniques. The initial ambiguity has to be determined with appropriate techniques to exploit the full accuracy potential of the GPS carrier phase measurements. The best and simplest possibility for determining the ambiguity would be the use of additional frequencies or signals. In main processing procedures, all the data shall be clean, and free of cycle slips. The next step is the phase data processing in single baseline mode. The setup, processing and output phases are the three phases of the main processing.

1.10 Self-Check Exercises



Short Answer Items

Instruction: Give short, brief, and precise answer for the following questions.

1) Why GNSS preferable than classical method of surveying?
2) How many GPS satellites are required for 3D positioning? Why?
3) List and explain the GPS positioning modes.
4) What are the procedures in GPS planning?
5) Explain the major differences between GPS, GLONAS and Galileo.
6) Discuss the basic concepts of GNSS data processing?
7) What is the difference between real-time and post-processing?
8) What are the outputs of the processing?
9) List the software’s that used for post-processing?

CHAPTER TWO: MANAGING CONTROL SURVEY WORKS

2.1 Introduction

Dear trainee! This chapter deals with the concept of managing control survey works. Before any survey can yield useful results, it is necessary to establish a set of fixed stations whose positions relative to one another are known usually to a higher accuracy than will be needed in the final result. A set of such stations is known as a control network.

Control surveys establish precise horizontal and vertical positions of control points or networks which gives an opportunity to originate or check the project. Triangulation, traversing, trilateration, and combinations of these basic approaches are the traditional horizontal control surveys methods. In addition, astronomical observations can be made to determine azimuths, latitudes, and longitudes. Rigorous photogrammetric techniques have also been used to densify the control points in a given area. Presently, the Global Navigation Satellite Systems (GNSS) surveying become preferable for large area surveying because of several advantages of using the satellite base positioning and navigation approaches.

2.2 Learning Objectives

After completing this chapter, you will be able to:

- Evaluating the existing Control Points
- Identify the criteria for assessing and validating existing GCP
- Identify resources and personnel required to manage control points,

Dear trainee! Before reading the following section, take ten minutes and try to explain the basic concept of control surveying and its importance for cadaster.

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2.3 Evaluate Existing Control Points

A large survey site requires many sets of measurement and calls for methods of tying these measurements together to conduct an accurate survey. A control points provides a framework

of survey, whose relative positions, in two or three dimensions, are known to prescribe degrees of accuracy. The areas covered by these points may extend over whole country and form the basis for the national maps of the country. Alternatively, the area may be relatively small, encompassing a construction site for which a large-scale plan is required.

Under the Proclamation, ESGII is mandated to collect, transform, generate, store, and disseminate the following sets of fundamental geospatial data sets in Ethiopia:

- Geodetic Control Networks (Ground Control Points)
- Remotely Sensed Imagery (Aerial Photographs, Satellite Imagery)
- Topographic (Base) Maps
- Thematic Maps
- Hypsography (Contours, DEM, Spot Heights, etc.)
- Administrative Boundaries (International, Regional, Zonal and District)
- Geographic Names
- Atlas (National, Regional, etc.) and others

In Ethiopia, the ground control points (GCPs) classified as zero, first, second and third order control points throughout the country. The first three orders GCPs established by EGII and the remaining by respective and others.

Ground Control Points (GCP) shall be required for the survey projects as a framework of survey. A visual inspection of these ground control station should be made in order to verify the markings on the cap and whether the monument has been disturbed. Any discrepancies or disturbances should be noted. To verify the position of a horizontal control station, observations and measurements to the reference marks should always be made. The observations to the reference marks should generally agree within stated accuracy of the reference ties.

Due to the earth internal movement; these points may not be stable. Consequently, the positional accuracy of assessed control points shall be validated in accordance with the existing standards established by EGII. For instance, the angular and linear misclosures committed in cadastral surveying measurements shall comply with the following traverse standards (*See Table 2*).

Table 2: Traverse Standard

	First Order	**Second Order**	**Third Order**
Angle	2” √N Or 1” per Station	10” √N Or 3” per Station	15” √N Or 5” per Station
Linear	1:35,000	1:15,000	1:7,500

N is number of stations

Activity	Discuss the requirement for control point evaluation .

Every new control station to be established shall be referenced to three or more second order national reference systems in a local datum or geodetic points situated within 15 km from the new stations.

1) Every new control station shall be free from GPS error causing physical factors like from significantly reflective surfaces, radio and electromagnetic radiation transmission sources and some other factors that can cover the GPS horizon.
2) Every new GPS station shall be fixed by at least three independent base lines obtained from not less than two observation sessions.
3) While establishing new control points all GPS base lines used for computing solutions shall be independent base lines.
4) All control stations in the cadastral measurements shall have one or more independent foresight stations at a distance not greater than 300 meters.
5) There shall be a minimum of one control station in 1 km x 1 km area of the cadastral project for flat terrain. For rugged, however, the number of control station could be higher. This implies in order to increase the accuracy of the projection.
6) All control network stations shall be marked by tablets of some non-corrodible metal set firmly in posts of concrete.
7) All permanent control station shall be allocated with an identification code and this code should be alphanumeric. This code shall be stamped on the top of the mark.
8) The surveyor shall prepare a location of established permanent control point sketch showing the mark position in relation to adjacent features.
9) The size of the permanent control point marking shall be: -

a. The second order control point marking is 300mm*300mm at the top and 400mm*400mm at the bottom and the total length is 700mm of which 200mm above the ground surface.
b. The tertiary control point marking is 200mm*200mm at the top and 300mm*300mm at the bottom and the total length is 500mm of which 150mm above the ground surface

2.4 Plan the Survey

The success of a survey starts with an intense, detailed, and comprehensive planning. Before you conduct a survey, you need to begin with brainstorming about the purpose of the survey, the goals and objectives, the creation of questions, and other important details included in utilizing the survey method. In surveying, the following tasks shall be conducted to achieve a desired goal.

2.4.1 Defining Project Tasks

A project plan, also known as a project management plan, is a document that contains a project scope and objective. It is most commonly represented in the form of a Gantt chart to make it easy to communicate to stakeholders. The tasks and activities that make up the project are planned along a timeline, taking into consideration task dependencies, and prioritizing important activities.

In the case of control survey, the project can be establishing new or densify the ground control points. Depending on the project, all the tasks should be listed clearly in the project plan and team members will be allocated to each task. The tasks include the reconnaissance, mission planning, establishing monument, measurement, processing, and others detail activities.

2.4.2 Organizational Rules, Guidelines and Standards

The Organizational rules and guidelines govern the internal organization and the duties, powers, and responsibilities of the executive bodies and all the employees of the organization. The experts of the organization shall duly respect the legal legislation, standards, and other quality of the project.

The most important reason for following organization rules and regulations is personal safety and the safety of employees, clients, and stakeholders. The standards also used to conduct

accurate survey, limit the scope and duration, make sequence and interdependence of tasks, and standardized data comes from different sources.

2.4.3 Determine the Resources

Here, we need to reconstruct a resource plan, through identifying all the required resources to complete the project. In addition, a schedule indicating when each resource will be used and any assumptions and constraints made during the resource planning progress. All the plans and schedules shall be in line with organizational rules, guidelines, and standards. For instance, GNSS instruments with full accessories, construction materials (steel, cement, etc.) for monument may be considered in establishing or densifying Ground Control Points (GCP). On the other hand, the human resource should be identified for the project depending on the required knowledge, skill, and attitude.



Ways of identifying and preparing employees for the project:

- Evaluate Performance of Employee
- Assign tasks related to individual strengths
- Assign tasks related to individual strengths
- Set up reverse mentorships
- Provide feedback frequently

2.5 Follow Up and Evaluate the Project Progress

The central activities undertaken during the follow up and evaluation phase of the project progress provide the basis for reviewing the total value of the project and for making recommendations for changes in the future. The aims of this phase are to:

- See if the objectives of the project are met,
- Assess the effectiveness of the project, activities/tasks, costs, and benefits,
- Provide feedback to participants, management, and project team,

Follow-up tools assist the person responsible for the survey project to adapt what is currently in place, to search for more effective and efficient way to achieve better results. Thus, many of the tools can be: review of monitoring, evaluation, continuous improvement, reporting and policy development as a result of intervention

2.6 Finalize the Survey Work and Check Submitted Data

In this phase, the GNSS data collected from the field should be downloaded to the software for post-processing and adjustment. The data shall be converted in to RINEX (Receiver Independent Exchange) format to handle it with any processing software.

Finally, the output of the processing or the coordinates can be transformed in to local system specifically Adindan-Ethiopia for local application. Currently, the official datum transformation parameters are 162, 12 and -206 in the direction of WGS84 to Adindan, -162, -12, and 206 for the reverse. For different applications, coordinate transformations can be conducted like from geodetic to Cartesian and others. The GCPs shall be documented using the standards with well description of the points and overall documentation.

It is very important to supervise work completion for the field data survey; each team member must understand their role, and adhere to the protocol. And the supervision on documentation and data archiving will be conducted after submission of the report. The data submission standards will be referenced prior to data collection so that the collection and management procedures lead to fulfilling the data submission standards.

2.7 Summary

Dear trainee! Control Surveying is the determination of the precise position of a series of stations distributed over an area to serve as the origin or reference to be used for checking of subsequent surveys. Control point provides a framework of survey, whose relative positions, in 2D or 3D are known. The areas covered by these points may extend over a whole country and form the basis for the national maps of that country. Alternatively, the area may be relatively small, encompassing a construction site for which a large-scale plan is required.

Alternatively, GNSS methods can be performed to extend control from an established network to the project site. These serve as the basis for originating or checking subordinate surveys for projects such as topographic and hydrographic mapping; property boundary delineation; and route and construction planning, design, and layout. Both horizontal and vertical control points need to be evaluated for their accuracy to ensure that undertaking works are in line with the standards of the quality management.

2.8 Self-Check Exercises



Short Answer Items

Instruction: Give short, brief, and precise answer for the following questions.

1) Discuss the basic requirement for evaluation existing Ground Control Points.
2) Identify the resources required for evaluation existing Ground Control Points?
3) List guidelines that can be used by the organization to identify personnel for the project.
4) Who is the responsible organization to establish high-order ground control points?

CHAPTER THREE: PERFORMING ADJUDICATION FOR LEGAL CADASTRE

3.1 Introduction

Dear trainee! This chapter deals with the concept of adjudication for legal cadaster. Adjudication is a basic task which will needs to be undertaken to establish Legal Cadaster. It is a process by which all existing land rights on a parcel of land are authoritatively ascertained. Adjudication is the process that precedes registration. The process of adjudication should simply reveal what rights already exist, by whom they are held and what restrictions or limitations there are on them.

Adjudication by itself is not altering existing rights or creating new ones. The law says except upon the decision of the legally authorized organ, it is prohibited to modify existing rights or to provide new land holding lights during the process of land holding adjudication. It establishes with certainty and finality what rights exist, by whom they are exercised and under what limitation. The whole process is needed only when there is a need for registration. Adjudication may be sporadic or systematic. While sporadic adjudication denotes the ascertainment of specific plot of land based on the request of the owner/holder of the land, systematic adjudication refers to comprehensive exercise of the process on a country, region or city level and based on legislation.

3.2 Learning Objectives

After completing this chapter, you will be able to:

- Identify the basic preliminary procedures used to perform adjudication
- Explain the ways to implementing adjudication
- Describe the use of land adjudication registration
- Explain the way to readjust Land in regularizing old occupants

Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts of basic preliminary procedures used to perform adjudication.

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3.3 Preliminary Procedures for Performing Adjudication

The newly adopted Urban Land Adjudication and Registration Proclamation No. 818/2014 recognize two types of adjudication processes in Ethiopia: systematic and sporadic land holding adjudications.

- **Systematic landholding adjudication:** is defined as a process of ascertaining existing rights on landholding within a defined landholding adjudication neighborhood.
- **Sporadic landholding adjudication:** is defined as a process of ascertaining periodically existing holding right in a landholding adjudication neighborhood based on sequential order of submission of the request by the holder.

3.3.1 Public Participation

Systematic landholding adjudication involves the participation of the residents of the selected landholding adjudication neighborhood within an urban administrative boundary. For this reason, the adjudication officer is responsible to notify the land holders in the selected adjudication neighborhood about the process before starting to carry out the adjudication work. Urban centers, through their adjudication officers are supposed to perform the following awareness creation activities regarding:

- Objectives of the adjudication,
- Required procedures,
- Grievance submission and
- Decision making.

This awareness creation process shall be restricted to the areas or parts of the urban center where adjudication is planned to be implemented. Further, it is also required by law that at least three representatives of the adjudication section community shall participate during the systematic adjudication process. For awareness creation purpose, public notice must be announced through posting it on public places or using other suitable and realistic ways such as radio and newspapers. Following the public awareness work, landholders are supposed to submit application requesting a land adjudication procedure to be carried out of their respective holdings. The purpose is that together with the application, landholders would also submit their documents (original and a copy thereof) supporting their holding rights, restrictions, and responsibilities.

3.3.2 Boundary Delineation and Other Preparations

Before starting the implementation of the adjudication process, first an index map of the landholding neighborhood must be prepared by the urban administration. Using this map, the adjudication officer must delineate the target adjudication section and neighborhood area. In Ethiopian urban legal cadaster, aerial photos are being prepared with detailed information (cadastral index map) that enables the officer to easily delineate the boundaries of the section. In order to do so, there are preliminary preparations which should be carried out by the urban center, such as:

- Preparation of cadastral index map,
- Providing unique identification numbers for each plots of land,
- Establishment of at least two surveying control points,
- Preparations of marking pegs,
- Printing and preparations of land use maps,
- Preparation of data collection forms,
- Preparation of registers (at center) and
- Organizing and preparations of existing holding files within the kebeles or urban land administrations.

3.4 Implementation of Adjudication

3.4.1 Document Verification

In order to implement the adjudication process, the officer is highly relying on two important sources of information. Firstly, the officer needs to access and have in-hand all the landholding files/documents organized and transferred to it from the land administration office (organ that permitted right) or kebeles. This particularly includes legal information (proving ownership/lease rights and obligations/restrictions), site plans and aerial photos. Secondly, the officer needs to collect a copy of the holding documents from each plot owner. Therefore, adjudication is carried out by verifying the consistency of the evidence presented by the person claiming to be the right holder with the evidence of the organ that permitted the right. The ascertainment process verifies three basic points.

1) All the legal register (owner/holder's identity, rights, obligations, and restrictions) which are documented in written form and collected from the owner and the kebeles are similar;

2) The spatial information concerning the location, size, and land use purpose of the plot on the ground is similar with what was documented in the urban administration; and
3) The documents submitted by the person claiming ownership/holding right: are not forged, containing proper seal and signature, are not illegible, are not expired or cancelled. Finally, representatives of the adjudication section residents should put their signature in attesting the verification process.

3.4.2 Demarcation and Definition of Boundaries

Adjudication officers are supposed to identify and demarcate specific plots from the cadastral map provided that they are clearly identifiable. In cases where there is lack of clarity, they need to use ground survey to identify the coordinates and thereby the area of plots. This measurement must be based on the agreement of the adjacent landholders. In the absence of agreement, the officer needs to refer the matter to Landholding Adjudication Grievance Handling Tribunal (LAGT).

The adjudication officer may be assisted by a boundary maker and cadastral surveyor. The cadastral surveyor shall measure the area using proper surveying instruments. He/she shall make sure that the control points are not displaced, and if displaced he/she shall establish new ones and put markers for future use.

3.4.3 Suspension of Land Adjudication

An adjudication process may be suspended and the case may be referred to another body (supervisor or LAGT) when one of the following things occurred:

- When an injunction order was given by legally authorized body before the beginning of adjudication work;
- Where there is inconsistency between the evidences presented by the landholder and the one collected from the organ that permitted land rights;
- When the landholder happens to occupy land area beyond the legally permitted one;
- When the adjacent landholders disagree on the exact boundary line and this cannot be established from the map;

3.4.4 Technology and Instruments Required

The adjudication officer may carry out the above activities alone or may be assisted by other experts such as surveyors. In any case, the following instruments and technologies are relevant to undertake the adjudication process especially related to surveying and mapping:

- **Surveying instruments**: such as hand-held GPS, total station or theodolite, GPS, GNSS, leather scanning, with all accessories, tape, etc.
- **Surveying software:** Eagle point, soft disc 8, Prolink, etc.
- **GIS software:** ArcGIS, Quantum, ERDAS, Leica Geo Office, etc.

3.5 Readjust Land in Regularizing Old Occupants

The above land adjudication process has been made for legally acquired land parcels. However, in case of the land held informally either on small or large scale, the urban administration may then recognize or regularize the holdings for different reasons. In such cases, readjustment of the land holdings is necessary in line with urban land laws or local development or structural plan. Since there is no national level law to govern such procedure, the following are common procedure used based on the experience of large cities like Addis Ababa.

i) Obtain Local Development Plan or structural plan of the area:

The Federal Urban Planning Proclamation No. 574/2008 provides two types of plans applied in urban areas: local development plan and structural plan. Urban structural plan is a narrower one that applies to small part of a city or town, whereas local development plan shows a relatively larger area's future plan. According to proclamation, structural plan includes:

- The magnitude and direction of growth of the urban center,
- Principal land use classes, Housing development,
- The layout and organization of major physical and social infrastructure,
- Urban redevelopment intervention areas of the urban center,
- Environmental aspects, and Industry zone.

Local development plan shall state, as may be appropriate:

- Zoning of use type, building height and density,
- Local streets and layout of basic infrastructure,
- Organization of transport system,
- Housing typology and neighborhood organization,

- Urban renewal, upgrading and reallocation intervention areas,
- Green areas, open spaces, water bodies, and places that might be utilized for common benefits,

The purpose of acquiring these plans is to ensure whether the plots held informally do fit with the plan or not. If the land holding fit with the plans, readjustment of land can be undertaken.

ii) Obtain the aerial photo or satellite image.

iii) Map should be prepared at the scale of 1:500 to 1:200 by overlaying LDP.

iv) Adjoining owners and neighborhoods must be negotiated and signed for the clear demarcation of their irregular boundary on the legal format prepared for the process. Note that holders of land may not agree on the demarcation line and since they lack legal evidence except personal testimonies urban administration must decide based on the urban plans and other regulations dictating the size of land.

v) Perform land readjustment on the neighborhood.

vi) Prepare a new subdivision plan according to land consolidation.

vii) Provision of new deed registers or tile certificate shall be carried out.

 Activity	Explain the problem of conducting land adjudication without public participation.

3.6 Land Registration

Adjudication is said to be completed where no appeal has been lodged to the LAGT. The completion has to be announced through public notice. After completing the adjudication process, registration will be made. Land registration is the official recording of legally recognized interests in land and is usually part of a cadastral system. From a legal perspective a distinction can be made between deeds registration, where the documents filed in the registry are the evidence of title, and registration of title, in which the register itself serves as the primary evidence.

At the same time, the adjudication officer shall enter all the data gathered into the land adjudication register. A land adjudication register is not the same with the land holding register. The landholding adjudication register is the base for the record of rights in the legal cadaster and it shall also be the main source of data when a landholding right certificate is requested and primary landholding rights registration is carried out following systematic

landholding adjudication. According urban land adjudication and registration regulation 234/2014, the landholding adjudication register shall have the following main content forms:

A) Land holders ‘detail information
B) Parcel detail information
C) Information of the rights, restrictions, and responsibilities of the landholding.
D) Detail information of documents submitted by the organ empowered to permit urban land use right and the landholder.

3.7 Summary

Dear trainee! Adjudication is the process of final and authoritative determination of the existing rights and claims of people to land. This may be in the context of first registration of those rights, or it may be to resolve a doubt or dispute after first registration. The process of adjudication should simply reveal what rights already exist, by whom they are held and what restrictions or limitations there are on them. In practice, the mere fact of a final and definitive recording of these rights is a significant change in those jurisdictions where previously there had been uncertainty.

The process of adjudication may be sporadic or systematic. The preliminary procedures to perform adjudication process are public participation and boundary delineation and other preparations. For implementing the Adjudication process verification of document, demarcation and definition of boundaries, Suspension of Land Adjudication and land readjustment shall be considered if necessary. After completing the processes of adjudication, registration will be undertaken. Land registration is the official recording of legally recognized interests in land and is usually part of a cadastral system.

3.8 Self-Check Exercises

**Short Answer Items**

Instruction: Give short, brief, and precise answer for the following questions.

1) Explain the concept and type of land adjudication.
2) Discuss briefly the procedure of land adjudication.
3) Explain the difference between land development plan and structural plan.
4) List documents and their sources used during verification steps of land adjudication.

CHAPTER FOUR: CONDUCTING CADASTRAL SURVEY PROJECT

4.1 Introduction

Dear trainee! This chapter deals with the concept of conducting cadastral survey project. Cadastral projects are intended to perform operations related to land registration. The building block of any cadastral projects is a parcel. In Ethiopia, real property registration proclamation was enacted at different period of time in order to provide procedures for the registration and transfer of land holding and the issuance of title deeds, as well as property taxation and the like. However, they faced major problems from the start and throughout its implementation which is mainly due to the absence of clear legal frameworks, focal organizations, and the appropriate utilization of technology and etc.

Nowadays, as a model area, Addis Ababa city commenced the implementation of a modern real property registration and land (cadaster) system development project. Which implies successful implementation of a real property registration system depends as much on institutional and organizational aspects as on the technological ones. This indicates that high priority needs to be given to aligning the development and implementation of essential institutional and organizational requirements. When all these are balanced a sustainable, efficient, and effective system is possible.

4.2 Learning Objectives

 After completing this chapter, you will be able to:

- Discuss the principles of cadastral project
- Identify cadastral project resource
- Prepare and plan cadastral project
- Identify skills to manage and monitor the project

 Dear trainee! Before reading the following section, take ten minutes and try to discuss the principles of urban cadastral project.

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4.3 Identify Project

Organizations perform two types of work: project work and operational work. Operational work is what keeps the organization in business. It is stable, unchanging, and keeps the doors open for business. Without operational work, the organization will not survive; it is the glue that holds the organization together. It provides the efficient functions that allow the organization to provide its products and services to the customer reliably over time. Operational processes are well defined and documented so they may be repeated identically every time. A project work, on the other hand, is a temporary endeavor undertaken to create a unique product or service. The purpose of a project is to attain its objective within limited time and resource. Cadastral surveying projects by nature require large number of budgets and may take longer period of time.

A Cadaster and cadastral map unless otherwise constantly up dated loses validity. For instance, Addis Ababa city administration in 1995 has decided to launch a cadastral project initially intended to register all property owners liable for property taxation and collect data that would enable the city administration to assess a value of a property more realistically. However, latter on the primary objective of establishing "a fiscal Cadaster" enhanced and the objective of the project was changed aiming at establishing a "multi-purpose Cadaster". The non-existence or the non-functioning cadastral system is believed to be the general problems which lead to the initiation of the project in Addis Ababa.

But, even if lack of proper land information system is common to most developing countries, the problems associated with it and the reasons to establish an information system may differ from country to country. Accordingly, the four main problems and reasons, which initiated the establishment of a cadastral or land information system apart from the general problems, were:

ii) Poor service delivery in land management and administration, especially in services related to:
   - Registration of transactions,
   - Building permits (maintenance and construction),
   - Application for title deed and title book,
   - Resolution of land disputes,
   - Land use change application,
   - Property taxation,

- Land supply

iii) The alarming increase of squatter settlement or illegal construction.

iv) Due to lack of sufficient information, it was impossible to plan and implement development projects.

v) Inadequate collection of property tax. As a result of inappropriate cadastral system, the city lacks the technical means to collect revenue from property taxes efficiently.

4.4 Organize Project Resources

It is said that project success often requires a greater level of involvement by project stakeholders. Key stakeholders can make or break the success of a project. Project stakeholders are individuals and organizations who are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or successful project completion. The project management team must identify the stakeholders, determine what their needs and expectations are, and then manage and influence those expectations to ensure a successful project. The key stakeholders on every project include:

- **Project manager:** the individual responsible for managing the project.
- **Customer:** the individual or organization that will use the project product.
- **Performing organization:** the enterprise whose employees are most directly involved in doing the work of the project.
- **Sponsor:** the individual or group within the performing organization who provides the financial resources, in cash or in kind, for the project.
- **Project Consultant:** play the role of advisor, planner, and leader in working with internal and external clients to devise and implement solutions related to process or quality improvement. They are a valuable resource to stakeholders seeking to identify and correct inefficiencies in workflow and processes.

Many times, project stakeholders have conflicting interests. It is the project manager's responsibility to understand these conflicts and try to resolve them. It is also the project manger's responsibility to manage stakeholder expectations. Be certain to identify and meet with all key stakeholders early in the project to understand all their needs and constraints.

In Ethiopia urban legal cadaster, a cadastral surveyor or a surveyor with special permit shall carry out surveying only through calibrated and checked surveying equipment. All electronic and optical survey measurement equipment shall be calibrated and checked every year and after any maintenance against its instrument constant. Dual frequency GPS receivers capable

of making carrier phase observations shall be used for establishing control stations in land boundary surveys. A surveyor shall be liable for any damage caused to a land holder or the institution that ordered the work as a result of field survey data collected by using surveying equipment not calibrated. tested or certified.

	List and explain key stakeholders for project organization and implementation.

4.5 Plan Tasks

In the Project System, you can plan the organization of the work and people in your project with the Work Breakdown Structure (WBS). The WBS is a multi-level structure that breaks all of the project work down into work packages and each work package has a work product, deliverable, or some milestone that allows us to measure the output associated with the work package. Once you have organized all project work into the WBS, you quantify the work in terms of costs (how much do you expect to spend on each work package) and schedule (how long will it take you to complete each work package). Accurately assign a measurable milestone to each work package, the combination of all quantified work packages (costs, time, and milestones) forms the Performance Measurement Baseline (PMB).

PMB is the detail project plan used to manage the project progress. To be brief, the planning phase begins when the project has been formally approved and funded. It is the most critical and intensive part of any project. Documents are formulated and revised to be used throughout the remainder of the project. This means, the planning phase involves creating of a set of plans to help guide the project team through the execution and closure phases of the project.

Cadastral processes constitute the activities necessary for access to land and land delivery. Access to land refers to the opportunities that are available for one to acquire any form of land rights. Land delivery refers to the channels that are used to supply land for various uses and the technical and legal procedures that are necessary to support the process. Four common cadastral procedures are recognizable in many parts of the world:

- **Adjudication**
- **Demarcation**
- **Surveying**
- **Mapping**

4.6 Manage and Monitor Project

Managing and monitoring project cadastral works involves effectively overseeing the implementation of cadastral surveys and related activities. Here are some key steps to help you manage and monitor project cadastral works:

- Develop a Cadastral Work Plan
- Allocate Resources
- Maintain Communication
- Establish Quality Control Procedures
- Conduct Field Surveys
- Review and Verify Survey Data
- Track Project Progress
- Address Issues and Changes
- Compliance and Legal Considerations
- Regular Reporting

By effectively managing and monitoring cadastral works, you can ensure the accuracy and integrity of survey data, meet project goals, and maintain compliance with legal and regulatory requirements. Regular monitoring and adaptation throughout the project lifecycle contribute to the overall success of cadastral projects.



Project Management encompasses

- Deciding what needs to be done
- Estimating costs
- Ensuring there are suitable people to undertake the project
- Defining responsibilities
- Scheduling
- Making arrangement for the work

4.7 Finalize Project

Provisions for dispute resolution are included in Proclamation 818/2014 and Directive 45/2014. Systematic Adjudication and Registration (SAR) can only commence in an adjudication neighborhood when an Adjudication Grievance Handling Tribunal is established in the adjudication sector and Community Observer Teams are established at neighborhood levels. Public awareness is a precondition, however has been undertaken with limited success to date-clearer and well-tested procedures are required. Following the completion of adjudication in an adjudication neighborhood, the completion is announced publicly. Any person aggrieved by decisions made in adjudication has 15 days to make an appeal, with these appeals to be resolved by the Adjudication Grievance Handling Tribunal.

The process could be enhanced by a policy to provide a range of dispute resolution services, including Alternative Dispute Resolution (ADR). Clearer policies and guidelines on land regularization would also improve this. After completing the activities of cadastral projects, reporting on the completion of the project should be made. A project report is an informative document that updates project managers and stakeholders about the status or progress of a project. It includes details relating to the accomplishments, risks, budget, and performance of the team members. It also helps in decision-making.

4.8 Summary

 Dear trainee! In Ethiopia, real property registration proclamation was enacted at different period of time in order to provide procedures for the registration and transfer of land holding and the issuance of title deeds, as well as property taxation and the like. Cadastral projects cannot be accomplished with the normal day to day activities by the government. It should be done within the framework of projects whether in operational or project manner.

In recent time, urban legal cadastral project has been implemented in Addis Ababa and 23 pilot cities. However, such kind of projects requires a project management which is the skills, tools and management processes required to undertake a project successfully. It encompasses all the activities needed to plan and execute a project deciding what needs to be done, estimating costs, ensuring there are suitable people to undertake the project, defining responsibilities, Scheduling, Making arrangement for the work and etc. The success or failure of cadastral projects needs to be reported to the concerned body of the government. Performance evaluation on the basis of the proposed project should be measured.

4.9 Self-Check Exercises

 **Short Answer Items**

Instruction: Give short, brief, and precise answer for the following questions.

1) Discuss the difference between operation and project work.
2) List and explain necessary skills for project management and monitoring.
3) Explain the common procedures to successfully implement urban cadastral project.
4) Explain the types of cadastral project implemented in Ethiopia.

CHAPTER FIVE: DEVELOPING SUBDIVISION SURVEY DESIGNS

5.1 Introduction

Dear trainee! This chapter deals with the concept of developing subdivision of survey design. Urban development is dependent on sets of standards and regulations that dictate the shape and form of our built environment. Whether it is street layout and width, or the placement and configuration of utilities and infrastructure, place making can rarely escape the framework imposed by codes and design regulations. Although there is a general agreement that some form of control is necessary to warrant the adequacy of public services and to ensure guided growth, little agreement exists about the degree of restriction and the type of requirements placed on development.

Subdivision means the division of a lot, tract, or parcel of land into two or more lots, plats, sites, or other divisions of land for the purpose, whether immediate or future, of sale or of building development. It includes re-subdivision and, when appropriate to the context, relates to the process of subdividing or to the land or territory subdivided. In simple terms, subdivision is the act of dividing land into pieces that are easier to sell or otherwise develop, usually via a map. It requires the ability to determine, collect and write specifications for appropriate process and documentation of subdivided lands.

5.2 Learning Objectives

After completing this chapter, you will be able to:

- Discuss the concept and types of subdivision
- Explain relevant information for subdivision
- Describe the working procedure of subdivision
- Identify potential stakeholders of subdivision process

Dear trainee! Before reading the following section, take ten minutes and try to describe the concept of subdivision.

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5.3 Nature and Type of Subdivision Service

Subdivision is the dividing of a single parcel of land into two or more parcels, each to be given a separate title. Subdivision is also used for existing lot line adjustments. One of the most basic design decisions facing settlement planners is how the land will be divided and used to provide for new development (subdivision process). Factors that influence this decision include the physical conditions of the site, market forces, surrounding patterns of development, and regulatory limitations. The size of the site also often influences development options; large parcels of several hectares can offer many opportunities for creative and diverse land plans, while small sites usually offer a more limited number of possibilities.

More formally, a subdivision could be defined as the division of any improved or unimproved land for the purposes of sale, lease, or financing. For this reason, legal processes have been established to ensure the following:

- Proper registration and title for individual parcels of land,
- Accurate identification of land by way of survey,
- Establishment of rights to tenure and occupation,
- Security for financing/cost recovery,
- Identification of boundaries for development,
- A formal procedure of conducting subdivision, and
- Allowance for taxation.

5.3.1 Factors Affecting Subdivision

It is important to keep in mind that land subdivision does not occur in a vacuum but is largely influenced by the surrounding natural features as well as the existing adjacent settlement structure. The success of a site's subdivision in achieving a distinct identity and "sense of place" can be measured in terms of how well the design relates to the specific site and its wider urban context.

The purpose of context analysis is to ensure that new subdivision and development is connected to, and integrated with, surrounding natural and developed areas, including planned and committed development for adjacent sites. The site analysis will ensure that site features (natural and cultural assets) and constraints (including noise, soil erosion, poor drainage, saline soils, and fire risk) inform the layout decisions to enhance local identity.

A. **Topography:** Land subdivision should aim to emphasis on diversity in land form, and the topography of the site is the most important structural element to start with. Topography is a major determinant of a site plan because topography influences the type and cost of development, controls the direction and rate of water runoff, adds variety to the landscape, influences the weather and climate, and affects the type of vegetation and wildlife.

B. **Soil conditions:** If the soil conditions are good for cultivation there is a reason for large private plots, allocations or other areas the residents can use for food production. Heaving clays or collapsible sands often require costly foundation solutions.

C. **Streams and flood plains:** Stream patterns need to be considered in the subdivision of a site in order to ensure that the subdivided land drains effectively. No subdivision may take place within the 50-year flood plain of streams and rivers, which often results in this land being set aside for open space.

D. **Plant cover:** It is important to retain as much of the existing plant cover as possible during the subdivision process.

E. **Frontage:** Whenever possible within the subdivision layout, residential plot should be orientated to maximize the northern aspect. In the case of block subdivision of smaller plot, it is preferable to orientate the blocks to run east-west rather than north-south as fairly narrow house units within a north-south block configuration tend to overshadow one another. However, it is not always possible or necessary to have plot subdivided in order to maximize the northern aspect.

F. **Wind:** The wind direction should also be considered with particular reference during plot subdivision.

5.3.2 Service Request

The subdivision and block layout have very tangible implications on the cost and maintenance of services. Not only the size of stands, but also the shape thereof has an influence on the layout and cost of services. The overall cost for infrastructure provided along any given street stays more or less the same regardless of the number of stands serviced along the street. Therefore, the narrower the street frontage of the stands, the more dwelling units share in the cost of the services and the lower the infrastructure cost per dwelling unit. It is therefore usually better to provide narrow, deep stands.

It is generally accepted that manholes are required at approximately 100m interval for the maintenance and repair of services such as sewerage as well as optimizing the cost for the installation of such services. It is also necessary that block lengths are kept as straight as possible as any changes in direction of the services requires an additional manhole to be added. Service reticulate can also be seen to influence the more detailed subdivision of the block into individual plot. Services can either be reticulated in the middle of the block or running within the road reserve. The mid-block reticulation of sewerage, water supply, electrification and telecommunication cables are often favored in lower income areas for cost reasons. By not having to contend with traffic loads and other services in the road reserve, services located at midblock can be laid at shallower depths.

5.3.3 Types of Subdivision

There are a range of different subdivision types as shown in the table below:

Table 3: Types of Subdivision

Type	**Detail**
Major residential development	This type of subdivision includes greenfield subdivisions and new settlements and has potential to create significant adverse effects.
Infill development	This category includes subdividing existing residential sections or redeveloping former commercial sites. These generally have minor effects on their own, but cumulatively the effects may be significant.
Rural subdivision	This includes lifestyle blocks or higher intensity land use. Generally have minor effects, but cumulatively the effects may be significant.
Subdivision in sensitive locations	This category includes subdivision in the coastal environment, in areas identified as outstanding natural character, outstanding natural landscape, amenity landscape, or significant natural area. A subdivision in these locations has the potential to create significant adverse effects.
Unit titles	Unit titles are a form of multi-party property ownership used for apartments and other intensive developments. Owners privately own a unit and share ownership of common property with other unit owners. A body corporate is established to allow decisions affecting the development to be made jointly by the unit owners.

Cross leases	Owners privately own an undivided share in the land and each dwelling is leased to the owner by the other land-owners. Major structural changes to your dwelling will need to be approved by the other owners and amendments made to the title.
Specialized subdivision	This category includes changes in types of tenure or allotments for utility or reserve purposes. These will generally have minor effects.
Boundary adjustments	A boundary adjustment is a form of subdivision involving the reconfiguration of lot boundaries, rather than the creation of additional allotments. These generally have minor effects, but may facilitate a change in land use or represent the first stage of a development proposal.

5.4 Relevant Information to Subdivision Service

When acquiring a property for development, the first step is to undertake due diligence. This is the process of gathering all the relevant information that affects the property. This information is mostly contained in the government registries or local authority searches that the agent obtains when selling a property. The search contains a list of all the information that relates to your property such as the zoning, the council rates, if the site is known to be contaminated that is if there are any outstanding issues affecting the property and any previous permits for development on the property.

The other important piece of information to be checked is the certificate of title. This document contains all the relevant information that applies to the property such as the owner's details, if a mortgage is registered on the property and whether there are any easements for services and utilities such as storm water, water, and gas electricity. The most important factor which affects the potential development of your property is the planning and the zoning.

There is need to verify what the zoning for the property is to be confirmed from the local authority/government. Form the local authority information regarding development of the property based on its zone class can be obtained. Local authorities, generally, have guidelines which provide the public which often summarize the key points that need to be considered when you subdivide your property.

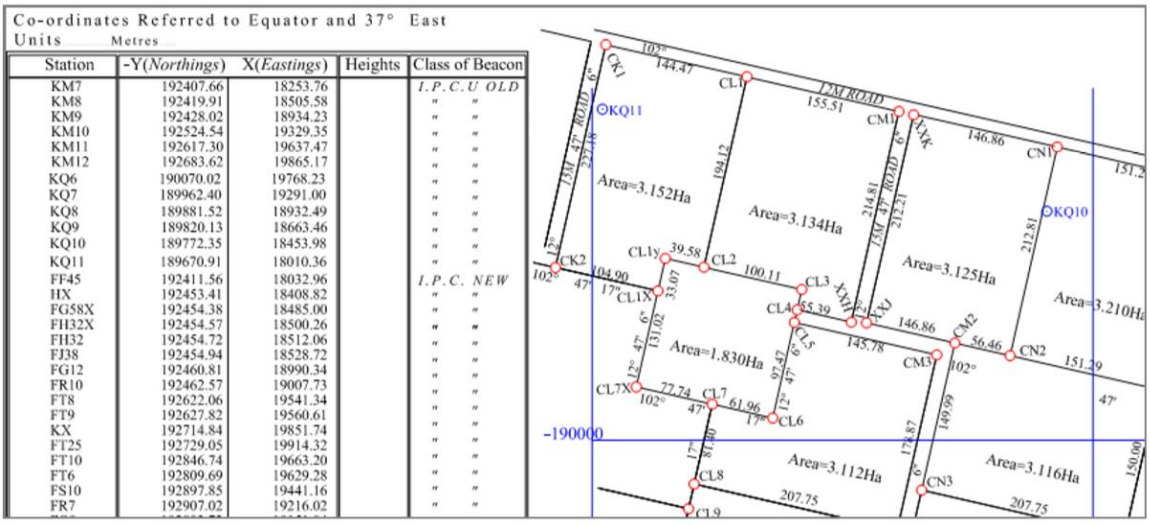
5.5 Develop a Submission for the Request

After identifying all potential issues in the subdivision proposal including comments from the local authority, assembled professional team need to address them in the final subdivision plan. The changes need to be addressed and then an application for subdivision is applied.

Subdivision is a great way to get ahead and make positive development. The process is complex that should incorporate different professionals and stakeholders. The Developer should be aware of the nature of title of the land, topography, slope and aspect, storm water flows, surrounding development, vegetation, trees, road and traffic situations and other physical characteristics pertinent to the design of the development.

5.5.1 The Local Government and Utility Authority Contributions

The local government will deal with each application on its merits; however, a number of policies have been adopted on matters not specifically covered by planning legislation to ensure a uniformity of approach. In principle, the proposed subdivision should satisfy the minimum design standards. These standards should not be interpreted as relieving the designer of the responsibility to properly assess all conditions and to use sound planning and engineering practices in the development of designs. The regional and national urban development standard is prepared to consider alternative approaches to subdivision design where the sub divider satisfies the standards. Local authority organizations shall actively participate in subdivision process.



Co-ordinates Referred to Equator and 37° East
Units ..... Metres .....

Station	-Y(*Northings*)	X(*Eastings*)	Heights	Class of Beacon
KM7	192407.66	18253.76		*I.P.C.U OLD*
KM8	192419.91	18505.58		" "
KM9	192428.02	18934.23		" "
KM10	192524.54	19329.35		" "
KM11	192617.30	19637.47		" "
KM12	192683.62	19865.17		" "
KQ6	190070.02	19768.23		" "
KQ7	189962.40	19291.00		" "
KQ8	189881.52	18932.49		" "
KQ9	189820.13	18663.46		" "
KQ10	189772.35	18453.98		" "
KQ11	189670.91	18010.36		" "
FF45	192411.56	18032.96		*I.P.C. NEW*
HX	192453.41	18408.82		" "
FG58X	192454.38	18485.00		" "
FH32X	192454.57	18500.26		" "
FH32	192454.72	18512.06		" "
FJ38	192454.94	18528.72		" "
FG12	192460.81	18990.34		" "
FR10	192462.57	19007.73		" "
FT8	192622.06	19541.34		" "
FT9	192627.82	19560.61		" "
KX	192714.84	19851.74		" "
FT25	192729.05	19914.32		" "
FT10	192846.74	19663.20		" "
FT6	192809.69	19629.28		" "
FS10	192897.85	19441.16		" "
FR7	192907.02	19216.02		" "

Figure 4: Sample Subdivision Plan

5.5.2 Legal Requirement and Organizational Guidelines

Land subdivision in municipalities is regulated by development plan and zoning bylaws. The development plan is a bylaw which outlines the long-term vision of a community and guides development within a municipality or planning district, and will specifically include policies on subdivisions. All development and land uses must conform to the policies in the plan. If a subdivision application is inconsistent with development plan policies, it cannot be approved. The planner reviewing the proposal will assist in determining, if application complies with these policies. If it does not comply, it may be advised to apply for a development plan amendment before proceed with the subdivision application.

The zoning bylaw divides the municipality or planning district into zones and prescribes permitted and conditional uses for land and buildings in each zone. The zoning bylaw must be generally consistent with any development plan bylaw in effect in the municipality. The zoning for your property will affect the way your property can be used. For example, a green and playground area development may not be a permitted use if your land is zoned for residential area.

	List potential stakeholder and professional that will involve in parcel subdivision plan and implementation.

5.6 Monitor Approval Process

Plan approval process should strictly follow the legislated process to avoid complains and possible court cases. The client should be advised all the approval processes and the expenses involved since he/she will have to meet the expenses. Most local authorities have laid down a process for approval of plans.

The approval process calls for public and other expert's participation. In order to reach a larger population, it is advised that the proposed development application be posted on public notice boards and also advertised on the most common print media. This will allow the public to send their comments. The advertisement for comments advertisement should have the contact person and deadline for submission.

Local authority planning unit receive and process planning permit application from developers. Although requirements for planning permit applications vary depending on region to region, some of the items that planning departments may require are:

- A completed permit application.
- An application fee, which is determined by the Authority where you reside or have purchased property to subdivide.
- A copy of the property title.
- A copy of the survey map for subdivision.
- Some Authorities require a plan of the existing property including any houses or sheds located on the property and any other significant features such as large trees.
- Some require how a new dwelling will be sited or positioned on the proposed allotment if the subdivision is intended for development.

The following information is generally required for most land division applications:

- A plan showing what you propose to do. Show the proposed allotment you are going to create and how big it will be. You also need to show how big the existing allotment will be once you divide the property.
- Show the open space areas for the existing house and any proposed house on the new allotment. Show the existing driveway and any proposed driveway for any proposed / existing dwellings.
- Show car parks for the existing house and any proposed carports or undercover car parks for the proposed dwelling.
- There is usually a requirement on publication of intended subdivision to ensure public participation and stakeholders.

5.7 Summary

 Dear trainee! A subdivision is the splitting of a parcel of land described on a certificate of title. A subdivision occurs when a single land title is split into two or more parts, property boundaries are rearranged, or a lease, mortgage or other instrument is registered that has the effect of subdividing the parcel. The purpose of subdivision is to provide land allotments of a size and location suitable for use and occupation. Any land development proposal firstly relies on the identification of a parcel of land (an allotment) upon which development can take place.

To create appropriate allotments for occupation, use and development, land parcels are usually divided (subdivided) according to location, size, shape, access, etc., by the process of subdivision. A subdivision plan prepared by a land surveyor that creates lots and blocks, and shows the location of the land, the location of the survey pins and markers, lot dimensions,

and other relevant information. The regulation of subdivision of land has generally been within the jurisdiction of regional and local authorities, initially to ensure adequate access and services but more recently to manage the extended effects of the intensification of land use resulting from subdivision.

5.8 Self-Check Exercises



Short Answer Items

Instruction: Give short, brief, and precise answer for the following questions.

1) Discuss the concept and types of subdivision.
2) List and explain factor affecting subdivision.
3) Describe the major procedures of subdivision.
4) List the potential professional's subdivision team members.
5) Discuss the required documents for urban planning permit.

CHAPTER SIX: PRODUCING BLOCK DIAGRAM

6.1 Introduction



Dear trainee! This chapter deals with the concept of producing block diagram. A block refers to photographs of two or more side lapping strips used to cover an area. It is a term used to describe and characterize all of the information associated with a photogrammetric mapping project such as projection, spheroid, and datum information, imagery used within a project, camera or sensor model information associated with the imagery, GCPs and their measured image positions, as well as geometric relationships between the imagery in a project and the ground.

Any successful execution of any photogrammetric project requires thorough planning prior to proceeding with the work. It requires block adjustment which is an important step in creating orthorectified image mosaic a collection of satellite images or aerial photographs. In general, block diagram preparation relies on adequate and well distributed tie points and GCPs for the block adjustment purposes.

6.2 Learning Objectives



After completing this chapter, you will be able to:

- Plan for block diagram preparations
- Conduct and execute block diagram
- Finalize tasks according to standards and guidelines
- Review and document the accomplished tasks



Dear trainee! Before reading the following section, take ten minutes and try to describe the basic concepts of block diagram preparations.

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6.3 Plans for Block Diagram Preparation

Successful execution of any photogrammetric project requires thorough planning prior to proceeding with the work. Planning, more than any area of photogrammetric practice must be performed by knowledgeable and experienced persons who are familiar with all the aspects of the subject. Block diagram preparation is one of the photogrammetric works accomplished while using aerial photographs for DEM and orthophoto generation. It is the first task to be done once after the aerial photo is taken. So, it needs to be performed in a planned manner to effectively manage time, cost and resources adequately.

One of the most important considerations that must be addressed in planning involves the decision of exactly what products (deliverables) will be prepared, identifying the activities needed to complete those deliverables together with their scales and accuracies. Planning for block diagram preparation also involves:

- Estimating the resource (Human and material) requirements for the activities;
- Estimating time and cost for the activities;
- Developing the schedule;
- Developing the budget;
- Organizing the needed professionals and materials (both the hardware and software)
- Preparing awareness for the professionals about the job and providing them technical training.
- Determine the authority, responsibility and accountability of each member in relation to the job.
- The working environment should be clean and free from any noise which may disturb the attention of the expertise and the provision of an eye glass since most of the tasks are accomplished working with workstations/computers.

6.4 Preparation of Block Diagram

6.4.1 Defining Block Diagram

Prior to performing any photogrammetric tasks within LPS Project Manager, a block must be created. A block is a set of flight lines processed simultaneously to cover an area not possible with one flight line. It refers to photographs of two or more side lapping strips used to cover an area.

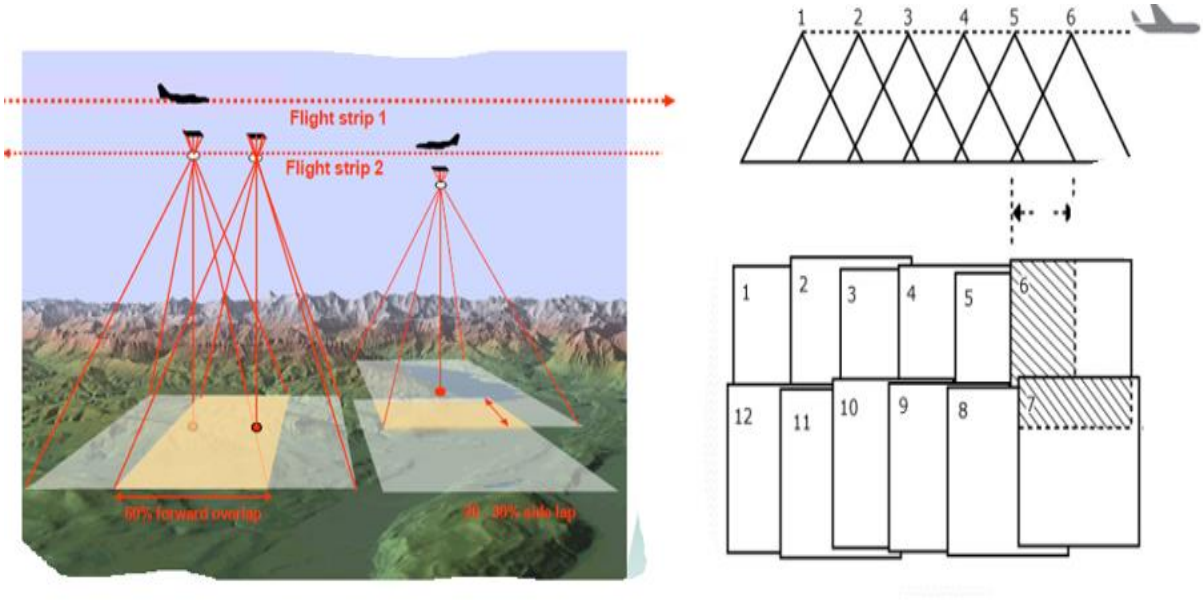


Figure 5: Forward and Side Over Laps of Adjacent Flight Strip

Block is a term used to describe and characterize all of the information associated with a photogrammetric mapping project, including:

- Projection, spheroid, and datum information,
- Imagery used within a project,
- Camera or sensor model information associated with the imagery,
- GCPs and their measured image positions, and
- Geometric relationships between the imagery in a project and the ground.

While creating a block diagram defining the project name, the sensor model, the reference coordinate system, the units, the mapping sensor rotation systems (Omega, Phi, Kappa), the characteristics of the imagery (for example, aerial or ground-based), and importing the exterior orientation information, which is the position and orientation of the camera/sensor at the time of exposure is required.

6.4.2 Techniques of Block Diagram Manipulation

Block adjustment is a technique used in photogrammetry for block diagram preparation. It is an important step in creating orthorectified image mosaic. Block adjustment applies to a set of images with overlaps and used in mosaicking satellite images or aerial photographs for an area or a project which is called a block. Block adjustment is the process of computing adjustment (or transformation) based on internal relationship between overlap images, ground control points (GCPs), a camera model, and applying the adjustment to the images within a block.

For a block diagram preparation there are three types of control points involved in block adjustment in which it relies on adequate and well distributed tie points and GCPs. These are: GCPs, Tie points and Check points.

Key inputs for block adjustment may include:

- **Tie points:** used to minimize the misalignment between images.
- **GCPs:** used for georeferencing the images to the ground.
- **Triangulation:** computes the transformation by minimizing and distributing the errors among images and control points.

A. Ground Control Points (GCPs)

Ground control points, shown as blue stars in the figure below, are identifiable features located on earth surfaces that have known ground coordinates x,y and z. The GCPs can be prepared in three ways:

- Survey points that come in a form of x,y and z.
- Ortho rectified image chips. If you have image chips for some features or locations within your block, create a mosaic dataset from these image chips, and compute control points from your mosaic dataset using the Compute Control Points tool,
- Ortho rectified image service. You can also compute control points based on a single ortho rectified image or image service, and add them to the control point table check points. Check points are known ground control points, but instead of them being used in computing adjustment, they are used in checking the accuracy of adjustment computation.

Activity

List the most common mapping sensor rotation system.

B. Tie Points: A tie point is a point that may not have known ground coordinates, but is visually recognizable in the overlap area between two or more images. The corresponding positions of the tie point in each overlapped image are identified and measured. The image above shows tie points depicted as black diamonds. Tie points can be computed based on automatic image matching technique. Some types of feature, such as large water bodies, desert areas, or cloudy areas, are difficult to find matches within the overlap areas.

C. **Check Points:** Check points are known ground control points that are used only for checking the accuracy of the adjustment; these points are not used in computing the actual adjustment. Enter the check points just as you would add a regular control point but later change the status of the ground control point to a check point.

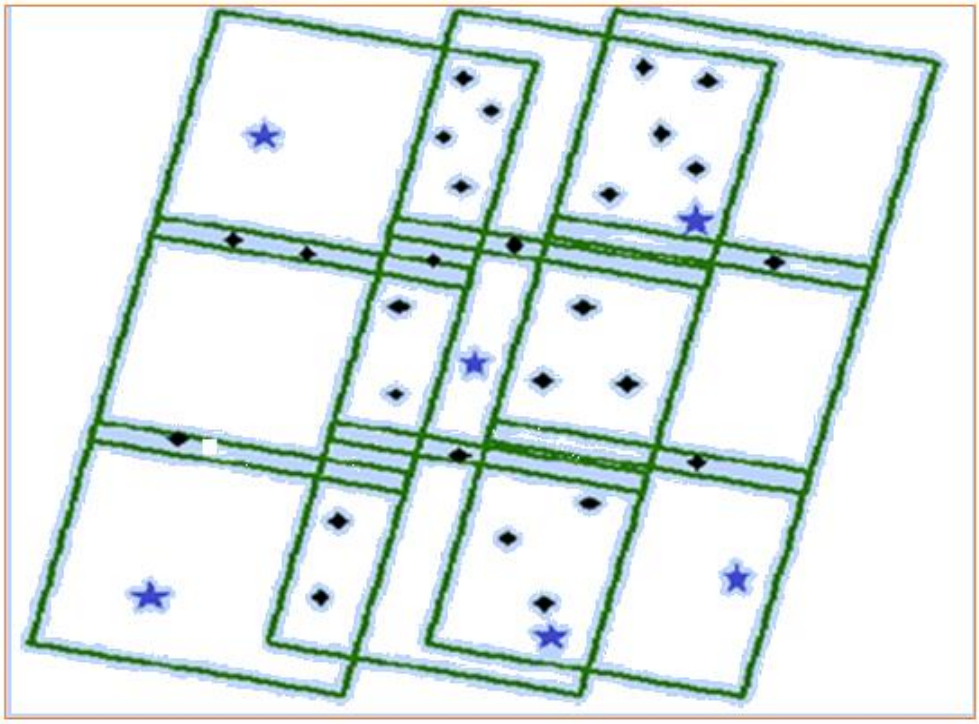


Figure 6: Photogrammetric Block With GCPs and Tie Points

Here is a generalized plan to help you with block diagram preparation for photogrammetry planning:

- Gather Project Information
- Define Coordinate System
- Identify Flight Parameters
- Plan Ground Control Points (GCPs)
- Determine Image Acquisition Geometry
- Assess Image Overlaps
- Block Division
- Block Connections
- Plan for Image Processing
- Documentation

It is crucial to note that the block diagram preparation may vary depending on the project's specific requirements, available resources, and software used. Consulting with experts in the field or professional photogrammetrists can provide more specialized guidance tailored to your specific project needs.

6.4.3. Important Flight Planning/Block Diagram parameters and Computations

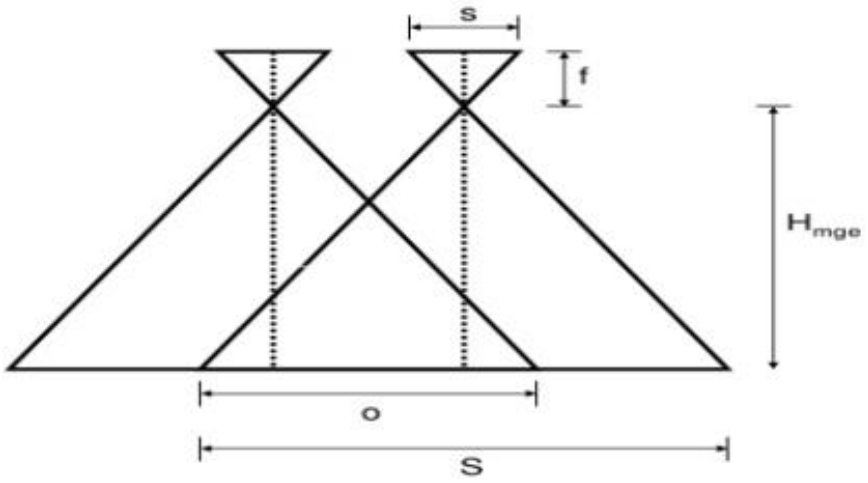
Successful execution of any photogrammetric project requires thorough planning prior to proceeding with the work. In this case, the first step of planning is determining of the project requirements. One of the most important considerations that must be addressed in planning between the client and the photogrammetrists involves the decision of exactly what products will be prepared, together with their scales and accuracies (Demirel et.al, 2015). Furthermore, the following issues are the requirements of the project;

- Project area and boundary
- Photo scale
- End lap and side lap
- Direction of strips,
- Coordinate system
- Project boundaries
- Existing and planned control
- Time schedule
- The scale of the flight map
- Final product needed
- Optimum flying season
- Camera type and film type should be determined.

Given the above requirements, other important flight parameters could be computed as follows to generate the block diagram.

Flying height of each flying Line

$H_{msl} = H_{mge} + m.g.e$



Where:
s = photoformat/size
F = focal length
H_{mge} = flying height above
m.g.e
O = overlap in %
S = Equivalent Ground
Distance of the photo format

Distance between Exposure Station

$$D_{exp} = D_e = S(1 - f.o.)$$

Where:
S = equivalent ground length of the photoformat size (s)
$S = (s_p)(s)$
f.o. = forward overlap (in decimals)
s = photoformat size
s_p = photoscale factor

Distance between Flight Lines

$$D_{fl} = D_f = S(1 - s.l.)$$

Where:
S = equivalent ground length of the photoformat size (s)
$S = (s_p)(s)$
s.l. = sidelap (in decimals)
s = photoformat size
s_p = photoscale factor

Total Number of Exposure/Photos

$$\text{total number of exposures} = (\text{number of exposures per flight line}) \times (\text{number of flight lines})$$

Where:

$$\text{number of exposures per f.l.} = \frac{\text{longer dimension}}{D_e} = \frac{\text{longer dimension}}{B}$$

$$\text{number of flight lines} = \frac{\text{shorter dimension}}{D_f} = \frac{\text{shorter dimension}}{W}$$

6.5 Finalize the Task

Once after the block diagram is produced reviewing all the work done as per the specification is very important. This helps to validate the overall processes of the block diagram production. Since it is the initial job in photogrammetry and a footprint for the next tasks such as DTM and orthophoto generation it should be archived both digitally as well as in hard copy.

6.6 Review and Document the Task

After completing all the required tasks of block diagram preparation a compiled report should be generated. The system provides possibility to view full statistics of adjustment, summary information about adjustment residuals and control data. So reviewing the quality of the preparation can be possible by having this statistical report.

The adjustment report displays the following values:

- Residual values calculated on GCP, check, tie points, and projection centres for the whole block and for each point;

- Catalogue of points coordinates;
- Images exterior orientation parameters;
- GPS corrections;
- Corrections for exterior orientation parameters.

6.7 Summary

Dear trainee! Block is a term used to describe and characterize all of the information associated with a photogrammetric mapping project. It is a set of flight lines processed simultaneously to cover an area not possible with one flight line. In photogrammetric application a block diagram is prepared with block adjustment technique. It is used to improve the georeferencing accuracy of a mosaic dataset.

For a block diagram preparation three control points are very helpful in block adjustment; GCPs, tie points and check points. GCPs have a known ground coordinate values of x, y and z used to georeference the images to the ground, tie points may not have known ground coordinates but is visually recognizable in the overlap area between two or more images useful for minimizing the misalignment between images and the check points are known ground control points that are used only for checking the accuracy of the adjustment. After completing all the required tasks of block diagram preparation a compiled report should be generated which provides full statistics of adjustment, summary information about adjustment residuals and control data.

6.8 Self-Check Exercises

**Short Answer Items**

Instruction: Give short, brief and precise answer for the following questions.

1) Identify and list basic planning parameters used for block diagram preparations.
2) List and distinguish types of control points used in block adjustment.
3) Describe the steps for creating a block.
4) What are the key input that should be considered in block adjustment.
5) List the values that the adjustment report should displays.

CHAPTER SEVEN: PERFORMING AERIAL TRIANGULATION AND DIGITAL TERRAIN MODEL (DTM) GENERATION

7.1 Introduction

 Dear trainee: This chapter deals with the concept of aerial triangulation and adjustment plus generating and editing digital terrain model.. The adequate preparation of the available photography for aero triangulation purposes is very important. The prime requirement for aero triangulation is that the photographs overlap. Block adjustment applies to a set of images with overlaps and overlaps of 30 percent or more produce better results.

Interior orientation is used to transform the image pixel coordinate system or other image coordinate measurement systems to the image space coordinate system whereas, Exterior orientation represents a transformation from the ground coordinate system to the image coordinate system. The main purpose of aerial triangulation is the determination of ground coordinates for a large number of terrain points and the exterior orientation parameters of aerial photographs using as few control points as possible. Therefore, any block consisting of two or more overlapping photographs requires that it be absolutely oriented to the ground coordinate system.

The earth's surface is a continuous phenomenon and there are different ways of representing such surfaces in digital form using a finite amount of storage. A DTM is a 3D representation of a terrain surface consisting of X, Y, Z coordinates stored in digital form. It helps to model, analyze and display phenomena related to topography or similar surfaces and it is an important topographic product and essential demand for many applications.

Topographic point measurements acquired from airborne and terrestrial laser scanning and photogrammetry commonly are used to generate 3D digital terrain models (DTMs). Different approaches are used in elevation data collection, the plotting of contour lines, the capture of spot elevations and break lines, and the collection of a point matrix. Points, TINs, contour lines, and DEMs are commonly used to generate a Digital Terrain Model for specific area as per the required application.

7.2 Learning Objectives

After completing this chapter, you will be able to:

- Perform interior orientation
- Perform exterior orientation
- Conduct triangulation and adjustment
- Identify requirements of Digital Terrain Model (DTM)
- Generate Digital Terrain Model
- Prepare for approval process

Dear trainee! Before reading the following section, take ten minutes and try to describe the basic concepts of interior and exterior orientation, triangulation and adjustment, and describe techniques used to generate Digital Terrain Model.

_____

_____

_____

7.3 Interior Orientation

Interior orientation defines the internal geometry of a camera or sensor as it existed at the time of image capture. The variables associated with image space are obtained during the process of defining interior orientation. Interior orientation is primarily used to transform the image pixel coordinate system or other image coordinate measurement systems to the image space coordinate system. The figure below (*See figure:13)* illustrates the variables associated with the internal geometry of an image captured from an aerial camera, where O represents the principal point and a represents an image point component of internal geometry. The internal geometry of a camera is defined by specifying the following variables:

- Principal Point
- Focal Length
- Fiducial Marks
- Lens Distortion

A. Principal Point: The principal point is mathematically defined as the intersection of the perpendicular line through the perspective center of the image plane. The length from the principal point to the perspective center is called the focal length. The optical definition

of principal point is the image position where the optical axis intersects the image plane. In the laboratory, this is calibrated in two forms: principal point of auto-collimation and principal point of symmetry, which you can see in the camera calibration report. Most applications prefer to use the principal point of symmetry because it can best compensate for any lens distortion.

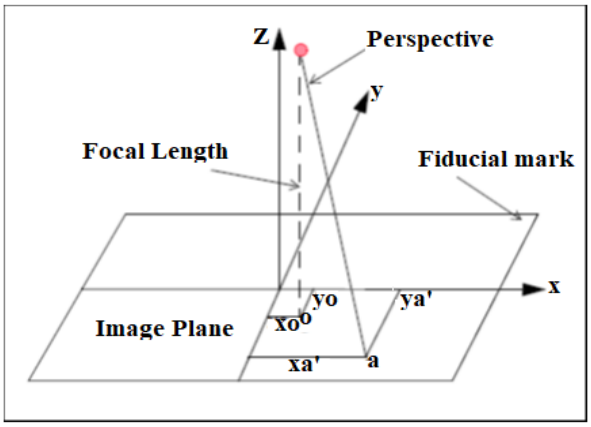


Figure 7: Internal Geometry Components

B. Focal Length: The image plane is commonly referred to as the focal plane. For wide-angle aerial cameras, the focal length is approximately 152 millimeters, or 6 inches. For some digital cameras, the focal length is 28 millimeters. Prior to conducting photogrammetric projects, the focal length of a metric camera is accurately determined (calibrated) in a laboratory environment.

C. Fiducial Marks: As stated previously, one of the steps associated with calculating interior orientation involves determining the image position of the principal point for each image in the project. Therefore, the image positions of the fiducial marks are measured on the image, and then compared to the calibrated coordinates of each fiducial mark. The measured image coordinates of the fiducial marks are referenced to a pixel or file coordinate system because the image space coordinate system has not yet been defined for each image. The pixel coordinate system has an x coordinate (column) and a y coordinate (row). The origin of the pixel coordinate system is the upper-left corner of the image having a row and column value of 0 and 0, respectively. The figure below *(See figure:14)* beside illustrates the difference between the pixel coordinate system and the image space coordinate system.

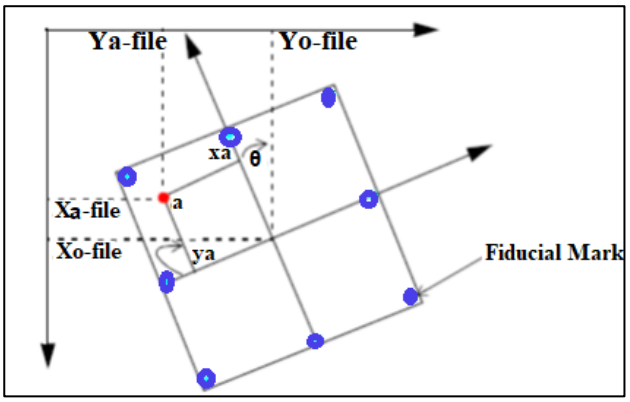


Figure 8: Pixel Versus Image Space Coordinate System

D. Lens Distortion: Lens distortion deteriorates the positional accuracy of image points located on the image plane. Two types of radial lens distortion exist: radial lens distortion and tangential lens distortion. Lens distortion occurs when light rays passing through the lens are bent, thereby changing direction and intersecting the image plane at positions deviant from the norm. The figure below *(See figure:9)* illustrates the difference between radial and tangential lens distortion.

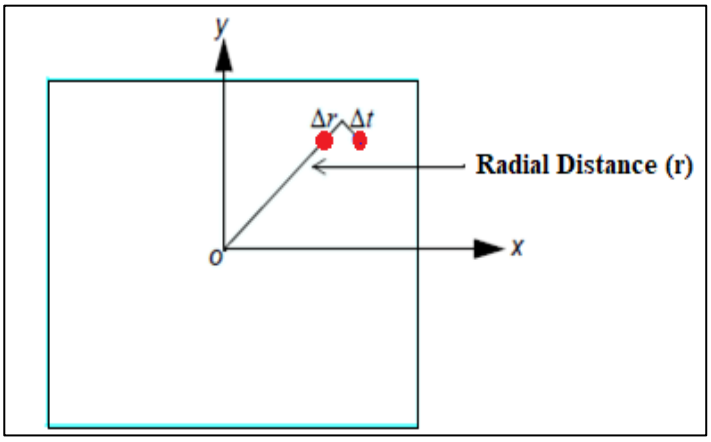


Figure 9: Radial Versus Tangential Lens Distortion

7.4 Exterior Orientation

Exterior orientation represents a transformation from the ground coordinate system to the image coordinate system. The exterior orientation is the position and orientation of the camera when the image was taken. In other words, it is the relationship between the ground and the image. Many photogrammetric cameras are equipped with on-board Global Positioning Systems (GPS) and sometimes with inertial navigation systems (INS) or inertial measurement unit (IMU) as well. These systems collect the exterior orientation directly on the plane.

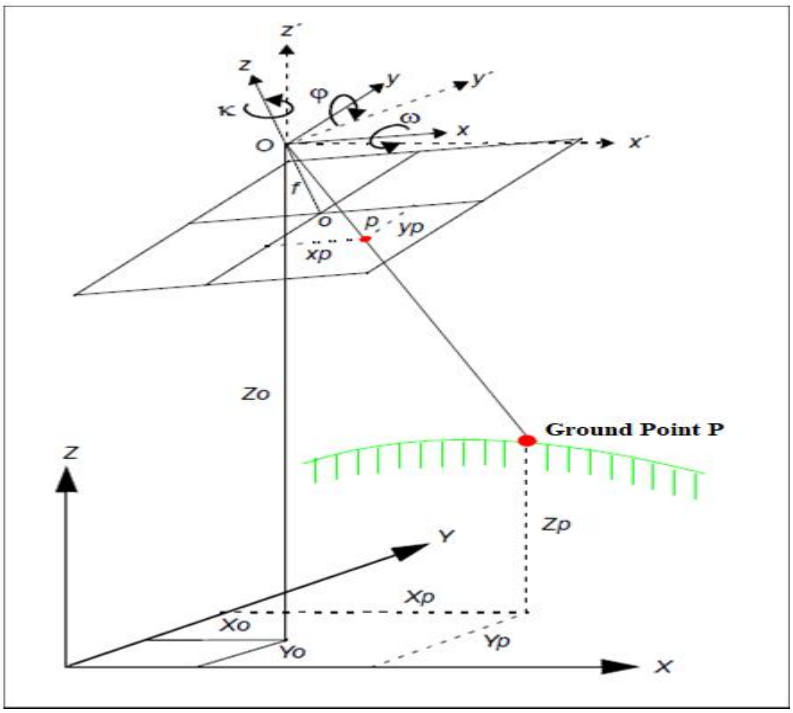


Figure 10: Elements of Exterior Orientation

In most projects, exterior orientation is computed from ground control points (GCPs) and tie points. The position of the camera means the x, y, and z location of the camera's focal point measured in a right-handed mapping coordinate system. The orientation of the camera is given by omega (the rotation about the x-axis), phi (the rotation about the y-axis), and kappa (the rotation about the z-axis). The x, y, and z coordinates and the omega, phi, and kappa angles are referred to collectively as the six parameters of exterior orientation.

Activity	List interior and exterior orientation parameters.

7.5 Aerial Triangulation and Adjustment

Aerial triangulation is a methods of coordinating points on the ground using a series of overlapping aerial photographs. Aerial triangulation has gone through different stages in the past; namely, radial, strip, and block triangulation.

7.5.1 Radial Triangulation

Radial triangulation is a graphical approach and based on the fact that angles measured in a photograph at the isocenter, located in the middle of line connecting the principal point and photo-nadir, are true horizontal angles and can be used for planimetric triangulation. For a vertical photography, the principal point and the photo-nadir coincide; therefore, the fiducial

centre is a suitable approximation of isocenter for this method. In this approach, the principal points of the neighbouring photographs are transferred and the horizontal rays can then be drawn for each photo. These planimetric bundles can be put together along a strip or in a block using two ground control points. The other points can be defined by multiple intersections.

7.5.2 Strip Triangulation

Strip triangulation was developed in the 1920s, where a Multiplex instrument was used to recreate the aerial photography mission. It is based on dependent pair relative orientation and scale transfer to ensure uniform scale along the strip. The sequential dependent pair relative orientation plus scale transfer starting from a controlled model is known as cantilever extension which is equivalent to an open traverse in surveying. If ground control points are used at the end or in between, the method is called "bridging" which is similar to a controlled traverse in surveying. Mechanical or graphical interpolation techniques were then used to fit the measured strip coordinates to the ground control.

7.5.3 Block Triangulation

Block triangulation (bundles or independent models) provides the best internal strength compared to strip triangulation. The available tie points in consecutive strips assists in the roll angle recovery which is one of the weaknesses inherent in strip triangulation. In terms of the computational aspect, aerial triangulation methods are categorized as:

A. **Analogue Aerial Triangulation:** This method uses a "first order stereo" plotter to carry out relative and approximate absolute orientation of the first model and cantilever extension. The strip or block adjustment is then performed using the resulting strip coordinates.

B. **Semi-Analytical Aerial Triangulation:** Relative orientation of each individual model is performed using a precision plotter (for example, Wild A10). The resulting model coordinates are introduced in a rigorous simultaneous independent model block adjustment. Independent models can also be linked together analytically to form strips which are then used for strip adjustment or block adjustment with strips.

C. **Analytical Aerial Triangulation:** The input for analytical aerial triangulation is image coordinates measured by a comparator (in stereo mode or mono mode plus point transfer device). A bundle block adjustment is then performed by using all image coordinates

measured in all photographs. An analytical plotter in comparator mode can also be used to measure the image coordinates.

D. Digital Aerial Triangulation: This method uses a photogrammetric workstation which can display digital images. Selection and transfer of tie points and measurement tasks that are performed manually in analytical triangulation are automated using image matching techniques. The procedure is fully automatic, but allows interactive guidance and interference.

7.5.4 Control Requirements for Photogrammetric Blocks

Any block consisting of two or more overlapping photographs requires that it be absolutely oriented to the ground coordinate system. The 3D spatial similarity transformation with 7 parameters (3 rotations, 3 translations, and 1 scale) is usually employed for absolute orientation and requires at least 2 horizontal and 3 vertical control points. Due to some influences caused by transfer errors (for example, image coordinate measurements of conjugate points), and extrapolation beyond the mapping area, the theoretical minimum control requirement is unrealistic.

Theoretical and practical studies showed that only planimetric points along the perimeter of the block and relatively dense chains of vertical points across the block are necessary to relate the image coordinate system to the object coordinate system. These measures also ensure the geometric stability of the block as well as control the error propagation.

7.5.5 GPS Assisted Aerial Triangulation

GPS can be used for direct positioning practically anywhere on earth and at any time. GPS has already had a revolutionary impact in various disciplines which are involved with navigation and geodetic positioning. A real time capability is required if GPS is used for navigation purposes. However, it was soon realized that GPS offers a very high accuracy for positioning in combination with post-processing methods.

Since the launch of GPS satellites in early 1980s, photogrammetrists realized the usefulness of GPS for their particular interests (For example, aero triangulation).



The four main areas in photogrammetry where GPS can be used:

- Establishment of ground control points using terrestrial GPS,
- GPS controlled survey flight navigation,
- High precision camera positioning for aerial triangulation,
- Positioning of other airborne sensors (for example, laser scanners).

The main purpose of aerial triangulation (AT) is the determination of ground coordinates for a large number of terrain points and the exterior orientation parameters of aerial photographs using as few control points as possible. The best scenario in mapping projects is to determine the exterior orientation parameters accurate enough so that the AT can be neglected. The accuracy for attitude parameters derived from multiple-antenna GPS observations is about 15 arc minutes, which is still far from what could be obtained from conventional block adjustment. Therefore, aerial triangulation is still one of the important steps in mapping and cannot be avoided.

The integration of GPS measurements into photogrammetric blocks allows the accurate determination of coordinates of the exposure stations resulting in a reduction of the number of ground control points to a minimum. Therefore, the goal is to improve the efficiency of aero triangulation by avoiding ground control points almost completely. The combined adjustment of photogrammetric data and GPS observations can be carried out by introducing GPS observation equations to the conventional block adjustment.

7.5.6 Bundle Blocks

A bundle of rays that originates from an object point and passes through the projective centre to the image points *(See figure:11)* forms the basic computational unit of aerial triangulation. Bundle block adjustment means the simultaneous least squares adjustment of all bundles from all exposure stations, which implicitly includes the simultaneous recovery of the exterior orientation elements of all photographs and the positions of the object points.

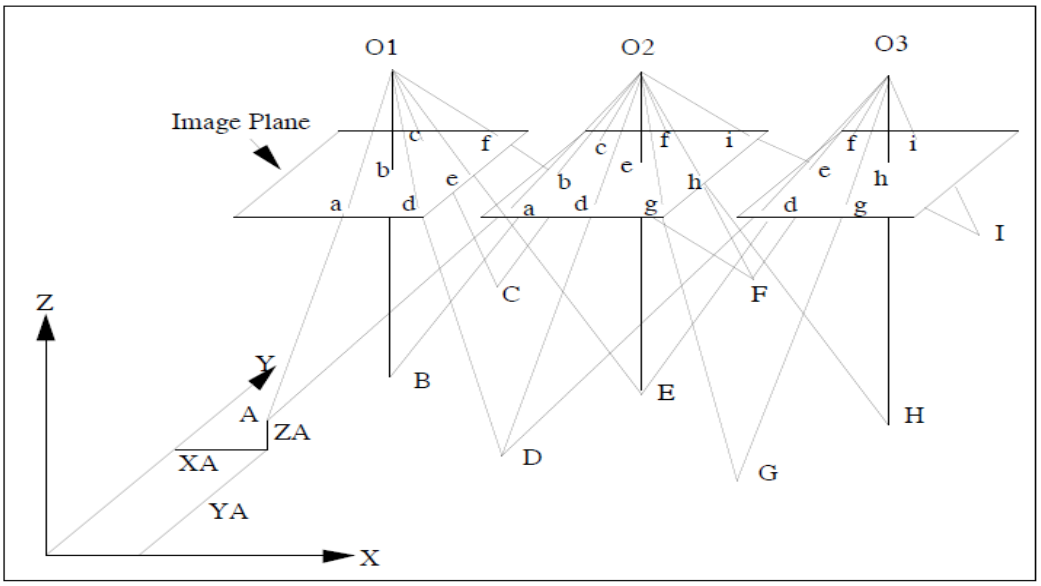


Figure 11: Bundle Blocks

The fundamental equation of aerial triangulation is the collinearity equation which states that an object point, its homologous image point, and the perspective centre are collinear *(See figure:18).*

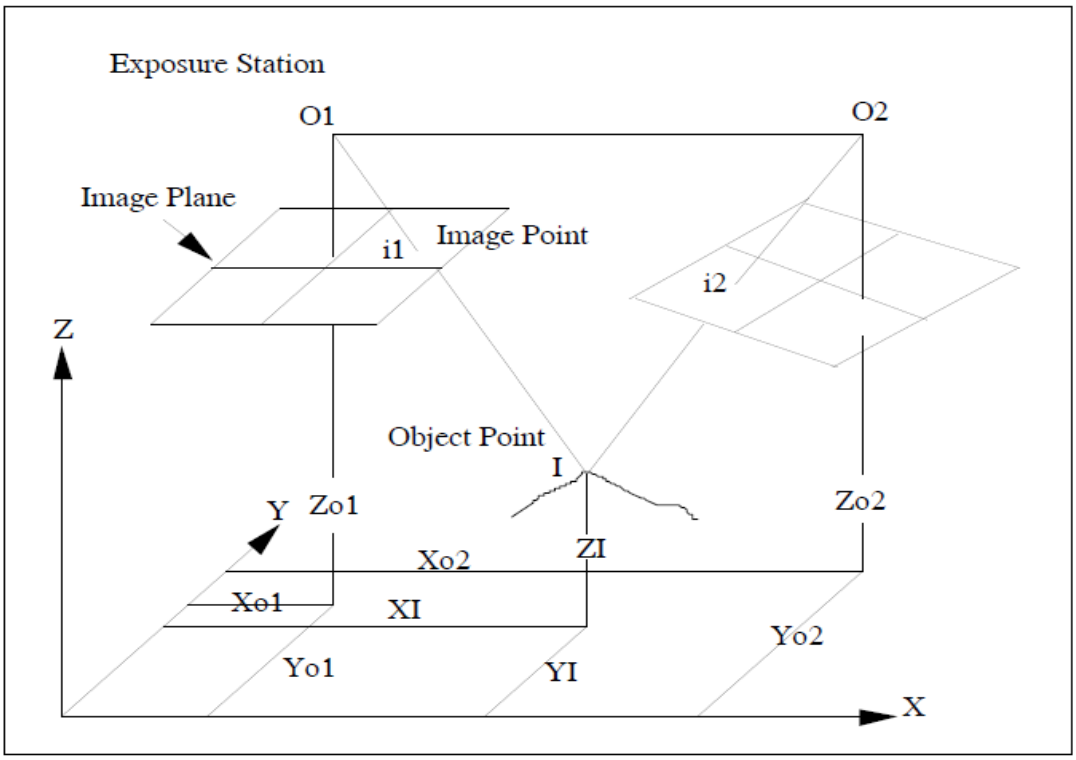


Figure 12: Collinearity Equation Diagram

The collinearity equations are given as:

$$F_x = x_i - x_o + C\frac{m_{11}(X_i - X_O) + m_{12}(Y_i - Y_O) + m_{13}(Z_i - Z_O)}{m_{31}(X_i - X_O) + m_{32}(Y_i - Y_O) + m_{33}(Z_i - Z_O)} = 0 \qquad 7.1$$

$$F_y = y_i - y_O + CK_y \frac{m_{21}(X_i - X_O) + m_{22}(Y_i - Y_O) + m_{23}(Z_i - Z_O)}{m_{31}(X_i - X_O) + m_{32}(Y_i - Y_O) + m_{33}(Z_i - Z_O)} = 0 \qquad 7.2$$

Where:

$$M = \begin{bmatrix} m_{11} & m_{12} & m_{13} \\ m_{21} & m_{22} & m_{23} \\ m_{31} & m_{32} & m_{33} \end{bmatrix} = \qquad 7.3$$

$$\begin{matrix} cos(\phi)cos(k) & cos(\omega)cos(k) + sin(\omega)sin(\phi)cos(k) & sin(\omega)sin(k) - cos(\omega)sin(\phi)cos(k) \\ -cos(\phi)sin(k) & cos(\omega)cos(k) - sin(\omega)sin(\phi)sin(k) & sin(\omega)cos(k) + cos(\omega)sin(\phi)sin(k) \\ sin(\phi) & -sin(\omega)cos(\phi) & cos(\omega)cos(\phi) \end{matrix}$$

And

(x_i , y_i) *are the image coordinates,*

(x_o , y_o) *are the principal point coordinates,*

C *is the camera constant,*

m_{ij} *is an element of the rotation matrix,*

(X_i , Y_i , Z_i) *are the object point coordinates,*

(X_O , Y_O , Z_O) *are the exposure station coordinates,*

M *is the rotation matrix,*

K_y *is the scale factor for y axis in digital camera.*

There are 6 unknowns in the collinearity equations, namely, the exterior orientation parameters$(X_O , Y_O , Z_O, \omega, \phi, k)$. The three rotation angles $(\omega, \phi, k)$are implicit in the rotation matrix M. The principal point coordinates $(x_o , y_o)$and camera constant (c) are considered to be known for the basic bundle approach. However, strong imaging geometry plus a minimum of three ground control points are needed to solve for the six unknowns per bundle which are then used to determine the unknown object coordinates of other measured image points.

7.5.7 Control Requirements

Any block comprised of two or more overlapping photographs requires to be absolutely oriented to the ground coordinate system. The 3D spatial similarity transformation with 7 parameters (3 rotations, 3 translations, 1 scale) is most frequently utilized for absolute orientation and require at least 2 horizontal and 3 vertical control points. Due to some influences caused by transfer errors and extrapolations beyond the mapping area, use of only the theoretical minimum control is unrealistic.

Theoretical and practical studies showed that planimetric points along the perimeter of the block and relatively dense chains of vertical points across the block are necessary to relate the

image coordinate system to the object coordinate system and also to ensure the geometric stability of the block as well as to control the error propagation.

The control requirements are different for mapping purposes and photogrammetric point determination projects. A spacing of 8-10 base lengths in planimetry along the perimeter of the block and dense cross chains (every 2nd strip) at both ends and 6-8 base lengths in between for vertical control are recommended for regular mapping. The dense perimeter control (For example, every two base lengths) and dense net of vertical points within the block (For example, every 2 base lengths perpendicular to the strip direction) and every 4 base lengths along the strip direction are required for photogrammetric point determination. The number of control points can be reduced by changing flight parameters, increasing side lap, and using multiple coverage. If the terrestrial surveys was laid out solely to establish perimeter control (i.e. by a traverse), it may lead to a weak geometric configuration, therefore, some cross connections would strengthen the geometry and absolute accuracy.

Aerial triangulation has become a powerful tool for point determination during the last two decades. The main reason is the rigorous application of adjustment theory which enabled simultaneous recovery of exterior orientation parameters and object point coordinates. The refinement of the collinearity model to compensate for systematic errors led to further increase in the accuracy by a factor of two or three. Today, an accuracy of the adjusted coordinates of 2 to 3 m, expressed at the photo scale can be achieved if the full potential is used.

The effects of un-modelled errors, especially gross errors, have not been studied thoroughly until a few years ago. Each block adjustment has to handle a certain percentage of gross errors which are generally detected and eliminated via residual analysis. However, there does not exist an accepted criterion about when to stop the process of elimination of possibly erroneous observations. Therefore, undetected gross errors may remain, hopefully, not adversely affecting the results. This leads to the theory of the reliability of adjusted coordinates.

7.6 Digital Terrain Model (DTM)

A digital terrain model (DTM) can be described as a three - dimensional representation of a terrain surface consisting of X, Y, Z coordinates stored in digital form. It includes not only heights and elevations but other geographical elements and natural features such as rivers, ridge lines, etc. With the increasing use of computers in engineering and the development of

fast three-dimensional computer graphics the DTM is becoming a powerful tool for a great number of applications in the earth and the engineering sciences.

DTM is an important topographic product and essential demand for many applications. Traditional methods for creating DTM are very costly and time consuming because of land surveying. In time, Photogrammetry has become one of the major methods to generate DTM. Recently, airborne Light Detection and Ranging (LiDAR) system has become a powerful way to produce a DTM due to advantage of collecting three-dimensional information very effectively over a large area by means of precision and time.

7.6.1 DTM Source Data

Topographic point measurements (XYZ) acquired from airborne and terrestrial laser scanning (ALS and TLS) and photogrammetry commonly are used to generate 3D digital terrain models (DTMs). Height information from the terrain surface in regular grid form gives a digital terrain model. The quality of a DTM is directly dependent on the grid interval and the data source from which it is generated. Depending on the required application information about break lines and embankments will be incorporated. The DTM is visualized through, For example, 3D-wire mesh models with colored height columns. Contour lines, cross sections, slope models or volume calculation can also be derived from a DTM.

A sufficient amount of height information is necessary in order to calculate a DTM. Such information is gathered from the photogrammetric restitution of spot heights and break lines in aerial photos (vector data) or from laser scanner mapping. The program doesn’t only generate the DTM, but also provides a variety of processes for analysis and visualization.

7.6.2 Data Collection Approaches

A number of standard approaches are generally employed in elevation data collection, the plotting of contour lines, the capture of spot elevations and break lines, and the collection of a point matrix. A break line is defined as a polyline that defines a slope reversal along its extent and may include both naturally occurring and man-made features. Common examples of break lines include ridges, valleys, edges of embankments, edges of rivers, curbs/ gutters, etc. Break lines are augmented by a number of spot elevations that fill in areas devoid of natural or man-made breaks in the terrain surface. A number of spot elevations are collected at identifiable points to leave behind a record of points that can be checked. Spot elevations are also collected at local maxima and minima that are not represented by a contour line.

7.7 DTM Generation

DTM is a structured surface that contains elevation data with some critical features of terrain such as ridge lines, peak points etc. During the DTM generating process, higher vegetation-horizons, buildings and also other, non-terrain objects are removed. Removing non-terrain objects to get bare earth is called filtering. The ground filtering is an essential step to separate points which are from the ground surface and which are from non-ground features for almost all topographic applications. Distinguishing ground from non-ground can be a considerable challenge in regions with high surface variability. Besides accurate DTMs can only be generated if non-ground points are removed successfully. The system provides possibility of generation of digital terrain model using different data sets.



The following datasets are used for generation of digital terrain model:

- Points
- Triangulation Irregular Network (TIN)
- Contour lines:
- Digital Elevation Model (DEM):

A. Points: point vector objects, located on relief surface;

B. Triangulation Irregular Network (TIN): one of the models of spatially coordinated data, used during designing of digital terrain model as elevation points in nodes of irregular network of triangles, that corresponds to Delaunay triangulation.

- TIN approximates the land surface with a series of non-overlapping triangles. Elevation values (Z values) along with x, y co-ordinates are stored at nodes that make up the triangles. The triangles are made from a set of points called mass points.
- Mass points can occur at any location, the more carefully selected, and the more accurate the model of the surface. Well-placed mass points occur where there is a major change in the shape of the surface, for example, at the peak of a mountain, the floor of a valley, or at the edge (top and bottom) of cliffs.
- A TIN affords a more efficient representation of terrain in terms of data storage.
- With a TIN, spot elevations can be acquired at critical points (mass points), which are high points, low points, location of slope changes, ridges, valleys and so on.
- Once these spot elevations have been collected, together with their X, Y coordinates, lines are constructed between the points forming a system of triangles covering the surface.

- Within each triangle, the surface is represented by planes, which are sloped in 3D-space. Each triangle side has uniform slope and system of triangles is called TIN model.

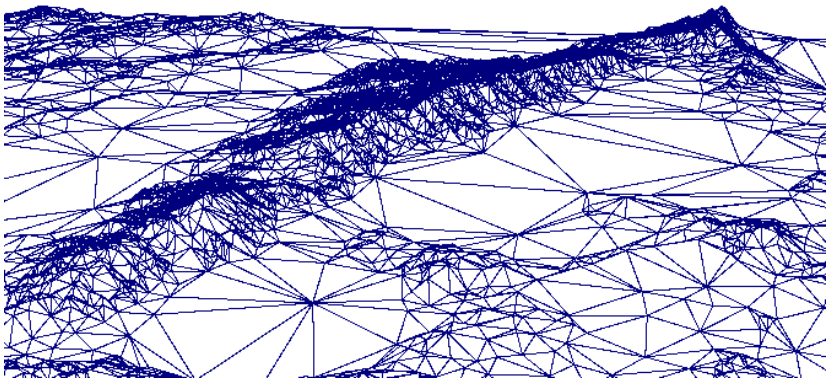


Figure 13: Triangulated Irregular Network

- The method generally used to construct TIN is known as Delaunay triangulation. In this method, the lines are drawn between points in closest proximity to each other without any lines intersecting.

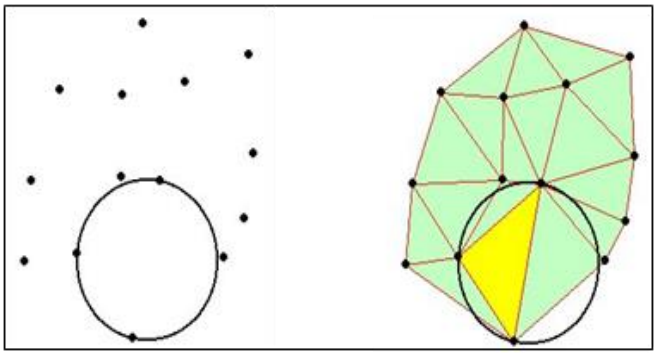


Figure 14: Delaunay Triangulation

- The resulting set of triangles has the property that of triangle, the circle that passes through the three vertices contains no vertices of any other triangle.
- A further generalization of TIN allows the inclusion of break lines. Break lines are lines, which have constant slope and are used to where there are discontinuities in the terrain surface, such as streams, shorelines, bridges, roads etc.
- Within the TIN, a break line will form the sides of two adjacent triangles and will have no other lines crossing it.
- By using break lines in a TIN, the terrain surface can be more faithfully represented and contours generated from the TIN will give a more accurate portrayal of the surface features.

C. **Contour lines**: vector lines that connect points with the same terrain altitude. It describes the elevation of terrain by contours. Contour lines connect points of equal elevation and the contour interval represents the vertical distance between contour lines. The arrangement and pattern of contour lines reflect the Topography. For example, closely spaced contour line indicates steep slope whereas, circular arrangement indicates conical hill etc.

- Contours are the most accessible source of terrain information for most map users.
- Contours are good for human interpretation. Closely spaced contours are a clear visual cue that the local terrain is steep.
- A sharp angle in a contour is a clue of a stream or ridge line. You can get a sense of the "lay of the land" by reading contours on a map. However, contours are generally poor for computer surface models. The collection of all points on contours does not make a good dataset for surfaces. It is difficult to remove data artifacts introduced from converting contours to raster's or TINs. Converting contours is usually a last resort for building a surface model. You can make a perspective view or perform surface analysis of contours only after they have been converted to a raster or a TIN.

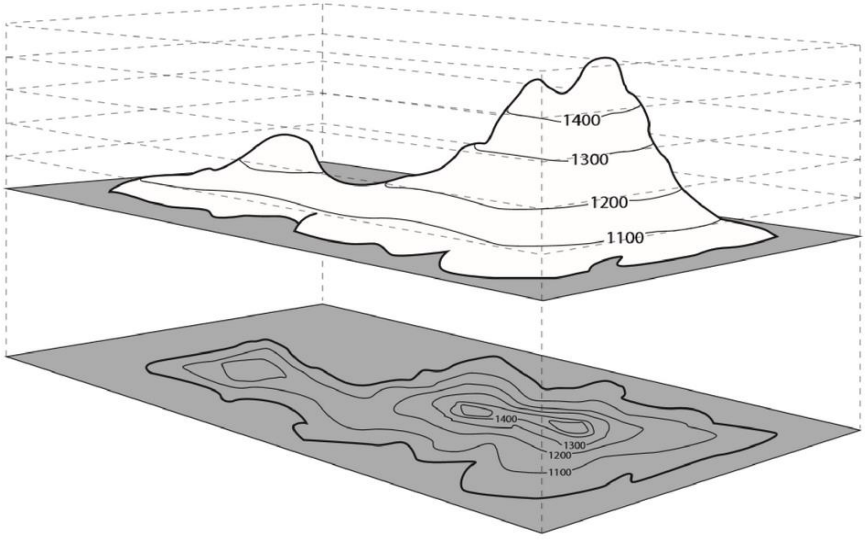


Figure 15: Contour Lines

D. **Digital Elevation Model (DEM)**: digital cartographic presentation of terrain surface as regular grid of elevation values.

- In regular grid DEM, spot elevations are determined for a uniformly spaced array of ground cells (grid).

- The figure below shows a three-dimensional representation of a rectangular DEM. In this figure lines are drawn to connect the center points of the grid array, which store the values for elevations.

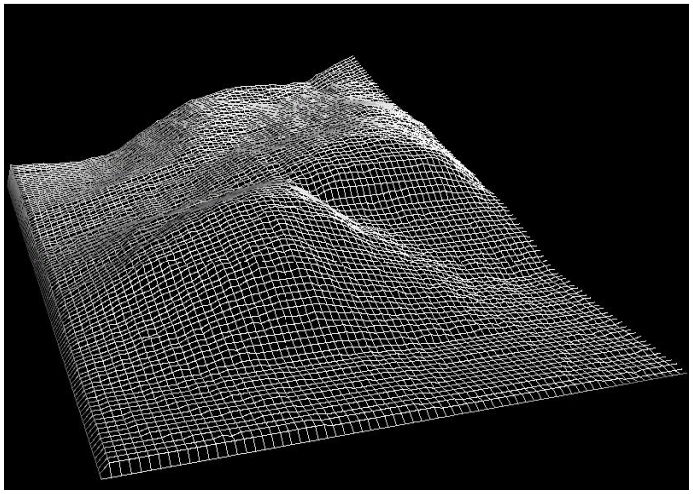


Figure 16: Regular Grid DEM

- Since the Z-values are stored as an array of numbers, they are compatible for computer processing using various algorithms. These algorithms include contour generation, volume and slope calculation, ortho photo generation and depiction of three-dimensional view.
- A disadvantage associated with regular grid DEM's is that for large areas of level or uniformly sloping terrain, a great deal of computer memory is wasted storing highly redundant elevation information. For example, if grid cell size is 1m x 1m to represent an area of 100 m x 100 m = 10,000 storage locations will be used to represent the elevations. And if the terrain is flat all 10,000 values will be same (high degree of redundancy).

Activity	What are the sources of DTM?

7.8 Editing DTM

Editing is the process of making changes to a geographic database by adding new objects or changing existing objects as part of data load or database update and maintenance operations. A database update is any change to the geometry and/or attributes of one or more objects or any change to the database schema.

A. **Task Specifications and Over-editing:** Most projects provide terrain data for the Ortho rectifying process, so the required level of accuracy of the terrain depends on the final ortho-rectification. Take care not to make your DTM more accurate that the final specifications for the ortho-rectifying process require.

B. **Ways to Visualize the Terrain for Editing:** Always look at the terrain three-dimensionally, with graphics superimposed on stereo images. Then, you can see if the graphics actually rest "on the ground". You only need to edit in areas where the graphics are not on the surface. You can display terrain graphically as contours, points, or mesh. When the cursor appears to be on the ground it will be considered as a good measurement. Some people have difficulty seeing three-dimensional stereo accurately enough to edit terrain. Display the terrain and start editing, using the thumb wheel, scroll wheel, or trackball of your mouse to move the three-dimensional cursor up or down. When the 3D cursor is on the same position in the left and right image then the cursor is on the ground. That is known as "putting the cursor on the ground" or "measuring the surface". When viewing in stereo, the cursor appears at "ground" level. If you look at the coordinate display, you can see the Z value change as the cursor moves up and down.

C. **Terrain-shaded Relief:** In an IMAGINE Viewer, use terrain-shaded relief to get an overall look of the raster DEM and to find blunders and unusual or impossible terrain features. Display the terrain shaded relief in an IMAGINE Viewer, and the images in Terrain Editor. Roam systematically throughout the terrain shaded relief looking for artifacts likely caused by blunders in the DTM. To review the DTM at any suspect point, center the measuring mark on the point in the terrain-shaded relief image, then look at the same area in the stereo images at high resolution and display terrain graphics.

D. **Perspective Views:** Use perspective views to rotate the DTM around to look for unnatural spikes.

E. **Initial Quick Edits:** During the initial phase of editing, strive for a quick, general cleanup of the DTM, not high precision. Do an overall, coarse editing. The approach you take will be depend on whether you are editing TINs or GRID DTMs.

 Activity	List the datasets used for generation of digital terrain model.

7.8.1 Editing TINs

There are a lot of points in the TIN that must be edited. One of the more efficient ways to approach TIN editing in this case is to start by deleting bad points.

- Start by making liberal use of the Area tools, such as Delete Points, Smoothing, and Eliminate Trees and Buildings. Use them to smooth areas, and to remove the effects of buildings, stands of trees, and other large obstacles anywhere that many of the mass points are wrong or not on the terrain surface.
- Next, put in break lines with the Break line tool, especially in regions where there are numerous mass points. The break lines do not have to follow true geomorphic lines. They can form lines on flat terrain, around hills, or anywhere that the DTM needs editing. When you add a break line to a TIN, it removes all mass points within a certain distance of the break line.
- The third step in initial TIN editing is to use the Delete function of the Point Editor. With it, you can quickly delete remaining points that are not on the ground. One of the attributes of this tool that allows you to work rapidly is that high pointing precision is not required. Be sure that the measuring mark is closer to the point intended to be deleted than to any other point. Finally, add points where required, or move the remaining points to correct positions.

7.8.2 Editing GRID

- Use the Directional Post Editing task panel to quickly move thru the gridded posts and change the cursor to the post elevation or the post to the cursor elevation.
- Use the Terrain Editing task panel to edit individual posts that are off the ground.
- Use the Area tools, such as Smoothing and Eliminate Trees and Buildings. Use them to smooth areas, and to remove the effects of buildings, stands of trees and other large obstacles anywhere that a lot of the mass points are wrong or not on the terrain surface.

 Activity	Explain the concept of aerial triangulation and adjustment.

7.9 Prepare For Approval Process

The approval process of aerial triangulation is done by assuring the working steps completeness and the final results consistency. This includes the following Assessment criteria:

- the relative orientation is satisfactory for all images in a block
- the residuals of AT compensation are smaller than 1.2 * pixel image size
- RMS values are less than 0.8 * pixel image size
- the Sigma value (assessment index) is situated in the interval of 1/3 and 3/4 * pixel image size
- RMSxy and RMSz for GCPs (also check GCPs) are smaller than the final GSD of the block
- The final products (Ortho in DEMs) meets the requirements set by urban cadastral legal standard No.03/2015 which stated:- Horizontal Accuracy in RMSE must not exceed two pixels size of Ground Sample Distance (in x and y) whereas the Vertical Accuracy in RMSE must not exceed three pixels size of Ground Sample Distance (in z). Regardless of the method, however, the positional accuracy of the final output should not exceed 40cm at scale of 1:2000.

7.10 Summary

 Dear trainee!, aerial triangulation includes interior orientation of block images, measurement of tie points coordinates on images, relative orientation of block images, as well as input of ground control points (GCP) coordinates to catalogue and measurement of these points coordinates images or their import and using exterior orientation data. After data collection to form a block for aerial triangulation the block adjustment is performed.

Aerial triangulation rigorous application of adjustment theory which enabled simultaneous recovery of exterior orientation parameters and object point coordinates and has become a powerful tool for point determination. The ultimate goal of work on aerial triangulation and block adjustment is defining of exterior orientation parameters that allow proceeding to block processing step, which includes stereo vectorization, creation of DTM, orthomosaic and 3D models.

DTM is a structured surface that contains elevation data with some critical features of terrain such as ridge lines, peak points etc. The automated DTM production process depends on the

DTM data sources. In these instances, you have to edit the error and reshape them so that they fit, reflect, and represent the earth's surface. Because accurate DTMs are required for the ortho mosaicking process, you need to ensure the DTM accurately reflects the ground. Otherwise, the resulting ortho will have less than optimal quality.

Accurate DTMs are also required to create 3D visualizations and simulations using. If the DTMs do not accurately reflect the terrain and features on the earth's surface, the quality of the 3D visualization will be very low. DTMs are also edited to add detail to the terrain dataset. For example, you may get a coarse-resolution DTM and want to densify it by adding detail in specific areas. You can do this manually using the stereo model (imagery) as a backdrop to ensure that the new DTM points actually are on the earth's terrain.

7.11 Self-Check Exercises



Short Answer Items

Instruction: Give short, brief and precise answer for the following questions.

1) What is interior orientation?
2) List variables used to define the internal geometry?
3) Discuss technological trends used so far for triangulation and adjustment techniques.
4) List and differentiate methods of block triangulation.
5) What is the use of block adjustment?
6) Describe different stages of Aerial triangulation and adjustment.
7) Discuss different categories of aerial triangulation based on computational aspect.
8) List the four main areas in photogrammetry where GPS can be used.
9) What is DTM and methods of generation DTM.
10) Discuss on data sources specifically used to generate DTM?
11) Compare and contrast on datasets used for generating DTM?
12) What is TIN? What are techniques used to edit TIN?
13) What is editing?
14) What is break line and elaborate with example.

CHAPTER EIGHT: PRODUCE ORTHO-PHOTO MAPS

8.1 Introduction



Dear trainee! This chapter deals with the concept of producing orthophoto. Ortho photographs are photographic images constructed from vertical or near vertical aerial photographs. Many end users of digital orthophotos today have very strong hardware and sophisticated software to view and manipulate orthophoto images. They require the ability to view selected image features and perform analysis such as relative distance, area, or even change analysis.

A digital orthophoto image is a raw digital aerial photo image rectified to a suitable DEM of the same area. Imagery either can be from existing sources (aerial photography or satellite/airborne imagery) or can be obtained specifically for the project. However, proper selection of imagery and ground control points are critical for producing final orthophoto. Ground control is required to rectify the imagery to its true geographical position on the earth's surface. At last, georeferenced images are used to construct the mosaic; software is used to automatically place each image in its correct position in which individual images can be mosaicked to produce a single digital image of a large area.

8.2 Learning Objectives



After completing this chapter, you will be able to:

- Plan and prepare for orthophoto production
- Perform image rectification
- Create and edit mosaic
- Produce orthophoto maps



Dear trainee! Before reading the following section, take ten minutes and try to describe orthopoto, and identify basic requirements used for orthophoto production.

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8.3 Plan and Prepare For Orthophoto Production

Orthpohot generationprocess starts from the basic flight planning and the process of taking arialnphotos.Planning and preparing for orthophoto production involves a systematic approach to ensure accurate and high-quality results. Here are the key steps to consider when planning and preparing for orthophoto production:Digitizing of the aerial photograph, Transfer of the digital image, Orientation, Preparation of the digital elevation model, Geometric transformation, and Mosaicking.

8.4 Image Rectification

Image Rectification is a process by which image distortions caused by topography and image orientation are geometrically corrected by the incorporation of a terrain model. Orthophoto process transforms a vertical aerial photograph in to the equivalent of traditional map. Yet it retains the advantages of a photograph-virtually displaying actual cultural and land features and the built environment rather than representing those features using symbols and lines. Several photogrammetric software which can be used to generate orthophotos are Leica Photogrammetric System (LPS), PCI Geomatica, Topcon pi 3000, Image Master, ERDAS Imagine, VirtuoZo and others. In this level, photogrammetric data from aerial photographs is used to generate orthophoto using ERDAS imagine software. The number and pattern of GCPs recommended for possible flight configurations are listed into the table below *(See Table:4).*

Table 4: Flight Configurations and Reccomended GCPs Pattern

Purpose/Method	Number of GCPs
Orientation of a single model	Minimum four (allows for testing of residuals)
Block adjustment for aerial triangulation, without airborne DGPS	One GCP every five base lengths (minimum) on the perimeter of the block and one GCP across all flight strips, every four base lengths.
DGPS controlled flight with cross strips (CBA-Method: Combined Block Adjustment)	One double GCP in each corner of a block and one double in the middle. Possible additional requirement of cross strips and more control within irregular blocks. Ambiguities which are not solved are removed as systematic errors in the Block Adjustment at great distances possible
DGPS controlled flight (no cross strips) (OTF-Method: Ambiguity resolution “on the fly”.)	One double GCP in each corner of a block and one double in the middle. GPS Reference stations should be at a range of 50-100 km from survey area, depending on possible interference.

Activity	Explain the concept of image rectification?

8.4.2 Data Merge and Radiometric Correction

This phase of the orthophoto process is the merger of the digital image and the DTM along with corrections in pixel intensity throughout the image. Software, used to merge the digital raster image with the DTM, makes adjustments in the horizontal location of pixels based upon their proximity to DTM points. This process removes the errors due to displacement and produces an image that is orthogonally accurate. This step adjusts the intensity of selected groups of pixels in the orthophoto to ensure that seams between mosaicked images are minimized and/or to bring out features of interest or minimize aberrations.

8.5 Image Mosaic

A mosaic is an assemblage of two or more overlapping images (tiles) used to create a continuous representation of a predefined area. Georeferenced images are used to construct the mosaic; software is used to automatically place each image in its correct position. Hundreds or even thousands of individual images can be mosaicked to produce a single digital image of a large area.

Mosaics of images may be prepared by matching and splicing together individual images. Differences in contrast/tone between adjacent images cause the checkerboard pattern that is common on many mosaics. This problem can be largely eliminated by preparing mosaics directly from the digital computer-compatible tapes (CCTs). Adjacent images are geometrically registered to each other by recognizing ground control points (GCPs) in the regions of overlap. Pixels are then geometrically adjusted to match the desired map projection. The next step is to eliminate from the digital file the duplicate pixels within the areas of overlap. Optimum contrast stretching is then applied to all the pixels, producing a uniform appearance throughout the mosaic.

Mosaicking is used for producing a visually appealing ortho image of large areas. In order to achieve this goal, the input images should have consistent geometric and radiometric characteristics so that the seams will be as less visible as possible in the output mosaic. Table 5 presents the main steps of the process and the quality checks to be followed.

Table 5: Best practice and QC for the production of orthomosaic

Operation	Best practice	Quality check
Radiometric pre-processing	Input images should be radiometrically homogeneous. Mosaic as much as possible only images acquired in a single collect (same conditions)	Images should be contrast, lightness (and colour) balanced . Similar types of objects not varying more than 10% in DN value (average).
Area selection	The most nadir chips of the images should be used for mosaicking to reduce distortion effects	Check the seamlines against the image nadir points and footprints
Seamlines	Run batch process with automatic seam generation but with user interaction for reviewing and editing seamlines	Visual check for full coverage at the AOI with seamlines polygons Seamlines not to cut through well-defined features

8.6 Ortho-photo Generation

Orthophotos (terrain-corrected, digitally-rectified aerial photographs in softcopy by digital photogrammetric techniques) are to be generated by the technical agency/vendor engaged for the purpose by Department of Land Records and Surveys (DLR and S). The flow chart indicates the technical process involved in generating orthophotos (*See figure 8.1*). Minimum 5 tie-lines are to be identified on the orthoimage (2 long distance diagonals, 1 long distance horizontal, 1 long distance vertical and 1 short distance tieline), and compared with their respective field measured lengths to check and validate the dimensional correctness of the orthoimage.

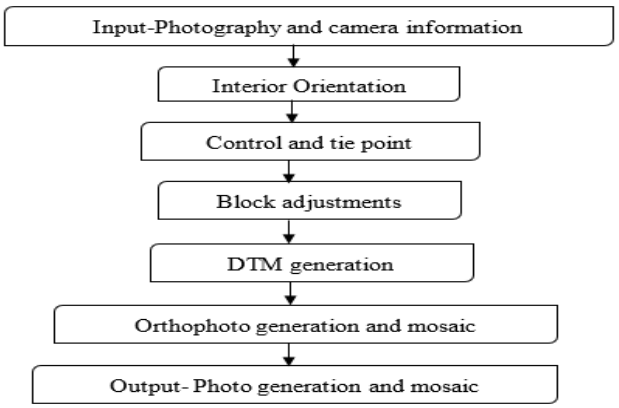


Figure 17: Process for Generating Orthophotos

8.7 Summary

Dear trainee! With the development of technology, Digital photogrammetry has started to be used widely in almost all areas about mapping. Especially digital orthophotos which are a photogrammetric products, are being used by lots of private sectors because of theirs easy interpretability. The processes used to generate orthophotos remove the effects of terrain relief displacement and tilt of the aircraft. When properly generated, these digital images have a predictable constant positional accuracy throughout the entire image.

Software merges the digital image with the DEM and aligns the image orthogonally. Currently, scanning technology and software allow end users to generate products that may appear as orthorectified images at very little cost. Production of final orthophoto requires consecutively captured images/photographs will full camera information, interior oreintation parameters, control and tie points, block adjustment, DTM generations, and orthophoto generations and mosaicking.

8.8 Self-Check Exercises

Short Answer Items

Instruction: Give short, brief, and precise answer for the following questions.

1) What are the things you need to consider in the process of orthophoto production?
2) Identify criterias used in order to select ground control points for the required imagery.
3) Explain the following and where you would use them:
    a) Image Mosaic b) Radiometric Correction
4) List and explain processes used to generate final orthophoto.
5) Discuss the recommended GCPs for possible flight configurations.
6) Explain the role of image mosaic in orthophoto production..

CHAPTER NINE: PERFORMING 2D AND 3D FEATURE EXTRACTION

9.1 Introduction



Dear trainee! This chapter deals with the concept of 2D and 3D feature extraction and merge contour. Planimetric feature extraction involves the creation of maps that show only the horizontal position of features on the Earths' surface, revealing geographic objects, natural and cultural physical features, and entities regardless of topographic information.

Planimetric maps are prepared from different sources by utilizing different techniques and methods. It can be prepared by using spatial data obtained from ground surveying, aerial photography or high-resolution satellite imagery. High accuracy planimetric mapping is capital intensive and costly if one is intending to do it by ground survey only. So, it is cost and time effective to survey aerially as in aerial photography mission and produce an orthophoto for 2D feature extraction. The extracted 2D features can be superimposed with contour for visualizing geographic datasets. However, the methods of locating contours depend up on the instrument used to determine the horizontal as well as vertical position of several points in the area.

In order to interpret and collect 3D information directly from imagery, at least two overlapping images taken from different perspectives are required. 3D Topographic maps help users see how the land changes in elevation and can be used to locate surface features in a given area, to find the way through a particular area, and to determine the direction of water flow in a given area.

A sterioscopic model is a 3D impression of an object of terrain received by an observer viewing two flat perspective images obtained from different points in space. With the simultaneous observation of such a stereoscopic pair of images, of a measurement mark, and of the superposition of the images, a highly precise alignment of the points of the images can be obtained.

The alignment can be used to identify the points and to measure coordinates. In general, when you are extracting features and edit in GIS environment directly inside 3D, consider using ArcScene for your localized, precision edits, and using ArcGlobe for globally managing sketches and feature placement.

9.2 Learning Objectives



After completing this chapter, you will be able to:

- Prepare requirements for 2D and 3D map production
- Perform 2D feature extraction and planimetric mapping
- Perform 3D feature extraction, stereo visualization and topographic mapping
- Finalize 2D and 3D feature extraction project
- Superimpose contour layers



Dear trainee! Before reading the following section, take ten minutes and try to describe techniques of extracting 2D and 3D map.

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9.3 Requirements for 2D and 3D Map Production

9.3.1 Requirements for 2D Map Production

Before any planimetric map preparation through 2D feature extraction method selection for appropriate source data or a base imagery is required. The base image is a back drop image from which features will be extracted. Planimetric maps are prepared from different sources by utilizing different techniques and methods. It can be prepared by using spatial data obtained from:

- Ground surveying,
- Aerial photography or
- High resolution satellite imagery

The production may take place independently or in a combination of all the above aforementioned sources of information based on the organizational procedures of using these sources of information. High accuracy planimetric mapping project by its nature is capital intensive and costly if one is intending to do it by ground survey only. So, it is cost and time effective to survey aerially as in aerial photography mission and produce an orthophoto for 2D feature extraction. We use an orthophoto as a back drop (base map) in GIS software to undertake 2D feature extraction using head-on digitizing.

Activity	List the commonly used source of spatial data.

9.3.2 Requirements for 3D Map Production

A topographic map is a detailed and accurate illustration of man-made and natural features on the ground such as roads, railways, power transmission lines, contours, elevations, rivers, lakes and geographical names. The topographic map is a two-dimensional representation of the Earth's three-dimensional landscape.

Information on topographic map:

- **Relief:** mountains, valleys, slopes, depressions as defined by contours
- **Hydrography:** lakes, rivers, streams, swamps, rapids, falls
- **Vegetation:** wooded areas
- **Transportation:** roads, trails, railways, bridges, airports/airfield, seaplane anchorages
- **Culture:** buildings, urban development, power transmission line, pipelines, towers
- **Boundaries:** international, provincial/territorial, administrative, recreational, geographical
- **Toponymy:** place names, water feature names, landform names, boundary names

The collection of geographic data is of primary importance for the creation and maintenance of a GIS. If the data and information contained within a GIS are inaccurate or outdated, the resulting analysis performed on the data does not reflect true, real-world applications and scenarios. Various approaches have been used to collect the vector data used as the fundamental building blocks of a GIS. These include:

- Using a digitizing table to digitize features from cartographic, topographic, census, and survey maps. The resulting features are stored as vectors. Feature attribution occurs either during or after feature collection.
- Scanning and georeferencing existing hardcopy maps. The resulting images are georeferenced and then used to digitize and collect geographic information.

- Ground Global Positioning System (GPS), total stations, and theodolites are commonly used for recording the 3D locations of features. The resulting information is commonly merged into a GIS and associated with existing vector data sets.
- Traditional stereo plotters and digital photogrammetry work stations are used to collect highly accurate geographic information such as orthorectified imagery, Digital Terrain Models (DTMs), and 3Dvector data sets.
- Remote sensing techniques, such as multi-spectral classification have traditionally been used for extracting geographic information about the surface of the Earth. These approaches have been widely accepted within the GIS industry as the primary techniques used to prepare, collect, and maintain the data contained within a GIS.

In general, the following steps involved in topographic mapping and 3D topographic mapping:

- Raster to Vector conversion of 3D topographic maps are conducted using high end, up-to-date CAD software such as ArcGIS, AutoCAD, MicroStation and etc.
- Different features of the 3D topographic maps such as contour lines, boundary lines, transportation, water areas, vegetation, habitations, forest areas etc. are captured
- These features are then digitized in different layers to generate a topographic map in vector format.
- The 3D topographic mapping is done by assigning the Z-values to the contours and generating the 3D terrain model of the topography.
- With the help of 3D topographic maps digital terrain models (DTM), digital elevation models (DEM) and triangulated irregular networks (TINs) can be created.

9.4 Perform 2D Feature Extraction and Planimetric Mapping

Planimetric feature extraction involves the creation of maps that show only the horizontal position of features on the Earths' surface, revealing geographic objects, natural and cultural physical features, and entities without topographic properties. Topographic features not captured such as roads, buildings, and bodies of water that are visible and identifiable on aerial photographs can be compiled into map features through photogrammetric surveying procedures. For 2D feature extraction and then to prepare a planimetric map, one needs the following as inputs:

- An orthophoto or satellite imagery
- ArcGIS or related software
- Computer at desktop level or workstation

The following guidelines are followed with respect to the extraction of planimetric features from the source materials.

- Each feature should be completely extracted or outlined with a continuous line
- No attempt should be made to draw the features in the appropriate map symbols as they are traced.
- Care should be taken when plotting objects having height, such as buildings and trees, to avoid tracing their shadows instead of their true positions. For example, buildings may have to be plotted by their roof lines.



Methods used for compiling planimetric maps from vertical photographs and satellite images.

- Tracing With The Use Of Reflection Instruments,
- Georeferencing Of Digital Imagery,
- Performing Heads-Up Digitizing,
- Manual Digitization.

Heads up digitizing and manual digitizing are mostly used for planimetric mapping.

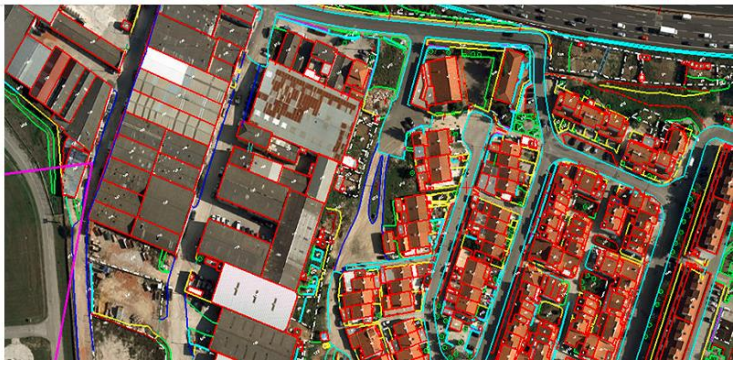


Figure 18: Sample Planimetric Map Extracted from Aerial Photograph

- **Heads-Up Digitizing:** This is the simplest way to extract vectors using raster layers (such as an aerial photograph or a satellite) as a backdrop layer is to digitize vector objects manually straight off a computer screen using a mouse or digitizing cursor. This method is called heads-up digitizing because the map is vertical and can be viewed without bending the head down. It is widely used for the selective capture of, for example, land parcels, buildings, and utility assets.

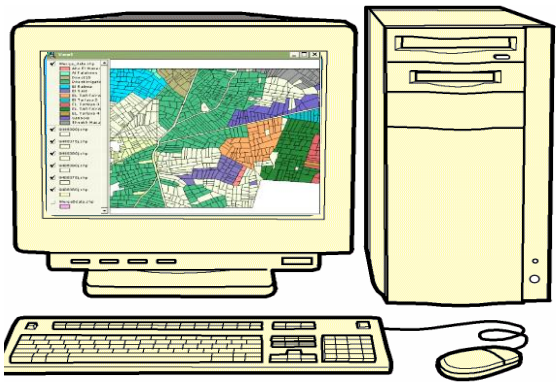


Figure 19: Onscreen Digitizer

- **Manual digitization:** This approach is less commonly used except by GIS professionals, and it requires expensive equipment. The process of using a digitizing table is to place a paper map on the table. The paper map is held securely in place using clips. Then a special device called a 'puck' is used to trace features from the map. The coordinates of each point are entered into the computer through digitizing pad or puck. A pair of X, Y coordinates for a single point, a series of X, Y pairs for a line and a series of X, Y pairs with a common point for polygon or area. It is a laborious and time-consuming process and hence mostly used for digitization of small area. Tiny cross-hairs in the puck are used to ensure that lines and points are drawn accurately. The puck is connected to a computer and each feature that is captured using the puck gets stored in the computer's memory.

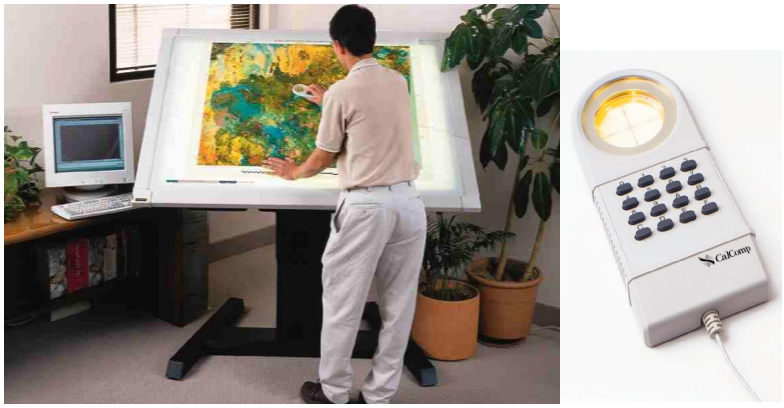


Figure 20: Manual Digitizing Table

9.5 3D Information from Stereo Models

In order to interpret and collect 3D information directly from imagery, at least two overlapping images taken from different perspectives are required. When using aerial photography, the photography is captured from two different camera exposure stations located along the direction of flight. As a result, a strip of overlapping images is captured. The amount of overlap varies according to distance between the two camera exposure stations. A greater distance between photographic exposure separations results in less

overlap. A smaller photographic exposure separation results in greater overlap. 60% overlap is the optimum overlap between the left and right photographs or images comprising a stereo pair. In order to collect 3D information from a stereo pair, the following input information is required:

- Position of each image comprising a stereo pair (that is, X, Y, and Z referenced to a ground coordinate system),
- The attitude, or orientation of each image comprising a stereo pair, which is defined by three angles: Omega, Phi, and Kappa, and
- Camera calibration information (that is, focal length, principal point).

This information is collectively referred to as sensor model information. Sensor model information is determined using bundle block triangulation techniques. When sensor model information is applied to a stereo pair, a DSM can be created.

Using 3D space intersection techniques, 3D coordinate information can be derived from a stereo pair. The figure *(See figure 32)* below illustrates the use of space intersection techniques for the collection of 3D point information from a stereo pair. 3D coordinate information can be derived from two overlapping images when sensor model information is known.

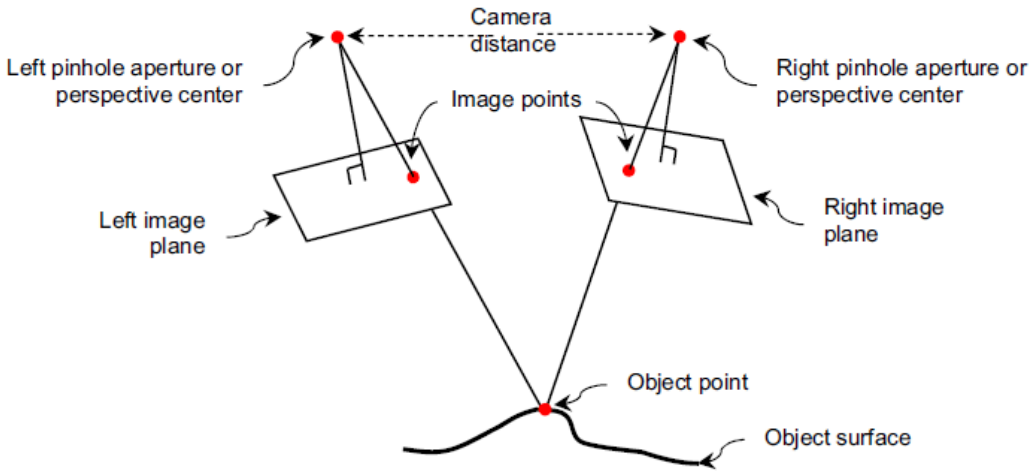


Figure 21: Stereo Model for Object Point

Once the 3D floating cursor has been adjusted so that it rests on the ground, the image positions of ground(object) point on the left and right images are known. In order to obtain accurate 3D coordinate information, it is important that the 3D floating cursor rests on the feature of interest. If the 3D floating cursor rests on the feature of interest, the corresponding image position on the left and right images reflects the same feature.

Parallax Stereo models provide a permanent record of 3D information pertaining to the given geographic area covered within the overlapping area of two images. Viewing a stereo model in stereo presents an abundant amount of 3D information. The availability of 3D information in a stereo model is made possible by the presence of what is referred to as stereoscopic parallax. There are two types of parallax: x-parallax and y parallax. X-parallax *(See figure:45)* illustrates the image positions of the same ground points appearing in the overlapping areas of two images (left, right). Note: The displacement between the top and base of storage tower in this photo stereo-pair.

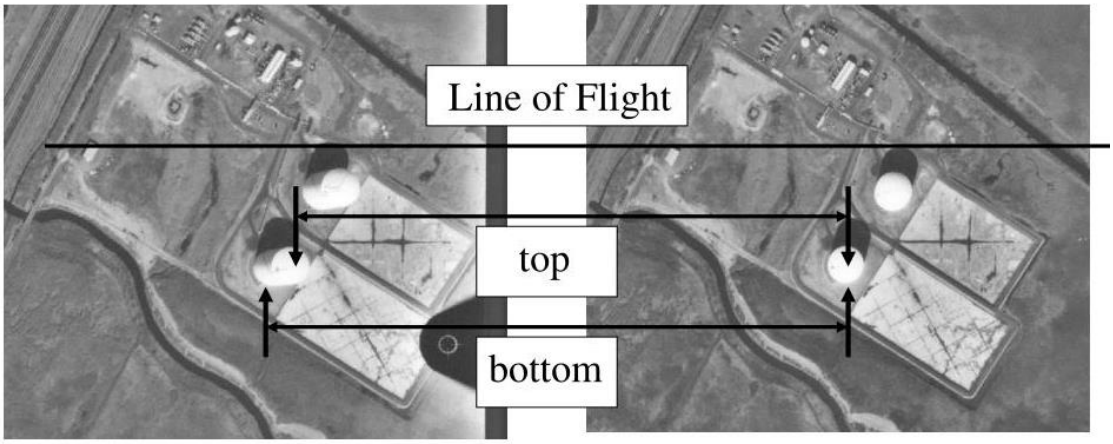


Figure 22: Stereoscopic Parallax

Parallax effects are introduced into the resultant image, using the DEM, making it viewable as a 3Dscene either as an anaglyph image or by 3D viewing goggles. This system mimics digital photogrammetry. As with photogrammetric software, digitizing is possible.

9.6 3D Feature Extraction and Topographic Mapping

The advanced photogrammetry suites, enables us to capture data from small to large scale, based on triangulated stereo models and further generate digital topographic maps, of high precision. It provides accurate digital planimetric feature extraction for cartography mapping and 3D topo mapping, by extracting vector or point information of railroads, buildings, hydrological features, vegetation etc., with coresponding id's and symbology.

Viewing the features superimposed on the 3-dimensional digital aerial photograph, ensures that editing and collection time is accurate and complete. Using the 3D Measure tool, you can digitize points, lines, and polygons. These measurements are recorded in units corresponding to the coordinate system of the image, which is in meters. You can also get more precise information such as angles and elevations. Layering and symbology can be customized to meet any specification or software format.

9.6.1 Collecting and Editing 3D GIS Data

The ArcGIS editing environment is available in all three ArcGIS viewing applications: ArcMap, ArcGlobe, and ArcScene. Features can be created, updated, and deleted directly within their current display environment. To edit in a 3D view, you will need to have an ArcGIS Desktop Basic license (or higher) plus the ArcGIS 3D Analyst extension. This will give you access to both ArcGlobe and ArcScene inside—the two 3D viewing applications for ArcGIS which you can display, analyze, and maintain your GIS data within a 3D context.

Editing the geometry of features in 3D is more complicated than in 2D, so it is expected that you will continue to do the bulk of your geometry edits inside ArcMap. When editing GIS features directly inside 3D, consider using ArcScene for your localized, precision edits, and using ArcGlobe for globally managing sketches and feature placement. Recommended and required cases where you would need to edit inside a 3D view are:



Things you need to take consider while editing inside a 3D view:

- Simple edits that you noticed while in the 3D view (such as editing attributes or moving points)
- Editing attributes that affect 3D display (such as extrusion height or feature base height)
- Placing point features (such as street furniture)
- Digitizing 3D lines, where the z-value is important (such as connecting 3D network datasets or creating vertical lines)
- Creating polygons where a 3D view assists digitizing (such as highlighting regions of high slope)
- Placing and updating multi patches imported from 3D models (such as buildings)

Editing in 3D does not support:

- Interactive update of the geometry or textures of multi patches
- Topology, Annotation, or Geometric Network edits
- Any published service layer such as a globe or map service

There are different important factors needs to be taken into considerations. These are:

- **Familiarity with your data and your layer settings:** For example, if you click to add a tree feature on top of a building, but the data is a 2D point feature class that is defined as being draped on the surface, the final displayed location of the new tree feature will be at

the clicked x,y location, but the feature's height will come from the surface. As a result, the tree will appear inside the building and probably out of your immediate view. By knowing your data and how it is being symbolized in 3D, this kind of confusing behavior can be avoided.

- **Do you need to maintain z-values for this layer?** Many types of features, such as street furniture, vehicles, and trees, live on the elevation surface and should be modeled as 2D features that obtain z-values, when needed, from a separate data source. This simplifies the data storage of the features and will automatically position them correctly if the underlying surface data improves. Other feature types, such as airplanes, line-of-sight lines, and underground subway lines, do not live on the elevation surface, and these features should have embedded z-values for correct placement inside 3D.
- **What units are the z-values in?** The best practice is to have x-, y-, and z-units match, so a Universal Transverse Mercator (UTM)-based line feature class should also model z-values in meters. This avoids confusion when editing, investigating, and analyzing your data in 3D.
- **What do the z-values represent in terms of height?** Z-values can be calculated as absolute (such as 23,000 feet amsl) or as relative to ground (such as 100 meters off the ground). While this setting should come naturally for each layer type, it is important to be aware of what kinds of z-values you are populating and maintaining in the geodatabase. For example, airplanes will have absolute heights, yet underground subway lines will have vertices that are relative to the ground.
- **Do you need features to snap in 3D?** Some features, such as 3D transportation networks, rely on connectivity in 3D. The snapping environment inside ArcGlobe and ArcScene is 3D-aware and should be used when digitizing features that need to share an x, y, z location. Again, be sure that the data and layers you are working with support the storage and display of the z-values you want to model.

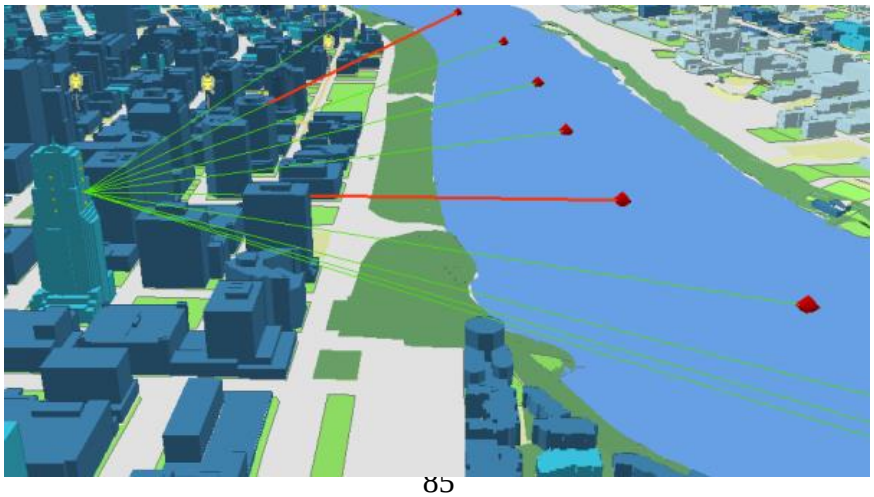


Figure 23: 3D object using ArcGIS 3D Analyst extension

Activity	Explain the process of 3D feature extraction.

9.6.2 Image Preparation for a GIS

Aerial photos and satellite images are fascinating sources for mapmakers since they can make the invisible visible and allow the extraction of important data for maps and GIS databases. Synthesizing the concepts associated with photogrammetry, remote sensing, GIS, and 3D visualization introduces a new paradigm for the future of digital mapping—one that integrates the respective technologies into a single, comprehensive environment for the accurate preparation of imagery and the collection and extraction of 3D GIS data and geographic information. This paradigm is referred to as 3D geographic imaging. 3D geographic imaging techniques will be used for building the 3D GIS of the future.

3D geographic imaging is the process associated with transforming imagery into GIS data or, more importantly, information. 3D geographic imaging prevents the inclusion of inaccurate or outdated information into a GIS. Sophisticated and automated techniques are used to ensure that highly accurate 3D GIS data can be collected and maintained using imagery. 3D geographic imaging techniques use a direct approach to collecting accurate 3D geographic information, thereby eliminating the need to digitize from a secondary data source like hardcopy or digital maps. These new tools significantly improve the reliability of GIS data and reduce the steps and time associated with populating a GIS with accurate information.

9.7 Super Imposing Contour Layers

Contour lines are a familiar way of representing surfaces on maps. A contour is a line through all contiguous points with equal height values. They indicate a vertical distance above, or below, a datum plane.

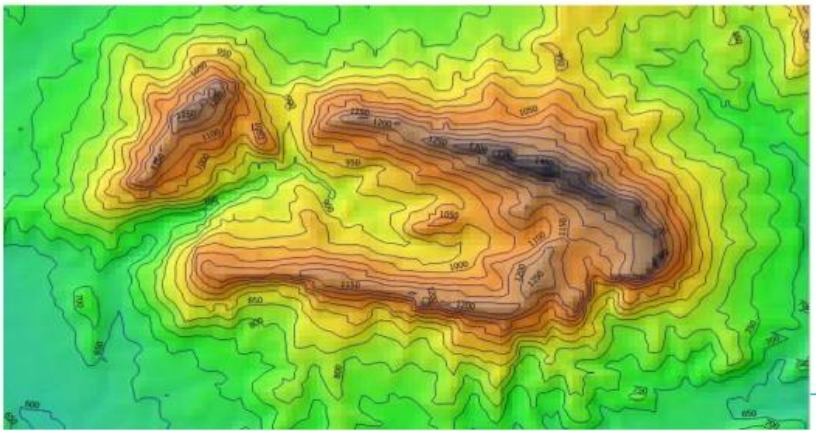


Figure 24: Sample Contour Superimposed on DEM

Contours begin at sea level, normally the zero contour, and each contour line represents an elevation above (or below) sea level. The distance between adjacent contour lines is as the contour interval. Starting at zero elevation the topographer draws every fifth contour line with a heavier line. These are known as index contours. At some place along each index contour, the line is broken and its elevation is given. The contour lines falling between index contours are called intermediate contours. They are drawn with a finer line than the index contours and, usually, do not have their elevations given.

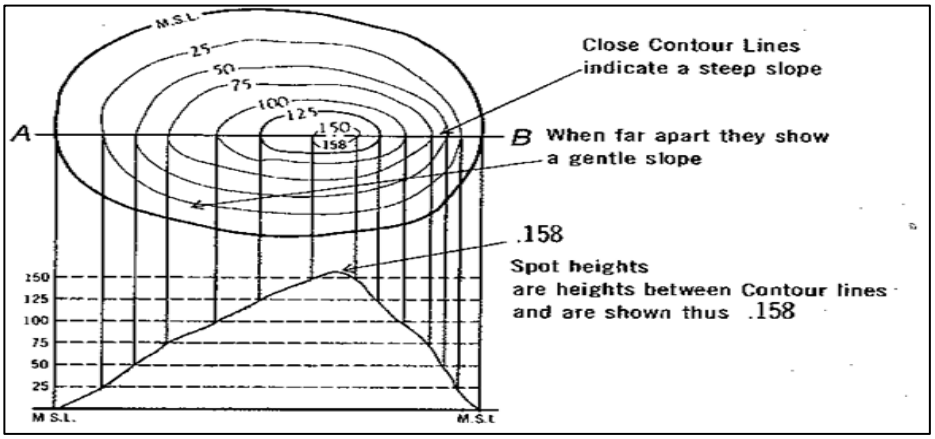


Figure 25: Contour Plans With Derived Profile

9.10 Summary

Dear trainee! Geospatial technology is getting better day by day. Planimetric maps are simple representation of the real world that can be prepared based on different source data with a 2D feature extraction. It consists both manmade and natural features. Photogrammetry techniques are mostly used for planimetric map preparations in which stereo pair imagery of aerial photographs are used for this purpose. Many classes are involved like roads, buildings, driveways, parking and many more. These precise and accurate maps are used for urban planning, utilities planning, infrastructure management, taxation and etc.

The collection of geographic data is of primary importance for the creation and maintenance of a GIS. The advanced photogrammetry suites, enables us to capture data from small to large scale, based on triangulated stereo models and further generate digital topographic maps, of high precision.

3D geographic imaging techniques are mostly used to collect accurate 3D geographic information, thereby eliminating the need to digitize from a secondary data sources. In general, the data and information required for building and maintaining a 3D GIS includes orthorectified imagery, DTMs, 3D features, and the non-spatial attribute information associated with the 3D features.

9.11 Self-Check Exercises



Short Answer Items

Instruction : Give short, brief and precise answer for the following questions.

1) Discuss the difference between heads-up-digitizing and manual digitizing.
2) Explain the importance of a base image or a back drop image for a 2D feature extraction.
3) Discuss on how contour are super imposed on a planimetric map.
4) Explain the mathods of contouring.
5) List and explain different types of indirect contouring.
6) Describe the steps used to extract 3D features from an overlapped image.
7) List the type of imagery used for collecting and editing geographic information.
8) Explain the steps involved in mapping and 3D topographic mapping.
9) Describe factor that affect 3D topographic mapping.
10) List the process of transforming imagery into 3D GIS data.
11) Duscuss the advantages of 3D GIS.

CHAPTER TEN: UNDERTAKING FIELD VERIFICATION AND COMPLETION

10.1 Introduction



Dear trainee! This chapter deals with the concept of undertaking field verification and completion. Field data collection is the most important component for application development. Prior to field data collection, it is necessary to have a well-organized methodology to evaluate available methods and tools for data collection, gap filling, verification and evaluation.

Preparation and plan for field survey has to be carried out by selecting equipment's, field verification and compilation method to verify and collect natural and man-made features, interpret, sketch, draw, organize output map information using map, aerial photograph, pocket stereoscope and GPS in the field. In general, it requires the ability to combine technical applications to collect and organize map information for map production. At last, present and document field verification results by considering continuity of adjoining map sheet.

10.2 Learning Objectives



After completing this chapter, you will be able to:

- Plan and prepare for field work
- Perform field data collection and verification
- Present and document field verification results



Dear trainee! Before reading the following section, take ten minutes and try to identify requirements used for undertaking field verification and completion.

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10.3 Plan and Prepare for Field Work

Data collection is the very expensive, time consuming, tedious and error prone. This means that when making decision on how data will be collected and validated for use in cadastral mapping there is a need for a clearly articulated plan, adequate resources, appropriate funding, and sufficient time. A key decision facing managers of such projects is whether to pursue a strategy of incremental or very rapid collection. A further important decision is whether data collection should use in-house or external resources. Before the data is collected an assessment of organization requirements is done which dictate the collection methods to be used.



Spatial data acquisition requirements may include:

- The geographical extent of the area (Data component)
- The time allocated to the project (Procedure component)
- The resources apportioned for data collection (HW and SW)
- The accuracy levels expected for the project (SW and procedure)
- The instruments available for use in data collection
- The personnel available (People component)
- Type of data to be collected and the format used.

Some questions need to be answered before deciding data collection techniques and scope.

- Are we planning to collect new spatial data or existing spatial data or attribute data?
- If from field, what are the possible options of data collection with their respective cost?
- What approaches of data collections are we planning, systematically or sporadic?

10.4 Perform Field Data Collection and Verification

Field data collection is the most important component for application development. Field data significantly affect the results of a project. Therefore, it would consume a substantial period of time unless field data collection is suitably designed, properly planned and executed with minimum gap fill data collection efforts. It is important for field data collection programs to carefully ascertain the required data, accuracy requirements and incorporate suitable verification tools. In order to achieve success of this process it is necessary to have a well-organized methodology to evaluate available methods and tools for data collection, gap filling, verification and evaluation.

A. **Identifying Map Coverage:** Defining the project area in geographical terms is important for the purposes of selecting the appropriate digital data from the service's collected on the geodatabase, acquiring, and registering digital ancillary data, metadata tracking, and edge matching.

B. **Interpreting different Features on the Map and Aerial Photograph:** Photogrammetry is largely applied in the Earth's surface survey and representation and in other fields of activity as well. In order to generate digital 3D models of topography, buildings, and objects, photogrammetry are the best techniques. In several cases, it can be used more efficiently that requires fewer labours, and more cost-effective than other kinds of field 3D data acquiring.

C. **Field Observations:** Sample points across the entire area will be selected during the preliminary interpretation. Whereas emphasis for designating sample sites is based on feature ambiguity, representative sampling of all classes within the classification system was also done to enable authentication of feature identity as specified in the interpretation and to some extent assist verify the appropriateness of the classification system. To ensure actual access to each sample site, proximity to the road network was given high weighting in the sampling criteria. Information collected from the field may include actual site GPS position readings, area name, land use/cover, topographic data, and socio-economic data.

D. **Preparation for Field Reconnaissance:** To ensure accurate and consistent interpretation of imagery and to resolve various problems, analysts need to conduct field reconnaissance to correlate imaging signatures with the observed field investigation. Preplanning of the field trip should include identification of different characteristics likely to be encountered, information about common features and their distribution, dominant land use some preliminary image analysis of sites to be field inspected. Analysts will want to select field sites near roads or public lands if access is limited.

E. **Photo Interpretation:** The examination of aerial photographs/images for the purpose of identifying objects and judging their significance or evaluation of existing features in a qualitative manner. Topographic features to be interpreted in stereoscopic view in the digital plotter are acquired as topographic data.

F. **Field Identification:** Obscurities in photo interpretation are confirmed in the field identification work. In the field identification, draft maps, existing maps, aerial photos and handy GPS are brought into the field. Polyester bases were overlaid on aerial photo prints and items verified in the field were arranged on the overlay. The method is very

time-consuming, and a more efficient method. The various field identification items will be examined and classified into features that can be: acquired with mapping instruments, acquired by field identification, and acquired from information, materials.

G. Preparation of Materials for Field Identification: The following materials shall be prepared before commencement of the survey:

- Output of topographic map data
- Orthophoto
- Superimposed prints of orthophoto and topographic map data
- Existing topographic maps
- Annotated sheets
- Description of bench mar

H. Field Sites and Data Collection: Field data sheets for selected sites should be completed. The exact location of the field photographs, site location referred to in notes and other information must be provided. Wherever possible, digital cameras, data recorders, and ground positioning satellite (GPS) should be used to provide information that is more accurate. Any handwritten field notes regarding changes observed should be clear and understandable. Time spent in the field is invaluable. To realize maximum results, it is often necessary to reassess some potential field sites based on work already completed versus time, access to sites and priorities.

I. Field Work as Verification: Image interpreters may conduct field verification exercises to ensure accurate and consistent interpretation of imagery. Field trip reports and Field Data Sheets provide documentation of the field verification efforts including, general descriptions of data collected on the field area, descriptions of surface different feature conditions, both on the imagery and at the time of fieldwork, and details about the quality of the source materials used.

 Activity	List and explain the process of field data verification.

10.5 Present and Document Field Verification Results

Photogrammetry can be used for mapping only what is visible on the photographs. Thus, if important features are obscured by trees, man-made structures or steep topography, they cannot be mapped. Therefore, a field completion activity has to take place to map the missing features. The field completion phase of the project should be used for accuracy testing of the map. The field completion is carried out to check important items in the topographic map data prepared in the digital compilation process. Since the period of the survey is limited and

a field verification survey had already been conducted, the field completion work plan is drawn up to investigate a minimum of important matters.



Information needs to be incorporated during field data completion:

- Important representations found during the compilation process.
- Items difficult to compile and subject to temporal change.
- Boundaries and annotations.
- Mistakes or omissions in representation of features to be acquired.

A final report on the quality and accuracy of the maps should accompany the submission of the final product. The report should review the accuracy of the control. The procedure used to determine the map's spatial and content accuracy should be documented as well. A statement, such as “this map meets the National Map Accuracy Standards” or “this map meets the project requirements”, is unacceptable. Any claim of accuracy or standard must be substantiated by an actual test and analysis. The testing methodology used and the findings of its implementation should be documented in a final report.

10.6 Summary



Data collection is the very expensive, time consuming, tedious and error prone. Before the data is collected an assessment of organization requirements is done. It is important for field data collection programs to carefully ascertain the required data, accuracy requirements and incorporate suitable verification tools. Photogrammetric projects require some amount of field work and it considers planning prior to commencement of undertaking field work. When undertaking field verification, the methods that will be used and equipment that are needed for the project must be fulfilled. Therefore, a field completion activity has to take place to map the missing features and it should be used for accuracy testing of the map.

10.7 Self-Check Exercises



Short Answer Items

Instruction: Give short, brief and precise answer for the following questions.

1) Discuss things to be considered during field work for planning in project.
2) Explain data collection activities to be done on field verification.
3) Explain the role of field reconnaissance during field verification.
4) List data and information that should be confirmed during the field completion
5) Describe the spatial data acquisition requirements.
6) What are the informations needed to be incorporated during field data compilation?

CHAPTER ELEVEN: ASSESSING APPLICATIONS FOR LEGISLATIVE COMPLIANCE

11.1 Introduction

Dear trainee! This chapter deals with the concept of assessing applications for legislative compliance relating to changes in land use and/or administration issues. Organizational legislation compliance assessment requires knowledge of relevant federal/ regional state legislation and regulations on land use changes, urban land administration issues, and communicating with stakeholders.

Land administration covers a number of functional areas in relation to governing the possession and use of land. It comprises a range of systems and processes to administer land rights, land valuation and taxation, and existing and future land use. Land administration systems are concerned with the social, legal, economic, and technical framework within which land managers and administrators must operate. Land legislations is one of the basic components of land administration that deals all land related issues focusing the use, ownership, and value. However, these legislations should be assed frequently using legislative compliance assessment guidelines and tools.

11.2 Learning Objectives

After completing this chapter, you will be able to:

- Explain the concept of legislative compliance tools
- Discuss the process of legislative compliance assessment
- Identify cadastral surveying laws and standards
- Perform the assessment of cadastral surveying implementation

Dear trainee! Before reading this chapter, take ten minutes and try to discuss the concept of legislative compliance tools.

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11.3 Legislative Compliance Assessment tools

Legislative compliance involves understanding the laws, legislation and regulations that apply to the department, and using a framework to make sure the department is complying with these laws. If the department is non-compliant with legislation, there is risk of facing penalties, liability, financial damage and reputational damage.

Legislative compliance assessment tools are commonly used by organizations to help them to understand their legal obligations and guidelines. One of the primary limitations of existing work principles is that they tend to consider each regulation in isolation. The interpretation of legal texts can be challenging, especially for people with non-legal backgrounds, as they often contain domain-specific definitions, cross-references, and ambiguities. Preparation for assessment of legislative compliance includes:

- Existing data concerning suitability of application for changes in land Use and administration issues shall be reviewed and confirm its consistence with legislative requirements.
- Ownership Title shall be identified and document should be prepared in line with program standards.
- Timing of inspection and data collection must be established with client following the client service delivery program.
- Purpose of the legislative compliance process and Specific issues must be clarified and communicated with stakeholders.

Over the years, several theoretical frameworks that support the modeling of legislation have been proposed, however only some of which were validated via the development of legal support systems. One of the major drawbacks of such approaches is the fact that some do not consider concepts like:

- **Soft-obligations** (i.e. Obligations that serve as recommendations rather than being mandatory or
- **Exceptions** (i.e. Scenarios where the obligations are not applicable).

Additionally, the models are only loosely coupled with the actual legislation text, making it difficult to verify the effectiveness of such systems. More recently, a number of compliance assessment tools have been developed. However, these systems are either composed of a handful of questions that are used to evaluate legal obligations or do not filter out questions that are not applicable for the company completing the assessment. One of the primary

drawbacks of existing organizations assessment tools is the fact that they do not currently consider related regulations.

For the data component, a generic legislative model, can be used to represent legislative obligations and relations. For the parsing process, first the text defining obligations is extracted from the legislations. Next, the relations are identified between the extracted obligations and represented according to the legislative model. Following on from this, the modelled obligations are translated into a format that can be read by the compliance system, referred to as Legislative instance. Finally, the last step involves making the legislative instance more understandable for the user. Questions are prepared for the obligations such that the tool asks the user for the fulfillment of the obligations. Associated definitions are also added to ensure intelligibility of the questions.

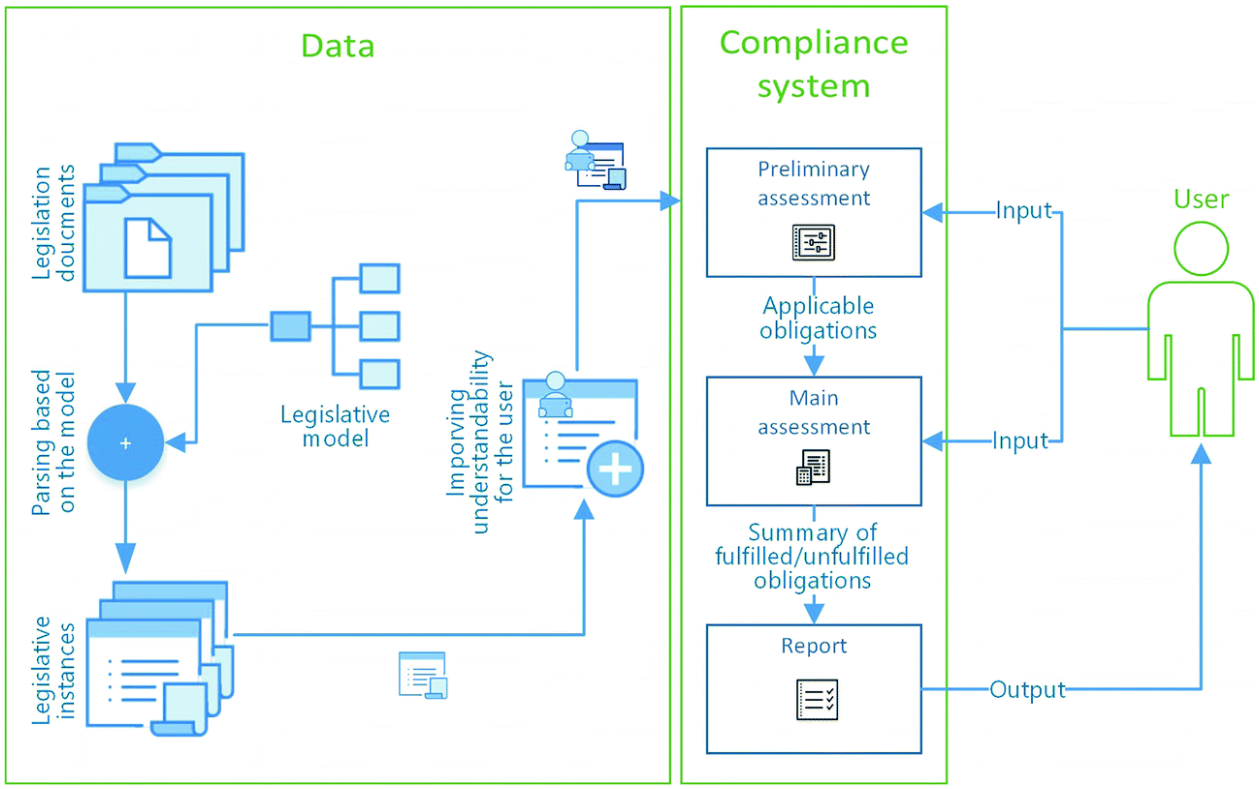


Figure 26: Legislative Compliance Assessment Tool

The legislative instance is passed as input to the compliance system which assesses compliance based on the user-input and the legislative instance. As the modelled legislations could potentially govern multiple scenarios, it is possible that not all the defined obligations would be relevant for a compliance assessment. Therefore, to ensure that irrelevant obligations are not shown to the user, the assessment process is divided into two steps:

i) Preliminary assessment; and

ii) Main assessment. In the first step, the legislative instance is read and input from the user is taken. The input relates to the different scenarios which could affect the applicability of the obligations.

Based on the input, the system shortlists the applicable obligations and presents the assessment to the user. In the main assessment, the user provides input regarding the fulfillment of the obligations within their company. Once the required input is received, the system generates a report with a list of fulfilled and unfulfilled obligations.



The Legislative Compliance System is made up of:

- Allocating responsibilities for legislative compliance,
- Proper resourcing of the Legislative Compliance System,
- Identifying and assessing legislative compliance obligations,
- Regular monitoring and reporting of legislative compliance including any compliance failures,
- Ongoing training of staff to enable them to fulfil their compliance obligations,
- Reviewing the Legislative Compliance System.

11.4 Evaluating Compliance Outcomes

11.4.1 Planning for Evaluation

The need for a compliance strategy is normally based on observations and indicators that suggest that specific compliance behavior warrants attention. For an evaluation to be worthwhile compliance strategies (whether of an enforcement, legislative, litigation or service nature) must have clearly defined objectives that are measurable. Without these, determining whether strategies affect land service, claimant behavior will largely be guesswork open to interpretation and subjective debate. It is important that evaluation criteria be determined at the time the treatment strategy is being chosen or developed. Consideration of how a change in land service claimant behavior is to be measured can often clarify the behavior to be targeted.



Careful evaluation planning may:

- Support the basis on which resources are deployed to the programme;
- Encourage multiple sources of data;
- Improve the accuracy of corporate reporting; and
- Help to determine whether alternative strategies should be considered.

11.4.2 Developing an Evaluation Framework

If an administration is to improve the effectiveness of its compliance programmes, it needs to be able to state the compliance benefits that have been achieved through the application of its compliance strategies. Land sector that fail to measure the effectiveness of their compliance strategies run the risk of continuing to sub-optimize their strategy selection. An evaluation framework provides the proper foundation for the continuous improvement of compliance strategies. Under this framework, those planning to apply a specific treatment strategy should address the following questions:

- **Target:** What risk is being addressed?
- **Objectives:** What is the treatment strategy intended to achieve?
- **Methodology:** What are the measurement methodologies used (including timeframes and external factors that could affect the measures and how they may be interpreted?)
- **Measures:** What compliance indicators were used in identifying the problem? What changes are expected to be seen in these indicators as a result of the strategy?
- **Data:** What data will be collected and how it will be collected to support the evaluation?

11.4.3 Carry out the Evaluation

As it is suggested earlier, no strategy should be implemented without a clear process by which the outcomes can be evaluated and reported. Measurement considerations must therefore, be an integral part of the development of a compliance strategy. In particular, the capture of pre and post intervention data is a priority in evaluating compliance campaigns whose objective is to change the tax compliance attitudes of a specific segment of the community.

11.4.4 Recognition the Difficulties of Evolution Compliance

Evaluation issues associated with measuring compliance for both the individual land service claimant and group or population level need to be considered when assessing the extent to which land user compliance may have changed over time because of a compliance strategy.

There are many factors that combine to influence land service claimant behavior that extend beyond the control of land administration. These include social and economic conditions including:

- National and global economic factors;
- Physical environment factors for example, droughts and floods; and
- Legislative factors and social, demographic and attitudinal factors.

These factors invite particular caution when measuring the 'tax gap' for both the individual taxpayer and corresponding population. A better approach is to develop proportionate or percentage measures rather than raising additional revenue from the intervention or treatment. These factors have less impact on measuring the effectiveness of narrowly focused compliance initiatives than the broadly-based ones. The use of random audit-based methods provides for an unbiased selection process to measure compliance levels and subsequent changes. However, care should be taken to:

- Minimise the opportunity cost of productive audit work forgone to perform audits on randomly selected cases without a known productivity outcome;
- Ensure there is no excessive burden on the taxpayer population; and
- Ensure audits are conducted uniformly otherwise the validity of results cannot be substantiated.

An issue arises when considering the implications of technical compliance and its basis for determination. To declare an individual or business compliant, we must establish the 'correct land service' that is given. Variability of interpretation of the legislation on the part of land service claimant, practitioners, concerned body. Rather than being analyzed by these problems, land sector should acknowledge that there is no one method that will unequivocally measure perfectly the impact of strategies on land service claimant behavior. To get most meaning and value from analysis, indicators of compliance must be interpreted systematically and in conjunction with the other. This allows reasonable judgments to be made on whether a particular compliance strategy has influenced behavior.

11.5 Assessment of Cadastral Surveying Implementations

Assessment indicators are aspects that can evaluate and compare the performance of urban cadastral system implementations. It is important that a cadaster is managed in a methodological way; in case there are different government levels (national, regional, local), it is critical how they cooperate with each other, and how the professional interaction works

between the two involved professions of lawyers and surveyors; it is also important where the financial responsibility lies for the whole system. The stakeholders of this level are the operational units that have to carry out the daily tasks of land administration. Their decisions have a short-term effect and they are responsible for products, services, and interfaces between units and towards clients and customers.

Assessment Indicators

In order to assess the performance of cadastral implementations, there should be indicators which should be considered. The stakeholder that should be interested in the overall assessment of the systems performance might be an independent board that would have the mandate to assess the system in a holistic way. This would include a regular review process of the objectives and strategic targets, the degree of satisfaction of clients and users, and how the whole system deals with visions and their integration.

Cadastral system implementation can be assessed with the following model (*See figure: 11.2*) which evaluates the performance of the whole institution holistically, and comprehensively. Detail explanations of the indicators are described below.

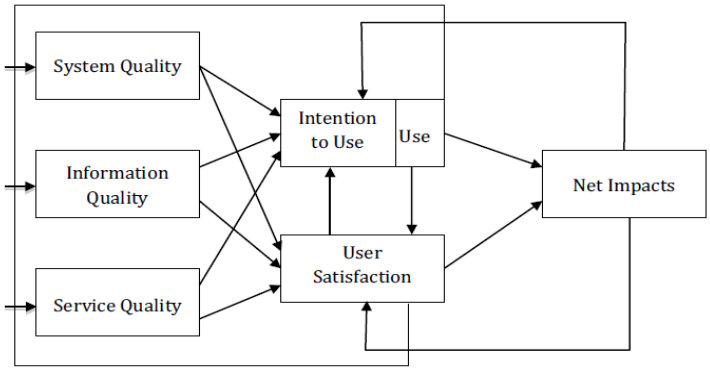


Figure 27: Performance Measure Indicators

System quality: refers to the desirable characteristics of an information system. For example, ease of use, system flexibility, system reliability.

Information quality: refers to the desirable characteristics of the system outputs; for example, relevance, accuracy, conciseness, completeness, understandability, currency, timeliness, and usability.

Service quality: refers to the quality of the support that system users receive from the information systems organization. For example, responsiveness, accuracy, reliability.

Use: refers to the degree in which employees and customers utilize the capabilities of an information system. For example, amount of use, frequency of use, appropriateness.

User satisfaction: refers to users' level of satisfaction with reports, Websites, and support services.

Perceived net benefit: refers to the extent to which information systems are contributing (or not contributing) to the success of individuals, groups, organizations, industries, and nations. For example: improved decision-making, improved productivity, increased sales, cost reductions.

11.6 Evidence Based Report and Recommendations

Every assertion should have to be supported by evidence. Factual detail (proof) will be required to back up the opinions and generalizations. In terms of assessing applications for statutory compliance, each written report or recommendation discovered in the report should be backed up by proof. Expert opinions may be necessary, and every expert must be familiar with the inspection and reporting writing ethics and formats. The data that we obtained utilizing various data collection techniques is the evidence in our case. Those supporting details could come from a variety of different sources. Stakeholders must participate in identifying and evaluating any legal precedents or activities related to land claims. Stakeholders include, but are not limited to:

- Local land users
- Land management organizations
- Regulatory agencies and committees at the local level
- Complaints from women and other vulnerable groups

11.7 Summary

Dear trainee! Compliance emphasizes state of conformity of regulated parties with legislative requirements. Compliance with legislation is a requirement of all individuals, clients, and organizations. Legislative compliance assessment is an essential process for land administration system to deal whether the legislation implemented accordingly or not. It is a structured and analytical process whereby the various dimensions of the legislation are assessed within a broader systems context, as well as being evaluated for specific entities and individuals within the system. The purpose of legislative compliance assessment is monitoring and reporting on compliance with key legislation. Legislative compliance supports local and regional land administration organizations activities system, and

compliance can integrate into day to day management by delegating responsibilities into the appropriate operational areas.

In general, compliance means conforming to a rule, such as a specification, policy, standard or law. Legislative compliance describes the goal that organizations aspire to achieve in their efforts to ensure that they are aware of and take steps to comply with relevant laws, policies, and regulations. Due to the increasing number of regulations and need for operational transparency, organizations are increasingly adopting the use of consolidated and harmonized sets of compliance controls. This approach is used to ensure that all necessary land governance requirements can be met without the unnecessary duplication of effort and activity from resources. Evaluation of compliance outcomes can be undertaken through planning for meaningful evaluation comprises of developing an evaluation framework, carryout evaluation finally by recognizing the difficulties of evaluation of compliance

11.8 Self-Check Exercises



Short Answer Items

Instruction: Give short, brief, and precise answer for the following questions.

1) Discuss the basic concepts and process of legislative compliance.
2) Explain the benefits of evaluating the compliance outcomes in the organization.
3) What strategies used by the organization to evaluate the compliance outcome?
4) What factors influence land service claimant behaviour the extend beyond the control of land sector?

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CHAPTER TWELVE: UNDERTAKING CADASTRAL SURVEYING WORK IMPROVEMENT

12.1 Introduction

Dear trainee! This chapter deals with the concept of undertaking cadastral surveying work improvement. A cadastral surveying is an interactive multitude of land administration sub-systems including adjudication, boundary definition and demarcation, surveying, registration, dispute resolution and information management. There has been a rapid rate of advancement in technology for surveying data collection tools: for example, total stations, Global Navigation Satellite Systems (GNSS), Digital Photogrammetric work stations as well as survey processing software such as AutoCAD, ArcGIS and so on.

These technological advancements have been well embraced by cadastral legislations and standards. There have been corresponding changes to the cadastral survey legislation and regulations which control the practice of cadastral surveying. Likewise, challenges may arise from the change and associated factors. Therefore, continuous cadastral surveying work improvements shall be conducted to identify the problem, opportunities, new ideas and finally implement the viable change.

12.2 Learning Objectives

After completing this chapter, you will be able to:

- Identify opportunities for process change
- Explain steps of improvement cycle

Dear trainee! Before reading the following section, take ten minutes and try to discuss with your group by the concepts of planning and organizing work activities.

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12.3 Identify opportunities for Process Change

Organizations identify a problem and then work to identify the root cause of the problem to come up with a solution for implementation. This stage consists analysis of the as in processes and identification of problem areas and potential improvements. Different factors drive process improvement, such as the need to fasten and simplify processes by reducing duplications and delays, the automation of parts of the process, the use of digital data rather than paper document, organizational changes, new or changing regulatory requirements, and the introduction of new and modernized procedures.

- **Performance measures:** On the basis of the as-in processes, determine the average time taken to complete the processes, the average number of consignments awaiting clearance, etc. Compare with targets set.
- **Identify bottlenecks:** Activity diagrams may help to identify bottlenecks. Can these be eliminated by additional resources, or by re-organizing the processes, carrying out processes in parallel rather than sequentially?
- **Best practice:** Do the current processes use the best international practices and standards?
- **Reduce data requirements:** Identify the minimum information needed to enable each process to be carried out. Can the amount of data be reduced from that currently demanded?
- **Harmonize data:** Can the data required by different processes/agencies be harmonized to simplify the requirements of those submitting the data (traders, transport suppliers, customs brokers, etc.)?
- **Single Window:** Can a single input be used by different agencies?
- **Electronic input:** Consider changing from paper input to computer input to reduce delays and errors

	Discuss some of the common factors that may lead to process improvement.

12.4 Improvement Cycle

The demand to improve organizations in urban cadastral service continues to increase as expectations change, new technologies emerge and demand for land development grows. An effective way to establish continual improvement within the organization is to conduct regular improvements plans. Improvement processes can be informal or formal and touch a variety of organization department and functions: information technology, employee

development and training, customer service satisfaction, etc. Regardless of the service delivery process and departments the organization trying to enhance, the improvement procedure follows a similar path. There are four major steps in the organization improvement cycle.

Step 1: Identify the need for change

The useful way to discover improvement opportunities is by conducting identification of organizations opportunities for change, which can be done with a simple organizational activities audit. The audit will identify current issues or potential risks for the organization.

Step 2: Analyze current process

Once organization have decided which process are going to be improved, the next step is need analyze the current procedure and guidelines. This way you can fully understand the process from A-Z and set realistic improvement objectives. To analysis the existing organizational activities and opportunities, the following question can be used:

- What in the process is broken?
- Which steps in the process create roadblocks?
- Which step requires the most time to complete?
- Which step causes the most delays?
- Are there any steps that cause costs/resources to go up or quality to go down?

Step 3: Obtain commitment and support

The third step in the process is to solicit organizational commitment for improvement. This is possibly the single-most important element in the process as the success of the project hinges on managerial support. At this stage you need to clearly present the necessity for change and how it impacts the organization. As process improvement can be time and resource intensive upper-management support is a must.

Step 4: Create improvement strategy

Once analysis phase completed you need to develop your strategy. It is recommended that you include what steps in the process are broken, why and how they should be improved and any financial and resource implications. It is recommended that you set realistic and measurable objectives that align with your overall strategic goals.



Detail Organizational quality Improvement process steps include:

Step 1: Identify Opportunities

Step 2: Establish a Team

Step 3: Set an Aim

Step 4: Understand the Problem

Step 5: Establish Measures

Step 6: Develop Ideas for Change

Step 7: Test Changes

Step 8: Implement Changes

Step 9: Spread Improvements

12.5 Cadastral System's work Improvement

The cadastral system's ultimate goal is to ensure high quality in the cadastral process through legal unity, outstanding service and information, and quick, accurate, and cost-effective processing. Having skilled staff is the single most significant aspect in attaining this. At a time when cadastral surveyors are in high demand, it's even more critical to identify models for developing staff so that their competence can handle increasingly difficult jobs.

The classification of each cadastral operation according to its difficulty is an important component. Because the entire cadastral procedure may be managed digitally, cadastral surveyors from all across the country can be assigned to it. The field survey can be done by a nearby field surveyor, and the rest of the cadastral process can be completed by a cadastral surveyor in any office across the country. Access to guide lines, regular talks between the employee and the manager, an open working environment, and, of course, well-educated cadastral surveyors are all basic requirements.

The cadastral process should be marked by legal consistency, excellent service and information, and quick, accurate, and cost-effective processing. According to organizational principles, problems are discovered and conveyed to necessary individuals to enhance service and prevent recurrence. The information is then transferred to the Land Registry in order to be accurate and timely.

12.6 Summary

Dear trainee! Since the development of cadastral system is very gradual without introducing modern technologies in the field of cadastral survey, improvement of cadastral system will never be efficient and effective. The options can have priority according to the accuracy, time, cost, and security of the system. Identify opportunities for process change Processes shall be monitored to ensure that they are cost effective, customer focused, error free and achieve the planned result.

Ideas for improvement shall be given prompt consideration and feedback to maximize possible benefits and compliance with relevant legislation must be incorporated. To implement organizational improvements an environment where improvements are sought and rewarded must be maintained and incentives can be offered. Organizational improvement may require to identify and coach relevant personnel, and review of ideas to ensure commitment to solutions. Each improvement ideas should be discussed and evaluated with stakeholders against existing practices, precedents and legislative or organizational restrictions to determine viability and compliance.

12.7 Self-Check Exercises

**Short Answer Items**

Instruction: Give short, brief, and precise answer for the following questions.

1) List the possible approach followed by organization during process improvement.
2) Explain major steps of the improvement cycle and Importance of work improvement.
3) Discuss the detail steps in organizational quality improvement process.
4) Describe challenges for cadastral surveying improvement.

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