TRAINING MODULE

FOR

CADASTRAL SURVEYING AND MAPPING

LEVEL II

BASED ON TVET OCCUPATIONAL STANDARDS



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

2D	Two Dimension
3D	Three Dimension
AOI	Area Of Interest
ASCII	American Standard Code for Information Interchange
BCR	Benefit Cost Ratio
CAD	Computer Aided Design
CBA	Cost Benefit Analysis
COTS	Commercial Off-The-Shelf
CSV	Comma Separate Variable
DBMS	Database Management System
DGM	Digital Ground Model
DR	Dispute Resolution
EDM	Electronic Distance Measurement
ESRI	Environmental System Research Institute
FGDC	Federal Geographic Data Committee
FIFO	First In First Out
GCP	Ground Control Points
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPX	GPS Exchange Format
GUI	Graphical User Interface
HR	Human Resource
ISO	International Organization for Standardization
IT	Information Technology
KML	Keyhole Markup Language
LIS	Land Information Systems
NVA	Non-Value Adding
OHS	Occupational Health and Safety
OS	Occupational Standards
PC	Personal Computer
PPE	Personal Protective Equipment

PR	Public Relation
PVT	Position, Velocity and Time
QA	Quality Assurance
QAT	Quick Access Toolbar
QC	Quality Control
RAM	Random Access Memory
RDF	Report Document File
RINEX	Receiver Independent Exchange format
RLF	Report Layout File
RMSE	Root Mean Square Error
RTK	Real Time Kinematic
SIO	Survey Information Only Plan
SIS	Signals In Space
SQL	Structured Query Language
SWOT	Strength, Weakness, Opportunities and Threats
TPM	Total Productive Maintenance
TS	Total Station
TVET	Technical and Vocational Education and Training
UPIN	Unique Parcel Identification Number
UTM	Universal Transverse Mercator
VA	Value Analysis
VE	Value Engineering
WGS	World Geodetic System
XML	Extensible Markup Language

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. This can be achieved 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 considering 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 trainees 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 **III** on **Cadastral Surveying and Mapping** occupation in land and land related fields.

The prime objective of these training materials is to facilitate the trainees with the identified competences specified in the OS. It comprises of **16** competences which includes the following areas: Operate and Maintain Surveying Equipment, Collect and Interpret Basic Cadastral Survey Data, Perform and Manage Advanced Surveying Computations, Plan and Conduct Cadastral Survey Expeditions, Set-out Basic Surveying Data, Develop and Use Spread Sheets, Integrate Cadastral Surveying Dataset, Perform Cadastral Drawing Applications, Perform Stereoscopic Model Formation and Feature Identification, Operate GIS Software to Geospatial Analysis, Produce Digital Data, Produce Base Map, Identify Land and Property Boundary, Apply Land and Planning Law to Surveying, Resolve Dispute through Negotiation, and Prevent and Eliminate MUDA using problem Solving Tools.

CHAPTER ONE: OPERATING AND MAINTAINING SURVEYING EQUIPMENT

1.1 Introduction

Dear trainee! This chapter introduces you the concepts of operating and maintaining surveying equipment. Surveying instruments, which include tape, level, theodolites, total stations, GNSS receivers and others are designed and constructed to provide years of reliable use. The accuracy and quality of a survey depend upon the condition of the surveying instrument and the experience of the surveyor. The life expectancy and usefulness of an instrument can be extended considerably by proper and careful handling, stowing, and maintenance. The shafts, spindles, pendulums, and electronics of precision instruments, although constructed for rugged field conditions, can be damaged by one careless act, or continued negation prescribed procedures for use, care, and adjustment of the instrument.

Each new instrument is furnished with an operator's manual. The manual contains a description of the instrument, specifications of its various components and capabilities, and applications. The manual also contains basic instructions for use of the instrument and describes recommended servicing and adjusting methods. The operator's manual should be kept with the instrument at all times. Each operator should thoroughly study the manual prior to use of the instruments, particularly whenever prescribed field adjustments are to be made. If the manual is lost, stolen, or damaged beyond use, a replacement copy should be obtained as soon as practicable.

1.2 Learning Objectives

After completing this chapter, you will able to:

- Explain the concept of planning process of surveying tasks
- Select appropriate surveying equipment used for data capture and set-out
- Conduct the basic adjustment for surveying instruments
- Describe the spatial reference systems used for surveying



Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts of basic surveying task planning.

_____

_____

_____

_____

1.3 Planning Survey Tasks

Proper planning and management are essential for a survey expedition to be successful and in order to minimize on cost and expenses associated with the project. A technical document that delineates the basic design of a survey or survey system must be developed prior to the initiation of a data collection. The document must address the objectives of the survey as indicated in the initial planning document; the survey design; the data collection plan; and the personnel resources, funds, and time needed to achieve high data quality. To meet this standard, the survey design plan must include the following:

i) A detailed discussion of the goals and objectives of the survey or survey system, including the information needs that will be met, content areas included and analytic goals.

ii) A discussion of the surveying design that describes how it will yield the quality of the data required to meet the objectives of the survey.

The discussion must identify the following:

- The Overall Surveying fields
- Suitable equipment for different measurements and nature of the surveying field before the data collection,
- Number and spatial space between surveying read
- Minimum substantively significant effect (For example, the smallest differences the survey is intended to measure);
- Minimum substantively significant effect for key reporting variables by reporting domains, etc.

A reconnaissance excursion is the first step in the organization process. This step ensures logistics planning; site evaluation and right equipment use is planned for adequately. A good reconnaissance assists in making the following preparations:

- **Transportation:** Mode of transport is selected in order to transport the survey team and the equipment to be used to the site. Logistics for day-to-day travel is done and cost incurred. If the site is close to the office, simple modes of transport can be adopted. If the site is far away, the transport cost increases and the planning process is more meticulous. Vehicle inspection should also be done regularly since the survey vehicle travels in hard-to reach areas that are off-road. The vehicle should also have ample space for proper storage of survey equipment.
- **Communication:** Mode of communication is established for both field to office and within the field environment. The various modes of communication include telephone, fax, mobile phone and email for field to office communication. In the field, the team may communicate over mobile phones, walkie-talkies and use hand of signs or verbally. The mode depends on the distance and urgency of the message.
- **Travel and Work Hours:** Work scheduling for both office and field work is set and a project time-frame is established. Departure and arrival times are recorded in the expenses schedule. Accommodation and lodging are also considered for long trips that require the survey team to stay near the site. This together with meals accounts for some of the cost in field allowances.
- **Map data acquisition:** the existing maps and auxiliary data are required to conduct proper survey work. The acquisition of this data is important and is inclusive of the planning and organization of field work.
- **Selection of survey equipment:** The suitable tools of survey are selected based on the type of job, area extents, project time frame field, scope of work and level of required accuracy. The equipment selected are check-listed and signed for from the storage room.
- **Authority:** It is important to acquire all the necessary approvals from the relevant authorities before embarking on the project. This may involve contacting the owner for permission and other technical support which may be required. This is important since guidance into the survey job may require some assistance from the property owner.

As part of the major surveying task, the risk management should be considered in the planning of OHS activities in the workplace. In doing so, adherence to the occupational health and safety (OHS); such as protecting one self and others from damages, need to be taken in to account.

1.4 Executing Task

1.4.1 Handling and Adjustment of Surveying Instrument

To a great extent, the accuracy and quality of surveying data will depend upon how well you take care of your surveying equipment. The term adjustment means bringing the various fixed parts of an instrument into proper relationship with one another. It is different from the ordinary operations of leveling the instrument, aligning the telescope, and so forth. Care of instruments has to be taken into considerations by understanding that every instrument is accompanied by a user's manual that tells you not only the proper operation and components of the instrument but also its proper care and maintenance.

1.4.2 Data Capturing and Setting-out

Traditionally, surveyors are used to compute the coordinates of a given points manually from angles measured with theodolite and distance with a steel band or Electronic Distance Measurement (EDM) device. However, Total Station simplified the procedure of traversing by integrating the EDM into the theodolite and reading all measurements digitally. As a result of this, coordinates could be computed automatically by the total station itself, which avoided manual computations. Introduction of satellite positioning systems has also provided the surveyor with an additional measurement technology to perform survey tasks. Global Navigation Satellite System (GNSS), in particular Real-Time Kinematic (RTK) GNSS, provides surveyors with an efficient tool to conduct their survey activities. Although, RTK GNSS is now widely used, there are still many surveyors who do not benefit from GNSS technology because of variety of reasons: perception of complexity of the instrument, cost of the instrument, accessibility of the instruments, and etc.

Every measurement in surveying needs reference surface as well as datum to locate a point coordinate. The reference surface should also be defined to measure the height of a point above it. Datum's (Reference Surfaces) are surfaces relative to which the measurement is taken and the coordinates or the relative position of points are determined. In surveying, a datum is a collection of constants, physical models, orientation and origin of, and it is used to define the coordinate system. Datum can be local (Adindan) or global (WGS 84) depends up on the required application. Datum also can be horizontal or vertical. Horizontal datum's are used for describing a point on the earth's surface, in latitude and longitude or another coordinate system whereas, Vertical datum's measure elevations or depths. In surveying, geoid and reference ellipsoid are the reference surfaces considering the figure of the earth.

Geoid (mean sea level): is mean equipotential surface of the earth's gravity field, which is used as a reference for height measurement in leveling. Geoid can be local or global.

Ellipsoid: is a mathematical surface obtained by revolving an ellipse about the earth's polar axis. It is a geometric reference surface that closely approximates the geoid and used by surveyors for the computation of geodetic and rectangular coordinates. For example, Clark 1880: local ellipsoid for Ethiopia, WGS 84: used in GNSS and others.

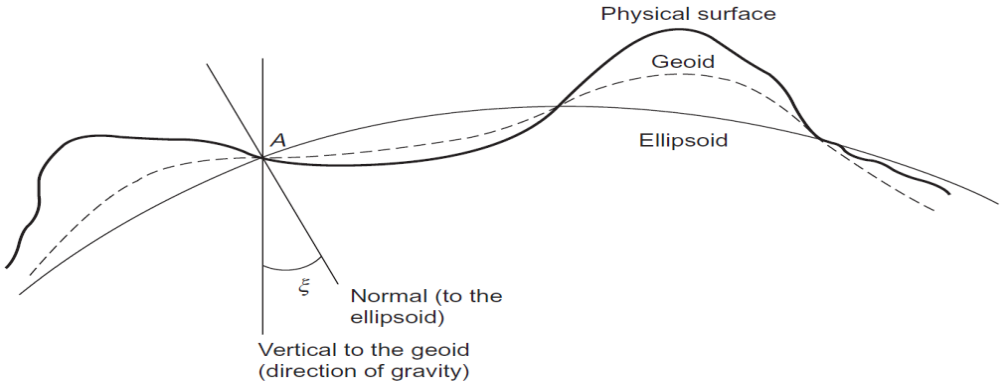


Figure 1.1: Geoid, Reference Ellipsoid and Topography

1.4.3 Limitations of Surveying Equipment

Despite many advantages, surveying using only total stations or GNSS has disadvantages. Surveying with a total station, unlike GNSS surveying, is affected by overhead obstructions. However, it is restricted to measurements between inter-visible points. GNSS is frequently used to bring control points to the survey site before continuing the survey with a total station. GNSS is only works when satellites are fee from obstructions such as trees, buildings, etc. However, if there is no satellite obstruction around the survey site, it is possible to collect both control points of the traverse and detail points of the areas to be surveyed.

1.4.4 Drawing Sketches, Elements and Standards

The ability to read drawing is the most important requirement of all technical people in any profession. Except for some freehand sketches, drafting in surveying in generally performed by mechanical means; for example, lines and surveying symbols are generally drawn with the aid of a straightedge, spline, template, etc. The drawings directly related to surveying are maps, profiles, cross sections, mass diagrams, and to some extent, other graphical calculations. Their usefulness depends upon how accurately you plot the points and lines representing the field measurements, you must adhere to the requirements of standard drawing practices.

Drawing a property map, include the following general information;

- The length each line, either indicated on the line itself or in a tabulated form, with the distances keyed to the line designation.
- The bearing of each line or the angles between lines
- The location of the mapped area as referenced to an established coordinate system
- The location and kind of each established monument indicating distances from reference marks
- The name of each road, landmark
- The names of all property owners, including those whose lots are adjacent to the mapped area
- The direction of the true and/or magnetic meridian etc.

1.4.5 Field Notes

Manually or electronically made field notes are necessary to document surveying results. Field notes are records that are kept of the field work that has been carried out. They typically contain measurements, sketches, descriptions and many other items of miscellaneous information. In the past, field notes were prepared exclusively by hand lettering in field books or special note pads as the work progressed and data were gathered. However, automatic data collectors, also known as electronic field book and survey controllers, have been introduced that can interface with many different modern surveying instruments. As the work progresses, they create computer files containing a record of observed data. Data collectors are rapidly gaining popularity, but when used, manually prepared sketches and descriptions often supplement the numerical data they generate. Regardless of the manner or form in which the notes are taken, they are extremely important.

1.4.6 Project Specifications

The surveying work shall be executed according to the specification and good standard of practice necessary to fulfill the objectives of the survey work strictly in accordance with the instruction and satisfaction of the organization goal. The specification shall be read in conjunction with the description of items in the schedule of quantities. The surveying team shall refer to the organization guideline for any discrepancy which may exist between the drawings, specification and corresponding items of the schedule for clarification before the actual surveying work. The work at site shall be carried out under the full-time supervision by

a qualified senior surveyor. The senior surveyor shall be responsible for and capable of coordinating the work of the surveying teams, setting out the work accurately, identifying immediately and positively the type of instruments to be deployed and the methodology of surveying to achieve speed and accuracy in the work and shall be fully conversant with the theory and techniques of traversing, triangulation, spot leveling survey work covered by the field work.

 Activity	• Do you think that planning is necessary before operating the surveying equipment? • From GNSS or total station equipment which one is more preferable around building or tree obstructions? • What activities are done by a surveyor in order to make good reconnaissance for the site before doing any surveying activities?

1.5 Finalizing Survey Task

After the required data has been collected, data gathered should be checked for their correctness and completeness. In land surveying, error is expected and no error free measurement is available. And these errors need to be differentiated in order to take the appropriate action. Some errors are acceptable if they laid with in the allowance limit and rejected if they are out of the tolerable limit. Eliminating errors and mistakes can be made even with repeating the measurement. Finally, after taking the required corrections and actions, the final corrected data should be submitted to the mapping experts.

Any organization/entity has its own legislation that governs the people working within. Within this legislation there are standards which this specific organization requires to be followed. A standard is a guiding document that needs to be fulfilled by the people in the organization. Organizational procedures are part of the institutional legislation and standards guiding operational aspects. These procedures are very specific so as to able to perform the required work as per the plan.

Organizational legislations are laws and rules governing the institution. The main functions of these legislations are to serve as fundamental roadmaps for the implementation of land and landed properties. In order to monitor and manage the progress of the implementation, there are standards which need to be followed so as to ensure quality delivery.

1.6 Summary

Dear trainee! All surveying activities have many surveying tasks. These tasks are classified into planning task, execute task and finalize task. Under planning task, the major activities the surveyor should work are a good reconnaissance. All surveying instruments (such as theodolites, levels, total stations, electronic measuring devices, and GPS receivers) have the manual guide for using and maintaining the instruments properly. By using instruction given from manual the surveyor can open the instrument and the surveyor shall have the knowledge on how to capture the data and set out, about the spatial reference, what are the limitation found in different surveying equipment. Once the surveyor operates the instrument, he/she should have free hand sketch on field.

After the reconnaissance, the real measurement will be done following the measurement standards. Depending on the site, GPS/Total station or both can be used. Error limit should be considered for its tolerance or rejection. If the measurement is not with in the allowable error limit, then the surveyor needs to check why and where the error was created. If the created error can be managed with systematic adjustment, it can be possible to proceed, but if the error is not manageable with systematic adjustment the surveyor needs to repeat the measurement again with utmost care. In conclusion, the correct measurement has to be submitted to the mapping team so as to produce the cadastral map.

1.7 Self-Check Exercise

**Short Answer and T/F Items**

Instruction 1: Give short, brief and precise answer for the following questions.

1. Define spatial reference and datum.
2) What is the difference between ellipsoid and geoid?
3) List down local ellipsoid and geoid used for Ethiopia?
4) What is the difference between total station and theodolite?

Instruction 2: Write 'TRUE' if the statement is correct and write 'FALSE' if it is wrong

1) The ellipsoid is chosen in such way that it best fits the surface of the area of interest.
2) When collecting GPS data, the number of and distance between features collected each day are the most important factors in determining the accuracy of the resulting data.
3) Coordinate system enables the interpretation of a set of coordinates as a representation of a position in a real-world space.

CHAPTER TWO: COLLECTING AND INTERPRETING BASIC CADASTRAL SURVEY DATA

2.1 Introduction

Dear trainee! This chapter introduces you the concepts of collecting and interpreting basic cadastral survey data. A cadastral survey is a branch of surveying that used to generate cadastral evidences to produce an outcome whose primary purpose is boundary determination. Cadastral surveying may include original survey and Resurvey .The purpose of the cadaster is to ascertain the location, size, type, and use of real property and to record data pertaining to value and ownership rights. The products of a boundary determination can be plans, certificates or digital data.

Different surveying techniques can be used to collect basic cadastral survey data. These are broadly classified as ground survey methods (steel tape, rope, total station, GNSS and others) and remote sensing methods (aerial photographs and satellite imagery). Cadastral data collection is the process of measuring information of the land parcel which enables one to provide cadastral information. This information is the basic infrastructure for urban land administration system. The practical implementations of each of the surveying technology are primary based on the accuracy requirement, cost of investment and time. Different countries use different cadastral surveying methodologies, often with varied approaches within a country.

2.2 Learning Objectives

After completing this chapter, you will able to:

- Identify the cadastral surveying data collection approaches
- Explain the principle of cadastral surveying data validation
- Interpret the collected survey data

Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts such as planning survey task, execute task and finalize task.

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2.3 Prepare for Surveying Data Collection

Before any surveying activities, surveying instruments shall be operated according to manufacturer specification. A survey plan is prepared by a surveyor showing the results of a survey, with distances (horizontal), angles and areas of appropriate, improvements. The plan may be prepared for subdivision or for showing the location of existing boundaries (re-establishment plan). The role of a land registration system like the cadaster should be regulated by laws and other administrative rules and guidelines for a uniform implementation of the system. These regulations should content as well some technical demands and rules for using the system and for maintaining it.

- The cadaster should be a parcel-based system (a piece of land belonging to a defined person or group of persons), i.e. information is geographically referenced to unique, well-defined units of land. These units are defined by formal boundaries marking the extent of land. Each parcel is given a unique parcel-number.
- Parcels are described with graphical and textual data. The cadaster shows their scope and the part of the surface to which they extend. All relevant facts, such as designation, location, size and use, plus the boundaries are based on cadastral surveys in which technical way ever.
- All information should be stored in a retrievable way, maintainable and updated by using the most economic methods in surveying and storing the data. The cadaster should be the only basic information system in the country. All users should be committed to use it for their own parcel-based special information systems so interrelations between different systems are possible.
- The cadaster should be accessible to the general public in accordance to the rights of protection of individual interests.
- The users of the cadaster should pay the services offered by the cadastral agencies. The provision of information from the system should be more or less based on cost recovery.

2.4 Data Collection

In cadastral system data collection is the process of updating and distributing measuring data information of the land parcel which enables one to provide cadastral information. This information is the basic infrastructure for urban land administration system.

The main task in the area of cadastral surveying is to collect data relating to plots of land and update the data as necessary. This means it makes a valuable contribution towards the safeguarding of real estate. The results of cadastral surveys are recorded in the plan for the land register. The process is accomplished with cadastral surveying tasks.

Cadastral surveys tasks may include:

- **Subdivision surveys:** subdivide land into smaller parcels in accordance to an approved subdivision plan.
- **Consolidation/Amalgamation:** unification of fragmented and neighboring parcels as per an approved plan so as to extract better benefits to best use of the land.

Cadastral surveys may be including Original surveys: - measure the unknown lengths and bearings of boundaries which no earlier survey has been done and Resurveys: - reestablish the boundaries of a parcel for which survey have previously been done.

Cadastral system records all information that describes the land parcel. These records can be kept in books, record cards or in a database on a computer. The form of the database may be held on a computer program like MS Access in a very simple manner or in a nation-wide operating computer system. Normally, analogue processes can be formed in a computer database.

The data can be given away on paper as well as in form of normal ASCII files so that customers can use these data as input in their special PC based databases. Links to the graphical part of the cadaster via the parcel number are possible. Still the parcel and its identifier (parcel number) seem to be the easiest and best imaginable basic unit for most purposes. In object-oriented database, all information is linked to points, polygons etc. Parcels are formed out of these objects. This kind of database has a lot of benefits, but the design is very complicated one so that developing countries should not start building up a cadastral system with such a database design.

Minimal elements of the cadastral records should be the parcel number, the name of the land owner and the size of the parcel. Additional elements can be registered as well but this is always a balance between cost and benefit and should only be registered if the maintenance is organized. Stored details for each parcel in the cadastral records may be

- name, date of birth, address, shares of the land owner,

- location of the parcel, like street-name, house number, center-coordinates,
- district and parcel-number,
- area of the parcel,
- type of land use,
- results from official soil assessment,
- internal information about year of creation of the parcel, year of maintenance, number of cadastral maps, number of survey plans,
- number of folio and property in the land register,
- Additional details about the parcel, like parcel is part of a consolidation project, polluted soil, historical monuments, parcel is part of a nature reserve or a water reserve etc.
- The right created, the responsibility given, and the restriction obliged

2.5 Errors and Mistakes Correction in Cadastral Surveying

Science and engineering often involve measurements of different types. In geodesy and surveying, geometrical quantities (such as angles, distances, heights, etc.) or physical quantities (such as gravity) are directly measured, producing large amounts of data which need to be processed. To some extent, a surveying project may be considered as a data production process, from data collection, data processing, to final presentation (graphically and/or digitally).

Statistically speaking, field observations and the resulting measurement are never exact. Any observation may contain various types of errors. The collected data are never exact and there will always be a degree of variance regardless of the survey instrument or method used. These variances are known as errors and will need to be reduced or eliminated to maintain specific survey standards. Even when carefully following established surveying procedures, observations may still contain errors. Errors, by definition, are the difference between a measured value and its true value. The true value of a measurement is determined by taking the mean value of a series of repeated measurements. Surveyors must possess skill in instrument operation and knowledge of surveying methods to minimize the amount of error in each measurement. Mistakes are errors that arise from inattention, inexperience, carelessness and poor judgment or confusion in the mind of the observer.

Appropriate corrections are made by:

- Properly leveling the survey instrument and targets.

- Configure the surveying instruments
- Entering the appropriate environmental correction factors in the data collector.
- Entering the correct instrument heights, targets heights, and prism offset in the data collector.
- Periodically calibrating the surveying equipment

In some measurement, errors are unpredictable and are often caused by factors beyond the control of the surveyor. Their occurrence, magnitude, and direction (positive or negative) cannot be predicted. Errors of this type are compensating and tend to at least partially cancel themselves mathematically. Because the magnitude is also a matter of chance they will remain, to some degree, in every measurement.

2.6 Validating survey measurement and reference system

Recording measurements and additional information can be logged by the data collector. To check each recorded and calculated value, validity determines what survey questions to use, and helps ensure that data collectors are using questions that truly measure the issues of importance.

Step 1: Establish face validity, a two-step process involves having your survey reviewed by two different parties.

Step 2: Run a pilot test.

Step 3: Clean collected data.

Step 4: Use appropriate analysis method. For example, Principal Components Analysis

Step 5: Check Internal Consistency.

Step 6: Revise Your Survey.

2.7 Finalize the Surveying Data Collection Process

Surveying data collection is the major activity intended to determining the terrestrial or three-dimensional positions of points and the distances and angles between them. After completing the measurements, the data need to be assured for its quality. This can be assured most commonly through least square adjustment. Least squares adjustment is a model for the solution of an over determined system of equations based on the principle of least squares of observation residuals. It is used extensively in the disciplines of surveying, geodesy, and photogrammetry, the field of geomatics collectively. The aim of adjustment is to reduce or eliminate errors from measurements.

The field work that involves capturing and storing of field data is carried out using instruments and techniques appropriate to the task in hand. The next step in the operation is that of data processing. The majority, if not all, of the computation will be carried out by computer, ranging in size from pocket calculator to mainframe. The methods adopted will depend upon the size and precision of the survey and the manner of its recording; whether in a field book or a data logger.

Data representation in analog or digital form may now be carried out by conventional cartographic plotting or through an automated system using a computer-driven flat-bed plotter. No matter what the work is, or how complicated, it must be set out on the ground in its correct place and to its correct dimensions, within the tolerances specified. To this end, surveying procedures and instrumentation are used, of varying precision and complexity, depending on the project in hand.

2.8 Summary



Dear trainee! Land surveying is the technique, profession, art and science of determining the terrestrial or three-dimensional positions of points and the distances and angles between them. These points are usually on the surface of the Earth, and they are often used to establish maps and boundaries for ownership, locations, such as building corners or the surface location of subsurface features, or other purposes required by government or civil law, such as property sales. Cadastral surveying is a surveying which conducted to determine the size, extent of a given parcels. Different surveying techniques can be used to collect basic cadastral survey data. These are broadly classified as ground survey remote sensing methods. This information is the basis for cadastral system works. The cadastral system activities are regulated by cadastral legislations and standards. Cadastral records shall be the parcel number, the name of the land owner and the size of the parcel.

2.9 Self-Check Exercises



Short Answer Items

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

1) How it is possible to bring uniform cadastral system throughout the country?
2) The data collected for cadaster shall include what?
3) What is the final output of the collected data?

CHAPTER THREE: PERFORMING AND MANAGE ADVANCED SURVEYING COMPUTATIONS

3.1 Introduction



Dear trainee! This chapter deals with the concept of performing and managing advanced surveying computation. Surveying requires some calculations to reduce measurements into a more useful form for determining distance, earthwork volumes, land areas, etc. Horizontal positions of permanent monuments around a project site can be established by traditional traverse, triangulation, or trilateration surveys from an established geodetic network on an installation or region. Alternatively, GPS methods can be performed to extend control from an established network to the project site.

One of the principles of surveying is that horizontal and vertical control must be established for detail surveying. The linear measurements can be made with distance measuring instruments like tape and EDM. The directions of lines can be also measured with angle measuring instruments like compass, theodolite, total station and etc. Then surveying computation can be conducted to integrate the results of measurements to get coordinate of a given points. The traverse in general consist reconnaissance, distance measurement, angular measurement, measurement of one reference direction, computation.

3.2 Learning Objectives



After completing this chapter, you will be able to:

- Discuss the concept of traverse computation
- Explain the procedure of traverse computation
- Perform area computation
- Solve problems involving circular curves



Dear trainee! Before reading the following section, take ten minutes and try to describe the basic concept of performing surveying computation methods.

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3.3 Perform Advanced Traverse Computation

3.3.1 Control Survey Methods

Control surveying is part of surveying in which high precision instruments and techniques are employed to locate points for subsequent surveying operations. Because it is used as a base for further work, it needs to be performed with more care and greater accuracy. Photogrammetry and topographic mapping require control, as doe's construction layout. Control provides the basic framework of coordinates required for many other surveying applications. Horizontal control can be carried out by:

A) Precise traversing
B) Triangulation
C) Trilateration and Combination of B and C.
D) Satellite Positioning

The exact method used depends on the terrain, equipment available, information needed and economic factor.

A) Traversing: It is the method of determining the length and direction of consecutive lines. The linear measurements are made with tape and relative directions of the lines. With traversing, a series of horizontal distances and angles are measured. This is generally cheaper due to shorter sights and convenience to carry out under less favourable weather conditions than the other methods. Its disadvantage is that there are fewer checks available for locating mistakes in the work and the whole system can easily sway or bend. To check a traverse, it is necessary to form a loop returning to its starting point or to tie it into previously established control points.

B) Triangulation: It consists of a series of joined or overlapping triangles in which an occasional line (called the base line) is measured and all other sides of the triangles are calculated from angles measured at the vertices of the triangles. The lines of a triangulation system form a network that ties together all the triangulation stations at the vertices of the triangles. A triangulation has the following advantages:

- More redundancies or checks are available i.e. more than one route can be followed to compute the length of a line.
- There is little tendency for the system to sway or bend i.e. azimuths can be easily and accurately carried or established throughout the system.
- Outstanding landmarks such as steeples, water tanks, etc. can be located by establishing directions from different stations.

Moreover, its disadvantages are it needs long range inter-visibility, which in turn requires the erection of special towers and signals, making the system the most expensive. A good weather is required to attain inter-visibility.

C) Trilateration

With trilateration, the length of the sides of series of joined or overlapping triangles are measured and the angles are computed from the lengths. It has the following advantages are:

- It is more accurate than the other two types due to the fact that distances can be measured more accurately than angles.
- It is generally less expensive than triangulation.
- More checks available.

Unlike triangulation, it is not easy to position transmission towers, steeples, water tanks, etc. by the EDM because to do so requires reflectors on those landmarks. These landmarks can be located if angular measurements are made to them. In combined triangulation and trilateration systems, all sides and angles in the joined or overlapping triangles are measured. This method provides the strongest control networks.

3.3.2 Computing Coordinates from Measurements

The coordinates of a new point can be calculated using the formulas of the polar. The Whole Circle Bearing (WCB) is determined from the existing coordinates and angle and distance to the new point have been measured.

Given: Coordinates of points P_1 and $P_2(x_1, y_1, x_2, y_2)$

Measured: Angle β_2 and Distance S_{23}

To calculate: Coordinates of point P_3 (x_3, y_3)

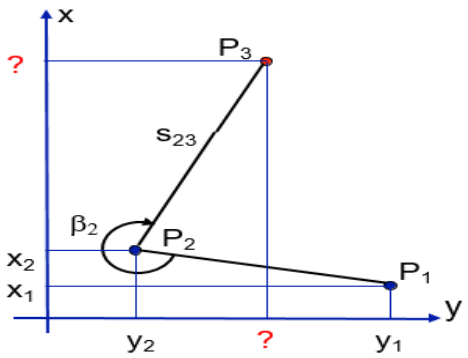


Figure 1: Coordinate from Measurement of Distance and Angle

Solution:

$t_{23} = t_{12} \pm 200 + b_2$

$x_3 = x_2 + s_{23} \cdot \cos(t_{23})$

$y_3 = y_2 + s_{23} \cdot \sin(t_{23})$

A) **Intersection by Angles:**

Given: Coordinates of points P_1 and $P_2(x_1, y_1, x_2, y_2)$

Measured: Angles β_1 and β_2

To calculate: Coordinates of point $P_3\,(x_3, y_3)$

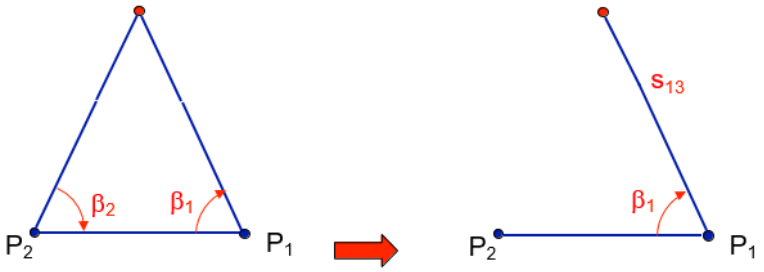


Figure 2: Intersection By Angle

Solution:

$$S_{13} = S_{12} \frac{\sin \beta_2}{\sin (\beta_1 + \beta_2)}$$

$$S_{23} = S_{12} \frac{\sin \beta_1}{\sin (\beta_1 + \beta_2)}$$

$$x3 = x1 + s13 \cdot cos\,(t12 + b1)$$

$$y3 = y1 + s13 \cdot sin\,(t12 + b1)$$

$$or$$

$$x3 = x2 + s23 \cdot cos\,(t21 - b2)$$

$$y3 = y2 + s23 \cdot sin\,(t21 - b2)$$

B) **Intersection by Distances: Example**

Given: Coordinates of points P_1 and $P_2(x_1, y_1, x_2, y_2)$

Measured: Distances s_{13} and s_{23}

To calculate: Coordinates of point $P_3\,(x_3, y_3)$

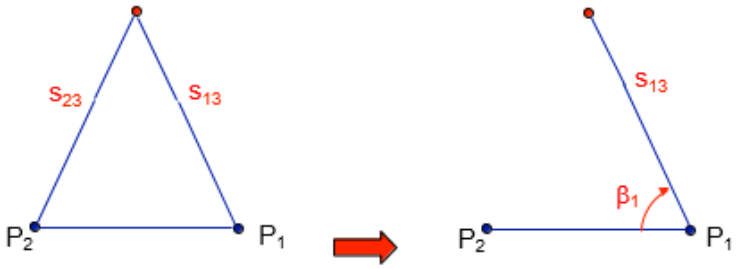


Figure 3: Intersection by distance

Solution:

$$\cos\beta_1 = \frac{s_{12}^2 + s_{13}^2 - s_{23}^2}{2 \cdot s_{12} \cdot s_{13}} \qquad \cos\beta_2 = \frac{s_{21}^2 + s_{23}^2 - s_{13}^2}{2 \cdot s_{21} \cdot s_{23}}$$

$$x3 = x1 + s13 \cdot cos\,(t12 + b1)$$

$$y3 = y1 + s13 \cdot sin\,(t12 + b1) \;\; or$$

$$x3 = x2 + s23 \cdot cos(t21 - b2)$$

$$y3 = y2 + s23 \cdot sin\,(t21 - b2)$$

C) **Resection**

This involves the angular measurement from *P* out to the known points *A, B, C.* It is an extremely useful technique for quickly fixing position where it is best required for setting-out purposes.

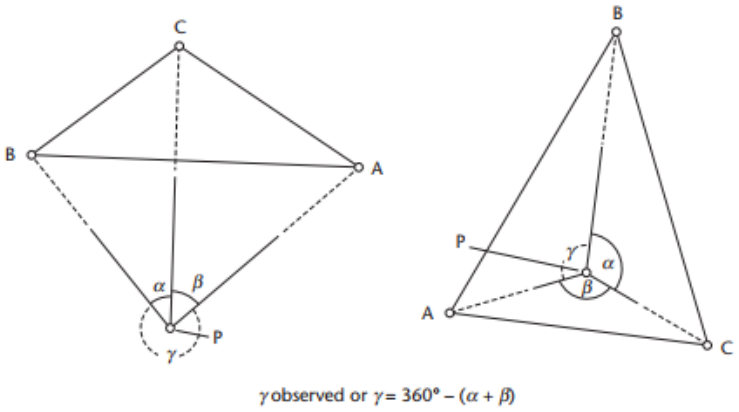


Figure 4: Resection

$$E_P = \frac{k_1 E_A + k_2 E_B + k_3 E_C}{k_1 + k_2 + k_3} \qquad N_P = \frac{k_1 N_A + k_2 N_B + k_3 N_C}{k_1 + k_2 + k_3}$$

where

$$\frac{1}{k_1} = \cot \hat{A} - \cot \alpha \;, \quad \frac{1}{k_2} = \cot \hat{B} - \cot \beta \;, \quad \frac{1}{k_3} = \cot \hat{C} - \cot \gamma$$

3.3.3 Solving and adjusting coordinates of a traverse

Simpler ways of adjusting traverses are shown in many surveying field methods texts. A sense of error in a traverse can be obtained by calculating coordinates for each point following the path of your traverse. After completing the traverse you should return to the starting coordinates, any difference is a measure of your total error. For a quadrilateral you would perform the following calculations:

- Fix one corner of quadrilateral, say the SW corner. This will have coordinates of (0,0,0). Assign the direction from the SW to the SE corners to be "east". Use your data to calculate the coordinate of the SE corner.
- From the SE corner, use the angle between lines from the SE to SW corner and SE to NE corner to calculate the coordinates of the NE corner.
- From the NE corner, use the angle between lines from the NE to SE corner and NE to NW corner to calculate the coordinates of the NE corner.
- From the NW corner, use the angle between lines from the NW to NE corner and NW to SW corner to calculate the coordinates of the SE corner. The difference between this calculated coordinate and (0, 0, 0) is your error of closure.

According to urban cadastral legal standard No.03/2015 the difference between the true value of measurement and the measured value of that measurement in a survey dataset (positional tolerance) shall not be greater than 20mm + 50 ppm. The tolerance for supplemental cadastral survey control points shall be horizontal and vertical angle = 30", EDM = 5mm allows accuracy of duplicate readings to be checked.

The angular and linear misclosure committed in cadastral surveying measurements shall comply with the following.

Table 1: 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 Station

The closing errors in a traverse are given in two forms.

3.4 Computation of Surveying Problems Involving Circular Curves

3.4.1 Circular Curves

Whenever the direction of a road or railway line is to be changed, curves are provided between the intersecting straights. This is necessary for smooth and safe movement of the vehicles and for the comfort of passengers. The curves required

may be in the horizontal planes or in the vertical planes. Accordingly, the curves are classified as horizontal curves and vertical curves. Horizontal curves are further classified as circular curves and transition curves.

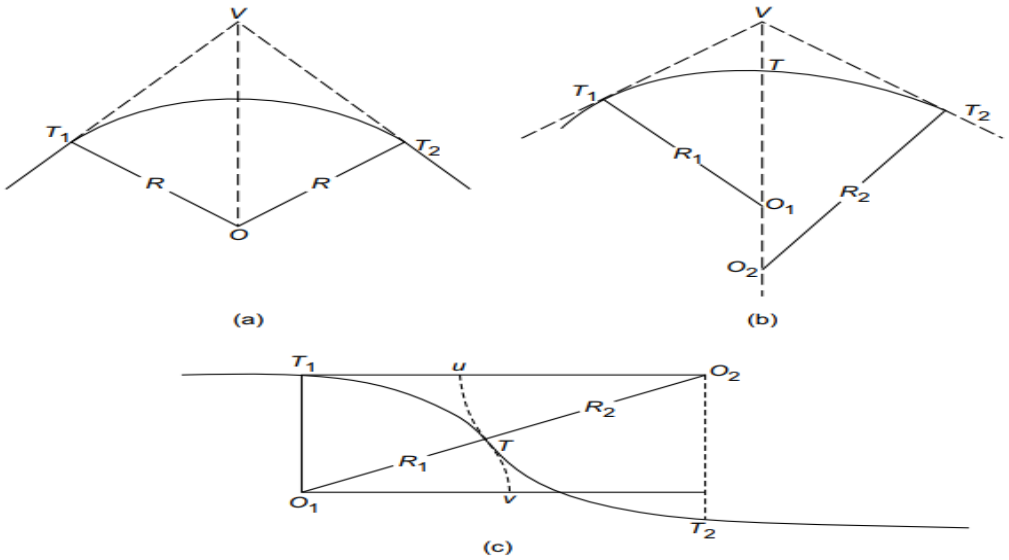


Figure 5: Circular curve

Elements of Simple Curve

Simple Curves have the shape of a circular arc. It is connecting the two tangents at an intersection. It has constant radius throughout the length. Degree of curve, D is termed as central angle that will be subtended by an arc for one station. Elements of simple cure are

- **Point of Intersection (PI):** The point of intersection marks the point where the back and forward tangents intersect. The surveyor indicates it one of the stations on the preliminary traverse.
- **Intersecting Angle (I):** The intersecting angle is the deflection angle at the PI. The surveyor either computes its value from the preliminary traverse station angles or measures it in the field. Radius (R) The radius is the radius of the circle of which the curve is an arc.
- **Point of Curvature (PC):** The point of curvature is the point where the circular curve begins. The back tangent is tangent to the curve at this point.
- **Point of Tangency (PT):** The point of tangency is the end of the curve. The forward tangent is tangent to the curve at this point.
- **Length of Curve (L):** The length of curve is the distance from the PC to the PT measured along the curve.
- **Tangent Distance (T):** The tangent distance is the distance along the tangents from the PI to the PC or PT. These distances are equal on a simple curve.

- **Central Angle (Δ):** The central angle is the angle formed by two radii drawn from the center of the circle (0) to the PC and PT. The central angle is equal in value to the I angle.
- **Long Chord (LC):** The long chord is the chord from the PC to the PT.
- **External Distance (E):** The external distance is the distance from the PI to the midpoint of the curve. The external distance bisects the interior angle at the PI.
- **Middle Ordinate (M):** The middle ordinate is the distance from the midpoint of the curve to the midpoint of the long chord. The extension of the middle ordinate bisects the central angle.
- **Degree of Curve (D):** The degree of curve defines the "sharpness "or "flatness" of the curve. The degree of curve (D) is the angle formed by two radii drawn from the center of the circle (point O) to the ends of an arc 100 feet or 30.48 meters long.

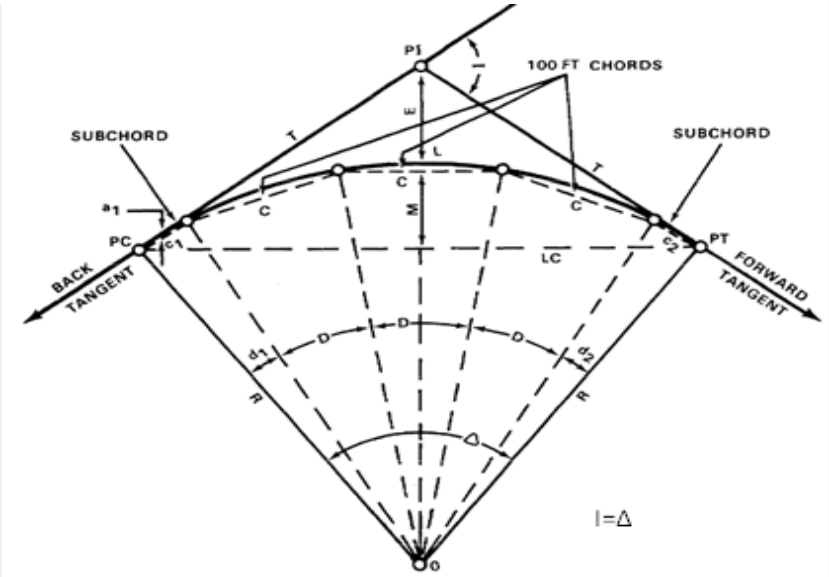


Figure 6: Elements of circular curve

Important Relationship in simple circular curve

1. Radius of curve (R)

a) Arc basis

$$\frac{D^0}{20} = \frac{360^0}{2\pi R} \qquad D^0 = \frac{360 * 20}{2\pi R} = \frac{1145.916}{R} \text{m}$$

b) Chord basis

$$\sin\frac{D}{2} = \frac{10}{R} \qquad\qquad R = \frac{10}{\sin\frac{D}{2}}$$

2. Tangent distance (T) – take triangle PC-PI-O

$$\tan\frac{\Delta}{2}=\frac{T}{R} \qquad T=R*\tan\frac{\Delta}{2}$$

3. Length of long chord (C) - take PC-PI

$$\sin\frac{\Delta}{2}=\frac{\frac{C}{2}}{R};\ C=2*R*\sin\frac{\Delta}{2}$$

4. The external distance (E) - Consider triangle PC-PI-O

$$\cos\frac{\Delta}{2}=\frac{R}{E+R}\ E=R(\sec\frac{\Delta}{2}-1)$$

5. The Middle ordinate (M) - consider AOD

$$\cos\frac{\Delta}{2}=\frac{R-M}{R}\ M=R\left(1-\cos\frac{\Delta}{2}\right)$$

6. The length of the curve (L)

i) by arc definition - the actual length of the curve

$$\frac{2\pi R}{360^0}=\frac{L}{\Delta} \qquad L=\frac{2\pi R}{360}*\Delta$$

ii) by the chord definition - the total length as measured along the chords of an inscribed polygon.

$$\frac{D}{20}=\frac{\Delta}{L}\ L=\frac{20}{D}*\Delta$$

7. Sub - Angle (d) is the central angle less than degree of curve (D^0) subtended by an arc length less than 20m or chord length less than 20m

i) by arc definition

$$\frac{20}{D}=\frac{l}{d}\ d=\frac{D}{20}*l \quad \text{sub arc}$$

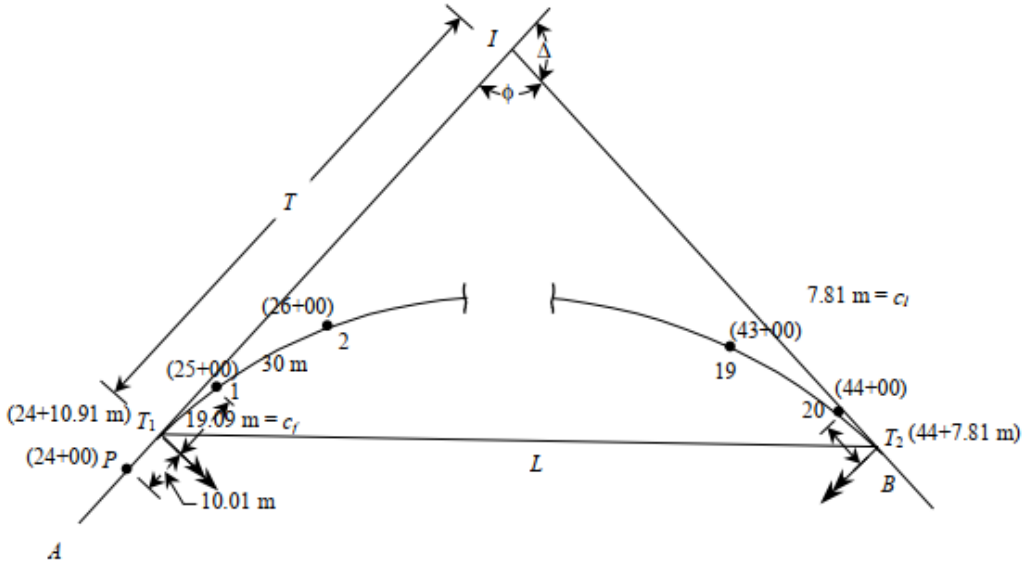
ii) Chord definition

$$\sin\frac{d}{2}=\frac{\frac{l_c}{2}}{R}\ l_c=2*R*\sin\frac{d}{2}$$

Example:1

The Chainage of the intersection point of two straights is 1060 m, and the angle of intersection is 120°. If radius of a circular curve to be set out is 570 m, and peg interval is 30 m, determine the tangent length, the length of the curve, the Chainage at the beginning and

end of the curve, the length of the long chord, the lengths of the sub-chords, and the total number of chords.



Solution:

Deflection angle $\Delta = 180° - \phi$

$= 180° - 120° = 60°$

$\Delta/2 = 30°$

(i) Tangent length $T = R \tan \Delta/2$

$= 570 \times \tan 30° =$ **329.09 m**

(ii) Length of curve $l = \pi R\Delta/180 = 570 \times \tan 30° =$ **596.90 m**

(iii) Chainage of P.I. = 1060 m

= (35 × 30 + 10) m

= 35 Full chain + 10 m

= 35 + 10

T = 329.09 m = 10 + 29.09

l = 596.90 m = 19 + 26.90

Chainage of $T1$ = Chainage of P.I. – T

= (35 + 10) – (10 + 29.09)

= **24 +10.91**

Chainage of T_2 = Chainage of $T_1 + l$

= (24 + 10.91) + (19 + 26.90) = **44 + 7.81**

Long chord $L = 2R \sin \Delta/2 = 2 \times 570 \times \sin 30° =$ **570 m**.

(iv) On the straight *AI*, the chainage of T_1 is (24 + 10.91). Therefore, a point *P* having chainage (24 + 00) will be 10.91 m before T_1 on *AI*. Since the peg interval is 30 m, the length of the normal chord is 30 m. The first point 1 on the curve will be at a distance of 30 m from *P* having chainage (25 + 00) and 30 – 10.91 = 19.09 m from T_1. Thus, the length of the first sub-chord= **19.09 m**. Similarly, the chainage of T_2 being (44 + 7.81) a point *Q* on the curve having chainage of (44 + 00) will be at a distance of 7.81 m from T_2. Thus, the length of the last sub-chord = **7.81 m**.

To calculate the length of the sub-chords directly, the following procedure may be adopted. If chainage of T_1 is ($F1$ + $m1$) and the length of the normal chord *C* is *m* then the length of the first sub-chord $cf = m - m1$; = 30 – 10.91 = 19.09 m. If the chainage of $T2$ is ($F2$ + $m2$) the chainage of the last sub-chord $cl = m2$ = 7.81 m.

(v) The total number of chords $N = n + 2$ where *n* = Chainage of the last peg – chainage of the first peg = (44 + 00) – (25 + 00) = 19
Thus $N = 19 + 2 =$ **21**.

Example:2

Two straight lines AB and BC intersect at chainage 10+020, the intersecting angle being 100^0. It is desired to connect these two tangents by a simple circular curve of 4^0. Calculate the elements of the curve and determine the chainage of the tangent pt. (arc basis)

Given; $D^0 = 4^0$

$$\text{Chainage of PI} = 10 + 020 \quad \Delta = 180 - 100 = 80$$

Solution

$$\text{Radius of the curve R} = \frac{1145.916}{4} = 286.5\text{m}$$

$$\text{Tangent Length T} = R * \tan\frac{\Delta}{2} = 286.5 * \tan\frac{80}{2} = 240.40\text{m}$$

$$\text{Long chord C} = 2 * R * \sin\frac{\Delta}{2} = 2 * 286.5 * \sin\frac{80}{2} = 184.16\text{m}$$

$$E = R\left(\sec\frac{\Delta}{2} - 1\right) = 286.5 * \left(\sec\frac{80}{2} - 1\right) = 87.50\text{m}$$

$$M = R * \left(1 - \cos\frac{\Delta}{2}\right) = 286.5 * \left(1 - \cos\frac{80}{2}\right) = 67.03\text{m}$$

$$L = \frac{2 * \pi * 286.5 * 80}{360} = 400\text{m}$$

$$\text{Chainage of PI} = 10 + 020$$

$$-\text{T} = -(0 + 240.40)$$

$$\text{Chainage of PC} = 9 + 779.6$$

$$+\text{L} = +(0 + 400)$$

$$\text{Chainage of PT} = 10 + 179.60$$

Example: 3

A circular curve of radius of 17.5 chains deflecting right through 32°40′, is to be set out between two straights having Chainage of the point of intersection as (51 + 9.35). Calculate the necessary data to set out the curve by the method of deflection angles. Also calculate the necessary data indicating the use of the control points shown in Fig. 15.6. The length of one chain is 20 m. present the values of the deflection angles to be set out using a theodolite of least count (a) 20″, and (b) 1″ in tabular form.

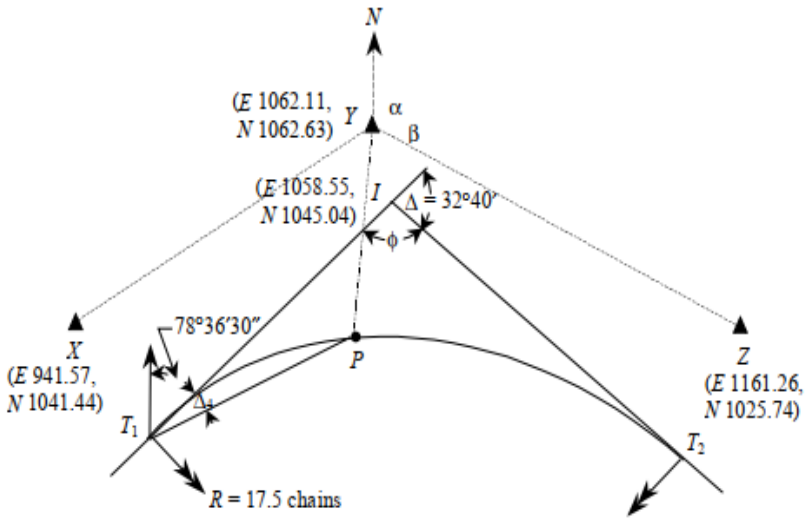


Figure 7: Example of circular curve setting out

Solution:

$R = 17.5 \times 20 = 350$ m

$\Delta = 32°40'' = 32.667°$

$\Delta/2 = = 16°20'$

Tangent length $T = 2R \tan\Delta/2 = 350 \times \tan 16°20' = 102.57$ m

Length of curve $l = \pi R\Delta /180 = \pi \times 250 \times 32.667°/180 = 199.55$ m

Chainage of $T1$ = Chainage of P.I. – T

= (51 + 9.35) – 102.57

= (51 × 20 + 9.35) – 102.57

= 926.78 m = 46 + 6.78

Chainage of *T*2 = Chainage of *T*1 + *l* = 926.78 + 199.55 = 1126.33 m = 56 + 6.33.

Length of first sub-chord *cf*= (46 + 20) – (46 + 6.78) = 13.22 m

Length of last sub-chord *cl* = (56 + 6.33) – (56 + 0) = 6.33 m

Number of normal chords *N* = 56 – 47 = 9

Total number of chords *n* = 9 + 2 = 11.

Coordinates of *T*1 and *T*2

Bearing of *IT*1 = α= 180° + bearing of *T*1*I*= 180° + 78°36’30’’= 258°36’30"

Bearing of *IT*2 = β = Bearing of *IT*1 – ϕ= Bearing of *IT*1 – (180° – Δ)= 258°36’30" – (180° – 32°40’)= 111°16'30’’

Coordinates of *T*1

Easting of *T*1 = *ET*1 = Easting of *I* + *T* sin α= 1058.55 + 102.57 × sin 258°36′30″= *E* 958.00 m

Northing of *T*1 = *NT*1 = Northing of *I* + *T* cos α= 1045.04 + 102.57 × cos 258°36′30″= *N* 1024.78 m

Coordinates of *T*2

Easting of *T*2 = *ET*2 = Easting of *I* + *T* sin β= 1058.55 + 102.57 × sin 111°16′30″= *E* 1154.13 m

Northing of *T*2 = *NT*2 = Northing of *I* + *T* cos β= 1045.04 + 102.57 × cos 111°16′30″= *N* 1007.812 m.

Tangential angles

δ =1718.9c*/R* minutes

δ1 =1718.9 x13.22*/*350 = 64.925′

δ 2 to δ10 =1718.9x*20/*350 = 98.223′

δ11 =1718.9x*6.33/*350 = 31.088′

The deflection angles for theodolites having least counts of 20″ and 1″, respectively, are given

in *table below*.

Point	Chainage	Chord length (m)	Tangential angle (′)	Deflection angle (′)	Angle set on 20″ theodolite	Angle set on 1″ theodolite
0 (T_1)	46+6.78	–	0.0	0.0	0.0	0.0
1	47+00	13.22	64.925	64.925	1°05′00″	1°04′55″
2	48+00	20	98.233	163.148	1°43′00″	1°43′09″
3	49+00	20	98.233	261.371	4°21′20″	4°21′22″
4	50+00	20	98.233	359.594	5°59′40″	5°59′36″
5	51+00	20	98.233	457.817	7°37′40″	7°37′49″
6	52+00	20	98.233	556.040	9°16′00″	9°16′02″
7	53+00	20	98.233	654.263	10°54′20″	10°54′16″
8	54+00	20	98.233	752.486	12°32′20″	12°32′29″
9	55+00	20	98.233	850.709	14°10′40″	14°10′43″
10	56+00	20	98.233	948.932	15°49′00″	15°48′56″
11(T_2)	56+6.33	6.33	31.088	980.0230	16°20′00″	16°20′00″

3.4.2 Compound Circular Curves

These consist of two or more consecutive circular curves of different radii without any intervening straight section.

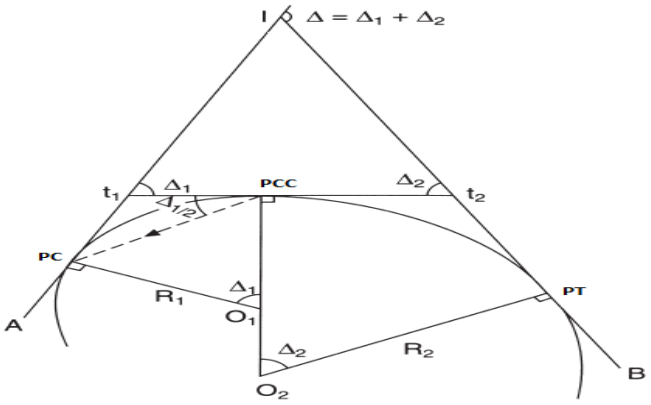


Figure 8: Compound Circular Curves

The design of such a curve is best done by treating each section separately and choosing suitable values for each circular arc. In compound circular curves, the tangents I-PC and I-PT are not equal.

3.4.3 Reverse Circular Curves

These curves consist of two consecutive curves of the same or different radii without any intervening straight section and with their centers of curvature falling on opposite sides of the common tangent.

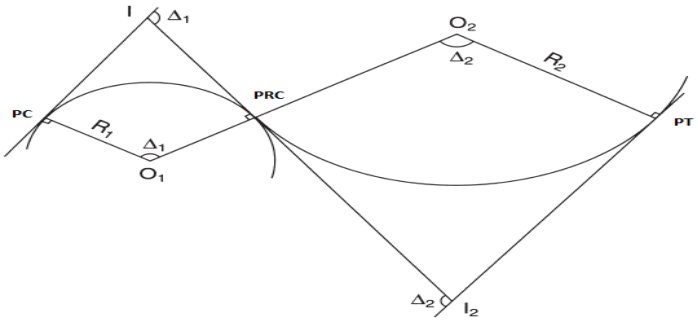


Figure 9: Reverse Curve

3.5. Summary

Dear trainee! The horizontal and vertical positions of the monuments in the control network have been determined by precise geodetic control surveys. Subsequent control surveys use the established monuments and bench marks to develop local project control networks. These local control monuments are used as a reference for the collection of preliminary, cadastral, and construction surveys.

A traverse is a chain of points connected by angular and linear measurements. The check on observations is provided by the agreement, obtained in computations, between the terminals of the traverse (terminal bearings and terminal co-ordinates) taken as fixed. This check is not sufficient, however, to serve as a check on the computations. As a matter of principle, computations should be free of errors; there are no limits of tolerance in computational work except for discrepancies arising from inaccuracy of last figures. Secondly, errors in computation may occur that are not revealed by the traverse misclosure, not to speak of compensational errors, the field for which is very favorable in traverse work.

3.6 Self-Check Exercises

Short Answer and workout Items

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

1) Discuss the concept of traverse computation.
2) List and explain types of traverse and the required measurements.
3) How the intersection angles can be measured in a loop traverse?
4) Describe briefly different methods of area computation.
5) Discuss elements of simple circular curve.

CHAPTER FOUR: PLANNING AND CONDUCTING SURVEY EXPEDITIONS

4.1 Introduction

Dear trainee! This chapter deals with the concept of planning and conducting survey expeditions. A successful survey expedition requires an appropriate set of measurements to be taken and recorded, without unnecessary deployment of human resources, equipment, tasks, and procedures. It can be achieved by means of planning and implementing. Planning is the basic step in the survey expedition which includes all the necessary detail activities in accordance with the defined objectives and organizational guidelines.

It should consider the technical and logistical components to ensure that supplies support the location, duration, and size of the field trip. Then, the team members will be formed and necessary preparation will be conducted in the office and field. The supervisor ensures that each group of surveyors and other personnel's conduct activities in accordance with the plan. In addition to this, the safety procedures and OHS requirements shall be applied during the survey operation. Lastly, reports will be prepared depending on the follow up activities.

4.2 Learning Objectives

After completing this chapter, you will be able to:

- Plan and organize a survey expedition
- Identify the safety and survival skills
- Discuss the follow-up activity and reporting

Dear trainee! Before reading the following section, take ten minutes and try to explain the basic concepts of planning survey expedition and its importance.

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_____

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4.3 Planning Survey Expeditions

A survey plan is the first and the most critical step in survey expedition, which encompasses understanding all tasks and activities required to be conducted, identifying the surveying equipment's, relevant surveyors, and supervisors with all necessary logistical consideration to achieve the desired goals. For example, the goal of the survey expedition may be to delineate boundaries of parcels with a give neighborhood. In addition, the survey plan should be flexible to allow for delays due to weather, equipment breakdown and other emergency cases that can be happen during implementation.

A site safety plan, which establishes policies and procedures to protect workers and the public from the potential hazards and dangerous circumstances must be developed before site activities proceed. The site safety plan must provide measures to minimize accidents and injuries that may occur during normal daily activities or during adverse conditions such as hot or cold weather. If the work must be done in these hazardous areas, then certain safety precautions should be followed. Safety vests of fluorescent yellow color should always be worn in these situations, and flagging materials of the same color can be attached to the surveying equipment to make it more visible. Depending on the circumstances, signs can be placed in advance of work areas to warn drivers of the presence of a survey party ahead, cones and/or barricades can be placed to deflect traffic around surveying activities, and flaggers can be assigned to warn drivers, or to slow or even stop them, if necessary.

Surveyors should be knowledgeable about the types of hazards that can be expected in any local area, and always be alert and on the lookout for them. To help prevent injury from these sources, protective boots and clothing should be worn and insect sprays can be used. Certain tools can also be dangerous, such as chain saws, axes, and machetes that are sometimes necessary for clearing lines of sight. These must always be handled with care. Also, care must be exercised in handling certain surveying instruments, like GNSS, total station, theodolites, levels, and others. Sometimes, the instrument accessories like long-range poles and level rods may need special care during working around overhead wires, to prevent accidental electrocutions.

Many other hazards that can be encountered when surveying in the field shall be considered in the planning phase. Thus, it is essential that surveyors always exercise caution in their work, and know and follow accepted safety standards. In addition, a first-aid kit should always accompany a survey party in the field, and it should include all of the necessary

antiseptics, ointments, bandage materials, and other equipment needed to render first aid for minor accidents. The survey party should also be equipped with cell phones for more serious situations, and telephone numbers to call in emergencies should be written down and readily accessible.

Site Safety Plan may incorporate the following key points:

- Name key personnel and alternates responsible for site safety;
- Describe the risks associated with each operation conducted;
- Confirm that personnel are adequately trained to perform their job responsibilities and to handle the specific hazardous situations they may encounter;
- Describe the protective clothing and equipment to be worn by personnel during various site operations;
- Describe any site-specific medical surveillance requirements;
- Describe the program for periodic air monitoring, personnel monitoring, and environmental sampling, if needed;
- Describe the actions to be taken to mitigate existing hazards (for example, containment of contaminated materials) to make the work environment less hazardous;
- Define site control measures and include a site map;
- Establish decontamination procedures for personnel and equipment.

In addition, the procedures that will be used and relevant personnel's for achieving the aims of the project shall be incorporated in the plan. These schemes may limit the required resources and logistical consideration.

4.4 Organizing a Survey Expedition

The technical and logistical considerations shall be organized in line with the survey plan and the desired goals. This step ensures logistics, site evaluation, personnel formation and right equipment selection considering the OHS requirements. The team will be formed including the relevant surveyors, work site personnel's and supervisors.

Reconnaissance survey may be conducted using suitable maps, photos, survey site descriptions and other available data. Then, the field visit will be undertaken and necessary survey camp site will be prepared. In general, the organizing phase shall consider the following major activities:

- Preparing the suitable surveying based on the type of job, area extents, project time frame field, scope of work and level of required accuracy.
- Facilitating the selected mode of transportation to transport the survey team, surveying instruments and other equipment to be used in the site.
- Logistics for day-to-day activities.
- Preparing the mediums for selected mode of communication for both field to office and within the field environment. For example, include telephone, fax, or others.
- Detailed work scheduling with the given timeframe
- Applying OHS to every phase and activities

4.5 Applying Safety and Survival Skills

4.5.1 Principles of the Search and Rescue

All the technical and other detail activities listed and the OHS shall be applied thoroughly to achieve the aims of the project. Search and rescue functions can be broken into two aspects:

- Search to carefully look for victims in order to find someone missing or lost and
- Rescue to free a trapped victim/casualty from confinement or from under rubble.

The basic principles to be followed during the Search and Rescue Operation are;

- Damaged buildings and facilities should only be approached from the least dangerous side.
- While surveying indoor space in buildings, do not use open fire (torches, kerosene lamps) for lighting.
- When searching for casualties, do not walk or stay near badly damaged and collapse-prone buildings.
- Do not allow many people to gather in one spot, in shafts, or floors.
- Do not go near collapse-prone walls or other constructions.
- Move very carefully over building ruins (only if it is absolutely necessary) as they are unstable heaps of fragments.
- When removing rubble from ruins, do not permit abrupt jerks, shaking, or strong blows at the site.

Components of Search and Rescue operation

- **Rescuers:** includes trained personnel and volunteers

- **Tools:** depend on their availability and the needs of the situation. For example, storm or earthquake damage may require tools for lifting debris whereas flood damage may require boats and ropes.
- **Time:** may be very limited for some victims. The first 24 hours after a disaster are called the "Golden hours" where an injured or trapped victim has an 80 percent chance of survival, if rescued.



Basic Steps of the Search and Rescue are:

- Search and Locate Victim,
- Gain Access to the Victim,
- Stabilize the Victim and
- Extract the Victim.

4.5.2 Basic Rescue Evacuation Techniques

Evacuation and safe rescuing of victim by applying simple manual techniques can save the life of the victim. Regular hands on practice and drills will help the rescuer to save lives in quicker and safer manners. There are many types of rescuing techniques. The most common and rescue evacuation improvised techniques are:

- **Ankle pull:** is the fastest method for moving a victim a short distance over a smooth surface. This is not a preferred method of patient movement.
- **Shoulder pull:** is preferred to the ankle pull. It supports the head of the victim. The negative is that it requires the rescuer to bend over at the waist while pulling.
- **One-person lift:** this only works with a child or a very light person.
- **Pack-strap carry:** When injuries make the rescuer carry unsafe, this method is better for longer distances than the one-person lift.

First Aid is the initial immediate assistance or treatment given to someone who is injured or has suddenly fallen ill before the arrival of an ambulance, doctor, or other appropriately qualified person. The followings are first aid priorities**:**

- Assess the situation quickly and calmly
- Protect yourself and casualties from danger
- Assess the conditions of all casualties
- Comfort and reassure the casualties
- Deal with any life-threatening conditions first
- Obtain medical aid if necessary

4.6 Conducting Follow-up Activity

It is widely accepted in the literature that follow-up is critical to effective professional development, particularly in conducting survey expedition. How the planned survey has been conducting in accordance with the planned resource and OHS plans. The results of the scoping survey are documented depends on the specific objectives of the survey. For each activity of the surveys that provide additional information for characterization surveys, the documentation should provide overall general and detailed information in formal written way. Based on this information, detailed reports will be prepared.

4.7 Summary

Dear trainee! In survey expedition which encompasses understanding all tasks and activities required to be conducted, identifying the surveying equipment's and relevant surveyors and supervisors with all necessary logistical consideration to achieve the desired goals. OHS plan, emergency supplies and emergency equipment shall be incorporated in the survey plan expedition.

The survey expedition plan will be implemented through considering all the technical, financial and OHS considerations. Search and locate victim, gain access to the victim, stabilize the victim, and extract the victim are the major steps of conducting search and rescue operation through considering the basic principles. This also helps the supervisors to conduct follow up activities and documenting the results and reports.

4.8 Self-Check Exercises

**Short Answer Items**

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

1) Define the following words: Survey expedition, OHS and First Aid.
2) List and explain the most common rescue evacuation techniques.
3) Explain the major considerations in the survey expedition plan.
4) Discuss the components of search and rescue and its basic steps.
5) Why we need to implement first aid?
6) List and explain the most common rescue evacuation techniques.

CHAPTER FIVE: SET-OUT BASIC SURVEYING DATA

5.1 Introduction

Dear trainee! This chapter introduces you the basic concept on how to set-out basic surveying data. Surveying is not only determining the relative location of features, includes establishing such points. These features are usually on the surface of the Earth, and they are often used to establish maps and boundaries for ownership, locations, such as building corners or the surface location of subsurface features, or other purposes required by government. In land surveying, setting out the reverse of surveying for data collection which plays vital role through transferring from designs and drawings into the ground. It establishes the location points for site boundaries, foundations, columns, center-lines of walls and other necessary structural parts. Also, it establishes the building's correct extent, angle and level. It entails the establishment of marks on the ground to define the position (x, y) and level (H) of elements of the construction work so that works may proceed with reference to design criteria.

The surveyor shall conduct the planning and preparation activities before he/she go to the field. The selected surveying instruments shall be checked for their safety and operability to minimize the amount of error in each measurement. In setting out process, the most critical aspect is to ensure that setting out data and an accurate plan of the project is available. The setting proceeds from control stations established during the cadastral, topographic or other survey stage or from national network. The simplest 3-4-5 method, intersection, polar coordinates and set-out using total station and GNSS instruments are the most commonly used methods of setting out.

5.2 Learning Objectives

After completing this chapter, you will be able to:

- Explain concept of setting out
- Prepare and identify methods of setting out
- Perform set out basic surveying data

Dear trainee! Before reading the following section, take ten minutes and try to explain the basic concept of setting out in land surveying.

5.3 Plan and Preparation to Set-Out

Planning is the preliminary task to be done prior to set-out survey. The project has to be planned to an appropriate level of details. Its main purpose is to set time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution.

Organizational guidelines are rules or legislations aim to streamline particular processes according to a set routine or sound practice. It may be issued by and used by any organization (governmental or private) to make the actions of its employees or divisions more predictable, and presumably of higher quality. In performing activities of the organization, these guidelines should be obeyed. Manufacturer guidelines shall be followed and tasks or activities contrary to this guideline may have an effect of the work**.**

5.3.1 Preparation Stage

Before you go to field, the surveyor shall prepare and check the surveying instruments for their safety and operability. In addition to this, the instrument shall be calibrated regularly to check the accuracy, precision or uncertainty of the instrument. A discrepancy is the difference between two or more measured values of the same quantity. However, measurements are never exact and there will always be a degree of variance regardless of the survey instrument or method used.

5.3.2 Operating Surveying Equipment

There are a number of instruments in land surveying which used for data collection and set-out activities. These are tape, compass, level, theodolite, total Station, GNSS, etc.

A. Total Station

Total station is a surveying equipment combination of Electromagnetic Distance Measuring instrument and electronic theodolite. It is also integrated with microprocessor, electronic data collector and storage system. The instrument can be used to measure horizontal and vertical angles as well as sloping distance of object to the instrument.

The electronic display unit is capable of displaying various values when respective keys are pressed. The system is capable of displaying horizontal distance, vertical distance, horizontal and vertical angles, difference in elevations of two observed points and all the three coordinates of the observed points. After we collected necessary survey data with Total Station, it can be downloaded to computers for further processing. The total station instrument is mounted on a tripod and is leveled by operating leveling screws. Within a small range instrument is capable of adjusting itself to the level position. Then vertical and horizontal reference directions are indexed using on board keys. It is possible to set required units for distance, temperature and pressure. Surveyor can select measurement mode like fine, coarse, single or repeated.

When target is sighted, horizontal and vertical angles as well as sloping distances are measured and by pressing appropriate keys, they are recorded along with point number. Heights of instrument and targets can be keyed in after measuring them with tapes. Then processor computes various information of the point data and it displays on screen.

This information is also stored in the electronic notebook. At the end of the day or whenever electronic note book is full, the information stored is downloaded to computers. The point data downloaded to the computer can be used for further processing. There are software's like ArcGIS, AutoCAD which can be used for producing base map and plotting contours at any specified interval and for plotting cross-section along any specified line. The following are some of the major advantages of using total station over the conventional surveying instruments:

- Field work is carried out very fast.
- Accuracy of measurement is high.
- Manual errors involved in reading and recording are eliminated.
- Calculation of coordinates is very fast and accurate. Even corrections for temperature and pressure are automatically made.
- Computers can be employed for map making and plotting contour and cross-sections. Contour intervals and scales can be changed in no time.

However, surveyor should check the working condition of the instruments before using. For these, standard points may be located near survey office and before taking out instrument for field work, its working is checked by observing those standard points from the specified instrument station.



a) Vertical drive
b) Focusing ring
c) Battery compartment
d) Tribrach foot screw
e) Stylus for touch screen
f) Touch screen
g) Circular level
h) Interchangeable eyepiece
i) Keyboard

Figure 10: GeoMax Zoom40 Normal face (face I)



a) Carry handle
b) Optical sight
c) Telescope, integrating EDM, AiM, NavLight, Scout
d) NavLight flashing diode - yellow and red
e) Scout, transmitter
f) Scout, receiver
g) Coaxial optics for angle and distance measurement, and exit port of visible laser beam for distance measurements
h) Communication side cover
i) Horizontal drive
j) Tribrach securing screw

Figure 11: GeoMax Zoom40 face II

B. Global Navigation Satellite System

GNSS Receivers process the Signals In Space (SIS) transmitted by the satellites, being the user interface to any Global Navigation Satellite System (GNSS). Even though the information provided by a generic GNSS receiver can be used by a wide range of Applications, most of them rely on the receiver's navigation solution, i.e. receiver computed Position, Velocity and Time (PVT).

Any of the GNSS surveying methods could be used on geospatial projects. Specifically, static surveys can be used to establish project control points and kinematic surveys can be used to produce maps for planning and design. Finally, real-time kinematic (RTK) surveys can be used to locate construction stakes.

In cadastral surveying, setting out using RTK surveying methods needs a minimum of two receivers. Each is equipped with a radio. One receiver occupies a nearby control station and the other, called the "rover," is moved from one point (to be set) to another. The points set must have their project coordinates known before setting any stakes. The base radio broadcasts the raw satellite signals from the base receiver to the rover. At the rover, the application software processes the satellite signals from both receivers in real time using relative positioning techniques. This determines the location of the rover relative the base station. If the observed coordinates do not agree with the required values for the point being staked, the GNSS controller will indicate the direction and distance that the rover must be moved. The rover's position is adjusted until agreement is reached and the stake is set at this location.

GNSS surveys are particularly useful in staking widely spaced points, especially in areas where terrain or vegetation makes it difficult to conduct traditional ground surveys. Staking subdivisions containing large parcels in rugged terrain, and setting slope stakes in rugged areas where deep cuts and fills exist, are examples of situations where GNSS surveys can be very convenient for construction surveying.



Figure 12: South Galaxy G1 Plus GNSS Antenna

Power on: Press the power button for once, all the indicators glow in red, after few seconds (around 10 seconds), the instrument completes initializing along with voice prompt about the working mode (for example, "Rover, internal radio mode"). After a while, instrument starts to track satellites.

Power off: Press the power button and hold for a while, after 3 beeps and the “Power off” voice prompt at the third beeping, release power button, the instrument will switch off.

Check working mode: Press the power button for once in the state of power-on, the instrument will prompt with voice message about current working mode (for example, “Rover, internal radio mode”).

Work mode: Press F key once, the Bluetooth, data and satellites indicators will blink together, and NewG1Pluswill say “start to set work mode”, at this moment, press power key once to confirm, and then press F key one by one, NEW G1Pluswill say “base mode, rover mode and static mode” one by one, when you hear the working mode you need, press power key to confirm.

Data link: After confirming the work mode, for example, we set the NewG1Plusinto base mode previously. Press F key once, the Bluetooth, data and satellites indicators will blink together, and NewG1Plus will say “start to set work mode”, at this moment, press F key once again, New G1 plus will say “select data link”, and then press power key once to confirm, and then press F key one by one, New G1 plus will say “base internal radio mode, base GPRS mode, base external mode and base Wi-Fi mode” one by one, when you hear the data link you need, press power key to confirm.

5.3.3 Responsibility of the Surveyor for Setting-Out

The setting-out surveyor should establish such a system of work on site that will ensure the accurate setting out of the works well in advance of the commencement of construction. To achieve this, the following factors should be considered.

- A complete and thorough understanding of the plans, working drawings, setting-out data, tolerances involved and the time scale of operations. Checks on the setting-out data supplied should be immediately implemented.
- A complete and thorough knowledge of the site, plant and relevant personnel. Communications between all individuals is vitally important. Field checks on the survey control already established on site, possibly by contract surveyors, should be carried out at the first opportunity.
- A complete and thorough knowledge of the survey instrumentation available on site, including the effect of instrumental errors on setting-out observations. At the first

opportunity, a base should be established for the calibration of tapes, EDM equipment, levels, theodolites, total station and GNSS.

- A complete and thorough knowledge of the stores available, to ensure an adequate and continuing supply of pegs, pins, chalk, string, paint, timber, etc.
- Office procedure should be so organized as to ensure easy access to all necessary information. Plans should be stored flat in plan drawers, and those amended or superseded should be withdrawn from use and stored elsewhere. Field and level books should be carefully referenced and properly filed. All setting-out computations and procedures used should be clearly presented, referenced and filed.
- Wherever possible, independent checks of the computation, abstraction and extrapolation of setting-out data and of the actual setting-out procedures should be made.

5.4 Set Out Basic Surveying Data

Setting out is the transfer of spatial data from a design, map or plan onto the ground. It entails the establishment of marks on the ground to define the position (x, y) and level (H) of elements of the property boundary and construction work so that works may proceed with reference to design criteria. Setting out therefore may be considered as the opposite of data collection surveying since it intends to determine by measurement the positions of existing features. In cadastral surveying, setting out will involve the placement of beacons to demarcate property boundaries and missing or lost monuments. Regardless of the task at hand, good surveying practices and techniques in setting out are essential in order to minimize errors.

In any setting out task, the most critical aspect is to ensure that setting out data and an accurate plan of the project is available. This is normally achieved by carrying out a detailed topographic survey of the project area followed by the design of the scheme (in case of cadastral survey) or an engineering structure. The designed project must then be set-out on the ground in its correct absolute and relative position.

The setting proceeds from control stations established during the cadastral, topographic or other survey stage or from national geodetic network. Where necessary, additional controls point can be placed near the project site and in such a manner that they must survive the overall process. At all stages of the setting out, the surveyor must apply the necessary and

independent checks to ensure errors are minimized and the required tolerances are achieved. A typical setting out exercise should involve the following task:

- Maintain field notes records
- Adopt and implement sensible filing procedures.
- Care of instruments and safe use at all times.
- Check for correctness of drawings / plans It is important to ensure that you have the correct information.
- Reconnaissance survey
- Observe project specifications: The surveyor should adhere to project specifications as spelled out in the contract document which sets the required tolerances for different setting out operations.
- Maintain accuracy: In practice this means that all design points must be set out from control framework.
- Communicate: Verbal communication is acceptable in most cases.

5.4.1 3-4-5 Method

Naturally, the longer the sides of your triangle set, the smaller is the chance to make mistakes. A very good method is therefore to use a tape measure and pegs, measuring out a triangle with legs of 3, 4 and 5 meters (See Figure 52). Lengths of 6, 8 and 10 or 9, 12 and 15 meters can also be used (in fact any three lengths of which the sum of the squares of the shorter two is equal to the square of the longer: $a^2 + b^2 = c^2$ with c naturally as the longest side).

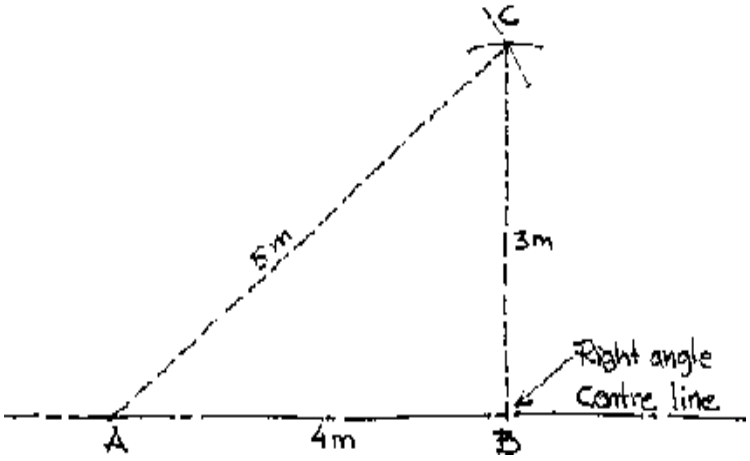


Figure 13: 3-4-5 method

The right angle is found as follows:

1) measure length A-B of 4 meters along the center-line of the road (drive in pegs exactly on point A and B);
2) circle a length of 5 meters around from point B;
3) circle a length of 5 meters around from point A;
4) point C is the point of intersection of both circles;
5) drive in a peg on point C; (B-C is now at a right angle to A-B).

5.4.2 Using Polar Coordinates

In below *Figure (See Figure 15) A, B* and *C* are control stations whose coordinates are known. It is required to locate point *IP* whose design coordinates are also known. The computation involved is as follows:

(1) From coordinates compute the bearing BA (this bearing may already be known from the initial control survey computations).
(2) From coordinates compute the horizontal length and bearing of B – IP.
(3) From the two bearings compute the setting-out angle AB (IP), i.e. β.
(4) Before proceeding into the field, draw a neat sketch of the situation showing all the setting-out data. Check the data from the plan or by independent computation.

The field work involved is as follows:

(1) Set up theodolite at *B* and backsight to *A*, note the horizontal circle reading.
(2) Add the angle β to the circle reading *BA* to obtain the circle reading *B – IP*. Set this reading on the theodolite to establish direction *B – IP* and measure out the horizontal distance *L*.

If this distance is set out by steel tape, careful consideration must be given to all the error sources such as standardization, slope, tension and possibly temperature if the setting-out tolerances are very small. It should also be carefully noted that the sign of the correction is reversed from that applied when measuring a distance. The best field technique when using a steel tape is carefully to align pegs at *X* and *Y* each side of the expected position of *IP* (See *Figure 15*). Now carefully measure the distance *BX* and subtract it from the known distance to obtain distance *X – IP*, which will be very small, possibly less than one meter. Stretch a fine cord between *X* and *Y* and measure *X – IP* along this direction to fix point *IP*. Modern EDM equipment displays horizontal distance, so the length *B – IP* may be ranged direct to a reflector fixed to a setting-out pole. The use of short-range EDM equipment has made this method of setting out very popular.

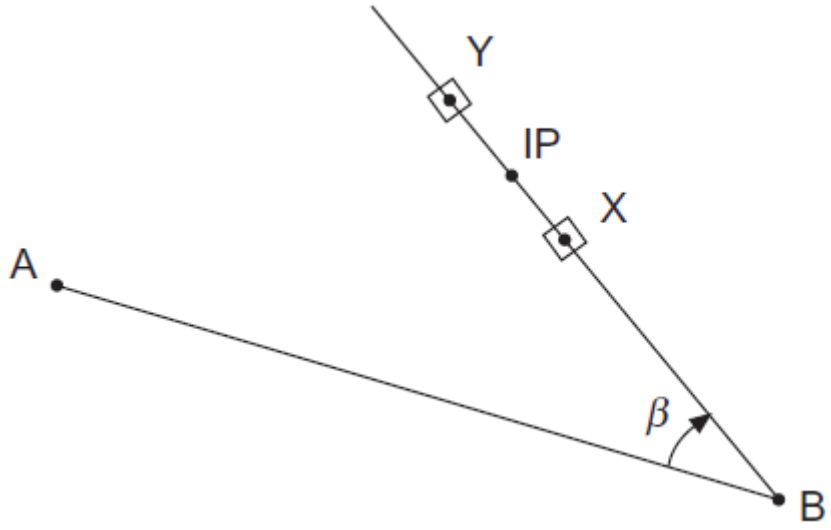


Figure 14: Setting out using polar coordinates

5.4.3 By Intersection

This technique, illustrated in below figure (*See Figure 53*) does not require linear measurement; hence, adverse ground conditions are immaterial and one does not have to consider tape corrections. The computation involved is as follows:

(1) From the coordinates of *A*, *B* and *IP* compute the bearings *AB*, *A – IP* and *B – IP*.

(2) From the bearings compute the angles α and β.

The relevant field work, assuming two theodolites are available, is as follows:

(1) Set up a theodolite at *A*, backsight to *B* and turn off the angle α.

(2) Set up a theodolite at *B*, backsight to *A* and turn off the angle β.

The intersection of the sight lines *A – IP* and *B – IP* locates the position of *IP*. The angle δ is measured as a check on the setting out. If only one theodolite is available then two pegs per sight line are established, and then string lines connecting each opposite pair of pegs locate position *IP*.

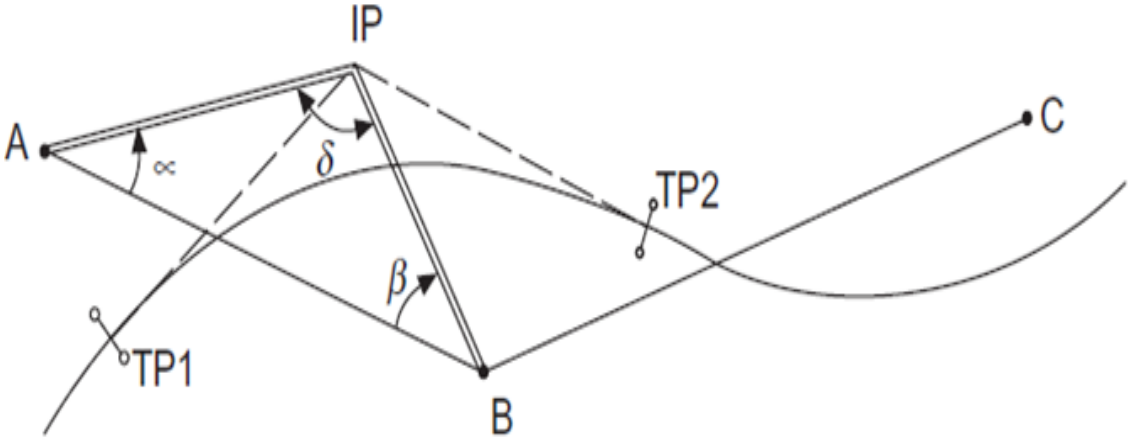


Figure 15: Setting out by resection

5.4.4 Using Total Station

Setting out points using total station instrument can be conducted as:

- Set up the instrument at a known point and set the horizontal circle.
- Enter the coordinates of the point to be staked out. (The program automatically calculates direction and distance to the point – the two parameters needed for staking out.)
- Turn the total station until the horizontal circle reads zero.
- Position the reflector at this point (point P).
- Measure the distance. (The difference in the distance D to the point P will be displayed automatically.)
- The coordinates of the points to be staked out can be transferred beforehand from your computer to the total station. Under these circumstances, you only need to select the point number. If two points are known, you can also use the resection method to set up and orient your instrument.

5.4.5 Using GNSS

1) Assemble and erect the equipment.

<u>At the base:</u>

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

<u>At the rover:</u>

- Mount the receiver onto a range pole. Power for the receiver is supplied by the internal battery in the receiver.
- Attach the controller to the holder.
- Connect the controller holder to the range pole.

2) Connect the controller and the receiver using the appropriate cable to Bluetooth.
3) If you are using an RTK radio survey, connect the controller, receiver, radio and, if required, the power supply.

4) Turn on the receiver.
5) Turn on the controller.
6) If you are using an RTK Internet or dial-in survey, connect the controller, receiver and, if required, the external device:
    - If the modem is an external device such as a cellular phone, turn on the device and connect it to the controller using Bluetooth or a serial cable.
    - Connect the receiver to the controller using Bluetooth or a serial cable.

Note: *If you are using an RTK dial-in survey, make sure you connect the equipment using the method configured in the survey style.*

To connect the controller to the receiver using Bluetooth:

- Tap menu and select Settings→ Connections →Bluetooth.
- In the Connect to GNSS rover field, select the receiver.
- Pair with the device.

In a GNSS survey, configure the stake method to control how setting out navigation information appears. The default method is *To the point*, where directions to the point are given from your current position.

To change the GNSS stake method:

1) Make sure you have entered an antenna height.
2) Tap menu and select Stakeout / Points.
3) If the Setting out point form appears beside the map showing a list, tap > Point to change to staking a single point.
4) Tap the Up arrow soft key. Tap Options.
5) In the Stake field, select the method. Select from:
    - **To the point:** setting out the point with directions from your current position. This is the default method.
    - **From fixed point:** setting out the point with cross-track information and directions from another point. Enter a point name in the from point field. Select from a list, key in, or measure this value.
    - **From start position:** setting out the point with cross-track information and directions from the current position when you start to navigate.

- **From last point staked:** setting out the point with cross-track information and directions from the last point that was staked out and measured. The staked point is used, not the design point.
- **Relative to azimuth:** setting out the point with the cross-track information and directions relative to a keyed-in azimuth.

5.5 Summary

Dear trainee! Setting out is the process of transferring from designs and drawings into the ground. It establishes the location points for site boundaries, foundations, columns, center-lines of walls and other necessary structural parts. Setting out used to establishment marks and lines to define the position and level of the elements for the surveying work so that works may proceed with reference to them. This process may be contrasted with the purpose of surveying which is to determine by measurement the positions of existing features.

The activities involved in setting out vary enormously from site to site, but, frequently, insufficient importance is attached to the process and it tends to be rushed to, supposedly to save time. Unfortunately, such haphazard procedures can lead to errors which in turn require costly corrections. This errors cam be categorized as personal, natural and errors emanated from the instrument. Such surveying error must be pre-determined and the survey team must designed a system to control the errors and that will help reduced the error without compromising the quality of surveyed data. It is the responsibility of the setting out surveyor to follow instrument manual and organizational guideline during setting out. During setting out careful site investigation and prepare is necessary to prepare instrument set out calculations, drawings, specifications and quantities for land surveying project.

5.6 Self-Check Exercise

**Short Answer Items**

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

1) Define what land survey and setting out mean?
2) Describe are the responsibilities of surveyor for setting out?
3) List surveying instrument and their application?
4) What are the factors that should be considered to minimize error during measurement?

CHAPTER SIX: DEVELOP AND USE SPREADSHEETS

6.1 Introduction

Dear trainee! This chapter introduces you the concepts of basic Microsoft Excel and spreadsheet creation. Microsoft Excel is a spreadsheet program that is used to record and analyze numerical data. Think of a spreadsheet as a collection of columns and rows that form a table. Alphabetical letters are usually assigned to columns and numbers are usually assigned to rows. The points where a column and a row meet are called a cell. The address of a cell is given by the letter representing the column and the number representing a row.

In general, spreadsheets store data sets, but they also provide a range of utilities such as simple family budget, preparing a purchase order, create an elaborate 3-D chart, or managing a complex accounting ledger for a medium size business and etc. to manage and process the data sets. This makes them particularly useful to businesses. Through preset and user-defined formulas, spreadsheets can perform mathematical, statistical, financial and organizational transformations on sets of data. Spreadsheets help to present data in organized ways and to inform future planning decisions. Businesses use spreadsheets in ways that are suited to their own services.

6.2 Learning Objectives

After completing this chapter, you will be able to:

- Develop a linked spreadsheet
- Use MS excel
- Automate Spreadsheet action using Macros
- Create Template to standardize spreadsheet
- Represent numerical data in graphic form

Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts of spreadsheet and its advantage.

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_____

_____

6.3 Developing a Linked Spreadsheet

A spreadsheet is a computer application or program that enables the user to tabulate and organize data. This data can then be used to make calculations, show graphical representations or analysis. In the business environment, spreadsheet linking is a useful function that adds a lot of value to developments but also a lot of risk. The concept of spreadsheet linking can be defined as the linking of data between two or more spreadsheets in the same workbook or between workbooks. The spreadsheet linking function is useful when you have to calculate values from spreadsheets with lots of information.

- A spreadsheet comprises of a grid of 'cells' arranged in rows and columns and information can be inserted into each cell.
- Each cell can contain text, numbers and formulas.
- A formula is a calculation based from the contents of cells or a total of a combination of cells. The total in that formula can change if the content of the combination cells used is also amended.
- Spreadsheets can be useful for home budgeting or accounting and they make it easy to display information.
- Spreadsheets can consist of a number of different worksheets that can include different data as well as enabling cells on one worksheet to be used and referenced on other different worksheets.
- Information can also be sorted and filtered by a spreadsheet.
- Spreadsheets have a number of tools included to support many different types of calculations and can include graphical presentations such as graphs, pie charts etc.

6.3.1 Spreadsheet File Organization

When you look at a spreadsheet program on screen, you see a rectangular table or grid of rows and columns. The horizontal rows are identified by numbers (1, 2, 3) and the vertical columns with letters of the alphabet (A, B, C). For columns beyond 26, columns are identified by two or more letters such as AA, AB, AC. The intersection point between a column and a row is a small rectangular box known as a cell. A cell is for storing data in the spreadsheet. Each cell can hold a single value or item of data.

A collection of rows and columns of cells forms a worksheet which refers to a single page or sheet in a workbook. Because, a worksheet contains thousands of cells, each is given a cell reference or cell address to identify it. The cell reference is a combination of the column

letter and the row number such as A3, B6, and AA345. So, to put it all together, a spreadsheet program, such as Excel, is used to create workbook files that contain one or more worksheets containing columns and rows of data storing cells.

Data Types, Formulas, and Functions

The types of data that a cell can hold include numbers and text. Important data types for exporting spreadsheets data are .csv (comma delimited) and .dbf (database files)

Formulas are one of the key features of spreadsheet software and are used for calculations usually involving data contained in other cells.

Spreadsheet programs include a number of built-in formulas called **functions** that can be used to carry out a variety of common and complex tasks.

	Discuss how spreadsheet is useful to organize a file within your organization.

6.3.2 Spreadsheet Design

Good spreadsheet design includes the follow characteristics:

- Design of the workbook
- The standards that are required by the company, and
- The areas of the worksheet.

A planned approach to workbook design will help avoid pitfalls that could be frustrating and time consuming. The company's standard requirements must be incorporated into any spreadsheets produced for that company.

Table 2: Things needed to create a spreadsheet

Accurate	If the numbers or calculations in the workbook are incorrect then the results and conclusions will also be inaccurate
Flexible	Easily changed and adapted for many situations
Clear	You need to be able to see quickly and easily what the numbers relate to and what you need to change
Efficient	Easy to use and entering data is a fairly easy process
Auditable	Easy to prove to someone else that you have got your calculations correct. Errors can be located quickly.

There are five basic steps to consider when creating a spreadsheet. These are:

1. **Planning:** Define the task to make sure you understand what the purpose of the workbook is, sketch on paper the type of output required, determine how the results will be displayed to be most meaningful, consider how the data will be supplied and how much there is, determine who will be using the workbook, do you need to use multi-worksheets or just one worksheet, will the worksheet be reused and can it be modified easily. The spreadsheet should contain areas for identification, documentation, input, work and output. There are three design that you can employ, namely block design, linear design and multi sheet design.
2. **Implementation:** Work out formulas from a pen and paper sketch, determine what data is constant and unchanging and that data that will be changing, decide how figures will be rounded, use meaningful range names to make it easier to read formulas, decide which formatting features you will use and which ones you will implement when building the worksheet and which ones you will leave until the worksheet is mathematically working and you want to make it look good.
3. **Layout:** The layout and appearance of your spreadsheet will aid people using it. Worksheet areas should be defined and arranged logically. Your spreadsheet can be enhanced with numeric, font, color and border format.
4. **Testing**: Check the accuracy of formulas, test using different types of data, Excel has an auditing tool that can be used to help trace and identify errors, printed hardcopy should be understandable and clear.
5. **Documenting:** The logic of the worksheet must be able to be followed by others and yourself at a later date. Documentation should include title, purpose, installation instructions, general instructions and details of macros. Documentation could be on a separate worksheet or in a blank area within the same workbook.

6.3.3 Organization and Task Requirements

Prior to commencing the designing a spreadsheet, it is important to identify the organization and task requirements in relation to data entry, storage, output, reporting and presentation requirements.

i) Data Entry

There are a number of methods of data entry. When creating a spreadsheet document from scratch you can start with a blank document and create your own spreadsheet data from the keyboard. Alternatively, you can import data from an existing spreadsheet. Your documents

or files can be saved electronically in a number of different places. You could save them on a USB memory stick, the hard disk on your PC or in a location on your organization's network. You should implement a system for naming your files so they can be easily located.

Your organization may also wish to save the file as a hardcopy, or printout. These could be kept in folders and filed appropriately in filing cabinets. Whether on disk or in the form of a paper document, the data needs to be stored in a secure location. If the data is stored on a compact disc, it could be stored in a rack or storage cabinet. If it is stored as a document in a filing cabinet, the cabinet should be locked, particularly if the data is confidential.

If the data is stored electronically, it should be backed up on a regular basis. This is good practice in the event that our PC has hardware problems or is infected by a virus. Similarly, we would want a backup in the event that we accidentally deleted the file!

ii) Output

There are a number of different options for to be considered regarding the output of your spreadsheet. Your spreadsheet may be:

- Included within the text of a report;
- Added as an attachment at the end of a report;
- Included in an electronic presentation, such as MS PowerPoint;
- Printed onto an overhead transparency, or Sent as part of an email.

Whichever form of output is utilized you need to ensure that the spreadsheet can be easily read (details not too big or too small) and that the spreadsheet will fit neatly onto a page or screen. Always test to ensure your spreadsheet will output as expected, and then adjust accordingly.

iii) Reporting and presentation requirements

Each company will have standards which all spreadsheets should follow. This could include: company details and logos, size and style of fonts, header and footer requirements, and formats for numbers, paper sizes, standard margins, and saving conventions. It is important to coordinate with relevant personnel to clarify the spreadsheet requirements and to ensure that documents you create meet the purpose for which they are intended.

Table 3: Sample template for spreadsheet design

Organization Details	Ambo University, Ambo Ethiopia Phone: +251112609016 Email: ambouniversity@ambou.edu.et.
Organization logo	Size of organization logo should not be altered Logo to be placed in top right-hand corner of spreadsheet.
Standard Font Main Headings 1st level 2nd level Header/footer	Comic Sans MS 10 pt. Comic Sans MS 16 pt. Comic Sans MS 14 pt. Comic Sans MS 12 pt. Helvetica or Arial 8pt
Header to include	Title of worksheet, date.
Footer to include	Page number, author, filename.
Paper Size	A4, Portrait or Landscape to be used dependent on size of worksheet. Worksheet to be centred horizontally and vertically on the page.
Margins	Top and bottom 1.5 cm. Left and right 2 cm
Number Formats	All dollar figures to have dollar sign. No decimal places to be used. Totals and important result figures to be highlighted using shading 20% and bold.
Saving Conventions	All filenames to display abbreviation of company name (Jacks) and identify purpose of workbook, try to use no more than 20 characters. Files to be saved in an appropriately named folder. Make sure a back-up copy is kept of all files in case of corruption to the original file.

6.3.4 Linking Spreadsheets

A link is a dynamic formula that pulls data from a cell of one worksheet and automatically updates that data to another worksheet. These linking worksheets can be in the same workbook or in another workbook. One worksheet is called the source worksheet, from where this link pulls the data automatically, and the other worksheet is called the destination worksheet that contains that link formula and where data is updated automatically.

Remember one thing that formatting of cells of source worksheet and destination worksheet should be the same otherwise the result could be viewed differently and can lead to confusion.

Two methods of linking data in different worksheets

We can link these two worksheets using two different methods.

a) Copy and Paste Link

- From source worksheet, select the cell that contains data or that you want to link to another worksheet, and copy it by pressing the Copy button from the Home tab or press CTRL+C.
- Go to the destination worksheet and click the cell where you want to link the cell from the source worksheet. On the Home tab, click on the drop-down arrow button of Paste, and select Paste Link from "Other Paste Options." Or right-click in the cell on the destination worksheet and choose Paste Link from Paste Options.
- Save the work or return to the source workbook and press ESC button on the keyboard to remove the border around the copied cell and save the work.

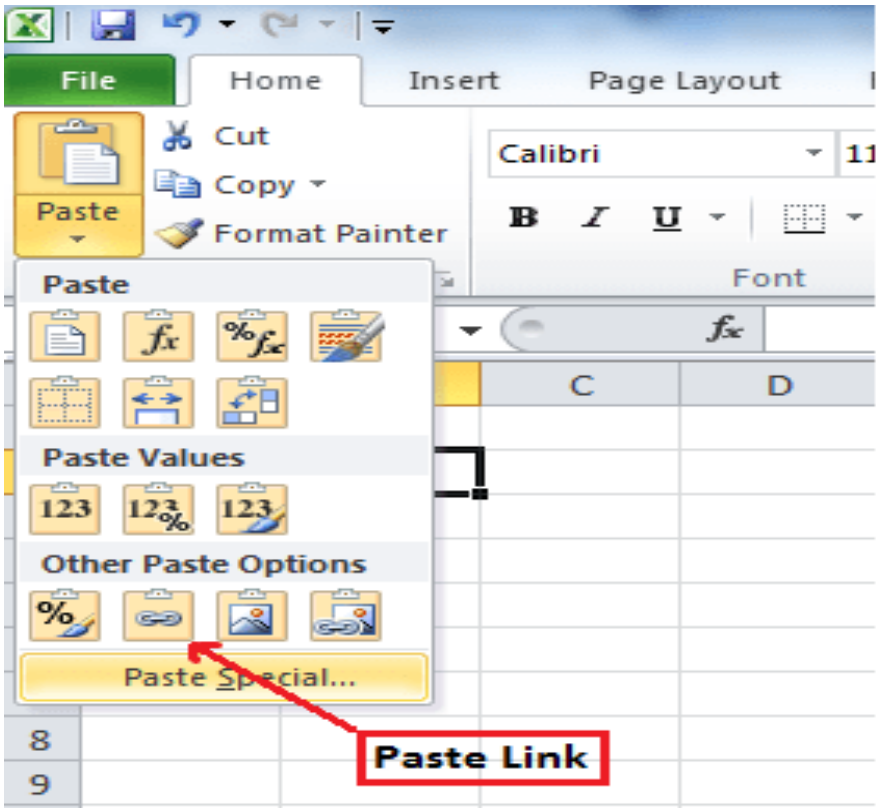


Figure 16: Copy and Paste Link tool

b) Enter formula manually

- In the destination worksheet, click on the cell that will contain link formula and enter an equal sign (=).
- Go to the source sheet and click on the cell that contains data and press Enter on the keyboard. Save your work.

Using these two methods, we can link a worksheet and update data automatically depending upon your requirements.

	What are advantages of linking spreadsheet data?

6.4 Automate and Standardize Spreadsheet Operation

Spreadsheets are used to model and manipulate data sets, create graphical visualizations, and inform future planning, and decision making. Microsoft Excel has functionality which allows users to automate spreadsheets and avoid entering the same information over and over again. Whether formatting a document a particular way, entering a range of information, or producing the same chart types over and over, a macro can help you perform these tasks with the push of a button.

6.4.1 Automating Spreadsheet Operation Using Macros

Macros are a set of stored functions that can be used to automate processes that are repeated often. They are tools which can be used to perform most of the redundant tasks with relative ease. They are a shortcut keyboard commands that allows you to automate a commonly used function to save time.

Macros are a powerful feature in Microsoft Excel, and they allow programmatic control over several excel functions. Applications that can take hundreds of cells of calculations can be done with a few lines of Macro code. Macros need to be checked during their development. Once they are in place, their compliance and functionality should be monitored as external and internal changes may mean they need to be amended.

Some tips on how to prepare your data for macros:

- Always begin your macro at the Home position
- Use the directional keys to navigate: Up, Down, Right, Left, End, Home, etc., and shortcut keys to expedite movement.
- Keep your macros small and focused on specific tasks.

- Macros require “relative” cell addresses, which means you “point” to the cells rather than hardcode the actual (or “absolute”) cell address (such as A1, B19, C20, etc.) in the macro. Spreadsheets are dynamic, which means they constantly change, which means the cell addresses change.
- Fixed values and static information such as names, addresses, ID numbers, etc. are generally entered in advance and not really part of your macro. Because this data rarely changes (and if it does, it’s just to add or remove a new record), it’s almost impossible to include this function in a macro.
- Manage your data first: Add, edit, or delete records, then enter the updated values. Then you can execute your macro.

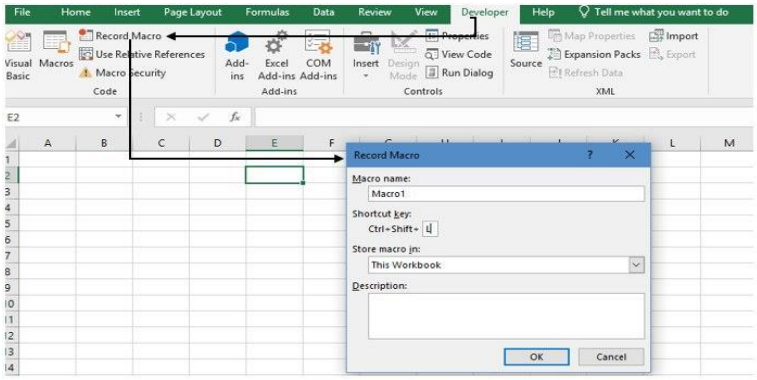


Figure 17: Sample Macro design

6.4.2 Standardizing Spreadsheet Using Template

Design formats in many organizations, all documents, whether those being sent from the organization or those for organization personnel use only, will follow a format or template that is designed to meet the organization’s criteria.

Templates are established style models used to create documents. Make sure you understand all of the organization’s requirements so you can maintain quality standards within your team and train new team members when needed. Learn the technical skills needed to manage design requirements and layouts. The layout of the document has a major impact on its readability and overall value as a communication device.

Here are the factors that need to be considered when designing a template:

- Choice of font or typeface;
- Text spacing; and
- Margin width etc.

New templates should be tested with your users to ensure they meet staff requirements, present well and can be used efficiently. It is often the case that in designing templates you build a model that suits the majority of users, but there are often niche users for whom you may need to alter existing templates or build new ones. Feedback is important as it helps you determine how useful the templates are, and what you can do to increase usability. When a template is developed, the creator should test the individual elements and macros (if any) to ensure they work. However, a true test of a document template can only be conducted when it is used to produce that document. Select a staff member from the appropriate area to test the template by creating a simple document. If the template works as expected, it is time to offer it to a wider range of users for feedback and evaluation. Here are several methods that can be used to obtain feedback:

- Focus groups;
- One-on-one interviews;
- Group feedback sessions.

	Explain the importance of automating and standardizing spreadsheet.

6.5 Representing Numerical Data in Graphic Form

The spreadsheet can be used to analyze data and convert numerical data into graphic form reflects the nature of data. The nature of spreadsheet program makes cross-platform importing and styling charts much easier, and boasts a fluid and visual interface. To make a chart, first ensure that you have numeric data.

6.5.1 The Nature of the Data

Think of the data that you have and how you want to show it. The groups of data are associated at every single data point determines the dimension of your data. If you are trying to represent the speed of a car with respect to time, this would be a 2D data group. If you are trying to represent the mass and velocity of a launching rocket over a period of time, your data are 3D. An energy landscape of (X, Y) coordinates and respective energy values are also a 3D data group. Anything dealing with parts of a whole, or adding up to a certain percentage, is a 1D data group. You can also create charts that presents to up to 7D (or more) of data, such as a scalar field in 3D directions, but most people find hard to register with more than 7 or 8 dimensions.

6.5.2 Types of Chart

Charts are often used to ease understanding of large quantities of data and the relationships between parts of the data. Charts can usually be read more quickly than the raw data. They are used in a wide variety of fields, and can be created by hand (often on graph paper) or by computer using a charting application. Based on the nature of data, data size, level of complexity, audience, way of presentation and others, appropriate type of chart will be selected.

a) One Dimensional Chart: Pie

Use a pie graph to show any amount of data adding up to 100%. For example, use a pie chart for counting votes. 40% are rabbit (blue), 24% are hamster (red), 26% are gecko (green), 10% are others (purple). Before you do anything, make sure all your data are of the same unit and can add up. You might not want to add the votes from one voting to those of another.

Legends are of utmost importance in a pie chart, without which you cannot know which one group of data is which. You can set up a legend by specifying which group is which on the data spread sheet. It would look even better of you can add figures on each slice and a title on the top.

Activity	Identify the nature of data in your specific project area.

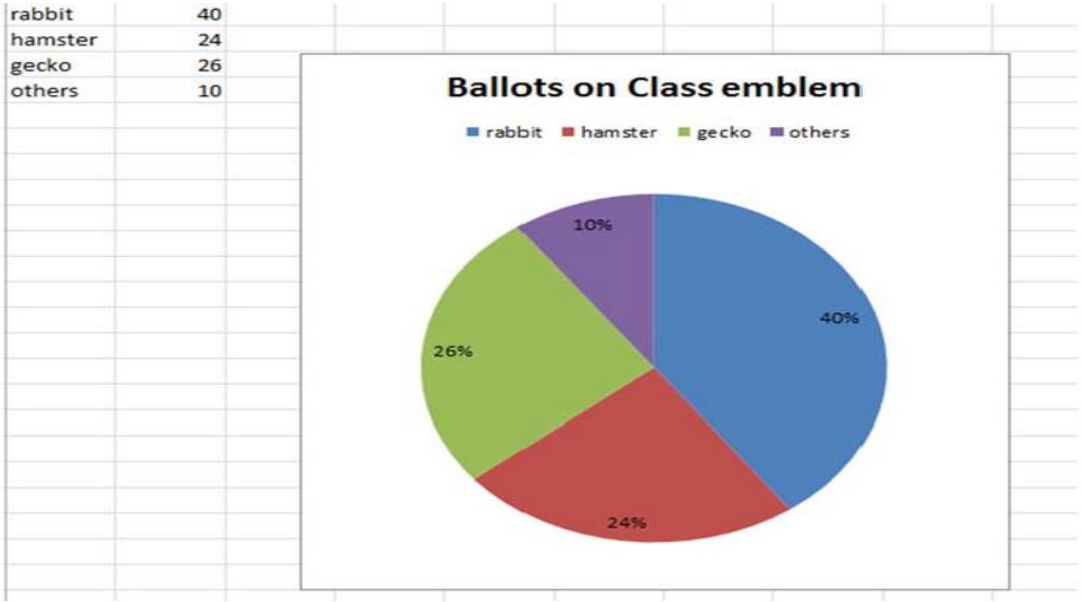


Figure 18: Pie chart

b) Two Dimensional

The most significant two types of 2D charts are column/bar charts and line/scatter charts. To choose between them, you might want to count the total number of your data points: usually anything above 5 data points requires a line/scatter charter, whereas for lower number data points a column/bar chart is better. This is because bar charts are more visual in nature and should convey all their information within one glimpse. Line and Scatter point charts are more analytical. Bar charts are excellent for presentations.

i) Column / Bar

Column chart and Bar chart are the same kind of charts only with different directions. It is good for data that uses dates or conveys the passage of time. When you set up your original data table, it is a good habit to have column titles and units. Notice 2D data have 2 columns. The number of data points would equal to the number of rows.

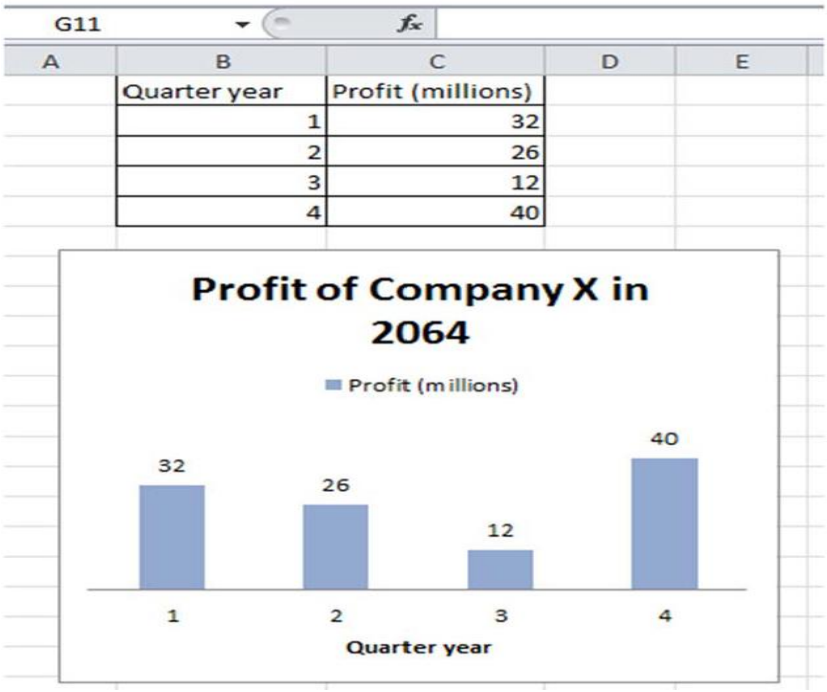


Figure 19: Column/Bar

ii) Line/Scatter

A line graph is just a scatter point graph with dots connected and evenly distributing a value along the x-axis. For this reason, it is much less used than a scatter point. Use a line/scatter graph to see a trend in one set of data, or to compare the trends of several sets of data. They are also good for graphs using dates or time. To produce a trend, we usually require a decent number of data points. Scatter point charts are widely used in research and industries because of its excellent potential to be analyzed.

A scatter point chart starts with a data table of more than 5 data points. For example, a free-fall process of 5 seconds with the distance travels measured every 0.5 seconds would have 11 data points. The resulting plot should have two variables: time and distance. The 2 variables, the independent variable should be on the x-axis and the dependent variable should be on the y-axis.

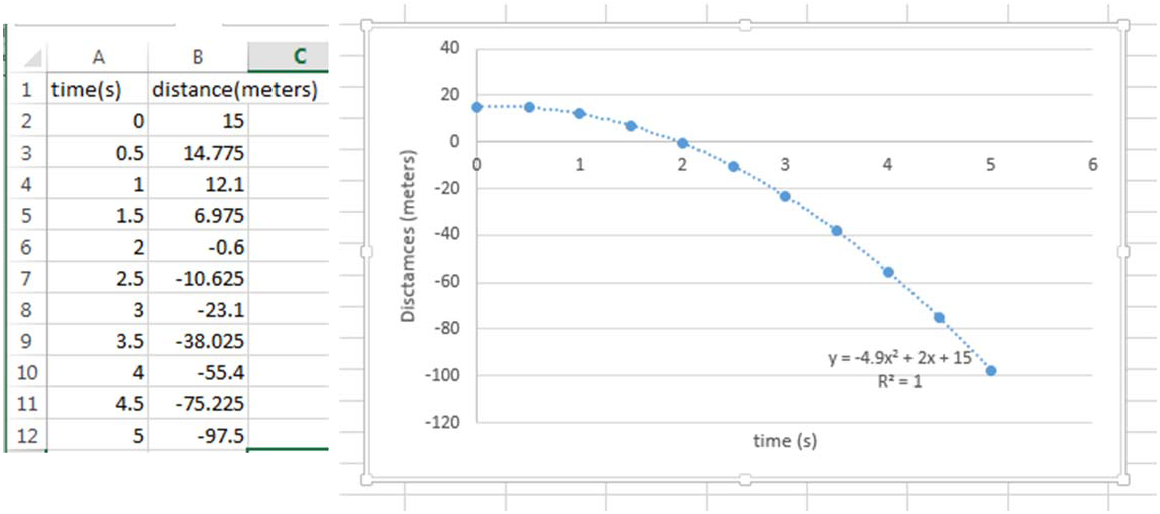


Figure 20: Line/Scatter

6.6 Spreadsheet Documentation

The necessity of spreadsheet documentation has made by institutions responsible for establishing standards. Documentation methods cover external file and internal file documenting, the subjective evaluation, internal data documentation and macro documentation.

The documentation objective is to ensure compliance to corporate governance. It is required to prove the basis of corporate decisions. According to Spreadsheet Modeling for Best Practice, a good documentation:

- Allows another person to use a model and what it is doing even if the model has been out of use for some time;
- Reduces the risk that the model falls into disuse because only one or two people know how to use or trust its results; and
- Reduces the number of irritating interruptions for the model developer, after handing over the responsibility for the model.

6.6.1 Documentation Content

According to Guide for Preparing, Documenting and Referencing, the goal is to facilitate quality assurance by the use of checklists, crossed-indexed tables of content and other processes. The content should specify:

- Job title and code;
- Title of the Spreadsheet Work-paper index;
- Specifying the data's location;
- The name of the person updating the spreadsheet with its date, its purpose the preparer, his title and the date;
- The reviewer's name and the date

6.6.2 Documentation Methods

a) External file documentation

Usually 'versioning' is done this way by keeping file inventory and recording any change made to it. This entails checkout and check-in controls and may involve file sharing and conflict resolution.

b) Subjective information

One of the main problems is to obtain information from data. The best way to do so is simply to have the author add the subjective information. There are some cases where the attempted goal has not been reached and so the author's intent becomes invaluable to the spreadsheet's appraisal. Producing significant documentation solely by computational means is neither realistic nor efficient. Complete documentation requires human intervention. This should be made as easy as possible and should limit itself to useful information. Too much data and information may be counter-productive.

c) Internal file documentation

Excel can be used to manage the inventory of Excel files. The advantage of this form of versioning is to evaluate the spread sheet's risk. Since all results are factual, they do not contain subjective opinions such as the purpose of the spreadsheet that could be added and could significantly improve its usefulness.

d) Internal data documentation

Excel provides a way to track the spreadsheet's internal history, with the tools, track changes and highlight changes menu. The file must have previously been identified as a shared workbook.

e) Documenting macros

Excel's macros are one of its most powerful features. They can completely change the information and if incorrectly used they can become a source of undocumented errors. It is essential that they be fully understood and checked. To achieve this end, an information structure similar to the one devised for cells should be applied.

6.7 Summary

Dear trainee! Spreadsheet is a computer application that simulates a physical spreadsheet by capturing, displaying, and manipulating data arranged in rows and columns. The spreadsheet is one of the most popular uses of the personal computer. Clients with complex, multi-sheet and multi-workbook models or data tracking systems can realize tremendous productivity and quality gains by working with us to implement systematic data organization and validation, automation of repetitive tasks, and data auditing, and reporting features.

Integration of multiple data sources and/or applications is a common need that can be automated to improve speed, accuracy, and reliability. Sometimes small custom applications or scripts must be written to deal with special data formats or special requirements for where to store the data for an application such as Microsoft Excel.

Spreadsheet documentation doesn't have to be a daunting task to do or to analyze. Using Excel's comments in a systematic way can become an efficient documentation method. This in turn will help to do the change control by updating and analyzing the comments in a systematic way.

Spreadsheet applications support charts, graphs or histograms to be generated from specified groups of cells that are dynamically re-built as cell contents change. The generated graphic component can either be embedded within the current sheet or added as a separate object.

6.8 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 when designing a spreadsheet and how do you apply them to spreadsheet design?
2) In your own words describe the difference between all these functions. In your answer give an example where you would use each.
3) Explain the following terms along with their advantages:
   A. Macro
   B. Template.

Task Sheet for Project Work

Task Sheet for Project Work (Prototype)

Project Name: Develop Linked Spreadsheet

Create a series of Excel spreadsheets to demonstrate the skills you have learned in this chapter.

You will need to demonstrate your ability to design a group of spreadsheets that:

- Have a link between one spreadsheet to another
- Demonstrates conditional formatting
- Use at least 3 functions from Excel and 1 formulae that you create
- Has at least 1 macro
- Uses a template you created to produce new workbooks
- Uses charts to help analyse data

You will need to provide printouts from spreadsheets and a copy of a chart.
Duration: 1 hours

Project 1: Basic Monthly Budget for Medical Office (Comprehensive Review)

	A	B	C	D	E
1					
2	Item				
3	Salaries	30000			
4	Medical Supplies	18000	13800	9000	19200
5	Medications	27000	20700	13500	28800
6	Rent	7500			
7	Office Supplies	3000			
8	Phone & Utilities	2100			

Difficulty-level: Advanced

Creating and maintaining budgets are common practices in many careers. Budgets play a critical role in helping a business or household control expenditures. In this exercise you will create a budget for a hypothetical medical office while reviewing the skills covered in this chapter. Begin the exercise by opening the above starter file.

Entering, Editing, and Managing Data

1. Activate all the cell locations in the Sheet1 worksheet by left clicking the Select All button in the upper left corner of the worksheet.
2. In the Home tab of the Ribbon, set the font style to Arial and the font size to 12 points.
3. Increase the width of Column A so all the entries in the range A3:A8 are visible. Place the mouse pointer between the letter *A* and letter *B* of Column A and Column B. When the mouse pointer changes to a double arrow, left click and drag it to the right until the character width is 18.00.
4. Enter **Quarter 1** in cell B2.
5. Use AutoFill to complete the headings in the range C2:E2. Activate cell B2 and place the mouse pointer over the Fill Handle. When the mouse pointer changes to a black plus sign, left click and drag it to cell E2.
6. Increase the width of Columns B, C, D, and E to 10.14 characters. Highlight the range B2:E2 and click the Format button in the Home tab of the Ribbon. Click the Column Width option, type **10.14** in the Column Width dialog box, and then click the OK button in the Column Width dialog box.
7. Enter the words **Medical Office Budget** in cell A1.
8. Insert a blank column between Columns A and B. Activate any cell location in Column B. Then, click the drop-down arrow of the Insert button in the Home tab of the Ribbon. Click the Insert Sheet Columns option.
9. Enter the words **Budget Cost** in cell B2.
10. Adjust the width of Column B to 13.29 characters.

Formatting and Basic Charts

1. Make the following format adjustments to the range A1:F1: bold; italics; change the font size to 14 points; change the cell fill color to Aqua, Accent 5, Darker 50%; and change the font color to white.
2. Increase the height of Row 1 to 24.75 points.
3. Center the title of the worksheet in the range A1:F1 vertically. Activate the range and then click the Middle Align button in the Home tab of the Ribbon.
4. Make the following format adjustment to the range A2:F2: bold; and change the cell fill color to Tan, Background 2, Darker 10%.
5. Set the alignment in cell B2 to Wrap Text. Activate the cell location and click the Wrap Text button in the Home tab of the Ribbon.
6. Copy cell C3 and paste the contents into the range D3:F3.

7. Copy the contents in the range C6:C8 by highlighting the range and clicking the Copy button in the Home tab of the Ribbon. Then, highlight the range D6:F8 and click the Paste button in the Home tab of the Ribbon.
8. Calculate the total budget for all four quarters for the salaries. Activate cell B3 and click the down arrow on the AutoSum button in the Formulas tab of the Ribbon. Click the Sum option from the dropdown list. Then, highlight the range C3:F3 and press the ENTER key on your keyboard.
9. Copy the contents of cell B3 and paste them into the range B4:B8.
10. Format the range B3:F8 with a US dollar sign and zero decimal places.
11. Sort the data in the range A2:F8 based on the values in the Quarter 4 column in ascending order. Highlight the range A2:F8 and click the Sort button in the Data tab of the Ribbon. Select Quarter 4 in the "Sort by" drop-down box and select Smallest to Largest in the Order drop-down box. Click the OK button.
12. Add vertical and horizontal lines to the range A1:F8. Highlight the range and click the down arrow next to the Borders button in the Home tab of the Ribbon. Select the All Borders option from the drop-down list.
13. Change the name of the Sheet1 worksheet tab to "Budget." Double click the worksheet tab, type the word *Budget*, and press the ENTER key.
14. Insert a pie chart using the data in the range A2:B8. Highlight the range and click the Pie button in the Insert tab of the Ribbon. Click the first option on the list (the Pie option).
15. Click and drag the chart so the upper left corner is in the center of cell H2.
16. Add labels to the chart by clicking the Layout 1 option from the Chart Layouts list in the Design tab of the Ribbon. Make sure the chart is activated by clicking it once before you look for the Layout 1 Chart Layout option.

Printing

1. Change the orientation of the Budget worksheet so it prints landscape instead of portrait.
2. Adjust the appropriate settings so the Budget worksheet prints on one piece of paper.
3. Add a header to the Budget worksheet that shows the date in the upper left corner and your name in the centre.
4. Add a footer to the Budget worksheet that shows the page number in the lower right corner.
5. Use the Save As command in the File tab of the Ribbon to save the workbook by adding your name in front of the current workbook name (i.e., "*your name* Practical Project 1").
6. Close the workbook and Excel.

CHAPTER SEVEN: INTEGRATE CADASTRAL SURVEYING DATA SETS

7.1 Introduction

Dear trainee! This chapter deals with the concept of integrating cadastral surveying datasets. Cadastral survey is a survey of boundaries of land units. A cadastral survey dataset provides an authoritative source of information as to where a boundary is located, where a parcel of land is located, and the attributes of that parcel and boundary.

The spatial integration of data from various sources requires an understanding about the positional accuracies of the geometries in the datasets to avoid mismatches and misinterpretations. Prior to data integration the survey record has to be carried out in order to check the results of the cadastral survey and the entry of the information in required platform. The recorded survey should be plotted and carefully reviewed to identify errors and incomplete collections. At last, the edited or updated survey record shall be validate to ensure the compliance with rules, procedures and standards set.

7.2 Learning Objectives

After completing this chapter, you will be able to:

- Integrate different datasets into a processing package
- Process integrated data using a processing package
- Conduct finalizing activity

Dear trainee! Before reading the following section, take ten minutes and try to discuss techniques of integrating different datasets.

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7.3 Cadastre Data Integration

7.3.1 Cadastre Concept

According to International association of geodesists (FIG), cadastre is normally a parcel based, and up-to-date land information system containing a record of interests in land (for example, rights, restrictions and responsibilities). It usually includes a geometric description of land parcels linked to other records describing the nature of the interests, the ownership or control of those interests, and often the value of the parcel and its improvements. It may be established for fiscal purposes (for example, valuation and equitable taxation), legal purposes (conveyancing), to assist in the management of land and land use (for example, for planning and other administrative purposes), and enables sustainable development and environmental protection.

The Cadastre forms part of the base data required in any public land information system. Since information about land parcels and land holdings is often needed by many different users, having a unified, standard cadastre for each jurisdiction helps to avoid duplication and assists in the efficient exchange of information. The cadastre is usually created and managed through a government organization. In some countries, cadaster may be the responsibility of local governments; in others it is a state or national responsibility. Examples of the data of general interest to a wide user community, that is usually considered part of the cadastre, include:

- Land parcels (For example, Location, boundaries, co-ordinates)
- Land tenure (For example, property rights, ownership, leases)
- Land value (For example, economic value, tax value, value of improvements)

7.3.2 Cadastre Survey Data

Cadastral surveying is a survey carried out for the purpose of providing information for the drawing of cadastral map. Cadastral survey, is simply defined as a survey of boundaries of land units. On the other hand, cadastral map refers to any map on scale large enough to show every field or plot of land and buildings. There are three sets of complimentary techniques of cadastral surveying are common: field/ground surveying, photogrammetry, and remote sensing; all of which are concerned with the discovery, recording, and presentation of spatially referenced data.

Cadastral survey information is often a base element in Geographic Information Systems (GIS) or Land Information Systems (LIS) used to assess and manage land and built infrastructure. Such systems are also employed on a variety of other tasks, for example, to track long-term changes over time for geological or ecological studies, where land tenure is a significant part of the scenario.

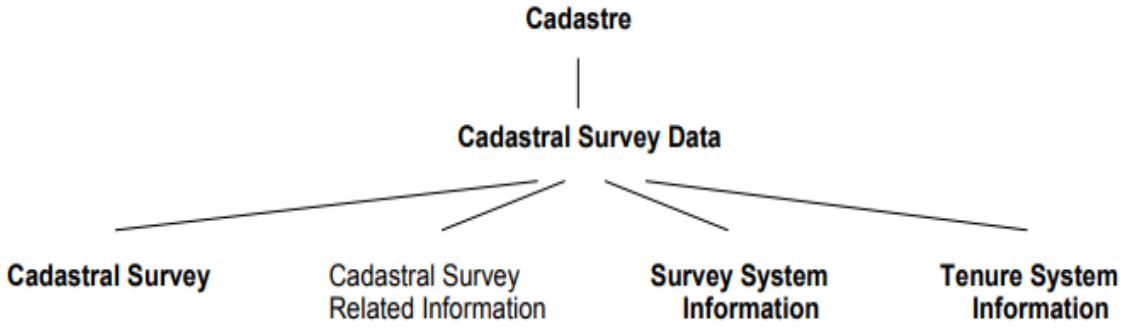


Figure 21: Cadastral Survey Data

A cadastral survey generally results in two different kinds of map outputs, the parcel index map and the specific parcel map.

A. **Parcel index map (PIM)**: showing all parcels in particular jurisdiction. This map should reflect unique parcel identifiers which act as an index to various cadastral and land registrations attribute data.
B. **Parcel map:** showing details of dimensions (distance, azimuth) of the parcel boundaries the coordinates of the parcel corners, a short description of the monumentation of and other standard map data. This map serves us as a legal description for all registered parcels.

7.3.3 Cadastre Survey Dataset

Cadastral survey dataset (CSD) is the set of cadastral survey data necessary to integrate a cadastral survey in to Cadastre. A cadastral survey dataset provides an authoritative source of information as to where a boundary is located, where a parcel of land is located, and the attributes of that parcel and boundary. This information enables the correct and unambiguous allocation and management of land rights and the correct re-establishment of the boundaries in the future.

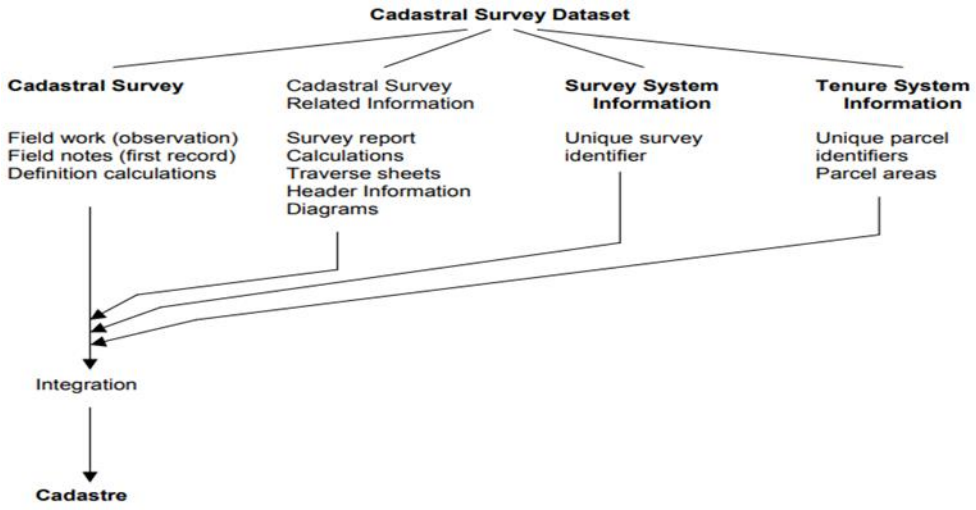


Figure 22: Cadastral Survey Dataset

7.3.4 Cadastre Data Integration

Data integration means combining data coming from different sources and providing users with a unified view of these data. This process becomes significant in a variety of situations both commercial (when two similar companies need to merge their Databases) and scientific (combining research results from different repositories).

Major factors needs to be addressed to integrate data properly:

- Identification of an optimal subset of the available data sources for integration;
- Estimation of the levels of noise and distortions due to sensory, processing, and environmental conditions when the data are collected;
- The spatial resolution, the spectral resolution, and data accuracy;
- The formats of the data, the archive systems, and the data storage and retrieval;
- The computational efficiency of the integrated data sets to achieve the goals of the users.
- The definition of the datum and coordinate system
- The projection method of the collected data

Data integration appears with increasing frequency as the volume and the need to share existing data explodes. In order to perform this integration process, we use the methodological guidelines for generating, integrating and publishing geospatial data. One of

the main advantage of integrating information from multiple data sources is it alleviates the burden of duplicating data gathering efforts, and enables the extraction of information that would otherwise be impossible.

	Discuss the cadastral survey outputs.

7.4 Processing Integrated Data

7.4.1 Survey Recording

This process includes the checking or examination of the results of the cadastral survey and the entry of the information in registration books and on cadastral index maps. A unique parcel identifier is allocated to each parcel. The examination can check on land policy matters (for instance, does the subdivision contribute to a suitable land use?); legal matters (such as the right of the applicant to conduct certain land activities); and technical matters (for instance, have the survey regulations been obeyed?). To lower examination costs, government authorities are putting more emphasis on quality assurance and more responsibility on practicing surveyors for the accuracy of their field data and survey plans.

7.4.2 Editing and Updating of Data

Editing survey data should be performed by the personnel involved with the collection. Each survey should be plotted and carefully reviewed to identify errors and/or incomplete collections. Common collection errors involve incorrect target heights and the improper use of feature codes and/or control codes. Any necessary corrections to the data should be completed prior to the transmittal to photogrammetry and surveys engineer.

Perhaps the primary function in the data storage and retrieval subsystem involves the editing and updating of data. Frequently, the following data editing capabilities are required: - Interactive editing of spatial data - interactive editing of attribute data; - the ability to add, manipulate, modify, and delete both spatial features and attributes (independently or simultaneously); and the - ability to edit selected features in a batch processing mode.

7.4.3. Validation

Data being submitted into the Cadastre needs to be validated. The primary purpose of validation is to ensure that the data complies with the rules and that it is able to be integrated into the digital Cadastre. Automated business rules should check that:

- New 3D parcel boundaries do not overlap underlying parcel boundaries to which they relate;
- New 3D parcels in a 3D cadastral survey dataset do not illegitimately overlap (some types of overlaps are permitted) other 3D parcels (new and existing);
- 3D cadastral survey datasets are in terms of the official national vertical and horizontal datum's;
- The 3D volume of any existing 3D parcel that is being subdivided (For example, a unit redevelopment of an apartment complex) is completely taken into account.
- The projection and coordinates system of the data

7.5 Finalizing Activity and Submitting Survey Data

Preliminary and supplemental surveys included in the project mapping are first submitted to the designated expert/surveyor. Raw and edited electronic survey files may be submitted via e-mail or written to a CD and sent by regular mail. Once a survey has been sent to the concerned body, the data files and correspondence are archived on a designated server. Photogrammetry and surveys engineer also maintains a database detailing the survey data collected for each project.

The submitted survey data must include pertinent project information. This information should include at a minimum the project name, section, number, and county. A brief description of the survey, raw and edited files, and relevant field notes should also be included. If a survey was requested by another Program or Section, the individual who made the request should be included in the correspondence.



A final survey report must include:

- All information requirements
- Purpose of survey
- Basis for determining the orientation of bearing
- Information on old marks (if available)
- Reference prior to correspondence

In certain situations, survey data may be required to be submitted in a coordinate file format. The submittal shall be accompanied by a cover letter and include the project information

described above. The cover letter should be signed and sealed by a registered Land Surveyor or Professional Engineer.

7.6 Summary

 Dear trainee! Cadastral survey dataset is the set of cadastral survey data necessary to integrate a cadastral survey in to Cadastre. Cadastral data is one of the more important types of geospatial data. Taking into account the importance of these data, several international bodies have worked for creating a standardized model for land administration.

Data Integration is widely used in different areas of scientific circles and ordinary life as well. It means combining data acquired from different sources and providing users with a unified view of these data. While integrating data from different sources different factors such as avaliable data sources, environmental condition during data collection, accuracy of the data formats of the data, datum and coordinate system, projection method for collected data and etc.

7.7 Self-Check Exercises

 **Short Answer Items**

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

1) What is cadastral surveying dataset?
2) What is the purpose of data validation?
3) Explain the benefits of integrating heterogeneous data sources.
4) What are the major factors to be considered to integrate data properly?
5) List the elements of final survey report.
6) Explain the process of data integration.

CHAPTER EIGHT: PERFORM CADASTRAL MAPPING APPLICATIONS

8.1 Introduction

Dear trainee! This chapter deals with the concept of performing cadastral mapping application. The information recorded in cadastral system includes an accurate description of the location of a parcel of land and who owns it. It may also record what the land can be used for (For example, residential or not, national park etc.) and may also show the location and shape of buildings. In some countries, it also records the value of a property. In these cases, the cadaster may also be used for land taxation purposes.

Cadastral map can be the foundation block of a cadaster which shows the existing situation of the parcels. It can be produced by a cadastral surveyor or a surveyor with special permit who accurately measures and records the boundaries of each property. This occurs whenever a new land parcel is created and each new survey produces a new survey plan. Because of this each plan is static in time, i.e. it represents the shape and status of the cadaster at the time of survey. Cadastral plans from different parts of the world may have different information. This is dependent on local legislation relating to the registering of cadastral plans into the local cadaster. However, properly registered cadastral drawings are the legal documents.

8.2 Learning Objectives

After completing this chapter, you will be able to:

- Identify cadastral mapping preparation requirements
- Create 2-D and 3-D drawings in CAD environment
- Produce finalized cadastral drawings

Dear trainee! Before reading the following section, take ten minutes and try to describe the software applications used to make cadastral map, create 2D drawing and 3D drawing.

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8.3 Cadastral Mapping Preparation in CAD Environment

Cadastral mapping is a document that shows boundaries of land ownership, by the production of documents, diagrams, sketches, plans, charts, and maps. They were originally used to ensure reliable facts for land valuation and taxation. Today the role of cadastral drawing deployed in to multifunction: land tenure, land use, land development, planning, land management and etc.

Before creating a map or a 3D model, a systematic transformation that may be is necessary in order to convert the data into symbols. In this process, visual symbols with their visual variables like size or color are the basic graphic components which the human perception system could handle. Based on static 2D map estimation and a perceptual level of organization, the following seven visual variables should be considered. These are:

- **Position:** Corresponds to a change in spacing between symbols. For example, we may arbitrarily increase the distance between two symbols.
- **Size:** Corresponds to a change in symbol size. For example, we may increase or decrease the line thickness.
- **Shape:** Corresponds to a change in symbol style. For example, we may use an arrow instead of a square to represent a point.
- **Value:** Changing a symbol's value is achieved by changes in darkness or lightness of the symbol.
- **Color:** Changing a symbol's color involves changes in hue without changes in value. Transparency and saturation also belong to color.
- **Texture:** Texture is the pattern, grain or material that is applied to the symbol.
- **Orientation:** Changing a symbol's orientation can be achieved by changing its general direction. Orientation is sometimes treated together with texture since it usually modifies the orientation of the pattern. For example, we can change the orientation of the lines included in the pattern.

Besides, the following five visual interpretation tasks associated to the visual variables shall prepared to create 2D drawings or 3D models successfully. These are:

- **Selective:** A visual variable could be said to be selective if users may easily distinguish the isolation between two groups of symbols only by their difference in this visual variable. The main question to be asked is: Does change in the visual variable allow users to select one object from a group of objects?

- **Associative:** A visual variable is said to be associative if users could easily distinguish the association between two groups of symbols only by this visual variable. The main question to be asked is: Does change in the visual variable allow users to identify a number of objects as a group?
- **Quantitative:** A visual variable is said to be quantitative if numerical relationship could be perceived by users from the differing of this visual variable. The main question to be asked is: Does change in the visual variable allow users to quantify the change?
- **Order:** A visual variable is defined as ordering the difference in this visual variable could indicate an order. The main question to be asked is: Does change in the visual variable allow users to observe a difference in the order?
- **Length:** Length is slightly different from the previous one since it addresses the question of how many changes in a particular visual variable can be used effectively. The question to be asked is: After how many changes in the visual variables the user can still distinguish the symbols?

Data acquisition of cadaster data will include cadastral surveys of 2D parcels and 3D objects with legal spaces. A cadastral survey is an important prerequisite for 3D data modeling where survey methods may include terrestrial survey (For example, GPS survey, terrestrial survey with Total Station) and photogrammetry (For example, terrestrial laser scanning and image matching methods).

Coordinate Systems and Spatial Data Format/Standard

AutoCAD use 2D and 3D Cartesian coordinate systems that locate data at fixed coordinates. X-, y-, and z-coordinates are not inherently geographic locations; instead they are locations relative to an arbitrary geometric origin (0,0,0). The x-axis can be thought of as an easting direction and the y-axis as a northing direction, but they do not necessarily translate to grid directions in your spatial data. Although it is possible to create CAD data that corresponds to the x,y coordinates of a projected grid zone, most CAD data is authored without this consideration. Typically, features are measured relative to other features using distances that have been measured at local ground elevations.

Data dictionary: an inventory that specifies the source, location, ownership, usage, and destination of all of the data elements that is stored in a database. All data that can be

processed can be accessed through this directory. In preparation of cadastral maps, vector and raster data are used.

Vector data: is a representation of the world using points, lines, and polygons. These data are created by digitizing the base data. They store information in x, y coordinates. Vector models are useful for storing data that has discrete boundaries, such as country borders, land parcels, and streets.

- Provide as ESRI Shapefile (s) or Geodatabase
- Must not contain topological errors – slivers, dangles, edit masks etc.

Raster data: raster data consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as temperature. Raster data is provided in the form of digital aerial photographs, imagery from satellites, digital pictures, or even scanned maps. Raster can be provided as a geo-referenced file in an ESRI-compatible format.

Projection: Spatial data covering the project area should be supplied in geographic coordinates using WGS84

Attributes: All attributes must be labelled clearly and logically. Unique identifiers must be unique.

Quality attributes: If data quality, accuracy, reliability and/or resolution vary markedly across the data.

Specifications: If a specification has been agreed to for project data over and above these minimum data requirements, then the data supplied must conform with that specification also.

Quality assurance: Data should be scanned for completeness, accuracy, and any errors before delivery.

Delivery: All final datasets to be delivered on portable storage medium (For example, CD, DVD, external hard drive) and labeled with title, data, project number and an index of contents.

Once all data have been acquired and fulfilled the above standard requirement, cadastral offices uses one of CAD software such as AutoCAD and GIS to produce cadastral drawing and spatial databases. As defined above cadastral property must be quantitatively mapped. The borders of each site are usually shown in cadastral maps available at registry offices, but there are many areas nationwide where such maps have not been prepared. In these areas, engineering drawing provisionally equivalent to cadastral map are prepared.

Activity	List visual variables should be considered during preparation of cadastral drawing.

8.4 Producing 2-D and 3-D Engineering Drawings Model

AutoCAD has capability of producing different engineering drawings for different professions. Cadastral drawings and models have been prepared based on AutoCAD and GIS. The application of AutoCAD Civil 3D should become apparent through the mini tutorials that will follow in the subsequent sub sections.

8.4.1 Setting Up a New AutoCAD for 3D Drawing

To start a new 3D model in AutoCAD, you need to change the workspace, and then open a new file by using a 3D template. The following steps explain how:

1. Open the Workspaces drop-down list on the Quick Access toolbar, or click the Workspace Switching button on the status bar and then choose 3D Modeling.

   Toolbars, palettes, and Ribbon panels flash on and off, and soon AutoCAD settles down to display the Ribbon, as configured for the 3D Modeling workspace with a few additional panels.

2. Click the Application button and choose New; then click Drawing.
   The Select Template dialog box appears.

3. Choose acad3d.dwt if you're working in imperial units or acadiso3d.dwt if you're working in metric. Click Open.

A 3D modeling space appears where, rather than look straight down at the drawing area, you look at it at an angle from above.

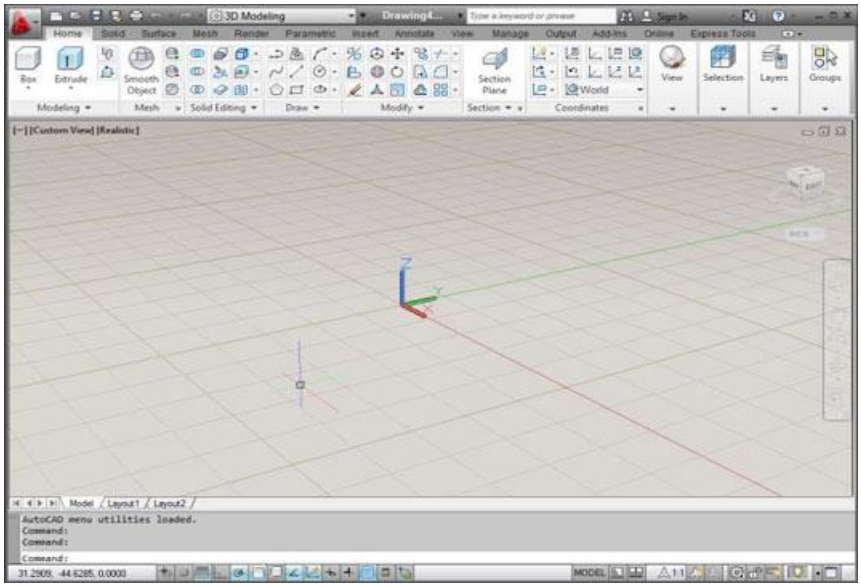


Figure 23: AutoCAD 3D Modeling Interface

8.4.2 Drawing settings in AutoCAD Civil 3D 2010

After creating the new drawing, the next thing to do is to setup the drawing in terms of units, parameter precisions, datum etc. This customizes your drawing to your liking so that the object drawing and labeling is meaningful and uniform.

1) On the Settings tab of the tool space, right- click on the drawing name and select Edit Drawing Settings… from the context menu. The Drawing Settings dialog box appears.
2) In the Units and Zone tab, change the parameters below as follows by selecting in their respective combo boxes:
    a. Drawing units = Meters
    b. Angular units = Degrees
    c. Scale = 1:1000
    d. Categories = UTM, WGS84 Datum
    e. Available coordinate systems = UTM-WGS 1984 datum, Zone 37 North, Meter; Cent. Meridian 39d E.
3) Click on the Ambient Settings tab to activate it. Click on the plus sign (+) on the property column of each item and review the current settings in the value column i.e. unit and precision. Change the units to meters and precision to 3 for linear parameters. However, for angular parameters, change the units to degrees and precision to 6.
4) Click OK to apply the settings. You've now created a new drawing and customized the settings to your standards. Save the file as you may be required to use it in subsequent sections.

8.4.3 Creating a drawing in AutoCAD Civil 3D 2010

1) Click on the Start button in the task bar and point to All Programs → Autodesk → AutoCAD Civil 3D → AutoCAD Civil 3D. Click to proceed. AutoCAD Civil 3D opens with a new default drawing named Drawing 1 (look at the top of the tree view in Prospector tab of the Tool space). You will now change the name of the default drawing to something meaningful (like the topographic site name) and save in your chosen location in the hard drive.
2) Click on the down arrow in the Application Window and select Save As from the dropdown menu. The Save As dialog box appears.

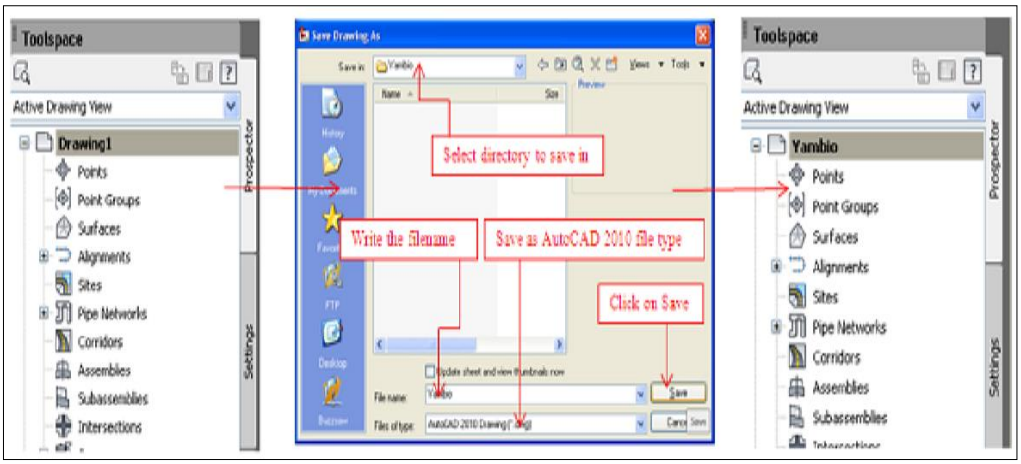


Figure 24: Creating a New Drawing in Civil 3D

3) Set the directory to save in, the filename and the file type. Click on Save. The drawing is saved in your chosen directory with the new name as shown in the figure.

8.4.4 Importing points into AutoCAD and Civil 3D

After creating the point group and description key set, we're now ready to import the point database into AutoCAD Civil 3D. As the points are imported, they'll be assigned to their respective point s groups and styled according to the description key set designed and activated.

1) Open the AutoCAD or the file you created in the previous section if you saved, if it is not open. This drawing is now empty but the settings had been customized.
2) Go to the insert tab and click on the Import from File button in the Import panel. The Import Points dialog appears. You need to set the file format to match the structure of your point database file that you are just about to import into AutoCAD Civil 3D.
3) In the Format combo box, click on the down arrow and select PNEZD (Comma delimited). This data format matches the structure of the point database to be imported. The column sequence in the point database file is POINT → NORTHING →EAST ING →HEIGHT→ DESCRIPTION (PNEZD).

   The point database file is in MS Excel CSV comma delimited format.
4) In the Source File (s) section, click on the Add button. The Select Source File dialog appears.
5) In the Select Source File dialog, browse to your MS Excel csv point database file (geomaestro.csv) and select it. Click Open. Back in the Source File (s) section of the Import Points dialog, the path to the survey point database is now set.
6) Uncheck all check boxes in the Advanced Options section of the Import Points dialog.

7) Click OK. AutoCAD Civil 3D runs though the database and creates the points.
8) Go to the View tab of AutoCAD Civil 3D and click on the Extent button in the Navigate panel to zoom the drawing area to the extent of the newly created points. You should see the points plotted in the drawing area (*See figure: 26*).

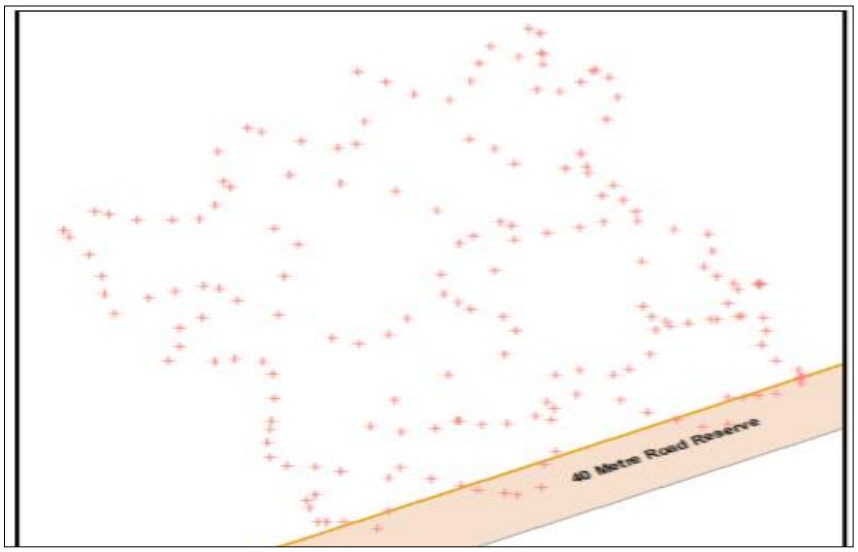


Figure 25: Point Data for Cadastral Property Plotted

9) Right – click on the Point Groups branch in the Prospector tab of the Tool space and select Update from the context menu. This process populates the respective points groups with the points that meet their criteria.
10) Save the drawing with meaningful name

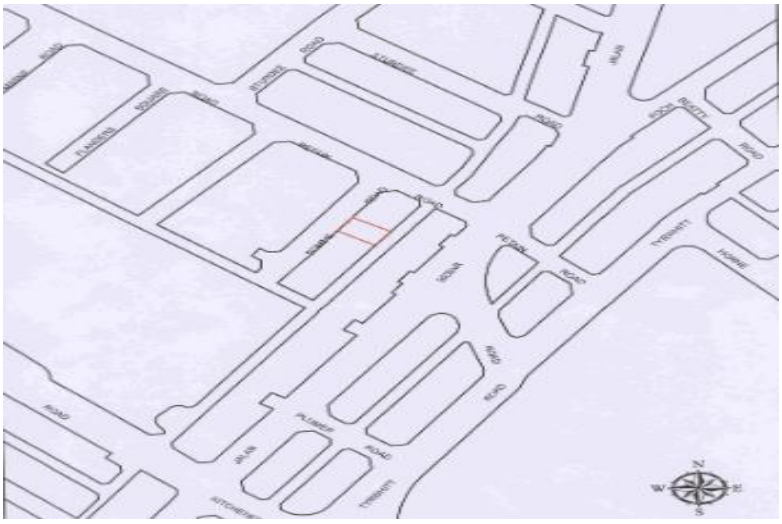


Figure 26: AutoCAD Drawing

8.4.5 Linking Drawing Entities/Layers to Database Attributes

After the drawing complete in the CAD file format, it exports into ArcMap to integrate computer-aided design drawings into attribute database. It allows display and query CAD datasets without first having to convert the drawing files to an ESRI format. The ability to

work with CAD drawings in ArcMap is particularly useful if your organization has existing CAD data resources that you need to use immediately in your work. Not only you can perform basic query and analysis functions using ArcMap tools, you can also snap directly to CAD features or entities when you update your database. This will show you how to import CAD features directly into your edit session, which will allow you to easily integrate CAD features into attribute.

8.5 Producing Cadastral Plans

After producing the final cadastral plans using CAD software, it assures that all map element incorporated before submitted the document. These include:

Title: Descriptive and meaningful title.

Location map: If appropriate, insert a map showing the context of the mapped area.

Colors: As a general rule, for large areas use light colours and **f**or small areas, use dark colours.

Fonts: The number of different fonts and sizes should be minimized.

Data source statement: Data source includes the original and nature of the information on the map, including derived or interpreted data.

North arrow: indicates reference direction.

Projection and data statement: used for referencing purposes.

Scale bar: Include scale bar, with optional statement of scale (Scale 1: xxx xxx)

Legend: Legend should clearly depict accurate coloring and labelling relevant to the information shown on the map.

Publication information: Include name of publisher, and place and date of publication.

Map number: Map number should be included if the map is part of a numbered series.

After completing the required map, detailed report that can convey the information which is used to explain the produce map to assist in decision making. Thus, before the project outputs are provided delivered to the Authority, all necessary document produced by the project must be checked to ensure that it meets the required standards. The key requirements for cadastral map are quality of special spatial data accuracy. In addition to this, element of cadastral map should be incorporated based on the project specification. Finally provide adequate on job training for relevant personnel about final map results.

8.6 Summary

Dear trainee! The cadastral plan is an individual map from the cadastral map series, in which the parcels are entered with the boundaries, parcel numbers and possibly types of use Cadastral map is a comprehensive register of the details related to the property of an area. These details include the precise location, dimensions, and other geographical classifications of the properties or individual parcels of land. The maps generated using cadastral mapping services help in effective management of public land records.

Cadastral drawing shows the boundaries of subdivisions of land, usually with the directions and lengths thereof and the areas of individual tracts, compiled for the purpose of describing and recording ownership. It may also show culture, drainage, and other features relating to use of the land. Cadastral mapping services provide all-inclusive solutions to land information system problems by focusing on various forms of land records. These maps can be prepared using different geospatial related software.

8.7 Self-Check Exercises

**Short Answer Items**

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

1) Elaborate the use of Data Dictionary and Spatial data specifications components in cadastral drawing.
2) Describe the basic map elements incorporated to finalize the cadastral plan.
3) Differentiate 2-D and 3-D drawings.

CHAPTER NINE: PERFORMING SIMPLE STEREOSCOPIC MODEL FORMATION AND FEATURE IDENTIFICATION

9.1 Introduction

Dear trainee! This chapter introduces you the concepts of stereoscopic model and feature identification. A pair of stereoscopic photographs or images can be viewed stereoscopically by looking at the left image with the left eye and the right image with the right eye. Stereoscopy is the science of using overlapping imagery acquired from different locations to produce a 3D model based on Porro-Koppe's principle that the same light path will be generated through an optical system if a light source is projected onto the image taken by an optical system. The principle will be realized in a stereo model if a pair of stereoscopic images are reconstructed using the relative location or tilt at the time the photography was taken. Such an adjustment is called relative orientation in photogrammetric terms.

Stereoscopes is a device that allowed the viewer's visual system to see a three-dimensional image from two side by side flat images. The main applications of stereoscopic techniques are the identification, measurement, and manual digitization of 3D features from vertical overhead imagery. Unlike a map, features on an aerial photograph are not generalized or symbolized. Air photos record all visible features on the Earth's surface from an overhead perspective. The process of studying and gathering information required to identify various cultural and natural features is called photo interpretation. With careful interpretation, air photos are an excellent source of spatial data for studying the Earth's environment.

9.2 Learning Objectives

After completing this chapter, you will able to;

- Explain the concept of stereoscopic vision
- Acquire the basic knowledge about different natural and manmade feature identification techniques
- Identify the basic parameters for photographic documentation

Dear trainee! Before reading the following section, take a moment and try to describe the concept of aerial photograph, stereoscopic model.

_____

_____

_____

_____

9.3 Stereoscopic Model

The three-dimensional model formed either using overlapping pair of aerial photographs/terrain photographs or satellite image is called stereoscopic or Stereo model. Stereoscopic vision (or as it is more commonly known, stereovision or depth perception) is ability to see three-dimensionally or to see length, width, and depth (distance) at the same time. This requires two views of a single object from two slightly different positions. Most people have the ability to see three-dimensionally. Whenever an object is viewed, it is seen twice once with the left eye and once with the right eye. The fusion or blending together of these two images in the brain permits the judgment of depth or distance.

The process of stereoscopy for aerial photography is as follows. At first the center of both aerial photographs, called the principal point, should be marked. Secondly the principal point of the right image should be plotted in its position on the left image. At the same time the principal point of the left image should be also plotted on the right image. These principal points and transferred points should be aligned along a straight line, called the base line, with an appropriate separation (normally 25-30 cm in the case of a stereo mirror scope).

Stereoscopy, sometimes called stereoscopic imaging, is a technique used to enable a three-dimensional effect, adding an illusion of depth to a flat image. Stereopsis, commonly (known as depth perception, is the visual perception of differential distances among objects in one's line of sight. Stereoscopic pictures are produced in pairs, the members of a pair showing the same scene or object from slightly different angles that correspond to the angles of vision of the two eyes of a person looking at the object itself. These two-dimensional images are then combined in the brain to give perception of 3D depth. Stereo model enable the user to view the overlapping area in adjacent pairs of photographs for the purpose of viewing and measuring 3D points in the image.

9.3.1 Flight Lines

An aircraft taking systematic air photo coverage of an area does so by making successive passes back and forth across it, usually in a north-south or an east-west direction. The line connecting principal point and conjugate principal point is called the flight line. This flight line ensures consistency in orientation and sun angle, which aids in photo interpretation. The orientation of the prints is at 90° to that of the flight lines. Overlap is the amount by which one photograph includes the area covered by another photograph, and is expressed as a percentage. To permit stereoscopic and photogrammetric analysis, there is usually a 60% forward overlap between successive photographs in the same flight line and 20–40% lateral overlap between adjacent flight lines. Considerable variation in the format size of photographs exists, although the most common size is 23×23 cm (9×9").

Ideally, each flight line should be a straight course but inevitably cross-winds and other problems of aircraft navigation can modify the flight path. It is not unusual, for example, to find that there has been 'crab' or 'drift' of the aircraft during the photographic mission

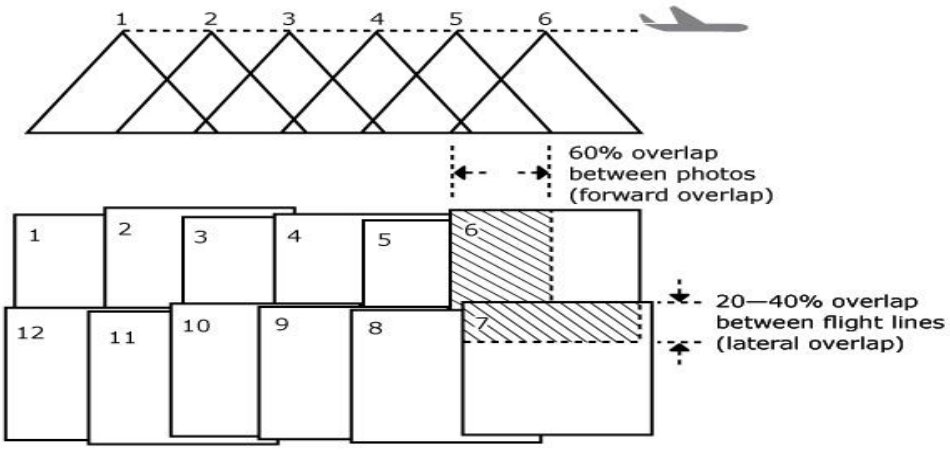


Figure 27: Flight path and overlaps for an aerial photographic survey

9.3.2 Mosaic

Image mosaicking is a method of constructing multiple images of the same scene into a larger image. The output of the image mosaic will be the union of two input images. Image-mosaicking algorithms are used to get mosaiced image. Image Mosaicking processed is basically divided in to 5 phases which includes:

- Feature point extraction,
- Image registration,
- Homography computation,

- Warping and
- Blending if Image.

Various corner detection algorithm is being used for Feature extraction. This corner produces an efficient and informative output mosaiced image. Image mosaicking is widely used in creating 3D images, medical imaging, computer vision, data from satellites, and military automatic target recognition

Mosaicking principles

- Input data sources need not be adjacent; overlap is allowed.
- Merge cannot use multiple input layers of the same name.
- A single output field can be generated from multiple input fields.

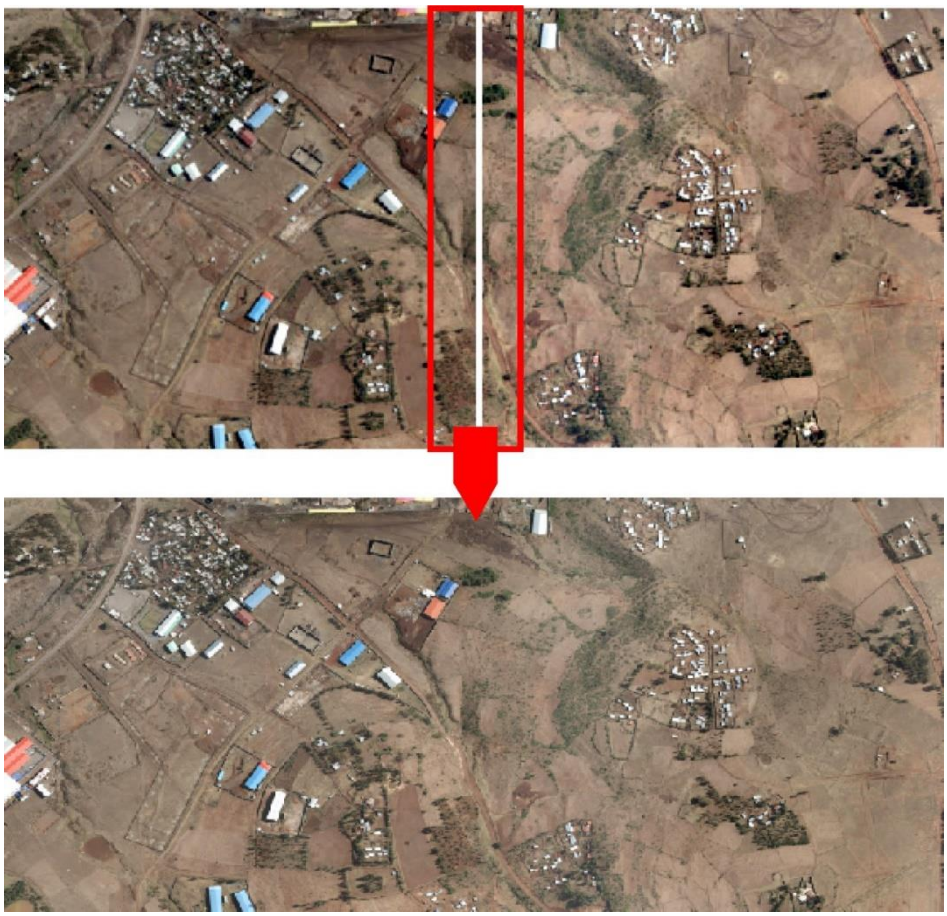


Figure 28: Mosaicking Imageries

9.3.3 Visualizing 3D View

The three-dimensional view which results when two overlapping photos (called a stereo pair), are viewed using a stereoscope is known as Stereoscopic coverage. Each photograph of the

stereo pair provides a slightly different view of the same area, which the brain combines and interprets as a 3D view.

9.3.3.1 Stereoscope

A stereoscope is an instrument that allows a separate vision of two photographs, so that the right eye looks only the right photo and the left eye looks the left photo; then our brain re-builds the two images in a single three-dimensional vision. Each eye, because it is separate, receives a slightly different view of the same object. These two different views are combined by the brain into a single 3-D model. The stereo effect is possible because we have binocular vision. There are several categories of stereoscopes and the most common ones are the following two categories.

A. Pocket stereoscopes/lens stereoscopes:

It is the simplest and least expensive. This stereoscope consists of two magnifying lenses mounted with a separation equal to the average interpapillary distance of the human eye. Sometimes, lens spacing can be adapted to accommodate individual eye spacing, and additional legs can be joined to raise the distance of the instrument from the working plane. Once folded in its case, a pocket stereoscope is not bigger than a common pair of glasses. When the legs are folded, it can easily be carried in a pocket for use in the field and for this reason is frequently called a pocket stereoscope. Most lens stereoscopes have two-power magnification and some are with four-power magnification. These stereoscopes are disadvantageous

- To view the central part of the photograph, the photo must be folded;
- Template annotation is quite difficult.



Figure 29: Pocket Stereoscope

B. Mirror stereoscope

This category belongs to the stereoscopes most commonly used by the majority of photo interpreters. Once positioned under the stereoscope, photographs can be annotated with no

need of further adjustment. This is possible due to a combination of mirrors and prisms that permits to place the photographs at a greater spacing than the observer's eye distance, thus avoiding photo overlap. Such stereoscopes typically have little or no magnification in their normal viewing mode. Binoculars can be fitted to the eyepieces to provide a magnification of 2 to 4 power, with a resulting decrease in field of view. With a mirror stereoscope using little or no magnification, the interpreter can view all or most of the stereoscopic portion of a 230 mm stereopair without moving either the photographs or the stereoscope.

In general, mirror stereoscopes are equipped with binoculars that can be fitted to the eyepieces to provide magnification of 2 to 4 power. Some mirror stereoscopes are also produced in simplified versions, smaller in size and without prisms, to be used in the field without the problems of pocket stereoscopes.

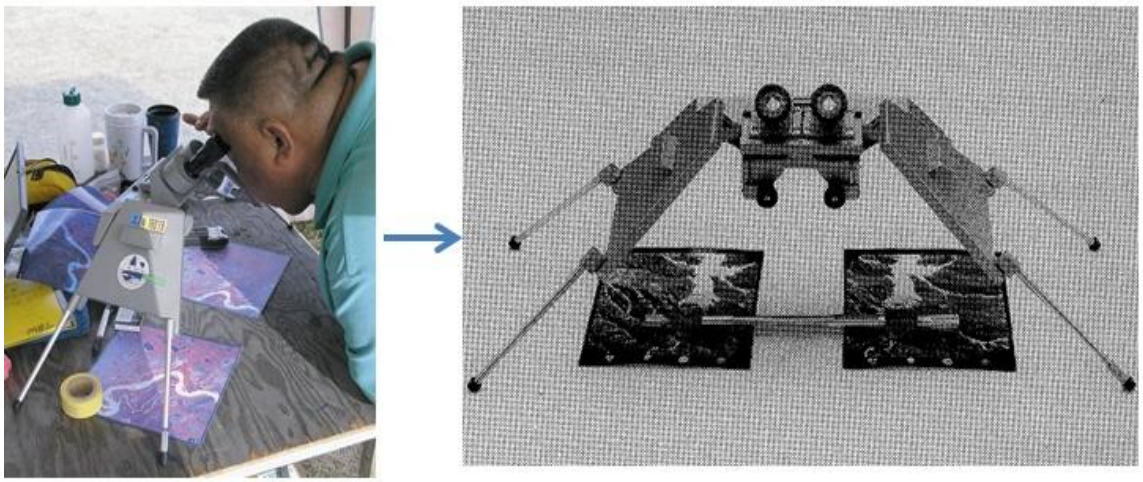


Figure 30: Mirror Stereoscope

Stereoscopy is a technique for creating or enhancing the illusion of depth in an image by means of stereopsis for binocular vision. Any stereoscopic image is called stereogram. Stereoscopy creates the illusion of three-dimensional depth from given two- dimensional images.

9.3.3.2 Method to Orient a Pair of Aerial Photographs

A method to orient a pair of aerial photographs for best three-dimensional viewing is outlined below:

- Arrange the selected pair of photos in such a way that the shadows on them generally appear to fall toward the viewer. It is also desirable that the light source enters the side away from the observer during the study of the photographs (See Figure 32).

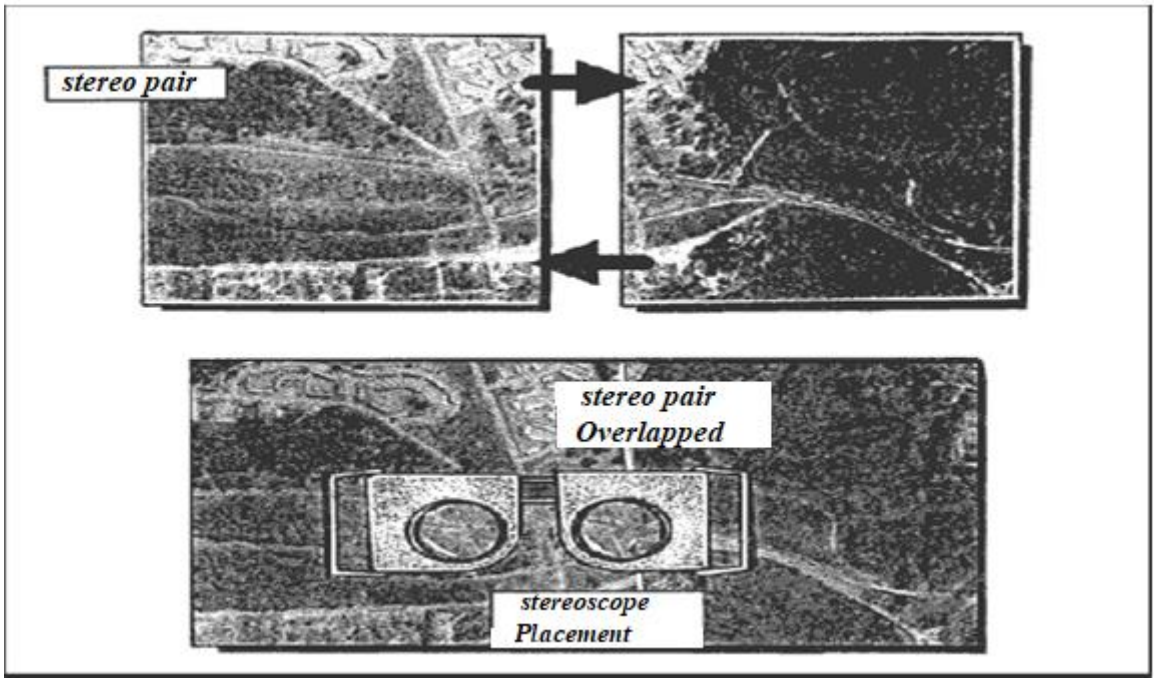


Figure 31: Method to Orient a Pair of Aerial Photographs

- Place the pair of photographs on a flat surface so that the detail on one photograph is directly over the same detail on the other photograph
- Place the stereoscope over the photographs so that the left lens is over the left photograph and the right lens is over the right photograph
- Separate the photographs along the line of flight until a piece of detail appearing in the overlap area of the left photograph is directly under the left lens and the same piece of detail on the right photo is directly under the right lens.
- With the photograph and stereoscope in this position, a three-dimensional image should be seen. A few minor adjustments may be necessary, such as adjusting the aerial photographs of the stereoscope to obtain the correct position for your eyes. The hills appear to rise and the valleys sink so that there is the impression of being in an aircraft looking down at the ground.
- The identification of features on photographs is much easier and more accurate with this three-dimensional view (See Figure 33). The same five factors of recognition (size, shape, shadow, tone, and surrounding objects) must still be applied; but now, with the addition of relief, a more natural view is seen.

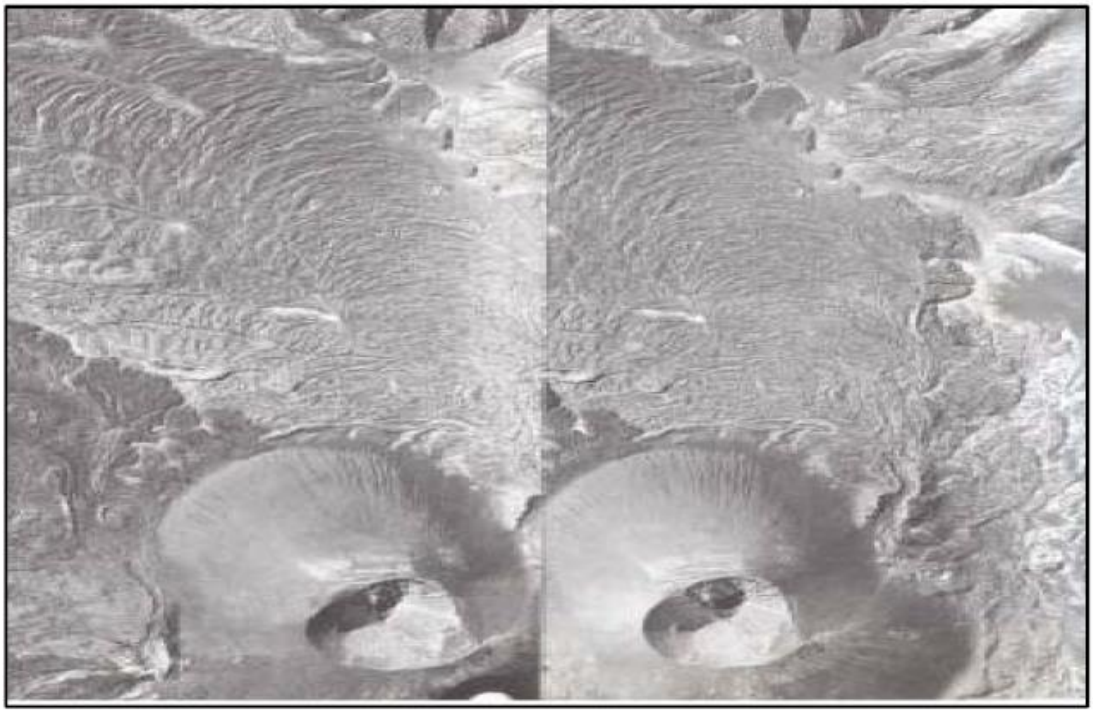


Figure 32: Stereoscopic View

9.3.4 Terms Associated with Stereoscopic Photographs

Floating Mark: A mark (dot or cross) seen as occupying a position in the three-dimensional space formed by the stereoscopic fusion of a stereo pair and used as a reference mark in examining or measuring the stereo-model.

Stereo meter or Parallax Bar: A measuring device containing a micrometer movement by means of which the separation of two index marks (i.e., floating marks) can be changed to measure parallax difference on a stereo pair of photographs.

Air Base: The line joining two adjacent camera stations, or the length of this line.

Photobase: The length of the air base as represented on a photograph. Corresponding Image Points: The images of the same object point on two or more photographs (formerly called "conjugate points").

Parallax: The apparent displacement of the position of an object with respect to a reference point or system, when viewed from a different position of observation.

Absolute Stereoscopic Parallax: On a stereo pair of equal principal distances, the absolute stereoscopic parallax of a point is the algebraic difference between the distances of the two corresponding images from their respective nadir points.

Parallax Difference: The difference in the absolute stereoscopic parallaxes of two points imaged on a pair of photographs.

Y Parallax: The difference between the perpendicular distances of the two corresponding images of a point from the vertical plane containing the air base. The existence of y parallax is an indication of tilt in either or both photographs and/or a difference in flight height (camera elevation); its existence will interfere with stereoscopic examination.

Angular Parallax, Parallactic Angle or Angle of Convergence: The angle subtended by the eye base of the observer at the object viewed.

Base Height Ratio: The ratio (B:H) between the air base and the flight height of a stereopair of photographs.

9.4 Identification of Natural and Manmade Features

The identification of features on a photograph is not difficult if the following facts are remembered. The view that is presented by the aerial photograph is from above and, as a result, objects do not look familiar. Objects that are greatly reduced in size appear distorted. Most aerial photography is black and white, and all colors appear on the photograph in shades of gray. Generally speaking, the darker the natural color, the darker it will appear on the photograph.

Identification requires not only the use of clues provided by the imagery, but also a working knowledge of the types of features likely to be found in the area, and how they would look from the vertical perspective. Some features are distinctive and readily identified. For other features, identification is an exercise in problem solving, using the different elements of photo interpretation to identify features, or to identify object-complexes from their components.

9.4.1 Image Interpretation

Image interpretation of remote sensing data is to extract qualitative and quantitative information from the photograph or imagery. It involves identification of various objects on the terrain which may be natural or artificial consists of points, lines, or polygons. It depends on the way how different features reflect or emits the incident electromagnetic radiation and their recording by a camera or sensor. In the very beginning, when digital images and computerized classification were not available, the aerial photographs were analyzed only by

visual interpretation. Accuracy of the interpretation depends on the training, experience, scale of photograph, geographic location of the study area, associated map, ground observation data etc. After the availability of satellite images, the data were categorized in two processing methods: analogue aerial photographs and digital satellite images. Though satellite images can be visually interpreted and aerial photographs can be processed by computers.

In image or photograph, some objects may be readily identifiable while other may not. It depends on individual perceptions and experience. The detail to which an image or photograph can be analyzed depends on the resolution of the image and scale of the photograph. Satellite images are generally have small scale than aerial photographs and cannot be analyzed stereoscopically.

9.4.2 Elements of Visual Interpretation

In our daily life we interpret many photos and images, but interpretation of aerial photographs and images are different because of three important aspects:

- the portrayal of features from an overhead, often unfamiliar, perspective;
- the frequent use of wavelengths outside of the visible portion of the spectrum; and
- the depiction of the earth's surface at unfamiliar scales.

Eight fundamental parameters or elements are used in the interpretation of remote sensing images or photographs. These are: tone or color, texture, size, shape, pattern, shadow, site and association. In some cases, a single such element is alone sufficient for successful identification; in others, the use of several elements will be required.

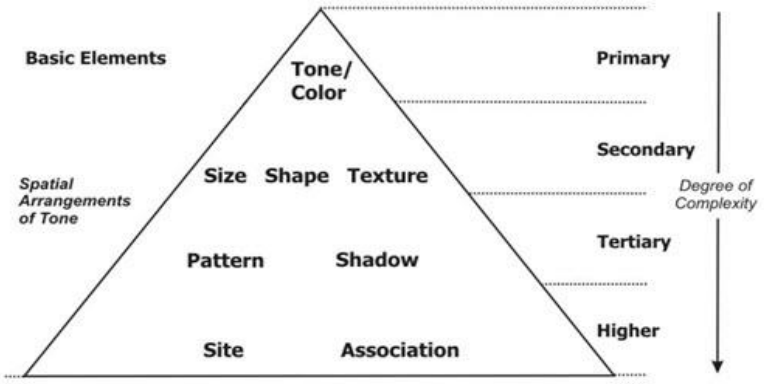


Figure 33: Ordering image interpretation elements

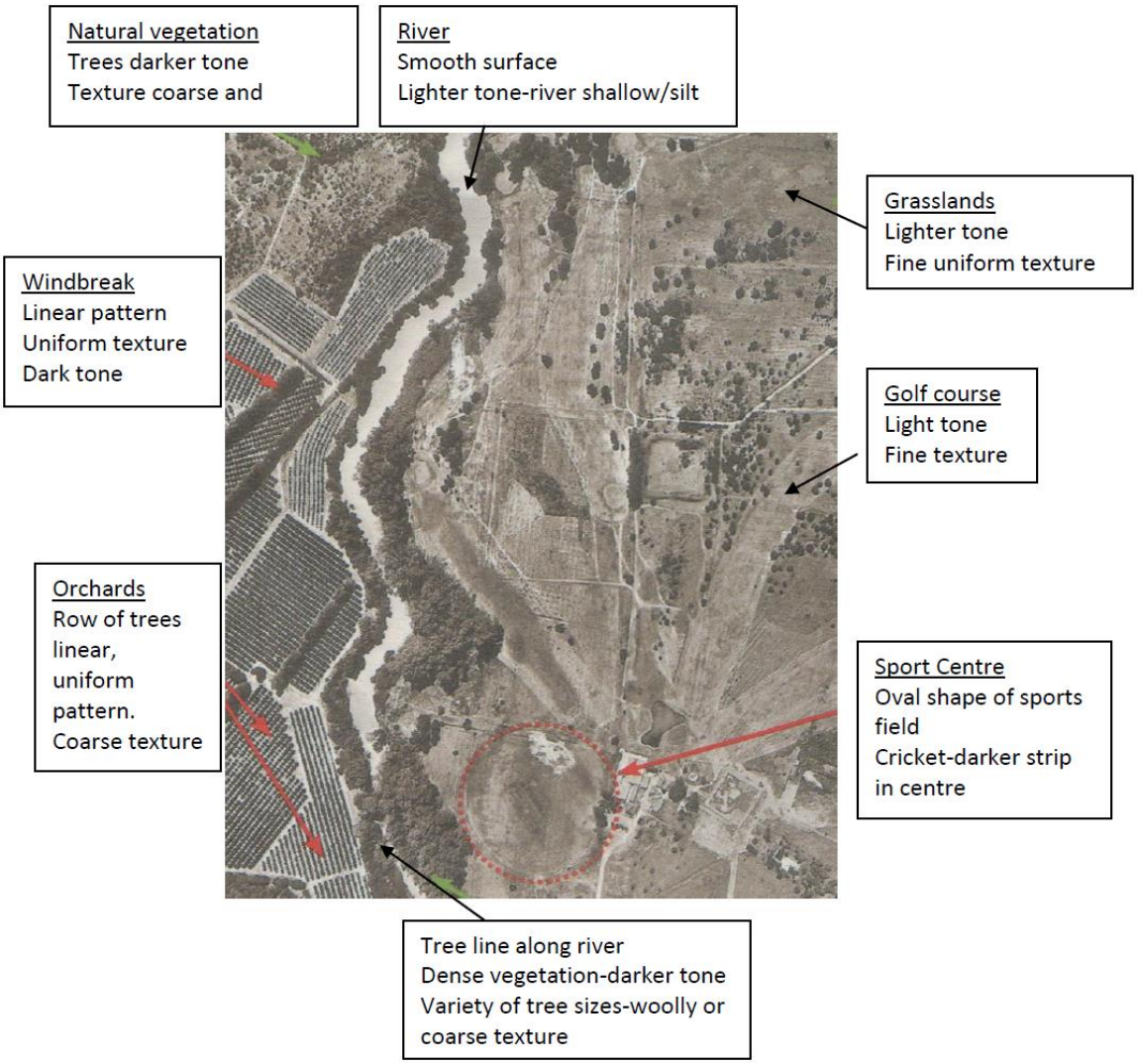


Figure 34: Vertical Aerial Photograph Interpretation

9.4.3 Relief Displacement

Relief displacement is another characteristic of the perspective geometry recorded by an aerial photograph. The displacement of an image point caused by changes in ground elevation is closely related to photographic scale variation. Relief displacement is evaluated when analyzing or planning mosaic or orthophoto projects. Relief displacement is also a tool that can be used in photo interpretation to determine heights of vertical objects.

The surface of the earth is not smooth and flat. As a consequence, there is a natural phenomenon that disrupts true orthogonality of photo image features. In this respect, an orthogonal image is one in which the displacement has been removed, and all of the image features lie in their true horizontal relationship.

9.4.4 Image/Photograph Quality

Image quality is a major factor governing the amount of information that can be extracted from a remote sensing product. The amount of information that can be extracted from a remote sensing data product (photograph or image) is primarily dependent upon its quality. It is therefore necessary first to have an idea of all the factors which affect image quality, before proceeding to interpretation and applications. Basically, there are two aspects to image quality: radiometric and geometric. Both collectively govern the amount of extractable information.

During visual interpretation, objects on an image or photograph are discerned from one another primarily by relative differences in brightness or color. It is a common experience that a bright object can be easily marked if located on a dark background. However, the same object may be difficult to locate against a bright background. Object or Brightness Contrast Ratio, i.e. the ratio of brightness of any two objects, is an important factor in deciding to what degree any two features occurring side by side on an image or photograph can be differentiated by visual inspection.



Factors affecting quality of images and photographs

A. Ground properties

- Contrast in relevant ground properties like albedo, thermal properties, geothermal energy etc. including topographic and slope aspects

B. Environmental factors

- Solar illumination and time of survey
- Path radiance
- Meteorological factors

C. Sensor system factors

- Diffraction. aberration etc. in optical imaging systems
- Effects of image detection and recording system
- Degradation due to sampling and quantization in images
- Vignetting
- Image motion
- Stripping

	• Periodic and spike noise D. Effects of duplicating systems E. Relief displacement F. Shift in position

9.5 Photographic Documentation

Photographs must be included as part of the required progress reports. The first progress report photographs shall document the appearance and condition of the building, structure, or site prior to and during work agreed upon in the executed Grant Award agreement. Subsequent progress reports shall document the appearance of the building, structure, or site during and after the completion of all work agreed upon in the executed Grant Award agreement.

A complete photograph must document:

- The site and environment;
- All areas where work will be taking place as per the approved scope of work;
- Close-ups of character-defining interior and exterior features;
- In the event that the project focuses on protection such as stabilization, include present conditions and details;
- In the event that the project focuses on community education, include photographs of examples of proposed products and drafts of design, development and the like.

9.6 Summary

Dear trainee! A stereoscope is a device for viewing a stereoscopic pair of separate images, depicting left-eye and right-eye views of the same scene, as a single three-dimensional image. Aerial photographs provide a three-dimensional overall view of the ground, and that this property makes them to be of great value for feature identification. Identification of three-dimensional features on an aerial photograph is possible only through stereoscope device. Those features can be tress, buildings, bridges, etc.

It is also noted that aerial photographs are taken to give an over-lap and side lap of 60% and 30% respectively. Such overlaps ensure that when two adjoining photos are inspected using a stereoscope, they give an apparently solid model of the ground. A stereoscope assists in obtaining a three-dimensional interpretation of the area covered by aerial photographs.

Finally, you have also learned about the organizational policies and guidelines for photographs and photographic documentation.

9.7 Self-Check Exercises



Short Answer and Multiple-Choice Items

Instruction 1: Give short, brief and precise answer for the following questions.

1) What is Stereoscopic vision?
2) Explain the function of flight line direction.
3) What is the difference between pocket and mirror stereoscope?
4) List the basic elements of visual interpretation.
5) What is the use of relief displacement?
6) Explain 3D visualization.



Task Sheet for Project Work

Task Sheet for Project Work (Prototype)

Work piece / Project Name: Air Photo Interpretation

Identify four man made and two natural features from the given Aerial photograph/satellite image data using the following equipment:

A mirror stereoscope

Ruler - This piece of equipment is made of celluloid or steel and is calibrated at one millimeter (1mm) intervals. The ruler is used for locating principal points and setting the principal lines.

Color pencil (for all types of surfaces)

Scotch tape

Tracing paper

You will need to provide different layer from extracted features.

Duration:1 hour

CHAPTER TEN: OPERATING GIS SOFTWARE TO SPATIAL AND NON-SPATIAL ANALYSIS

10.1 Introduction



Dear trainee! This chapter introduces you the basic concepts of GIS software for spatial analysis. A Geographic Information System (GIS) is a computer-based tool for mapping and analyzing geographic phenomenon that exists, and events that occur, on Earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. A GIS has four main functional subsystems. These are: a data input subsystem; a data storage and retrieval subsystem; a data manipulation and analysis subsystem; and a data output and display subsystem.

GIS also integrates five key components: hardware, software, data, people, and methods. In most GIS software, data is organized in themes as data layers. This approach allows data to be input as separate themes and overlaid based on analytical requirements. The choice of data input method in GIS is governed largely by the application, the available budget, and the type and the complexity of data being input. Generally, spatial analysis utilizes spatial and non-spatial data in order to improve one's understanding and develop informed decisions in solving real world problems. GIS Metadata documents record the necessary information about a dataset to ensure that the dataset is understood by colleagues, is used properly, can be shared with other organizations, and can be preserved for use in the future.

10.2 Learning Objectives



After completing this chapter, you will be able to:

- Discuss the working principles of GIS
- Explore and query geographic data in GIS software
- Solve problems using GIS
- Produce report based on basic spatial analysis and archiving



Dear trainee! Before reading the following section, take ten minutes and try to describe the working principles of GIS and its applications.

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10.3 Basic Principles of Geographic Information Systems (GIS)

10.3.1 Definition and Concepts of GIS

Geographic Information System (GIS) is a computer-based tool for mapping and analyzing geographic phenomenon that exists, and events that occur, on Earth. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies.

Map making and geographic analysis are not new, but a GIS performs these tasks faster and with more sophistication than do traditional manual methods. A GIS can be made up of a variety of software and hardware tools. The important factor is the level of integration of these tools to provide a smoothly operating, fully functional geographic data processing environment. Overall, GIS should be viewed as a technology, not simply as a computer system.

In general, a GIS provides facilities for data capture, data management, data manipulation and analysis, and the presentation of results in both graphic and report form, with a particular emphasis upon preserving and utilizing inherent characteristics of spatial data. The ability to incorporate spatial data, manage it, analyze it, and answer spatial questions is the distinctive characteristic of geographic information systems.

10.3.2 Components of GIS

An operational GIS also has a series of components that combine to make the system work. These components are critical to a successful GIS. A working GIS integrates six key components: Hardware, Software, Data, People, Network and Methods.

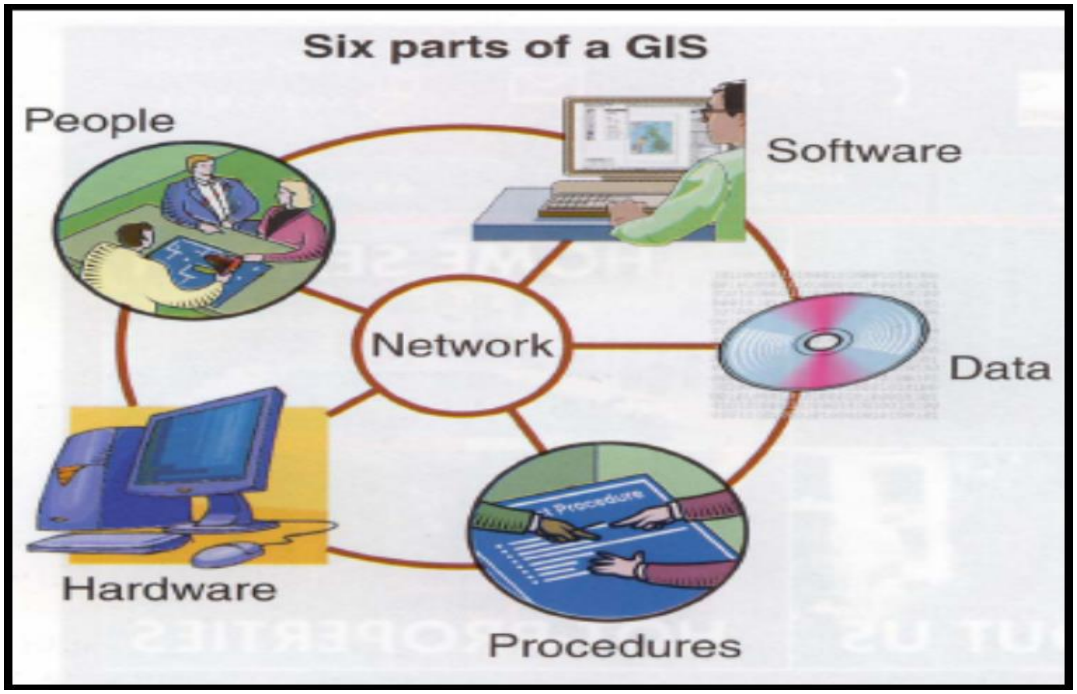


Figure 35: Components of a GIS

A. Hardware

Hardware is the computer system on which a GIS operates. Today, GIS software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

B. Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are:

- A database management system (DBMS)
- Tools for the input and manipulation of geographic information
- Tools that support geographic query, analysis, and visualization
- A graphical user interface (GUI) for easy access to tools

C. Data

Perhaps the most important component of a GIS is the data. Geographic data and related tabular data can be collected in-house, compiled to custom specifications and requirements, or occasionally purchased from a commercial data provider. A GIS can integrate spatial data with other existing data resources, often stored in a corporate DBMS. The integration of spatial data (often proprietary to the GIS software), and tabular data stored in a DBMS is a key functionality afforded by GIS.

D. People

GIS technology is of limited value without the people who manage the system and develop plans for applying it to real world problems. GIS user ranges from technical specialists who design and maintain the system to those who uses it to help them perform everyday work. The identification of GIS specialists versus end users is often critical to the proper implementation of GIS technology.

E. Methods

A successful GIS operates according to a well-designed implementation plan and business rules, which are the models and operating practices unique to each organization. As in all organizations dealing with sophisticated technology, new tools can only be used effectively if they are properly integrated into the entire business strategy and operation.

F. Network

It refers to both the computer, and social network. Both of these networks assist in the dissemination of data. Where the dissemination of data is through transferring of data sets or collaboration, sharing the data from a GIS is a very common and useful operation. Additionally, these networks allow for the display of information in the form of web maps, web applications, or even paper maps using our social network.

10.3.3 GIS Subsystems

A GIS has four main functional subsystems. These are:

- a data input subsystem;
- a data storage and retrieval subsystem;
- a data manipulation and analysis subsystem; and
- a data output and display subsystem.

A. Data Input

A data input subsystem allows the user to capture, collect, and transform spatial and thematic data into digital form. The data inputs are usually derived from a combination of hard copy maps, aerial photographs, remotely sensed images, reports, survey documents...

B. Data Storage and Retrieval

The data storage and retrieval subsystem organize the data, spatial and attribute, in a form which permits it to be quickly retrieved by the user for analysis, and permits rapid and accurate updates to be made to the database. This component usually involves use of a

database management system (DBMS) for maintaining attribute data. Spatial data is usually encoded and maintained in a proprietary file format.

C. Data Manipulation and Analysis

The data manipulation and analysis subsystem allow the user to define and execute spatial and attribute procedures to generate derived information. This subsystem is commonly thought of as the heart of a GIS, and usually distinguishes it from other database information systems and computer-aided drafting (CAD) systems.

D. Data Output

The data output subsystem allows the user to generate graphic displays, normally maps, and tabular reports representing derived information products.

10.3.4 Applications of GIS

Major areas of GIS application can be grouped into five categories as follows.

- **Facilities Management:** Large scale and precise maps and network analysis are used mainly for utility management. AM/FM is frequently used in this area.
- **Environment and Natural Resources Management:** Medium or small-scale maps and overlay techniques in combination with aerial photographs and satellite images are used for management of natural resources and environmental impact analysis.
- **Street Network:** Large or medium scale maps and spatial analysis are used for vehicle routing, locating house and streets etc.
- **Planning and Engineering:** Large or medium scale maps and engineering models are used mainly in civil engineering.
- **Land Information System:** Large scale cadastre maps or land parcel maps and spatial analysis are used for cadastre administration, taxation etc.

Table 4: Major areas of GIS applications

Area	GIS Application
Facility Management	Locating underground pipes and cables, Planning facility maintenance, Telecommunication network services, Energy use tracking and planning
Environment and Natural Resource Management	Suitable study for agricultural cropping, Management of forests, agricultural lands, water resources, wetlands, etc. Disaster management and mitigation, waste facility site location

Street Network	Car navigation (routing and scheduling), Locating houses and streets, Site selection, Ambulance services, transportation planning
Planning and Engineering	Urban planning, Regional planning, Route location of highways, development of public facilities
Land Information System	Cadastre administration, taxation, zoning of land use, land acquisition

10.4 Exploring and Querying Spatial Data

10.4.1 Data type, Model and Scale of Measurement

The basic data type in a GIS reflects traditional data found on a map. Accordingly, GIS technology utilizes two basic types of data. These are:

- **Spatial data:** describes the absolute and relative location of geographic features.
- **Attribute data:** describes characteristics of the spatial features. These characteristics can be quantitative and/or qualitative in nature. Attribute data is often referred to as tabular data.

The coordinate location of a parcel would be spatial data, while the socio-economic characteristics of that, e.g. owner ID, owner name, land tenure, etc., would be attribute data. Other data types, in particular image and multimedia data, are becoming more prevalent with changing technology. Depending on the specific content of the data, image data may be considered either spatial, e.g. photographs, animation, movies, etc., or attribute, e.g. sound, descriptions, narration's, etc.

In order to visualize natural phenomena, one must first determine how to best represent geographic space. Data models are a set of rules and/or constructs used to describe and represent aspects of the real world in a computer. Two primary data models are available to complete this task: raster data model and vector data model.

Vector Data Model

A vector representation is composed of three main elements: points, lines and polygons. Points are spatial objects with no area but can have attached attributes since they are a single set of coordinates (X and Y) in a coordinate space. Lines are spatial objects made up of connected points (nodes) that have no width. Polygons are closed areas that can be made up of a circuit of line segments.

Raster Data Models

Grid cells are the most common raster representation. Features are divided into cellular arrays and a coordinate (X, Y) is assigned to each cell, as well as a value. This allows for registration with a geographic reference system. A raster representation also relies on tessellation: geometric shapes that can completely cover an area. Although many shapes are possible (for example, triangles and hexagons), the square is the most commonly used.

Scale of Measurement

It is important to have a good understanding of the data which needs to be represented on a map. One must recognize the scale of measurement for a particular data set because the scales determine the kind of mathematical operations that can be performed on the data. These scales of measurement are described below:

A. Nominal Scale

It only satisfies the identity property. The values assigned to variables are descriptive; they cannot be used for mathematical comparisons. For example, on the basis of gender we can classify individuals into ‘male’ and ‘female’ but neither of the gender is higher or smaller than the other.

B. Ordinal Scale

This scale has the properties of both identity and magnitude but the interval between any two values is indeterminate. It generally uses the operators “greater than”, “equal to” or “less than” for ordering the observations. For example, the result of an athletic event declares the ranks secured by various athletes but the ranks themselves do not describe by what time a rank holder has finished the race with respect to another athlete.

C. Interval Scale

This scale has the properties of identity, magnitude and equal intervals. The Fahrenheit scale for measuring temperature is made up of equal temperature units, so the difference between 10- and 20-degrees Fahrenheit is equal to the difference between 40- and 50-degrees Fahrenheit.

The use of interval scale tells whether one is greater or smaller than the other and it also quantifies the amount by which one is greater or smaller than the other. For example, the temperature of a city recorded on the first day of a month is 15 degrees and on the second day

is 20 degrees. So, we can say that the temperature on the second day is higher than that on the first and the second day is 5 degrees hotter than the first day.

D. Ratio Scale

The ratio scale has the properties of identity, magnitude, equal interval and absolute zero. Having true zero allows for computing ratios. Weight is an example of ratio scale. Weights can be given ranks, units along the weight scale are equal to each other and weight has an absolute zero. 0 kg means there is no weight and 100 kg are said to be twice of 50 kg.

A wide variety of data sources exist for both spatial and attribute data. The most common general sources for spatial data are:

- hard copy maps;
- aerial photographs;
- remotely-sensed imagery;
- point data samples from ground surveys; and
- Existing digital data files.

Attribute data has an even wider variety of data sources. Any textual or tabular data than can be referenced to a geographic feature. For example, a point, line, or area, can be input into a GIS. The attribute (non-spatial) can be acquired from legal documents, statistical data, questionnaire, interview and others.

10.4.2 Data Input Techniques

Since the input of attribute data is usually quite simple, the discussion of data input techniques will be limited to spatial data only. There is no single method of entering the spatial data into a GIS. Rather, there are several, mutually compatible methods that can be used singly or in combination.

The choice of data input method is governed largely by the application, the available budget, and the type and the complexity of data being input. There are at least four basic procedures for inputting spatial data into a GIS. These are (*refer to Chapter 13*):

- digitizing;
- Automatic scanning;
- Entry of coordinates using coordinate geometry; and
- Conversion of existing digital data.

10.4.3 Spatial Query

A spatial query is a special type of database query supported by geodatabases. The spatial queries differ from SQL queries by allowing the use of geometry data types such as points, lines and polygons and it consider the spatial relationship between these geometries. It is a set of spatial conditions characterized by spatial operators that form the basis for the retrieval of spatial information from a spatial database system. The query expressed as a combination of spatial conditions (For example, using Euclidean distance we can retrieve the following query point. Select Oromia woredas within a distance of x asphalt road) for extracting specific information from a large amount of spatial data without actually changing these data.

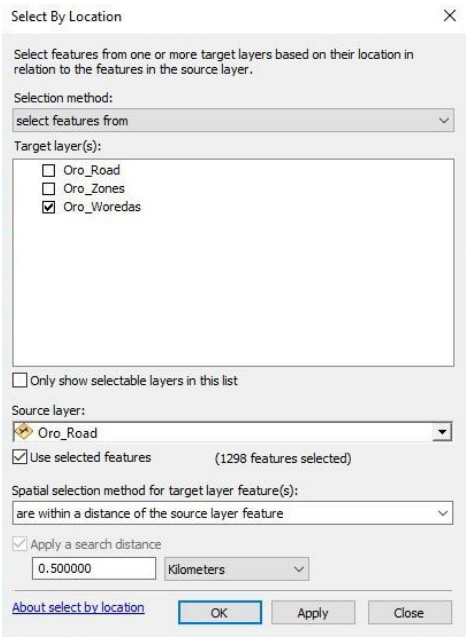


Figure 36: Spatial query

10.4.4 Attribute Query

Attribute queries are an extremely common GIS spatial operation. Attribute queries select a subset of records based on values of specific attributes. Each attribute query must specify three things: an attribute field, a set algebra operator, and an attribute value.

For example, if we had a data set of land parcels for sale and interested in selecting parcels that are at least six hundred km^2 area, our attribute query would be:

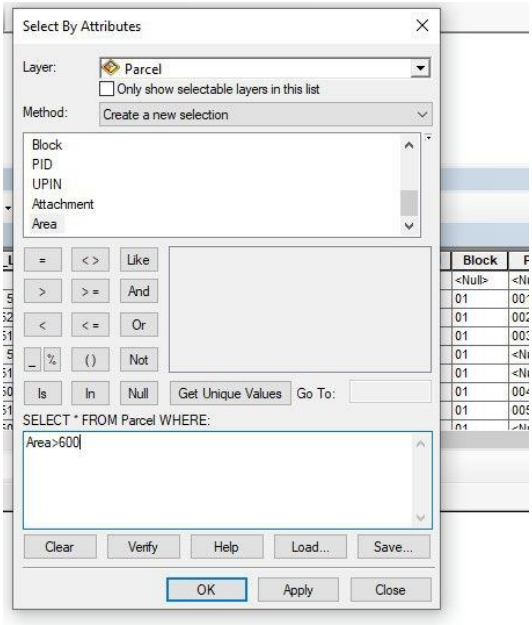


Figure 37: Attribute query

Where ‘Area’ is the attribute field, ‘greater than’ is the set algebra operator, and ‘six hundred’ is the attribute value we wish to evaluate. Attribute queries can also select records based on multiple attributes combined together using Boolean operators, such as ‘and’, ‘or’, and ‘not’.

10.5 Spatial Data Analysis using GIS Software

10.5.1 Spatial Data Layers

In most GIS software, data is organized in themes as data layers. This approach allows data to be input as separate themes and overlaid based on analytical requirements. This can conceptualize as vertical layering the characteristics of the earth's surface. The overlay concept is so natural to cartographers and natural resource specialists that it has been built into the design of most CAD vector systems as well. The overlay/layer approach used in CAD systems is used to separate major classes of spatial features. This concept is also used to logically order data in most GIS software. The terminology may differ between GIS software, but the approach is the same. A variety of terms are used to define data layers in commercial GIS software. These include themes, coverage’s, layers, levels, objects, and feature classes. Data layer and theme are the most common and the least proprietary to any particular GIS software and accordingly, as used throughout the book.

In any GIS project a variety of data layers will be required. These must be identified before the project is started and a priority given to the input or digitizing of the spatial data layers. This is mandatory, as often one data layer contains features that are coincident with another,

e.g. lakes can be used to define polygons within the forest inventory data layer. Data layers are commonly defined based on the needs of the user and the availability of data. They are completely user definable.

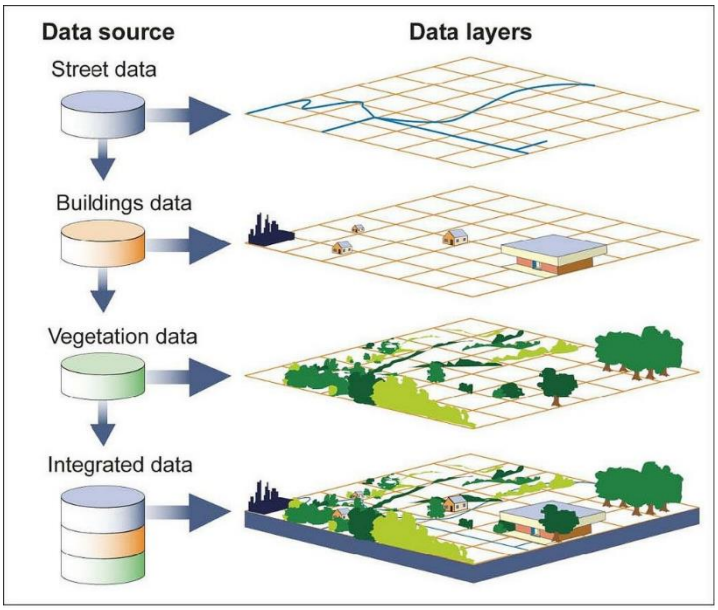


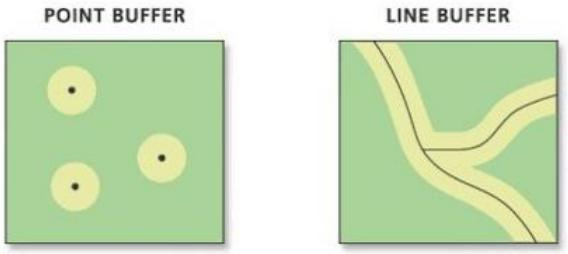
Figure 38: Spatial Data Layers

When considering the physical requirements of the GIS software, it is important to understand that two types of data are required for each layer, attribute and spatial data. Commonly, data layers are input into the GIS one layer at a time. As well, often a data layer is completely loaded. For example, graphic conversion, editing, topological building, attributes conversion, linking, and verification, before the next data layer is started. Because there are several steps involved in completely loading a data layer it can become very confusing if many layers are loaded at once.

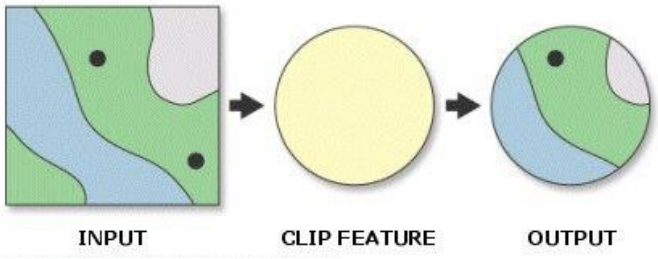
10.5.2 Geo-processing Techniques

Geoprocessing is a framework and set of tools for processing geographic and related data. The comprehensive suite of geoprocessing tools can be used to perform spatial analysis or manage GIS data in an automated way. A typical geoprocessing tool performs an operation on a dataset such as a feature class, raster, or table, and creates a resulting output dataset. In addition to the suite of tools, geoprocessing is also a powerful framework that supports control of the processing environment and allows you to build custom tools that can further automate your work. Some of the most commonly used geoprocessing tools are available with any ArcGIS license. These include Buffer, Clip Dissolve, Integrate, Intersect and Union.

- **Buffer:** is one of the Analysis tools used in calculating proximity. This tool creates a new feature class of buffer polygons around polygon, line, or point features.



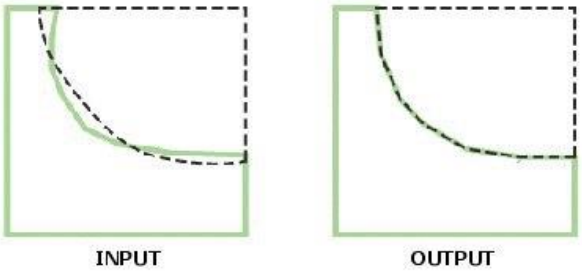
- **Clip:** is one of the Analysis tools used for extracting features or parts of features from a feature class. This tool uses a polygon boundary to cut features and their attributes from a feature class.



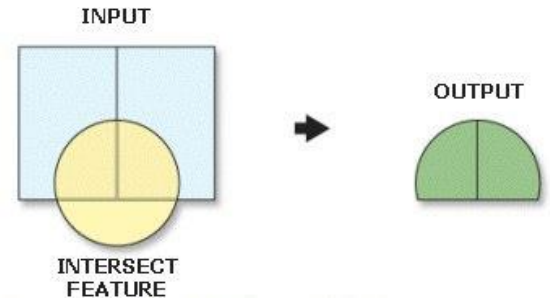
- **Dissolve:** is one of the Data Management tools used for generalizing features. This tool combines like features based on a specified attribute or attributes.



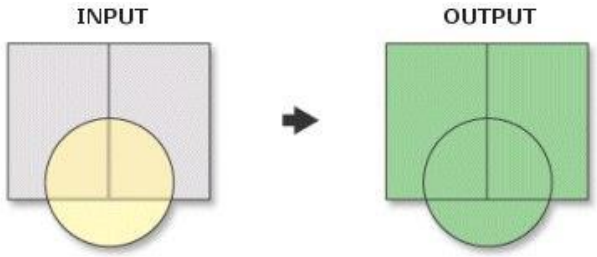
- **Integrate:** is one of the Data Management tools for manipulating feature classes. This tool compares feature classes and makes identical or coincident any lines or vertices that are within a certain distance of one another.



- **Intersect:** is one of the Analysis tools used to perform overlay analysis on feature classes. This tool builds a new feature class from the intersecting features common in both feature classes.



- **Union:** is another Analysis tool used to perform overlay analysis on feature classes. This tool builds a new feature class by combining the features and attributes of each feature class.



10.5.3 Spatial Overlay Techniques

Overlay analysis is a group of methodologies applied in optimal site selection or suitability modeling. It is a technique for applying a common scale of values to diverse and dissimilar inputs to create an integrated analysis.

Suitability models identify the best or most preferred locations for a specific phenomenon. Types of problems addressed by suitability analysis include:

- Where to site a new housing development
- Which sites are better for deer habitat
- Where economic growth is most likely to occur
- Where the locations are that are most susceptible to land slides

Overlay analysis often requires the analysis of many different factors. For instance, choosing the site for a new housing development means assessing such things as land cost, proximity to existing services, slope, and flood frequency. This information exists in different raster with different value scales: birr, distances, degrees, and so on. You cannot add a raster of land cost (birr) to a raster of distance to utilities (meters) and obtain a meaningful result.

The following lists the general steps to perform overlay analysis:

- Define the problem.
- Break the problem into sub models.
- Determine significant layers.
- Reclassify or transform the data within a layer.
- Weight the input layers.
- Add or combine the layers.
- Analyze.

Overlay Methods

In general, there are two methods for performing overlay analysis: vector overlay (overlaying points, lines, or polygons) and raster overlay. Some types of overlay analysis lend themselves to one or the other of these methods. Overlay analysis to find locations meeting certain criteria are often best-done using raster overlay (although you can do it with feature data). Of course, this also depends on whether your data is already stored as features or raster's. It may be worthwhile to convert the data from one format to the other to perform the analysis.

- **Vector Overlay**

The key elements in feature overlay are the input layer, the overlay layer, and the output layer. The overlay function splits feature in the input layer where they are overlapped by features in the overlay layer. New areas are created where polygons intersect. If the input layer contains lines, the lines are split where polygons cross them. These new features are stored in the output layer and the original input layer is not modified. The attributes of features in the overlay layer are assigned to the appropriate new features in the output layer, along with the original attributes from the input layer.

Below is an example of line-on-polygon overlay. The line is split at the polygon boundaries, and each of the resulting line features has the original line attributes plus the attributes of the polygon it fell within.

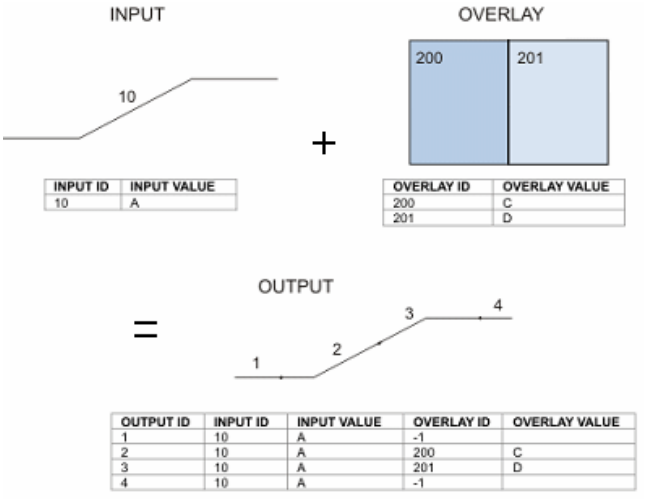


Figure 39: Vector overlay

- **Raster Overlay**

In raster overlay, each cell of each layer references the same geographic location. That makes it well suited to combining characteristics for numerous layers into a single layer. Usually, numeric values are assigned to each characteristic, allowing you to mathematically combine the layers and assign a new value to each cell in the output layer.

Below is an example of raster overlay by addition. Two input raster's added together to create an output raster with the values for each cell summed.

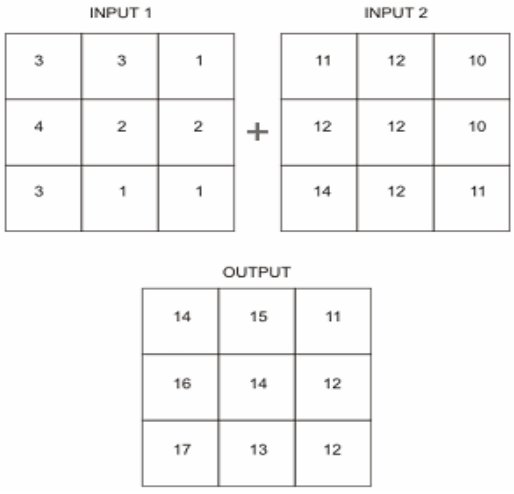


Figure 40: Raster overlay

10.5.4 Cartographic Integrity and Quality Assurance

Quality Assurance (QA) is the process of beginning a set of rules or best practices to confirm the production of quality of geospatial data. Quality testing has several benefits including less data recapture, because quality requirements have formerly been identified and are being measured and monitored continually. QA is usually thought of as acting tests on information

to make sure its accuracy. Quality Assurance plans can approximately be classified into two categories. One is Visual QA and another one is Automated QA.

- **Visual QA:** The Visual inspections will find the existence of error data, missing data or spatial accuracy of information. Visual checks are often achieved by using hard-copy plots or on-screen views.
- **Automated QA:** The Visual validation of geospatial data is reinforced by machine-controlled QA strategies. The geospatial data are often automatically checked for adherence to database design, attribute accuracy, logical consistency, and referential integrity. The machine-controlled QC should occur in combination with visual examination.

Data Acceptance Criteria

a) **Position Accuracy:** The positional accuracy is that the measurable value that embodies the positional change between 2 geospatial layers or between a geospatial layer and reality.
b) **Completeness:** The completeness of data validation refers the presence or absence of features, their attributes, and relationships in a data model. So, the completeness is a validation of the extent and range of a dataset reference to completeness of coverage, classification and verification.
c) **Logical Consistency:** A spatial data set is alleged to be logically consistent once it complies with the structural characteristics of the particular data model and when it is well-matched with the attribute constraints defined for the set.
d) **Thematic accuracy:** The thematic accuracy refers to the accuracy of a mapped land use /land cover class at a specific time compared to what was really on the ground at that time.
e) **Attribute checks:** The attribute checks analyze the attribute values of features and tables. Attribute checking will be utilized for evaluating easy field validation tasks just like a geodatabase domain, or more complex attribute dependencies.

10.6 Produce Report and Archiving Data

10.6.1 Reporting

A report lets you organize and display the tabular data that's associated with your geographic features. Sometimes you'll want to print out a report to distribute with your map, export the

report to a static format like RDF (report document file) or PDF to be shared, put the report directly on the map layout, or save the report as an RLF (report layout file) that can be rerun.

The two native file formats for reports in ArcGIS are RDF and RLF. After following the steps outlined below to create a report through the Report Wizard, you can create an RDF of your report using the Report Viewer. An RDF creates a static report of your data, essentially a snapshot of your data at that time. You can also create an RLF of your report using the Report Designer. An RLF creates a template of your report. The RLF includes all the fields in the report, how they are grouped, sorted, and formatted, along with all the other report elements that you add to your report's layout. When you rerun or reload an RLF file, the report will regenerate based on the source data. If the data has been updated or edited in any way, those changes will be reflected in the rerun report.

10.6.2 Archiving Data

Metadata is a term used within the computer science community to denote characteristics or quality of data. There are many definitions of what is classified as metadata, mostly dependent on the expected uses of the metadata. In an extreme view, metadata may mean absolutely everything ancillary to the "datum" or measurement (meaning there is little real data and lots of metadata). On the other extreme, metadata may be just a few identified properties that support a certain application.

The FGDC metadata standard is organized into approximately 300 data elements, 199 of which can be valued; the remainder are grouping elements (compound elements) which give an overall structure to the standard. Of these 199 elements, several dozen are considered "mandatory" and around 100 are considered "mandatory if applicable", a classification which requires interpretation by the user. The rest are optional to provide structured places for information that would otherwise become lost in generalized comment fields.

The Standard is broken into ten sections and each data element has a number to ease in human navigation. Only the mandatory elements within the Identification and Metadata Reference sections are absolutely required to prepare a bare minimum metadata entry. One quickly discovers, however, how ineffective this limited subset would be in the appraisal of data quality.

Close review of the FGDC Metadata Standard reveals a set of "production rules" which declare the syntax of content as far as:

- Optionality
- Repeatability
- Representation

If an element is declared optional and it is a compound element, then the elements "under" the compound are effectively optional. A traversal of the metadata standard will reveal a cascade of decision points, like branches in a tree which, when included, require the consideration of the remaining "leaves" on the branch. Omitting an optional or mandatory-of-applicable branch is permitted. Inclusion of random metadata elements is not permitted by the structure of the standard as the elements are out-of-context.

10.8 Summary

Dear trainee! GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. A GIS, is an integrated set of hardware and software tools used for the manipulation and management of digital spatial (geographic) and related attribute data.

A GIS has a data input, data storage and retrieval, a data manipulation and analysis, and a data output and display subsystems. An operational GIS also has a series of components that combine to make the system work. These components are critical to a successful GIS. These are hardware, software, data, people and methods.

The choice of data input method is governed largely by the application, the available budget, and the type and the complexity of data being input. Geospatial technologies are a term used to describe the range of modern tools contributing to the geographic mapping and analysis of the Earth and human societies.

In general, a GIS provides facilities for data capture, data management, data manipulation and analysis, and the presentation of results in both graphic and report form, with a particular emphasis upon preserving and utilizing inherent characteristics of spatial data.

10.9 Self-Check Exercise

**Short Answer Items**

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

1) Define geographic information system?
2) Briefly describe main functional subsystems of a GIS?

3) List and explain key components of GIS?
4) Discuss about spatial data layers?
5) Discus basic procedures for inputting spatial data into a GIS?
6) Define metadata?

Project 1: - Arc Catalog and Arc Map Activity Background

Practical Training

i. Start – ArcGIS – Arc Catalog for initializing Arc Catalog in your computer
ii. Go to Catalog tree and navigate to your working folder to explore the data using three options (i.e. Content, Preview, and Metadata) of your Arc Catalog window
iii. Further explore the Metadata using the three options (i.e. General, Spatial, and Attribute) under the Metada tab.
iv. Start – ArcGIS – Arc Map for initializing Arc Map in your computer
v. Add ethio_region.shp in ArcMap.
vi. Right click on ethio_region.shp and select properties option. Select Symbology tab on layer properties dialog box.
vii. Select unique values under category option, and set Region for the value field, and click on Add All values tab to preview all the regions in Ethiopia.
viii. Finally click Apply and Ok to see the Ethiopia symbolized by region in ArcMap
ix. To differentiate the different regions of Ethiopia, use label option on when you right click ethio_region in the table of content section of ArcMap. Make sure that you set label field to Region on layer properties dialog box.

Project 2: - Geo-referencing (Geometric Correction)

i. Add **toposheet** in ArcMap. Dock Georeferencing toolbar in ArcMap by right clicking on the space to the right of Help Menu and select Georeferencing option from the dropdown list.
ii. Make sure that toposheet file in the layer dropdown list.
iii. Click on Add Control Points button from the Georeferencing toolbar. Left click for selection and right click for inserting X and Y coordinates on the ground control points as per stated on the table below.
iv. Use View Link Table to inspect the total RMSE of the selected GCPs for Georeferencing. In this case it is enough to accept RMSE up to 10 for the tutorial purpose.

v. Select Rectify option under the Georeferencing toolbar dropdown list. Specifiy the following as follows and leave the rest by default; Name: ref_toposheet and Format: Grid.

vi. Click Save to execute the Georeferencing task in ArcMap.

vii. Use define Projection tool to correct the projection parameters for ref_toposheet.grd file as follows:

   a. Click on Coordinate System tab and click select from Spatial Reference Properties dialog box- select Projected Coordinate System from browse Coordinate System dialogue box – UTM- Other GCS-Adindan UTM 37N.prj-Add-OK-OK.

viii. Finally check for the correctness of ref_toposheet in new Arc Map window.

Project 3: - Data Capturing in ArcGIS (Digitization and CAD Data Conversion)

1. Digitize/extract man made or natural features as point, line or polygon from the georeferenced scanned map or the given satellite image/aerial photography.
2. Export the data you have created under task 1 into the CAD file format.

Project 4: - Data Storage and Organization (Geodatabase Building)

1. Create a personal or file geodatabase under your working directory.
2. Create feature datasets for cadaster data under the above created geodatabase.
3. Create feature classes for identified objects in the real world under each feature datasets.
4. Create an adjacency relationship/topology for each feature classes by keeping the required topology rules.

CHAPTER ELEVEN: PRODUCE DIGITAL DATA

11.1 Introduction

 Dear trainee! This chapter introduces you the basic concept on how to produce a digital data. Digital Data helps you see where and know more in a wide range of circumstances. Modern GIS technologies use digital information, for which various digitized data creation methods are used. The most common method of data creation is digitization, where a hard copy map or survey plan is transferred into a digital medium through scanning and geo-referencing capabilities.

Data conversion involves transforming data sources into digital GIS formats and organizing them within the GIS database to meet users' requirements for geospatial applications and the decision support products they produce. Primary sources used in data conversion are often paper maps and records, aerial photography, satellite imagery, global position system (GPS) and computer aided design (CAD) files. Once the data is digitalized, it has to be geo-referenced in which it defines transforming an uncorrected, raw image/maps from an arbitrary coordinate system in to a map projection (geographic) coordinate system.

One of the basic objectives for producing digital data is to extract features which aim at reducing the number of features in a dataset by creating new features from the existing ones (and then discarding the original features). These new reduced set of features should then be able to summarize most of the information contained in the original set of features.

11.2 Learning Objectives

 After completing this chapter, you will able to:

- Explain concept of digital data
- Identify digital data conversion techniques
- Perform geo-referencing task
- Identify and extract features

Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts of producing digital data; data conversion, geo-referencing and feature extraction.

_____

_____

_____

_____

11.3 Existing Data Conversion

Data conversion is an important part of the process of building a database for use with a GIS because it not only standardizes the database but is also useful for filling the gaps. These gaps can come from data needs that are unmet by the large amount of geographic information already existing in standardized digital GIS data sets available from governmental agencies and commercial vendors via the Internet.

A variety of methods are used for converting maps, records and existing digital data into a digital form that can be used by a GIS. Most of these methods convert information that appears on aerial photograph, existing maps or records to a combination of vector-based images, raster images, and text in database or text files.

Other methods are used to convert a raster image of a map or record to a vector or text based digital file. Usually there are various documents and digital data to be converted and the conversion methods used depend on the form of the original sources. The following principal forms of GIS data conversion: Map digitizing, Keyboard entry, Photogrammetry, Scanning, Automated conversion, Field Survey, Field Inventory and Data Translation.

11.3.1 Scanning and Automatic Conversion

Compared to manual digitizing, scanning is very quick and less costly. The result of scanning an existing document or map is a raster image, recording a value of dark or light for each grid cell or pixel of the scan. However, the scanned image can be displayed as the background image after geo-referencing.

The pattern recognition algorithms have been developed to recognize lines, symbols and annotations from the scanned image to the vector format. Moreover, editing and translation software, are available to convert to vector format.

A variety of scanning devices exist for the automatic capture of spatial data. However, different experiences have shown that most scanned data require a substantial amount of manual editing to create a clean data layer. Given these basic constraints, some other practical limitations of scanners should be identified. These include:

- Hard copy maps are often unable to be removed to where a scanning device is available, for example, most companies or agencies cannot afford their own scanning device, and therefore must send their maps to a private firm for scanning;
- Hard copy data may not be in a form that is viable for effective scanning, for example, maps are of poor quality, or are in poor condition;
- Geographic features may be too few on a single map to make it practical, cost-justifiable, to scan;
- Often on busy maps a scanner may be unable to distinguish the features to be captured from the surrounding graphic information, for example, dense contours with labels;
- With raster scanning there it is difficult to read unique labels (text) for a geographic feature effectively; and
- Scanning is much more expensive than manual digitizing, considering all the cost/performance issues.

A scanner is a device that captures images from photographic prints, posters, magazine pages, and similar sources for computer editing and display.



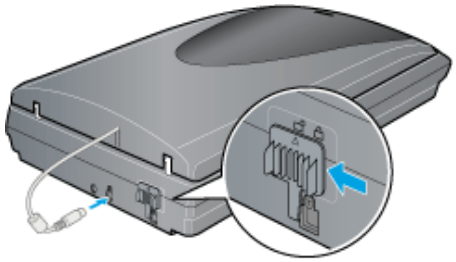
Figure 41: Scanning device

Scanning Procedures

Scanning an Image/Aerial photo comprises of the following steps.

Step 1: Turning on the scanner

1. Before turning on the scanner, make sure the transportation lock is in the unlocked position and the scanner is connected to your computer. In addition, note that the document cover's cable is connected.



2. Turn on the scanner. The Start button light blinks, and then stays green, meaning the scanner has completed its initialization.



Step 2: Placing your materials on the document table

You can scan two types of materials: reflective documents (photos or paper) or transparent materials (film). See the appropriate link below to set your materials on the document table.

Step 3: Starting the software and scanning an image

Step 4: Saving the result as an image file

After scanning an image, be sure to save it, following the steps below.

1. Select *Save As* from the *File* menu in Adobe Photoshop Elements.

2. Type a file name, select a file format, and then click *Save*. See the following section for the file formats.

File Formats

While scanning an image/photograph you need to select an appropriate image format supported by your image processing application software. The most commonly used file formats are described in the following table.

Table 5: Image file formats

Format (File extension)	Explanation
BMP format (*.BMP) (Windows only)	BMP is a standard image file format in Windows. Most Windows applications including word processor applications can read and treat images in this format.
TIFF format (*.TIF)	TIFF is a file format which is designed for data exchange between applications such as graphics software and DTP software.
JPEG format (*.JPG)	JPEG is a compressed file format, which allows a choice in compression quality. However, if the compression is too high, the image quality deteriorates. The image quality also deteriorates every time the image file is saved in JPEG. If you edit an image file after saving it, the original image should be preserved in a file format other than JPEG.
EPS format (*.EPS)	EPS is a PostScript file format. Most illustration and DTP applications are compatible with EPS.
PICT format (Macintosh only)	PICT is a standard image file format for Macintosh. Most Macintosh applications including word processor software can read and prepare images in this format.

11.3.2 Geo-referencing

Most of projects in GIS environment require geo-referencing of some raster data. Geo-referencing is the process of defining exactly where on the earth's surface an image or raster dataset was created. Many times, these coordinates are obtained by doing field surveys collecting coordinates with a GNSS or total station devices for few easily identifiable features in the image or map. In some cases, where you are looking to digitize scanned maps, you can obtain the coordinates from the markings on the map image itself. Using these sample coordinates or GCPs (Ground Control Points), the image is warped and made to fit within the chosen coordinate system.

Geo referencing can be understood as the process of conveying real coordinates to the spatial data. One of the basic advantages of geo-referencing is consistency, completeness, and reliability of referenced spatial information is simultaneously improved. It is used to establish a relationship between images and object coordinate systems. It is crucial to make satellite and aerial as well as terrestrial imagery useful for mapping.

While geo-referencing the dataset, selection of Ground Control Points (GCP) plays crucial role in keeping the exactness of features position. Some guidelines for the selection of GCPs are:

- They should be easy to confirm as representing the same geographic location (street intersection, political boundary, landmark, etc.).
- They should be spread across the image to be registered, one suggestion is to select a control point near each of the corners of the image and few throughout the interior will often work well.
- Good overlap between the two dataset is also important.
- Make sure you are clicking as close as possible to the same geographic location, zooming in can help in this process.

A. Resampling and Rectification

One of the important requirements of rectifying satellite images/aerial photographs or existing maps is the highly accurate control data, especially for rectifying high-resolution them. There are some traditional methods to obtain the control data, such as selecting control points from the proper scale cartographic maps, or, getting high accuracy control data by field survey.

Rectification is the transformation process of digital images carried out to obtain distortion free versions of the images. Transformation parameters are obtained by using ground control points (GCP) on the uncorrected raw image and their corresponding points on the map or on an ortho-rectified image. Whereas, resampling means you're changing the pixel dimensions of an image. When you down the sample data, you're eliminating pixels and deleting information as well as reducing the detail from your image. Unlikely, when you up sample data, you're adding pixels and enhancing the detail from your image. This technique will be applied by the concept of interpolation. In short, rectification is removing geometric distortion from a raster or a vector object. Rectification is usually achieved by aligning raster

features or vector coordinate positions with features on a base map or other coordinate reference framework.

Reasons for Geo-referencing and Rectification are:

- Due to inherent geometric distortions, aerial and satellite images generally need to be geo coded before they can be used in geo-scientific analysis
- Data fusion: overlay a number of different images of the same area to combine their bands containing data into a single image dataset. The individual images must be geo-referenced to a compatible coordinate system
- Comparing images for change detection
- Creating composite image maps
- Making measurements
- Mosaicking images

11.3.3 Mosaicking and Subsetting

Satellite imageries come in varying swath widths, depending on their source of acquisition. For example, the QUICKBIRD imagery is 16.5 km swath width and the SPOT imagery is just 60 km swath width. These images cover large swathes of land but in most of the cases the Area Of Interest (AOI) does not covered by a single satellite image. We need to assemble the satellite images which cover the individual parts of AOI to form a single composite. This composition process is known as *Mosaicking*, it requires very accurate radiometric and geometric corrections to the constituent imageries.

Sometimes, for management or other reasons, only a part of the entire image needs to be displayed or processed to convey the information or to represent the whole. Therefore, it becomes necessary to extract the area of interest from the images/ mosaics, and this extraction process is known as *Subsetting*. In some software packages, it also called as Extract, Clip or Cut.

11.4 Feature Extraction

Feature extraction is a process of dimensionality reduction by which an initial set of raw data is reduced to more manageable groups for processing. A characteristic of these large data sets is a large number of variables that require a lot of computing resources to process. The technique of converting geographic data either from a hardcopy or a scanned image into vector data by tracing the features is called digitization. During digitizing process, features

from the traced map or image are captured as coordinates in either point, line, or polygon format.

11.4.1 Types of Digitizing Methods

The process of representing an analogue signal or an image by a discrete set of its points is known as Digitizing. This data after conversion is in the binary format, which is directly readable by computer. There are several types of digitizing methods.

- **Manual Digitizing:** It is done using digitizing tablet. The operator manually traces all the lines from his hardcopy map and creates identical digital map on the computer. It is very time consuming and level of accuracy is also not very good.
- **Heads up digitizing** (also referred to as on- screen digitizing) is the method of tracing geographic features from another dataset (usually an aerial, satellite image, or scanned image of a map) directly on the computer screen. So, in this level of accuracy increases and time taken decreases.
- **Interactive tracing method:** It is improvement over Heads-up digitizing in terms of speed and accuracy.
- **Automatic Digitizing:** It is automated raster to vector conversion using image processing and pattern recognition techniques. In this technique computer traces all the lines, which results in high speed and accuracy along with improved quality of images

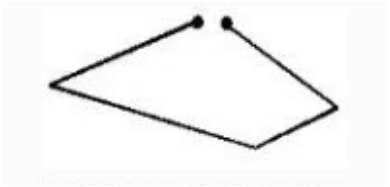
11.4.2 Types of Digitizing Errors in GIS

Since most common methods of digitizing involve the interpretation of geographic features via the human hand, there are several types of errors that can occur during the course of capturing the data. The type of error that occurs when the feature is not captured properly is called a positional error, as opposed to attribute errors where information about the feature capture is inaccurate or false. These positional error types are outlined below, and a visualization of the different methods is shown at the bottom of this section.

During the digitizing process, vectors are connected to other lines by a node, which marks the point of intersection. Vertices are defining points along the shape of an unbroken line. All lines have a starting point known as a starting node and an ending node. If the line is not a straight line, then any bends and curves on that line are defined by vertices (vertex for a singular bend). Any intersection of two lines is denoted by node at the point of the intersection.

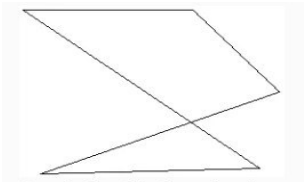
A. Dangles or Dangling Nodes

Dangles or dangling nodes are lines that are not connected but should be. With dangling nodes, gaps occur in the line work where the two lines should be connected. Dangling nodes also occur when a digitized polygon doesn't connect back to itself, leaving a gap where the two end nodes should have connected, creating what is called an open polygon.



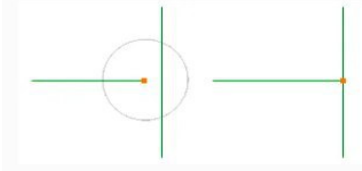
B. Switchbacks, Knots, and Loops

These types of errors are introduced when the digitizer has an unsteady hand and moves the cursor or puck in such a way that the line being digitized ends up with extra vertices and/or nodes. In the case of switchbacks, extra vertices are introduced and the line ends up with a bend in it. With knots and loops, the line folds back onto itself, creating small polygon like geometry known as weird polygons.



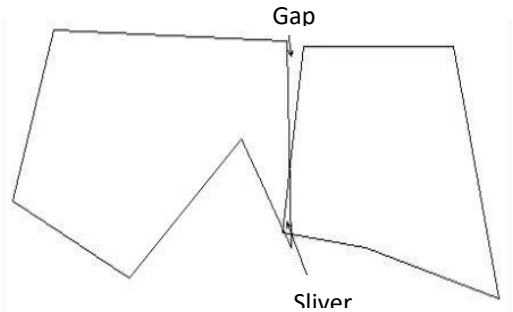
C. Overshoots and Undershoots

Similar to dangles, overshoots and undershoots happen when the line digitized doesn't connect properly with the neighboring line it should intersect with. During digitization a snap tolerance is set by the digitizer. The snap tolerance or snap distance is the measurement of the diameter extending from the point of the cursor. Any nodes of neighboring lines that fall within the circle of the snap tolerance will result in the end points of the line being digitized automatically snapping to the nearest node. Undershoots and overshoots occur when the snap distance is either not set or is set too low for the scale being digitized. Conversely, if the snap distance is set too high and the line endpoint snaps to the wrong node. In a few cases, undershoots and overshoots are not actually errors. One instance would be the presence of cul-de-sacs (i.e. dead ends) within a road GIS database.



D. Slivers

Slivers are gaps in a digitized polygon layer where the adjoining polygons have gaps between them. Again, setting the proper parameters for snap tolerance is critical for ensuring that the edges of adjoining polygons snap together to eliminate those gaps. Where the two adjacent polygons overlap in error, the area where the two polygons overlap is called a sliver.



E. Summary for Digitizing Errors

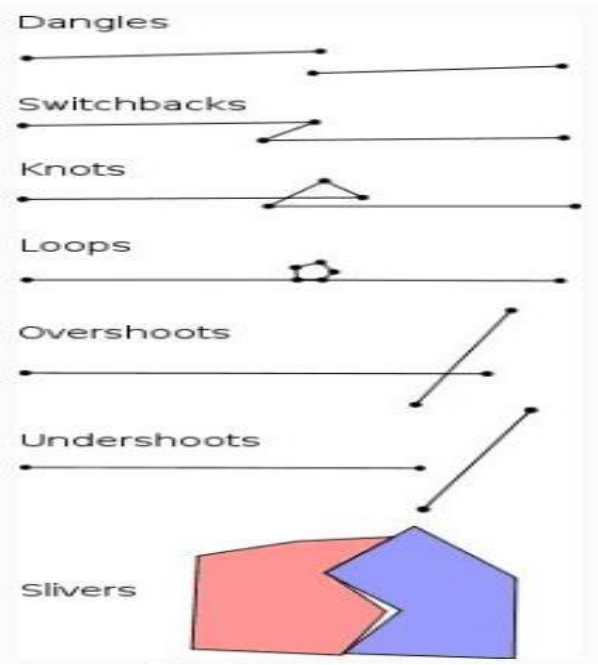


Figure 42: Types of digitizing errors

11.5 Summary

Dear trainee! Digital data can be produced from different sources. The most widely used data sources are surveying, photogrammetry, remote sensing and existing maps. To obtain those data, they need to present or exist in digital manner. Scanning is one of the methods used for the automatic capture of spatial data.

The scanned image/map must be geo-referenced for defining exactly where on the earth's surface an image or raster dataset was created and rectified to remove geometric distortion from a raster or a vector object. The features from the scanned and geo-referenced image needs to be dimensionally reduced in which an initial set of raw data can be grouped and traced by the technique called digitization in which the traced image/map are captured as coordinates in either point, line, or polygon format.

11.6 Self-Check Exercise

Short Answer and Fill the Blank Space Items

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

1) Explain digital data conversion techniques.
2) What are the procedures to be followed during scanning?
3) What is geo-referencing? What are the criteria for selection of control points during geo-referencing?
4) The process of converting geographic features on a paper map into digital format is called _____?
5) List and elaborate the types of digitizing methods and digitizing errors.

CHAPTER TWELVE: PRODUCE BASE MAP

12.1 Introduction

Dear trainee! This chapter introduces you how to collect, interpret, sketch, draw, input, organize and output base map using surveying equipment and GIS software. Ground surveying techniques and the technology of GIS has developed so fast over the past few decades that they are now accepted as essential tools for the production of base map and effective use of it. A base map is the graphic representation at a specified scale of selected fundamental map information; used as a framework upon which additional data of a specialized nature may be compiled.

There are two ways in which base maps may be produced: ground survey and remote sensing data. Ground survey data can be collected using surveying instruments like total station and GNSS receiver. But, the remote sensing data can be collected without physical contact between the sensor and the target. Aerial photography and satellite imageries are the remotely sensed data.

The quality of base maps as an output from ground survey is much dependent on the improved quality of the survey work. Improved quality of surveying increases the readability of base maps. The instrumentation, procedures and standards involved in making ground survey have considerably improved and results the enhancement in the precision of observation and accuracies of the ground survey. In turn, the greater output of the basic source data to be used for making base map has accelerated the production of the base maps with high quality.

12.2 Learning Objectives

After completing this chapter, you will able to:

- Describe basic concepts of base map preparation
- Identify basic features require for base map preparation
- Perform ground surveying for identified features
- Develop and present a base map.



Dear trainee! Before reading the following section, take ten minutes and try to discuss on how to prepare a base map.

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12.3 Planning for Base Map Preparation

A digital base map is a primary element for developing a Geographic Information System for organized urban development which serves as a reference map on which you visualize geographic information. Base map forms the framework for overlaying other relevant details related to infrastructure, land base, utility networks, property details etc. to create any intelligent GIS map. An accurate base map can lay the foundation for efficient infrastructure planning, monitoring and management. Our systematic approach for base map preparation ensures accuracy and effectiveness. The preliminary work to be done prior to starting everything to produce base maps such as; field surveying to collect data for base map preparation is planning.

The project has to be planned to an appropriate level of details. Its main purpose is to set time, cost and resources adequately to estimate the work needed and to effectively manage risk during project execution.

The production of base map project planning generally consists of:

- determining how to plan (For example, by level of detail or rolling wave);
- developing the scope statement;
- identifying deliverables and creating the work breakdown structure;
- identifying the activities needed to complete those deliverables and networking the activities in their logical sequence;
- estimating the resource requirements for the activities;
- estimating time and cost for activities;
- developing the schedule;
- developing the budget;
- risk planning;

- Gaining formal approval to begin work.

The planning should comply with the organizational legislation and standards, which workers of the respective organization are to be governed by and should obey it. Organizational procedures are part of the institutional legislation and standards guiding operational aspects. These procedures are very specific so as to able to perform the required work as per the plan.

12.4 Base Map Preparation

12.4.1 Office Survey

Before starting the actual base map preparation work, there are some common activities to be done in the office. While planning to go to survey and make a map using the obtained survey data it is required:

- To assess the availability of surveying and mapping instruments and software first. Your packages (set of equipment) should be fulfilled; this may include checking the status of installed software for the survey instruments and workstations/computers, batteries, required accessories, etc. which are necessary for accomplishing the planned land survey and making of the base map. You need to check out all the instruments to be employed for their safety and operability.
- To organizing resources: Once the plans are formulated, the next step is to organize the men and material in order to accomplish those plans. Organizing is a process through which the firm establishes its structure and determines the authority, responsibility and accountability of each member in relation to the job. Thus, organizing involves
    - Giving each member a specific task
    - Establishing departments and divisions
    - Delegating authority to the members
    - Establishing channels of authority and communication
    - Creating a system to coordinate the works of the members
    - to managing human resources

This function deals with the creation and maintenance of human resources through employment, compensation, benefits, training and development, and industrial relations measures. It aims to put in place Human Resource (HR) policies in order to deal with wage fixation, working conditions, and promotional opportunities for prospective employees. The steps involved in the staff function are:

- Determining the type of people to be hired
- Recruiting prospective employees and selecting the best ones from them
- Compensating the employees
- Training and developing the employees
- Setting performance standards and evaluating the employees' performance
- Counseling the employees

12.4.2 Field Survey

Before performing base map features survey, you need to check out your packages (set of equipment) and it should be fulfilled; this may include checking the batteries, the required accessories, etc. which are necessary for accomplishing the planned land survey. You need to check out all the instruments to be used for their safety and operability. In addition to this selection of crew members should be done wisely and orienting them about the project is very important. Base map features survey generally involves the following steps:

1. Project Specifications and plan

This involves the definition of the specifications including the products to be generated, potential users' needs, required accuracies, data type selection (map content), delivery format, schedule and costing.

2. Calibration of surveying instruments

The calibration of the surveying instruments must be carried out to ensure proper adjustment of the instrument before conducting any surveying measurements on the ground.

3. Site reconnaissance

Conducting site reconnaissance is the key to any project and the most important in the series of survey. The term reconnaissance means the first inspection of the target area interims existing control points, possible sites, far new observation station as the permanence marking of those stations' dictation of possible obstacle and possible solution to overcome them. It has vital significance in establishing control points network (surveying base) at this stage reconnaissance survey area to be mapped this means one has got some ideas regarding the mental map about the terrain and feature of the ground.

4. Reference point selection

All planimetric measurements are carried out through the network of control points. It could be made by traverse, triangulation or trilateration methods. The provision of ground control points is helpful based on which data about features is collected referencing it and provides a means of linking the surveyed data to ground details.

Two types of control points are needed to position map features accurately. Horizontal control used to identify the location of selected features, establish correct scale and map orientation by allowing accurate positioning of the map's features. The other is vertical control which allows the determination of elevation of selected points for the correct placement of a topographic maps contour.

5. Data collection sheet preparation

It is helpful for recording the values of measurements obtained during the real field data collection.

6. Perform base map features survey (Field data collection)

This is the step at which ground survey is conducted and measurements of the selected data types have to be gathered by the use of survey instruments.



Figure 43: Field surveying

12.4.3 Organize Surveyed Data

Survey data organization and preparation is the crucial step that follows the collection of any survey data which aims to make the acquired surveyed data fit for use. It includes the process of manipulating or transforming the raw data into meaningful results which can be analyzed in any geospatial software tool, and ultimately presented in a way that answers the intended project activity. The raw data collected on the field and stored in the data collection sheet need to be readjusted and organized in the manner suitable for the desired application. For example, if the data collected with total station instrument, it needs to be downloaded to computer and the coordinates should be arranged using tabular formats (station, Easting, Northing, Elevation and Description). On the other hand, the surveyed data collected with GNSS surveying instruments, we will use their own processing (software South Geomatic Office (SGO) for South Galaxy G1 Plus GNSS receivers) or we have to convert the raw data to Receiver Independent Exchange format (RINEX) format to conduct the processing with

any software. In this process, the software will download all of the observation files into one subdirectory on the computer. This directory is part of the project's directory. As the observation files are downloaded, special attention should be given to checking station information that is read directly from the file with the site log sheets. Catching incorrectly entered items such as station identification, antenna heights, and antenna offsets at this point can greatly reduce later problems during processing.

12.5 Develop and Present a Base Map

Mapping involves a number of functions including identification, field verification and methods for data capture and storage, generation of map products in digital formats, procedural documentation and application of technology.

Once field data is gathered, adjusted and validated the next step is starting to prepare the base map. Validating the survey data before starting the real mapping work is important for the better output and it needs to be validated according to the specifications set. Then the adjusted data can be imported using the selected software (ArcGIS) and the map will be produced referencing the sketches made while conducting base map feature survey.

Verification of Map Features

This stage involves verification of map features in the field. A field check is necessary to ensure the completeness of features representation in the project area, exactness of the features represented on the base map as compared to the real features on the ground, etc. For example, sometimes features which may appear seasonally in the real world are represented as they are permanent features, features which exist during the field data collection may not exist this time, information about the holding boundaries while collecting data may be changed either expanded or narrowed at the time you need to compile and print out your map, and so on. These needs to be updated on the base map before the compilation and printing out the map.

Another important job in the field is the verification of place names (geographic names) and political boundaries. This often requires looking at historical records and talking to local residents and consulting the administration of the respected project area.

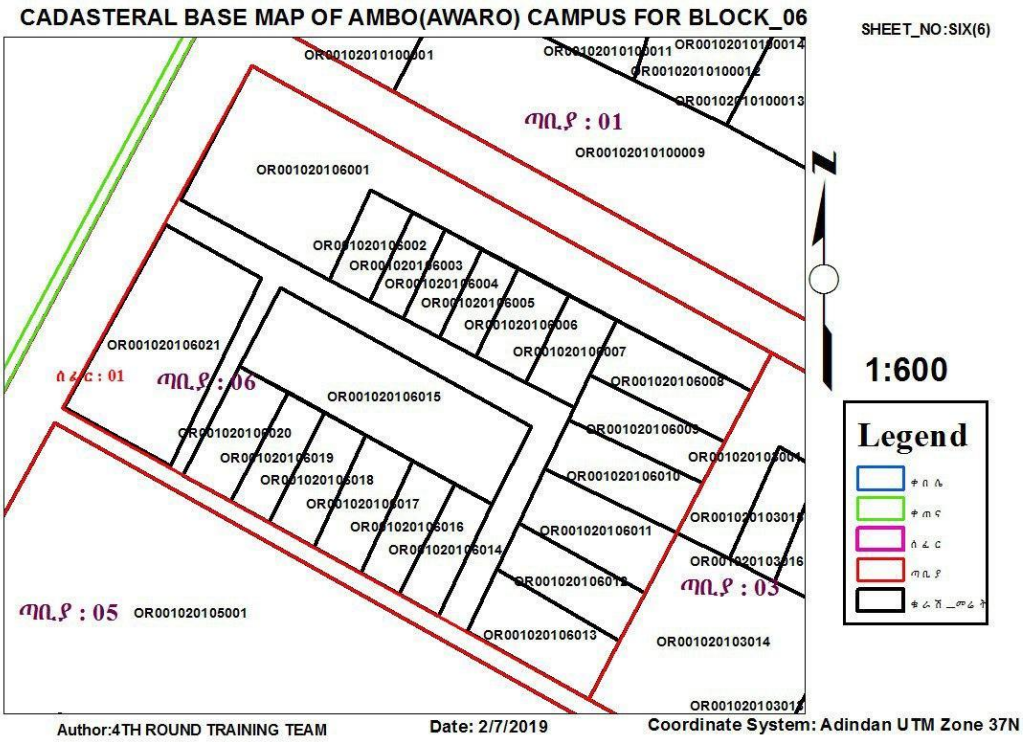


Figure 44: Sample cadastral base map

Quality Review

This is the final stage in which all the defects identified during the field verification in the draft work of the base map will be removed and corrected as well as the map becomes ready for printing.

Before the final printed maps or digital data are accepted, it is always important to conduct a quality test. This ensures the adherence to specifications, consistency and accuracy of both printed map and digital data. Products/work outputs and work performance are checked against organization quality standards and specifications. Work outputs and performance delivered are evaluated using the appropriate evaluation parameters and in accordance with organization standards. The quality team fixes the quantity of quality measures with their respective reference and score as shown below. Causes of any identified faults are identified and corrective actions are taken in accordance with organization policies and procedures.

Cadastral Base Map Content

- Administrative boundaries,
- The location of major natural and manmade features such as roads, water features, hedge lines, elevation etc.
- Parcel boundaries,
- Building footprints,
- Permanent survey control points,
- The scale of cadastral base map,
- Northing,
- Legend of the map,
- Author of the map, Date the map was prepared,
- Map projection,
- Title/ Sheet Number

12.6 Summary

Dear trainee! A base map is the graphic representation at a specified scale of selected fundamental map information; used as a framework upon which additional data of a specialized nature may be compiled. Base map provides a primary medium by which the locations of cadastral parcels can be related to the geodetic reference framework; to major natural and man-made features such as bodies of water. roads, buildings, and fences; and to municipal and political boundaries. The base map also provides the means by which all land-related information may be related graphically to cadastral parcels.

Base map can be prepared from either ground survey or remotely sensed data. Due to cost and time factor, most base maps are still produced using remote sensing methods. But with much better quality and accuracy, it is also prepared using ground surveying even though it is costly and time consuming. The production of base maps using ground surveying requires the knowledge of some procedural steps and using of appropriate instruments and software. These are producing project specification and setting plan, calibration of survey instruments, site reconnaissance, reference point selection, data collection sheet preparation, performing base map feature survey, organizing and validating data, appropriate software selection for instance GIS, entering into the actual map production, field verification, and map compilation and finally quality checking.

12.7 Self-Check Exercise



True False and Short Answer Items

Instruction 1: Write "True" if the statement is correct and "False" if it is incorrect.

1) Photogrammetric technique is the only means of base map production.
2) One of the reconnaissance works conducted for surveying is checking for the established survey control point's existence.

Instruction 2: Explain briefly.

1) What is the advantage of ground surveying over remote sensing?
2) List down the overall procedural steps of base map production using ground surveying and GIS.
3) What the content of cadastral base map.

CHAPTER THIRTEEN: IDENTIFYING LAND AND PROPERTY BOUNDARY

13.1 Introduction

Dear trainee! This chapter introduces you about concepts of identifying land and property boundary. The fundamentals of land ownership and land boundaries date back to the very roots of civilization, and matters relating to possession and control (ownership) of land are well documented in historical records. Indeed, the territorial control of land has been a fundamental issue in the rise and fall of empires throughout history (for example, the Roman Empire) and the cause of a great number of the world's wars since the beginning of civilization.

In particular, our land tenure (manner of possession) system is fundamental to, and provides investor and community confidence in; development planning, economic growth and sustainability social stability through housing and employment, financial security in economic development and property markets, natural resource and environmental management and sustainability. Land ownership systems also underpin, government policy making and program delivery, taxation, land administration and the distribution of electoral boundaries, land use management and regulation.

Parcels are not simply subdivided and consolidated as we need. They are required to meet some basic features and standardized characteristics. They must fulfill the requirements set to do so. This requirement for sub dividing or consolidating parcels varies from country to country and even from town to town with in a country due to the fact that the plan consent varies from place to place that is set based on the development level of that particular town/place.

13.2 Learning Objectives

After completing this chapter, you will be able to:

- Describe the concept of parcel subdivision and consolidation
- Identify boundary delineation procedures
- Perform subdivision or consolidation in a given parcel

Dear trainee! Before reading the following section, take ten minutes and try to

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13.3 Parcel Subdivision and Consolidation

Subdivision is the act of dividing land into pieces that are easier to sell the property on it or otherwise develop. Subdivision is a procedure used to divide property into smaller areas of land called parcels. Normally, a subdivision is needed in order to sell the property on it, lease, or finance the newly created parcels. Parcel subdivision is the process by which a single parcel of land divided into two or more parcels, each to be given a separate title. For any parcel to be subdivided the following requirements and general provisions should be considered:

Any landholding may be subdivided in to two or more holdings when,

- the landholding is first registered by the land holding registering institution
- the registered landholding is not restricted by any means and legal body
- the creditor has notified his consent in writing for the sub-division of the registered landholding which is subjected to surety and attachment
- If an authorized body ascertains the sub-division of the parcel is in accordance with the required size and form of currently enforced urban plan.

When the subdivision creates a need for a new contract to protect the interest of public since land belongs to the state and the public, in order to implement this contractual agreement shall be received from the right providing institution concerning the subdivided holding. The newly created right, restriction and responsibility of the sub-divided holdings shall be registered for each holding separately pursuant to the contract received from the right providing institution. Whereas,

Parcel consolidation is a sequence of operations designed to re-organize two or more land parcels in an area and regrouping them into merged holdings with more regular form and with improved access. In this case a separate title each parcel has before consolidation is also changed and the newly consolidated holdings should hold a single title.

The following general provisions shall be applicable, if there is a need to consolidate two or more adjacent landholdings and create a single holding:

a) When it ascertained that the holdings to be amalgamated are registered and the right, restriction and responsibility of the landholdings are similar,
b) When the body authorized to protect the urban plan and land use right provides a guarantee that the amalgamation of adjacent holdings would not create any problem in view of the urban plan and land use and other related laws.
c) When there is no a road, river, stream, vacant urban land or landholding registered under the name of another person between the holdings to be amalgamated.
d) If one or all of the holdings to be amalgamated have been acquired through sale, donation or inheritance, transfer of title shall be carried out first.
e) If old possession and lease holding are to be amalgamated, the right providing institution shall first convert the holdings tenure system in to a lease system and shall be submitted after the conclusion of the contract.
f) The amalgamated holding shall not be registered in an injunction registry as subjects of surety, attachment and injunction
g) If the holdings to be amalgamated are under the surety, attachment, injunction registry subject to surety or attachment, the consent of the guarantor or who registered the attachment shall be secured.
h) If the holdings acquired through lease are to be amalgamated details of the right, restriction and responsibility shall be prepared by the right providing body afresh; separate and prepare such right, restriction and responsibility for registration and to register them thereof.

13.4 Updating Parcel Data

Cadastral information is only useful if it is kept up-to-date and is legally binding. It is therefore essential to ensure that the information (data relating to property boundaries, buildings, addresses and various other details) must be kept up to date in accordance with the applicable legislation. Cadastral information updating refers to record the parcel information change in the real world into the land register within a specified time period. In another words, cadastral information updating is the process of changing the existing information to the latest new information usually by adding something new. During the updating process, there may be modification of spatial and/or non-spatial information related to a specific parcel.

13.5 Boundary Delineation Procedures

All demarcation activities should be in line with the legislation and organizational guidelines. Before conducting the actual boundary demarcation, the demarcation team should conduct reconnaissance and follow all demarcation procedures.

13.5.1 Reconnaissance

Reconnaissance is the field visit and inspection which the surveyor makes in the area he/she is to survey. Reconnaissance enables the surveyor to have an overall view of the type of terrain he/she is to work in, and to assess more correctly the types and magnitude of problems to be encountered. On the basis of such assessment the surveyor is able to: determine a suitable plan of the work; estimate the personnel, materials and time requirements; conceive the most appropriate techniques to execute the survey and thus derive reasonable cost estimates for the survey. A well reconnaissance job is a job half done, for thereafter the surveyor is well set to plan, organize and expeditiously undertake the job efficiently and with confidence.

13.5.2 Demarcations

Demarcations after the reconnaissance, the work of setting out block boundaries can start. A block is usually an area which is bounded by roads on all, or most of its sides. It may consist of one large plot or several plots of medium sizes or many small plots. In a given layout, therefore there will be many such blocks. Block demarcation is followed coordination of selected block corners, computations, checking of computations and lastly setting out of the individual plots.

Procedures of Boundary Demarcation

Cadastral surveys are surveying whose aim is to demarcate, create, measure, define/describe and record the position of boundary land as property. Their ultimate purpose is being to give unambiguous, graphical, numerical or descriptive information relating to location, extent, shape and size of land parcels. Such information is vital in the support of a register of titles for land ownership and transfer of rights in land.

- **Survey Planning:** The municipality that is conducting the survey make plan by contacting and adjusting with organizations concerned.
- **Hold a Briefing for Local Residents:** The municipality official holds a briefing on the survey's substance and necessity for local residents

- **Confirmation of Boundary (Parcel Investigation):** Landowners clarify their own land boundaries for Cadastral Survey. The municipality official in charge visits the actual place referring to data based on old recorded map etc. The landowners concerning the boundary confirm their land boundaries with mutual agreement. And also, municipality official investigates landowner, parcel number, type of land and so on. Put piles along the boundary after the confirmation. The piles display the settled boundaries for each parcel of land. The Parcel Investigation is the important step of Cadastral Survey.
- **Boundary Survey:** Settle the topographic control point, which is the basic reference of survey, and survey to determine the position on earth for each parcel following some process by surveyor. After determining the position for each parcel, surveyors make the accurate map (cadastral map) based on each result and measure the dimension.
- **Making cadastral record:** Integrating results of the Parcel Investigation and Boundary Survey, municipality official makes a draft of cadastral record.
- **Confirming the results of Cadastral Survey:** The record and map are displayed to the public for some days at the municipality office. A person who find any mistakes on the results may report it. Record and map confirmed here becomes the final product of the Cadastral Survey.
- **Submit the product of Cadastral Survey to registry office:** The copies of Cadastral Survey product (Cadastral map and Cadastral record) will be submitted to registry office. Land registry book is revised according to the cadastral record and replace old registry map with new cadastral map officially kept at registry office. Registry office utilizes the product of Cadastral Survey as a material of Immovable Registration in the future.

13.6 Summary

Dear trainee! Parcel boundary lines define the extent of the legal limits of ownership of any parcel of land. Parcel subdivision and consolidation alter the parcel boundary as a result of many legal reasons. Parcel subdivision is the act of dividing parcel into pieces that are easier to sell the property on it or otherwise develop. A plan of subdivision allows an applicant to divide land into two or more new parcels of land that can be disposed of separately. The only new parcels that can be created by a plan of subdivision are lots, roads, reserves or common property etc. Standards for subdivision and consolidation vary on a county-by-county basis, but generally, records are researched and there is a field visit to locate existing boundary evidence. Parcel consolidation is “a sequence of operations designed

to re-organize two or more land parcels in an area and regrouping them into merged holdings with more regular form and with improved access. To perform parcel subdivision the parcel should be registered, not restricted by any means and legal body, if there is an interest on the parcel by a third body that third body has to notify his consent, comply with the urban plan as a requirement. And for the parcels consolidation/merging first of all the parcels to be consolidated should be registered, should get guarantee from the urban plan, the parcel shouldn't be separated by any feature like road and they should share the same boundary, the parcel has the same right type, etc.

13.7 Self-Check Exercise



Short Answer Items

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

1) What is the difference between parcel subdivision and parcel consolidation?
2) Explain how the parcel subdivision and consolidation can be updated?
3) What are the procedures for boundary delineation?

CHAPTER FOURTEEN: APPLYING LAND AND PLANNING LAW TO SURVEYING

14.1 Introduction



Dear trainee! This chapter introduces you the basic concept on how to mark out urban structures and identify urban lots, parcel boundary demarcation and the improvements thereon. Remark survey carried out by local government or authorized land surveyor to re-establish an existing boundary in accordance with the legislations, including marking, directly or by the use of reference marks on the ground. Survey marks placed by a surveyor to define the boundaries or corners of a nominated parcel of land. A surveyor's field notes define those marks placed in the course of the survey.

Azimuth is the angle between a celestial body (sun, moon) and the North, measured clockwise around the observer's horizon. It provides the direction of a given land and land related features. Identification is a survey that is required for the purpose of identifying a parcel of land and the related existing buildings and improvements. Identification Surveys are typically requested when buying or selling property in order to establish the location of the property boundary, determine possible encroachments by or upon the land, locate the buildings with respect to the boundaries and investigate any easements, restrictions or covenants over the land that is noted on the title.

14.2 Learning Objectives



After completing this chapter, you will be able to:

- Explain the concept of azimuth
- Conduct remark and identification survey
- Prepare comprehensive land surveying report

Dear trainee! Before reading the following section, take ten minutes and try to explain the basic concept of how to mark out parcels and urban structures.

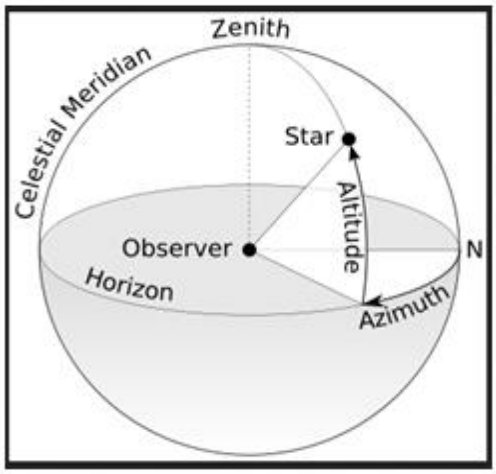
14.3 Azimuth Determination for Land Surveying

14.3.1 Basic Principles of Azimuth

Azimuth is the direction of a celestial object, measured clockwise around the observer's horizon from north. So, an object due north has an azimuth of 0°, one due east 90°, south 180° and west 270°. Azimuth and altitude are usually used together to give the direction of an object in the topocentric coordinate system. On other words, the azimuth is the angle formed between a reference direction (in this example north) and a line from the observer to a point of interest projected on the same plane as the reference direction orthogonal to the zenith.

In land navigation, azimuth is usually denoted as alpha (α) and defined as a horizontal angle measured clockwise from a north base line or meridian. Azimuth has also been more generally defined as a horizontal angle measured clockwise from any fixed reference plane or easily established base direction line. Today, the reference plane for an azimuth is typically true north, measured as a 0° azimuth, though other angular units (grad, mil) can be used. Moving clockwise on a 360-degree circle east has azimuth 90°, south 180°, and west 270°.

Azimuths or compass bearings are stated in a system in which both north or south can be the zero, and the angle may be measured clockwise or anticlockwise from the zero. For example, a bearing might be described as "(from) south, (turn) thirty degrees (toward the) east" (the words in brackets are usually omitted), abbreviated "S30°E", which is the bearing 30 degrees in the eastward direction from south, i.e. the bearing 150 degrees clockwise from north. The reference direction, stated first, is always north or south, and the turning direction, stated last, is east or west. The directions are chosen so that the angle, stated between them, is positive, between zero and 90 degrees. If the bearing happens to be exactly in the direction of one of the cardinal points, a different notation, e.g. "due east", is used instead.



North	0°	South	180°
North-northeast	22.5°	South-southwest	202.5°
Northeast	45°	Southwest	225°
East-northeast	67.5°	West-southwest	247.5°
East	90°	West	270°
East-southeast	112.5°	West-northwest	292.5°
Southeast	135°	Northwest	315°
South-southeast	157.5°	North-northwest	337.5°

Figure 45: Azimuth determination

14.3.2 Procedures for Azimuth Determination and Calculation

To determine of azimuth of a given feature, the following steps shall be followed.

- Use the compass to determine north.
- Point the compass in the direction of the object (Turn the compass to point in the direction with the azimuth you want to measure)
- Locate the North Star, Polaris. ...
- Find the distance between the North Star and the object. ...

Mathematically, azimuths can be calculated using the following formula. If the azimuth of a given line is not known, it can be calculated from the two coordinates of a line. Assume that there are two pints: point A (X_1, Y_1) and point B (X_2, Y_2);

$$Azimuth\ (AB) = tan - \frac{X2 - X1}{Y2 - Y1}$$

After calculating the azimuth, one of the two coordinates can be calculated. This can be done; coordinate of B;

$$X_B = X_A + L\text{Sin}\alpha$$

$$Y_B = Y_A + L\text{Cos}\alpha$$

14.3.3 Assumed Azimuth

In land surveying, there are conditions in which azimuths can be determined and fixed through assumption. The assumptions of azimuth origins as a field expedient until the required data are available. This type of assumption can take any directional orientation. But the associated problem is a map developed with this assumption cannot be aligned with national or international grids.

14.4 Undertake a Mark-Out Survey

14.4.1 Direct and Indirect Determination of Coordinates

In land surveying, there are mechanisms by which you can calculate coordinates: direct and indirect approaches. By direct coordinate calculation means when angles, distances and azimuths are measured with theodolite and calculated coordinates are performed with manual. This approach is somewhat outdated with the advancement of technologies that brought total station to replace theodolite. The indirect approach of coordinate calculation is performed with total station instrument where the instrument is installed with software that can compute coordinates from the measured angles, azimuths and distances. This approach has made easier the work of coordinate determination.

14.4.2 Traverse and calculations from the street azimuth and side fix

Traverse is a method in the field of surveying to establish control networks. It is a method of surveying in which length and direction of lines between points on the earth are obtained by or from field measurements and are used in determining positions of the points. Traverse measurements in the field, will measure; the lengths of each traverse line and the bearing of each line.

Traverse networks involve placing survey station along a line or path of travel, and then using the previously surveyed point as a base for observing the next point. Traverse and calculations from the street azimuth and side fix are made to set out rear corners by indirect means.

There are two types of traverse: (a) closed and (b) open. In both cases the traverse consists of a network of stations, marked as A, B, C… and traverse lines joining the stations together. The purpose of the traverse is to establish the co-ordinates of each station starting from a single station of known co-ordinate which we have taken to be station A. Traversing consists of fieldwork and office work principles. The fieldwork comprises reconnaissance, measurements of the traverse length and the horizontal angle between adjacent traverse lines. The direction (Azimuth/Bearing) of one of the traverse lines from the meridian should also be determined.

14.4.3 Re-mark Survey

Remark (or Repeg) survey means a survey required only for the purpose of reinstating an existing title or boundary, including marking, directly or by the use of reference marks, that title or boundary on the ground. Survey marks placed by a surveyor to help define the boundaries or corners of a nominated parcel of land. A surveyor's field notes define those marks placed in the course of the survey. These surveys are carried out by authorized land surveyors to re-instate and re-mark your certificate of title boundaries and title corners in accordance with land surveyor's legislation. This legislation requires the surveyor to connect into map grid of local coordinates and prepare a Re-mark Plan.

The survey must be undertaken in accordance with accepted Survey Methodology and results in a Plan being produced. If instructing firstly have a look at those links relating to survey fees, terms of contract and survey methodology.

Matters that affect the boundary redefinition process are (but not restricted to):

- The age and proximity of the most recent adjoining surveys and the survey marks that may or may not still exist. The older the most recent survey, the less likelihood that survey marks from that survey still exist. Unfortunately, the existence of such marks cannot be confirmed until the survey is under way. In many cases there are no marks left in the vicinity. This then requires the surveyor to survey to out-lying corners to either find additional old marks or to utilize other further afield evidence to satisfy himself the land that his client is entitled to.
- The slope of the land.
- The extent and thickness of the vegetation. Note that surveys by GNSS require reasonably clear access to the sky.
- The proximity or otherwise of Map Grid of survey control marks. These are red coloured 'brass plaques' placed at random throughout the state.
- All surveys that involve the placement of survey marks must be registered at the Lands Titles Office by means of the preparation of a Plan and lodging of same.

We have been gradually working towards a situation where now with such 'tools' as GPS (note not always the total solution) we spend 50% of the time in the field and the remainder in front of the computer. Boundary Surveys and solutions by GPS require very good preparation and uploading of resultant data to the GPS Data Recorder. GPS is simply another,

quicker way of measuring. It does not supply a magical solution to boundary issues but allows the surveyor to more quickly seek solutions in the field, if he\she is well prepared. His\her expertise is still required to form an opinion of the boundary entitlements in accordance with accepted practice.

Some regulations that come into play when boundaries are under survey are:

- The surveyor must form an opinion of the location of the end of a boundary line if attempting to place a mark along the boundary line (i.e. a line peg).
- The surveyor must connect into adjoining boundaries by their surveys or the best available evidence to ensure that adjoining properties maintain their entitlements.
- Best available evidence may mean, due to lack of information or evidence that the surveyor must measure further afield to come to a 'best' opinion. Note that 'further afield' can mean either further 'away' in distance or further back in time and age of surveys to come to a considered opinion.

In the absence of evidence to the contrary the following is the order in which different methods of definition should be adopted, subject to abnormal conditions:

- Natural features, such as rivers, cliffs etc.
- Original marking of grant boundaries, road surveys, alignment or resumption surveys.
- Monuments and abutments.
- Original marking of private surveys.
- Occupations.
- Measurement.

Measurement is a 'tool' used by the surveyor to assist in forming his\her opinion of a boundary. Once he\she has formed an opinion the surveyor then must mark and reference his\her survey and provide appropriate measurements on a plan lodged with the Recorder of Titles. The need to undertake new survey measurements to a certain accuracy (as set down by legislation) and prepare a plan is to ensure that in future, the then surveyor can rely on those measurements and plan to assist in redefining the relevant boundaries.

14.4.4 Identification Survey

Identification survey is a survey required for the purpose of locating and identifying a particular title of boundary, including the relationship of improvements to that title of boundary, but not requiring the boundary to be marked. It confirms that what you have seen

on site is reflected in the title you purchase. It clarifies the relationship between the improvements (fences, buildings, sheds, driveways etc.) at the location with the title boundaries. It does not redefine the boundaries of the site (the boundaries are not certified as correct for legal purposes) nor provide level or contour information, it gives a general relationship between the boundaries and the improvements. It does not result in survey marks, boundary or corner pegs being placed and should not be used as the basis of a building or structure set-out. Some common reasons to conduct identification surveys are:

- Marking of boundaries for new fencing or building work;
- Checking for building encroachment issues;
- Locate the buildings with respect to the boundaries
- Resolving disputes with neighbors over land boundaries; and
- To confirm the ownership of improvements on and close to boundaries.
- Investigate any easements, restrictions or covenants over the land that are noted on the title

All identification surveys are subject to survey methodology and the rules of boundary re-establishment which can result in substantial increase in fees. Older surveys, travel, slope and vegetation effect survey costs. Occasionally, there is a need to lodge an Identification Survey as a SIO (Survey Information Only Plan) to register any survey matters that need to be available to the Register. This generates additional costs.

14.5 Survey Report

Report is a document containing information organized in a narrative, graphic, or tabular form, prepared on ad hoc, periodic, recurring, regular, etc. manner. First of all, you need to consider your brief very carefully and make sure that you are clear who the report is for and why you are writing it, as well as what you want the reader to do at the end of reading: make a decision or agree a recommendation, perhaps.

Survey reports should be an important part of documenting surveying activities. Survey reports provide a flexible format to provide a complete, comprehensive, and clear narrative of the surveyor’s opinion. The report provides a methodical method to document the background information and the analysis performed. The report also provides a narrative of the services performed, limitations, problems, concerns, and recommendations. The main purpose and uses of survey reports are to:

- provide more detail and information

- coerce surveyor to do a better job with analysis and justification
- force organization
- provides a ready source of information for others
- provide an organized archival source for the surveyor



Content of Survey Report

- Firm/client/project
- Purpose
- Specifications/standards
- Survey or site related information (title concerns, wetlands, etc.)
- Record location
- Azimuth
- Declinations
- Tolerances and calculations
- Conduct of the survey/actions taken
- Comments on reliability •
- Problems encountered
- Analysis
- Results
- Concerns
- Recommendations
- Revised parcel description

14.6 Summary



Dear trainee! Surveyors express angles in several ways. When specifying directions, as is done in the preparation of a property survey, angles may be specified as bearings or azimuths. An azimuth is an angle between 0° and 360° measured clockwise from North. A bearing is an angle less than 90° within a quadrant defined by the cardinal directions. "South 45° East" and "135°" are the same direction expressed as a bearing and as an azimuth. Direction calculations can be performed in either a clockwise or counter-clockwise manner about a traverse. There are specific rules for calculating in either direction. To calculate azimuths clockwise around a traverse: Subtract the interior angle from the back azimuth of the preceding line. To calculate azimuths counter-clockwise around a traverse: Add the

interior angle to the back azimuth of the preceding line. Azimuths may be referenced to true North, to magnetic North, to an azimuth taken from plans, or from an assumed direction. In addition, azimuths may be forward or backward.

Remark surveys accurately relocate the title corners of a property, replacing pegs where the originals are found missing or in poor condition. A remark survey does not change your title, but re-establishes the title boundaries based on evidence found on the site. Identification surveys are carried out to define and establish property boundaries. It is important for all property owners to ensure that their land ownership rights are protected. It also identifies and locates structures and improvements on a parcel of land. It shows the distances from relevant structures to the boundaries of that land. Existing easements, covenants and restrictions are identified and any encroachments documented. The basic difference between a remark survey and identification survey is that a Remark Survey places pegs that can be used for construction, whereas an Identification survey shows the relationship between the improvements (fences, buildings etc.) and the boundaries, no pegs are placed.Survey reports should be an important part of documenting surveying activities. Survey reports provide a flexible format to provide a complete, comprehensive, and clear narrative of the surveyor's opinion.

14.7 Self-Check Exercise



Short Answer Items

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

1) Discuss and explain how azimuths can be determined to start survey measurement.
2) Explain the difference between remark and identification survey.
3) List and explain the reasons to conduct identification survey.
4) What are the requirements for preparing comprehensive survey report?
5) Describe laws and regulations which are required for land surveying activities.

CHAPTER FIFTEEN: RESOLVE DISPUTE THROUGH NEGOTIATION

15.1 Introduction

Dear trainee! This chapter introduces you the basic concept of dispute and alternative dispute resolution mechanisms. Dispute is an inevitable and pervasive aspect of human life. It occurs between two individuals, groups, organizations, communities and nations and even two regions in the form of disagreement, grievances, problems and tensions. By extension, this poses a question of when and how the conflict is resolved since a delay in addressing conflicts may lead to severe instabilities in the community and henceforth the political system of a given society. Conflict resolution is one of the serious challenges of governance and as a result, legitimacy of conflict management and resolution mechanisms is critical. Adequate approaches of land conflict management are required for peaceful political, social, and economic use of land.

There are several methods available for resolving disputes between two parties. Dispute Resolution (DR) is used to define the full range of dispute (claim) resolution mechanisms, which includes negotiation, mediation and arbitration. Negotiation, which is a dialogue between two or more people or parties, intended to reach an understanding, resolve point of difference, or gain advantage in out-come of a dialogue, to produce an agreement upon courses of action, to bargain for individual or collective advantage and to craft outcomes to satisfy various interests of two parties involved in negotiation process. Negotiation is a process where each party involved in negotiating tries to gain an advantage for themselves by the end of the process.

15.2 Learning Objectives

After completing this chapter, you will able to:

- Explain the concept of disputes and their causes
- Identify dispute resolution mechanisms
- Describe how negotiation resolve different disputes
- Evaluate the success of negotiation as dispute resolution mechanism



Dear trainee! Before reading the following section, take ten minutes and try to discuss dispute and dispute resolution mechanisms in your organization.

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15.3 Causes and Consequences of Conflict

Conflict is a social fact in which at least two parties are involved and whose origins are differences either in interests or in the social position of the parties. Consequently, a land conflict can be defined as a social fact in which at least two parties are involved, the roots of which are different interests over the property rights to land: the right to use the land, to manage the land, to generate an income from the land, to exclude others from the land, to transfer it and the right to compensation for it. A land conflict, therefore, can be understood as a misuse, restriction or dispute over property rights to land. Land conflicts defined as such can be aggravated if the social positions of the parties involved differ greatly. The nouns 'Conflict' and 'Dispute' are used interchangeably. A crucial step towards the reduction of conflicts is to better understand the apparent demands and interests and – although they cannot necessarily be healed if previously injured– the underlying feelings and emotions, too. Important information to find an adequate solution for each (land) conflict is gained by increasing this understanding of the positions and attitudes of the conflicting parties.

In order to successfully resolve land conflicts, it is important to be aware of the many different types of land conflicts. One difference is found in the identity of the actors involved, some of them being legitimated to act in the way they do, others not. Other differences are found in aspects of the land itself, whether the conflicts occur on state, private or commonly owned land. Still other differences result from the complexity of causes of the conflict, as well as how these influences and intensify one another. Finally, the dimension of a land conflict varies significantly which makes a major difference for its resolution. Understanding the specific nature of the land conflict under consideration is a vital step in its eventual resolution. Land conflicts occur in many forms. There are conflicts between single parties (as for instance boundary conflicts between neighbors), inheritance conflicts between siblings and disputes over the use of a given piece of land.

15.3.1 Causes for Conflict

Corruption, bribery, fraud, nepotism, favoritism in land administration and state land management is a widespread problem, and leads to a high number of land conflicts all over the world. Many other land conflicts result from the multiple sales and double allocation of land, either due to legal pluralism or undocumented customary tenure, or due to competing state agencies all legitimized to do so. The main sources of conflict in these areas are uncertainty of boundaries or allocation of the same piece of land to more than one person. Uncertainty of boundaries occurs when the land marks by which the real boundaries are defined no longer exist. These conflicts can be linked to many factors like improper documentations, weakening customary tenure institutions, transparency, and their structures for accountability and stewardship, manipulation of customary laws, land grabbing and tenure insecurity.

Due to rural-urban migration as well as natural population growth, most cities in developing countries cannot formally absorb all their citizens. People therefore tend to squat on public land as the chances of being evicted there are slightly lower than on private or common land. The problem remains, however, for the city as well as for the squatters living in uncertainty. The details of the causes are discussed below.

15.3.3 Consequences of Land Conflict

The level and scale of the disputes around land pose huge challenges to conflict resolution institutions. Legislation on land is inadequate, difficulties arise between the customary and 'official' system to administer land disputes, and the judicial system is not equipped to deal with the task placed upon it.

All land conflicts, no matter how peaceful or violent they are, produce negative consequences for individual people as well as for the entire society. Many families across the world have seen their shelters, their homes being bulldozed out of existence. Whenever there is a land conflict, someone suffers economic consequences. In extreme situations, people find themselves landless and/or without shelter. In the case of a farmer, this often includes the loss of his/her production base. But that's not all.

Where there are many land conflicts, social stability within society is affected, as land conflicts undermine trust and increase fear and suspicion often between formerly close people such as neighbors and family members. Violent land conflicts or simply the fear of becoming a victim of them can also have a traumatizing effect on those who are or feel at risk. In

addition, whenever state land is allocated illegally it generally affects the nation's budget negatively and often results in ecological destruction or social exclusion.

15.4 Alternative Dispute Resolution Mechanisms

For effective dispute resolution, one must go down the path of discovering what a person must consider when communicating. It is important to understand what people experience in daily communications including the art of listening, what we remember, what we absorb from our conversations and how we translate that information into useful communications methods to achieve business goals.

Basically, when disputes are arisen, there are three resolving mechanisms. They are: Negotiation, Arbitration and Litigation. Those mechanisms can be applied based on the degree of the dispute. They are hierarchical, in that, if the first solution does not work, the next solution will be applied and then, the final solution will be applied. When the degree of disputes is increasing from simple to complex, then resolving mechanism also goes from negation-to-arbitration-litigation which means that from informal to formal dispute resolution mechanisms. Some of dispute resolution mechanisms are:

A. Negotiation

Negotiation is a process where two parties in a conflict or dispute (fight) reach a settlement between themselves that they can both agree on. Negotiations are reached through discussions made between the parties or their representatives without an involvement of the third party. Each party should consult or see a lawyer before settling down the matter, so that they are well aware of their rights and duties in respect to the matter or dispute they are willing to solve. It is easier to negotiate when the two sides have some shared interests and some opposed.

B. Mediation

Mediation means the process in which a neutral (means not supporting any one side) third party assists the parties in conflict to reach a solution. The third party is called the mediator and the mediator facilitates communication between the parties. It requires that the parties are willing to face each other and to find a compromise. The mediator follows a strict procedure, giving each party the opportunity to explain its perceptions and to express its feelings, forcing the other party to listen and finally moderating a discussion aimed at finding a solution with which both parties can live. Preferably, the moderator should not propose solutions but may

lead the way towards them. At the end, a written contract is signed by all parties and the mediator seals the agreement. Mediation can be done in any situation as long as the parties are willing to find a compromise.

C. Arbitration

Arbitration refers to the process where the decision is made by a third party. The arbitrator hears the case as presented by the parties in conflict or dispute (fight) and make decision or award in the same way as a Judge would. The arbitrator is expected to make direct suggestions on how to settle the conflict. He/she is more influential and powerful than moderators, tutors or mediators. He has decision-making authority. Therefore, arbitration can be used even at the peak of a conflict. What makes it different from adjudication is that the arbitrators are accepted and trusted by both parties. The arbitrator may be appointed by all conflicting parties or be a respected person traditionally responsible for dispute settlement.

15.5 Negotiation as Dispute Resolution Mechanism

To achieve success in negotiations, effective communications must be a focal point of the strategy employed. From listening to communicating both verbally and nonverbally, all the signals sent (and received) affect the outcome of your negotiation efforts. You must develop an overall communication plan and know how as well as when to use the various communication skill techniques during the negotiation process. Understanding the difference between tactical and strategic negotiations will also affect the types of communication skills used and the degree of openness employed during negotiations.

Communication is a two-way street that requires everyone involved to exchange messages. Between parties, communication includes acts that confer knowledge and experiences, give advice and commands, and ask questions. These acts may take many forms, in one of the various manners of communication. The form depends on the abilities of the group communicating. Together, communication content and form make messages that are sent towards a destination. Good communication requires both verbal and non-verbal skills as well as listening skills to find solutions that respond to the underlying issue at hand. It is the cornerstone of any productive negotiation.

Negotiation occurs in business, non-profit organizations and government branches, legal proceedings, among nations and in personal situations such as marriage, divorce, parenting, and everyday life. Negotiations have particular importance in business. Some people say that

"the business life is a permanent negotiation with other people who are defending their own interests". Many people wrongly assume that nothing is negotiable unless the other party indicates that this is the case, a more realistic view is that everything is negotiable.

15.5.1 Negotiation Process

There are four stages in the process of negotiation.

a) **Preparation:** when it comes to preparation, there is basically a need to have a clear idea of how to go about with starting points. One of the keys to effective negotiation is the ability to express own thoughts clearly to the other party.
b) **Exchanging Information:** the information provided to other party must always be well-researched and must be communicated effectively. If there are any doubts, they should always be clarified.
c) **Bargaining:** the bargaining stage could be said to be the most important of the four stages. This is where most of the work is done by both parties. This is where the actual deal will begin to take shape. Bargaining is never easy. Both parties would have to learn to compromise on several aspects to come to a final agreement. This would mean that each party would therefore have to give up something to gain another.
d) **Closing and Commitment:** The final stage would be where the last few adjustments to the deal are made by the parties involved, before closing the deal and placing their trust in each other for each to fulfill their role.

15.5.2 Outcomes of Negotiation

An outcome is a possible result of negotiation. Outcomes can be general or specific, factual or subjective, absolute or relative. If negotiation only consists of both sides identifying a preferred outcome, making it their goal and forcing it on the other, haggling or arguing will result. These results are unwise decision (or no decision), inefficiency and potential damage to relationships. Entering negotiations with only a specific outcome in mind can be very counterproductive. Negotiators should consider the wider goals. Three outcomes are possible when negotiating:

- Win-win (both sides win).
- Win-lose (one side wins, the other loses).
- Inefficient but equitable (all items shared equally).

Generally, the outcome after negotiation can be reached when both sides come to consensus and commit to the agreement. The agreement would also help the negotiators to maintain

ongoing communications and interactions between the negotiating parties so that future negotiations can take place and lead to a better situation.

15.6 Evaluating the Success of Negotiation

The complexity of the negotiating process will vary according to the size and complexity of the proposed deal as well as the attitudes adopted by the parties involved. The actual negotiation process in terms of time and intensity depends on the following factors:

- the goals and interests of the parties,
- the perceived interdependence between the par-ties,
- the history that exists between the parties,
- the personalities of the people involved, and
- the persuasive ability of each party

Basically, there are two types of negotiation process that differ fundamentally in their approach and in the relative prospects for the stability of the agreement that is reached.

- **Integrative or win-win approach**: in these negotiations the prospects for both sides' gains are encouraging. Both sides attempt to reconcile their positions so that the end result is an agreement under which both will benefit - therefore the resultant agreement tends to be stable. Win-win negotiations are characterized by open and empathetic communications and are commonly referred to as partnership agreements.
- **Distributive or Win/Lose Approach**: in these negotiations each of the parties seeks maximum gains and therefore usually seeks to impose maximum losses on the other side. This approach often produces agreements' that are inherently unstable. Capable negotiators understand that the stability of the outcome is important and focus on more than simply maximizing the concessions that can be extracted from the other side.

15.7 Recognizing Stress Management

Whilst there are an infinite variety of negotiation scenarios, most negotiations are defined by three characteristics:

a) There is a conflict of interest between two or more parties. What one wants is not necessarily what the other want.
b) Either there is no established set of rules for resolving the conflict, or the parties prefer to work outside of an established set of rules to develop their own solution.

c) The parties prefer to search for an agreement rather than to fight openly, to have one side capitulate, to break off contact permanently or to take their dispute to a higher authority.

Many land conflicts can be predicted and if not avoided at least mitigated if provisions are made against them in time. It is therefore crucial to be aware of those changes and occurrences that have the potential to trigger land conflicts. Once a potential cause of conflict has been identified, the extent of possible land conflicts and the scope of their social, economic, ecological and political consequences should be roughly calculated, and immediately communicated to decision-makers and responsible land management experts at both the central and local level. Land conflict experts should preferably discuss with these decision-makers which measures should be taken to avoid massive land conflicts. Failing that, proposals should be made to them.

15.8 Summary

Dear trainee! A dispute arises when two or more people or groups perceive that their interests, needs or goals are incompatible and they seek to maximize fulfilment of their own interests or needs, or achievement of their own goals Dispute resolution generally refers to one of several different processes used to resolve disputes between parties, including negotiation, mediation, and arbitration. Negotiation is a dialogue between two or more people or parties, intended to reach an understanding, resolve point of difference, or gain advantage in out-come of a dialogue, to produce an agreement upon courses of action, to bargain for individual or collective advantage and to craft outcomes to satisfy various interests of two parties involved in negotiation process.

Negotiation is a process where each party involved in negotiating tries to gain an advantage for themselves by the end of the process. Therefore, negotiation is intended to aim at compromise. There are four stages in the process of negotiation: Preparation, Exchanging Information, Closing and Commitment, Bargaining. In addition to negotiation, there are other mechanisms to resolve disputes: arbitration and mediation.

There is no doubt that reduced to its essence negotiation is a form of interpersonal communication. To achieve success in negotiations, effective communications must be a focal point of the strategy employed.

15.9 Self-Check Exercise

 **Short Answer Items**

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

1) What is conflict and how does it arise?
2) Discuss on how disputes can be resolved.
3) Describe the alternative dispute resolution mechanisms.
4) List and explain the negotiation process.
5) Discuss the outcomes of negotiation.

CHAPTER SIXTEEN: ELIMINATING AND PREVENTING MUDA

16.1 Introduction

Dear trainee! This chapter introduces you the concept of preventing and eliminating MUDA/wastes in workplace. It covers responsibility for the day-to-day operation of the work and ensures Kaizen elements are continuously improved and institutionalized. Waste/MUDA is any activity which consumes resources, such as money, time, energy and materials that does not create value and can be eliminated.

MUDA means wastefulness, uselessness and futility, which is contradicting value-addition. Value-added work is a process that adds value to the product or service that the customer is willing to pay for. Customer is a person who buys products or services from a store, restaurant or other retail seller. Internal customer is the customer within a production line/service delivering sequence that is next to the previous process and makes his/her own process. External customer is the customer that buys the final out put product/service of the enterprise.

There are two types of MUDA, Type 1 and Type 2. MUDA Type 1 includes non-value-added activities in the processes that are necessary for the end customer. For example, inspection and safety testing does not directly add value to the final product; however, they are necessary activities to ensure a safe product for customers. MUDA Type 2 includes non-value-added activities in the processes, but these activities are unnecessary for the customer. As a result, MUDA Type 2 should be eliminated.

16.2 Learning Objectives

After completing this chapter, you will able to

- Identify wastes/MUDA in workplace
- Explain effective methods to eliminate wastes/MUDA

Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts of wastes/MUDA.

_____

_____

_____

16.3 Identify Waste/MUDA

16.3.1 The Concept of Waste/MUDA

Waste/MUDA is any activity which consumes resources, such as money, time, energy and materials that does not create value and can be eliminated. There are two types of wastes: obvious wastes and hidden wastes. It is important to uncover and eliminate the latter since they are usually bigger. Wastes take the shape of an iceberg; the tip consists of the obvious wastes while the seen bulk under the water contains the hidden wastes. Wastes are not necessarily ugly, and most are outside the waste can! Waste can be in the form of unnecessary output, input, or processing. It can be in the form of materials, stocks, equipment, facilities, man-hours, utilities, documents, expenses, motion, and other activities that do not add value.

The value added by an activity should be a positive value. Ideally, the value added by the activity is equal to or greater than the costs incurred during the activity. Value from the customer's point of view is independent of the cost to produce the product or provide the service. Value for any product/service is defined by the customer. It could be the quality of product/service (or) the price that the customer pays for (or) the on-time delivery and/or a combination of all three. But, sometimes Value-adding activities of an organization may not directly translate to an additional cost paid by the customer. It could result in acquisition of more customers (i.e. increase in market share) whereby the organization recovers its cost of the Value-adding activities. It is based on the customer's expectations, as identified by the effectiveness indicators for the process. There are two types of customers:

- Internal customer
- External customer

Internal customer: is the customer within a production line/service delivering sequence that is next to the previous process and makes his/her own process. Internal customers have a relationship with, and within, your company, either through employment or as partners who deliver your product or service to the end user, the external customer. Less obvious but certainly still significant, stakeholders and shareholders are also internal customers. All of these may or may not purchase your product or service.

External customer: is the customer that buys the final out put product/service of the enterprise. External customers are the people that pay for and use the products or services

your company offers. This customer could be a one-time purchaser or a person who've you worked with long-term and to whom you've provided add-ons or customization options. External customers are also known as "clients" or "accounts."

The three categories of Operation

1) Net Operation/Value Adding Operation
2) Non-Value Adding Operation
3) "MUDA''

1. Net Operation/Value Adding Operation

It is part of an operation that adds value to make parts and products or deliver service. In other words, it is part of the operation that the customer exactly needs / willing to pay for.

Value Adding (VA) are the activities which add value (actual or perceived) to the product or the service. A Value-adding-activity is commonly defined as one which is not wasteful. We also like to commonly use three checks for value addition.

- A value adding activity is one that customer is willing to pay for.
- A value adding activity is transformational by nature.
- A value adding activity is done first time right.

For examples: Milling, Turning, Grinding, Assembling, Welding and Printing/photocopying a document etc.

2. Non-Value Adding Operation

Waste or Non-Value Adding (NVA) is any activity which adds cost or time without adding any value or any activity which does not satisfy any of the above three conditions is a waste or a non-value adding activity in a process. Focus should be in eliminating such activities. For example: waiting, rework, setting up/adjustments, loading paper to a photo copy machine/printer and etc. Non-Value-Added Activities involve work that consumes resources, but does not add value to the product or service. These are activities that do not add value to the product or service, but are currently necessary. For example, this work might be required by:

- Customer contract or specification
- Industry standard such as ISO 9001
- Government regulation

- Outdated work method or equipment

3. "MUDA''

MUDA is a Japanese word meaning wasteful activity which use resources, time or cost without adding value. In other words, it is anything unnecessary in operation that affects the quality of the product/service, productivity, delivery time and also production cost. MUDA can be eliminated immediately. For example: Unnecessary motion/searching for tools, unnecessary transportation of materials, over production, Inventory, Waiting /idle time, making defects and over processing, etc.

16.3.2 Classification of Wastes/MUDA

A number of methods for categorizing types of waste have emerged. We will review some of these models to get a deeper understanding of what waste is and how to find it and eliminate it.

A. The three Mus
B. The 5M + Q + S
C. The flow of goods
D. The seven deadly wastes

A. The Three MUs

In this way of thinking about waste, the goal is to achieve a condition where capacity and load are about equal. In other words, there are just the right number of workers, materials and machines to make just the right amount of product that is being ordered and deliver it on time to the customer. In Japanese this is expressed with the terms MUDA, MURA and MURI.

MUDA: refers to processes or activities that don't add value. These types of waste do not help your business or workers in any way. They increase costs and make tasks take much longer than they should. Wastes are defined as follows:

- **Overproduction:** occurs when items are manufactured before they are required.
- **Over processing:** occurs when more work is put into a product or service than is actually required.
- **Inventory:** is important, but storing too many or too few supplies and finished goods increases costs and can take valuable space.
- **Transportation:** is the movement of products and supplies from one area to another.
- **Motion:** is the physical movement of a person or machine required to complete work.

- **Waiting:** is when work or projects come to a halt or slow because machines have yet to finish producing the required goods, products have not arrived, or some other task is holding up the rest of the project.
- **Defects:** occur when errors and rework are created because of your processes.

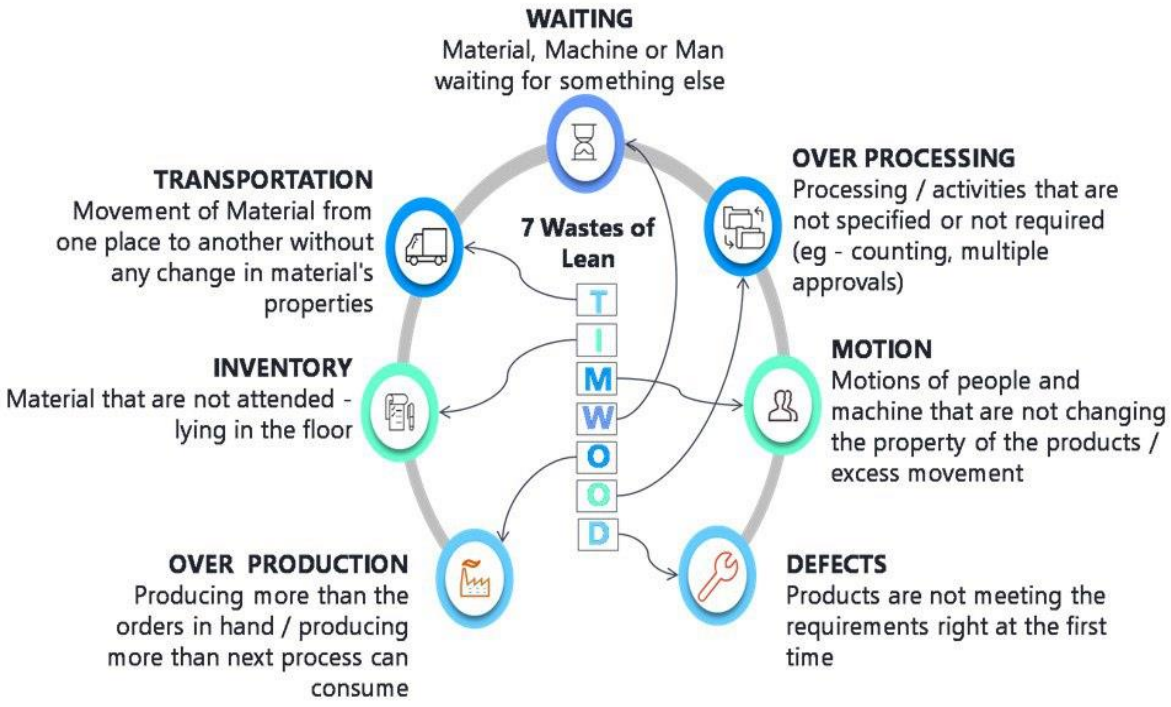


Figure 46: The seven types of MUDA

Finding and eliminating MUDA is essential if you want to reduce costs, improve efficiency, and increase profits. However, if you don't also address MURA and MURI, these benefits will be inconsistent or may even fade over time.

MURI: overburden, can result from MURA, and from removing too much MUDA (waste) from the process. "Beyond one's power" is an especially potent definition for MURI, as it refers to employees or equipment that has been overburdened. The dangers of MURI should be obvious. Employees who are overworked experience greater levels of burnout, and a lack of situational awareness caused by exhaustion can be extremely dangerous, particularly in industries that rely on heavy machinery or dangerous chemicals. Likewise, equipment that's stressed too much will break down more frequently, and can create wholly new hazards for anyone nearby.

MURA: refers to "unevenness" or "irregularity", specifically, irregularity in production levels. Consistently stable levels of production allow a business to effectively implement maintenance procedures and reduce worker fatigue, while uneven production leads to more

frequent equipment failures, employee burnout, and increased difficulty in accurately planning for the future. In production environments with low-volume, high product variation, flexibility is more important than in high-volume, low-product variation environments. When MURA is not reduced, one increases the possibility for MURI and therefore MUDA. MURA can be reduced by creating openness in the supply chain, change product design and create standard work for all operators.

B. The 5M + Q + S

Another way of thinking about waste is to focus on the areas where waste may occur: the 5M (man, material, machine, method and management), plus quality and safety. Some of the main forms of waste that you will uncover by focusing on these aspects of production include, walking, waiting, searching, material storage and handling, large machines, conveyers, wasteful production methods, inventory, defective goods, errors, inspection, etc.

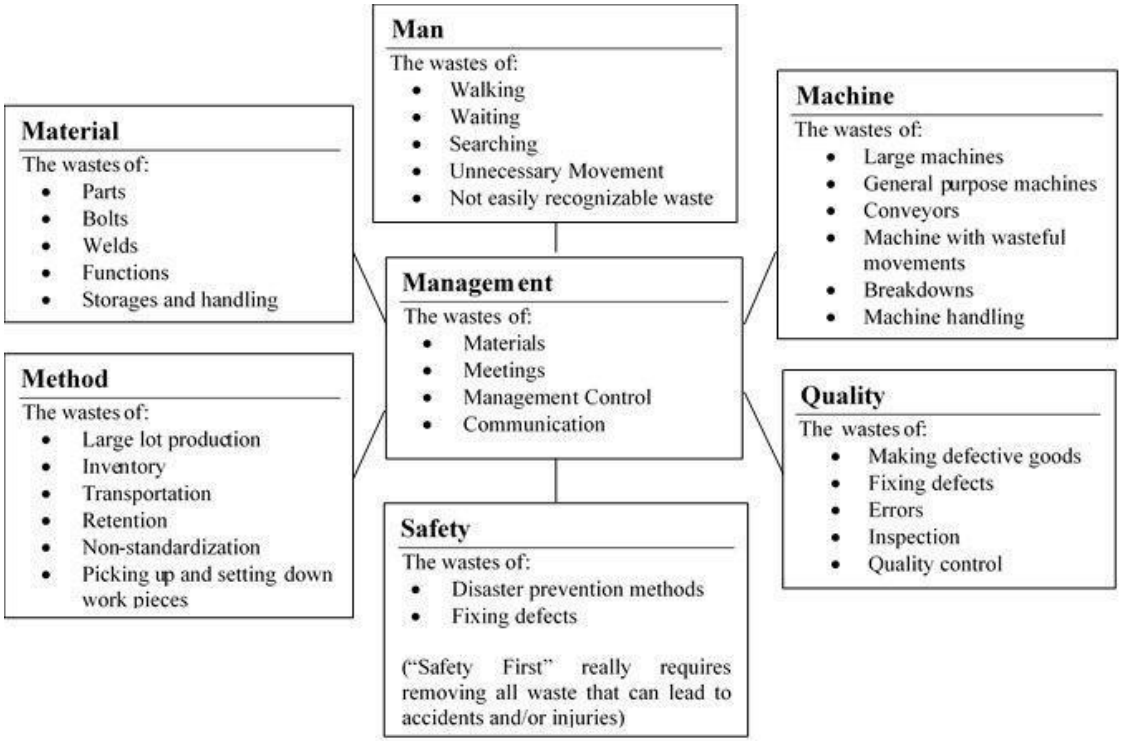


Figure 47: Implementing 5M + Q + S

C. The Flow of Goods

A third way of thinking about waste is to focus on the flow of goods in production. The flow of goods typically discussed in the following figure (See Figure 4).

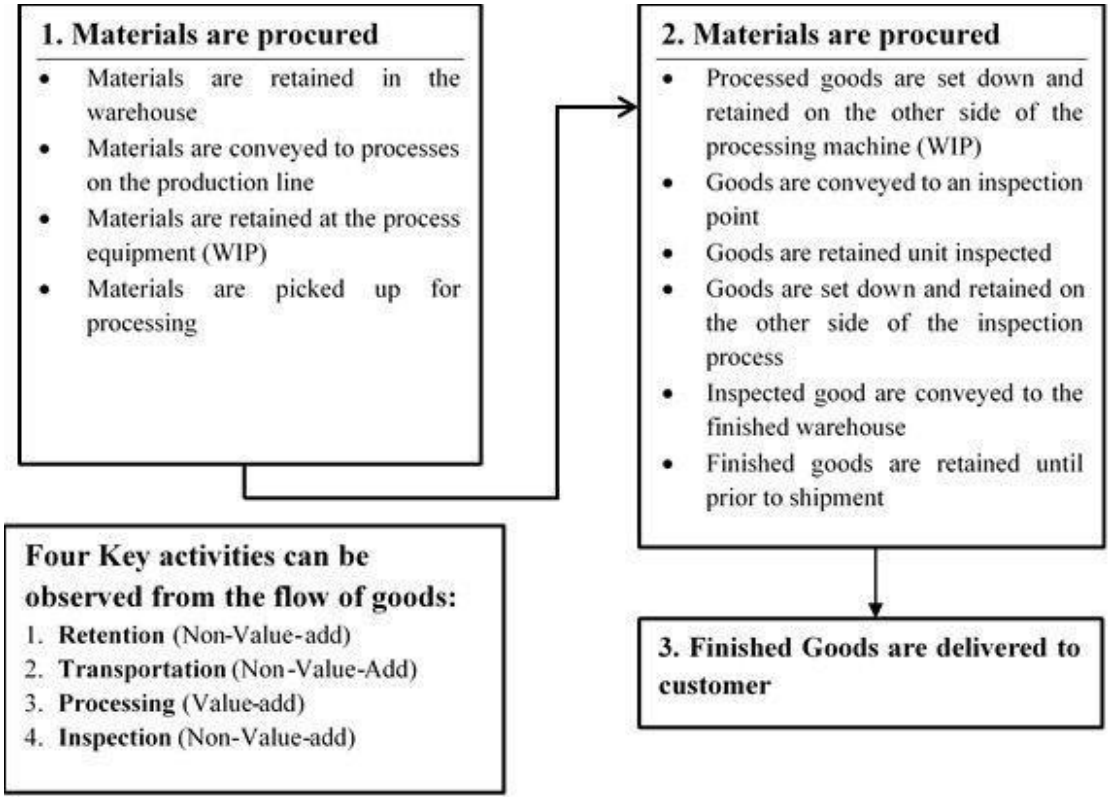


Figure 48: The flow of goods

D. The Seven Deadly Wastes

The most well-known category of wastes is the "seven deadly wastes", which captures the essence of all the ideas discussed above and simplifies them to help you root out waste throughout your production process. You will need strongly motivated people with an instinct for seeing and removing waste. Identifying and eliminating these seven types of waste (TIMWOOD) will forge the path to lean production.

- Transportation
- Inventory
- Motion
- Waiting
- Overproduction
- Over-Processing
- Defect making

16.3.3 Causes and Effects of types of Wastes/MUDA

Table 6: Cause and effect of type of Waste/MUDA

Types of Waste/MUDA	Cause	Effect
1. Transportation	• Poor layout • Shish-skilled workers • Sitting to perform operations • The need for conveyance systems is assumed	• Waste of space • Production deterioration • Expansion of transportation • facilities • Occurrence of scratches • Increase production time and cost • wastes time and energy
2. Inventory	• Acceptance of inventory as normal or as a "necessary evil" • Poor equipment lay out • Long changeover times • Shish-kabob or large lot production • Obstructed flow of goods • Anticipatory production • Defective parts • Upstream process is too fast for the downstream process	• Waste of space • Needs for inspection, and transportation • Expansion of working fund • Shelf life may expire • It ties up cash • Makes FIFO inventory management more difficult
3. Motion	• Isolated operations • Low employee morale • Poor work layout • Lack of training • Undeveloped skill	• Increase in manpower and processing • Unstable operation • Increases production time • Can cause injury
4. Waiting	• Obstruction of flow	• Waste of manpower, time,

	• Poor equipment layout • Trouble at the upstream process • Capacity imbalances • Large Lot-production	and machines • Increase in the in-process inventory • Failed delivery dates • Poor workflow continuity
5. Overproduction	• Large-lot production • Anticipatory production (producing product in advance of demand) • Inability to achieve short changeover times with the large equipment used in mass • production systems • Creating enough stock to replace the number of defective parts produced • Overstaffing or too much equipment • Machines that turn out parts too quickly	Companies often have overproduction as a result of large-lot manufacturing methods or mass production. There are several unfortunate effects of over production: • Anticipatory buying of parts and materials • Blocked flow of goods • Increased inventory • No flexibility in planning • Occurrence of defects
6. Over-Processing	• Inadequate study of processes • Inadequate study of operations • Incomplete standardization • Materials are not studied	• Unnecessary processes or operation • Increase in manpower and man-hour • Lower workability • Increase in defects • Can reduce life of component
7. Defect	• Emphasis on downstream inspection • No standard for	• Increase in material cost • Productivity deterioration • Increase in personnel &

	inspection work • Omission of standard operations • Material handling and conveyance	processes for inspection • Increase in defects and claims • Invite reworking costs

16.3.4 Waste/MUDA Identification

It is not easy to find waste when you look at the production line or the warehouse or an operation. If you have never been involved in improvement activities you will find it even harder to discover waste that may be right in front of you. Waste is everywhere, in every operation; it is so common and you are so used to it that it is hard to see.

Benefits to the company include:

- **Cutting the hidden costs of production:** It is estimated that 80 percent of production activities and associated costs are non-value-added, or waste. When factories begin to focus on identifying and eliminating waste, the impact on the bottom line is astronomical.
- **Increased customer satisfaction:** Customer satisfaction rises as a direct result of implementing lean production. When waste is eliminated from production, deliveries occur on time and product quality goes up.

The steps to effective waste identification are:

1) Make waste visible
2) Be conscious of the waste
3) Be accountable for the waste.
4) Measure the waste.

16.4 Eliminate Wastes/MUDA

16.4.1 Elimination of the types of Wastes/MUDA

A) How to Eliminate Overproduction Wastes?

In order to balance capacity and load without overproducing, you must implement the advanced methods of lean production:

- Full work
- Line balancing
- Pull production using kanban.

- Quick-changeover operations.
- Level production - small-lot, mixed production

B) How to Eliminate Inventory Wastes?

- U-shaped manufacturing cells, layout of equipment by process instead of operation.
- Production leveling
- Regulating the flow of production
- Pull production using kanban
- Quick changeover operations

C) How to Eliminate Motion Wastes?

- Gradually switch to flow production
- Create U-shaped cell layout of equipment
- Make standardization through
- Increase training
- Increase operator awareness about motion during an operation

D) How to Eliminate Transportation Wastes?

Basically, conveyance waste is corrected by redesigning equipment layout to create a flow between operations. Then you will be able to take out much of the complexity in the conveyance system and decrease material handling to a minimum. Some of the lean production methods that address conveyance flow:

- U-shaped manufacturing cells
- Flow production
- Multi skill workers
- Standing to perform operations
- Higher utilization rate
- Water beetles (material handlers in the kanban system of pull production)

E) How to Eliminate Waiting/Idle Time Wastes?

- Production leveling
- Product-specific layout
- Mistake-proofing
- Human automation
- Quick changeover

- Autonomous maintenance
- Line balancing

F) How to Eliminate Defect Wastes?

- Standard operations
- Mistake-proofing devices
- Full-lot inspection
- Building quality in at each process
- Flow production
- Elimination of the need to pick up and set down work pieces
- Improvement of jigs using human automation
- Promotion of value analysis and value engineering

F) How to Eliminate Processing Wastes?

- More appropriate process design
- Review of operations
- Improvement of jigs using automation
- Thorough standardization
- Promotion of value analysis (VA) and value engineering (VE) technique

Tools and Techniques to eliminate Wastes/MUDA

- 5S
- Layout improvement
- Brainstorming
- Andon
- U-line
- In-lining
- Unification

- Multi-process handling & Multi-skilled operators
- A.B. control (Two-point control)
- Cell production line
- Line balancing
- Build in quality at each process, etc.

16.4.2 Reporting Methods and Formats/Checklists

Kaizen Effect Evaluation Sheet

Name of the process: _____

Work Place:_____

Problem Solving Title:_____

Part One: Quantitative Results

S. No.	Improvement Indicators	Before Kaizen	Target	After Kaizen	Improvement (%)	Remark
1	MUDA Elimination Indicators					
	1.1 Tools and Equipment					
	1.2 Parts Saving					
	1.3 Raw Material saving					
	1.4 Transportation					
	1.5 Motion in Meter					
	1.6 Transaction Time					
	1.7 Excess Stock/Inventory					
	1.8 Expired material/Stock					
2	Productivity indicators					
	2.1 Lead time					
	2.2 Machine down time					
	2.3 Frequency of Machine failure					
	2.4 Production volume per day					
	2.5 Labour saving					
	2.6 Labour productivity					
	2.7 Delivery Time					
3	Quality Indicators					
	3.1 Defect rate					
	3.2 Raw Material damage in %					

	3.3 Number of Customer complaints					
4	Other Indicators					
	4.1 Number of New inventions					
	4.2 Minimized Cost of Production					

Part Two: Qualitative Results

Describe the Qualitative results and change that are achieved by MUDA. Elimination/Reduction based on the indicators listed below

S. No.	Improvement Indicators	Description of the Result
1	MUDA Elimination capacity of workers	
2	New inventions and Improvements by workers	
3	Motivation of workers	
4	Awareness about Safety	
5	Corporate culture of kaizen	
6	Team work	
7	Transaction Time	

Name of Worker: _____

Signature: _____

Date: _____

Name of Leader: _____

Signature: _____

Date:

16.5 Prevent Occurrence of Wastes/MUDA

16.5.1 Methods of Waste Prevention

We have discussed how you discover waste and what to do to remove it; but it doesn't end there. Unfortunately, problems always crop up, and we prevent them from becoming sources of waste, we will be right back where we started in no time at all. That is one reason why one of the very first things mentioned about discovering waste adopting the right attitude. If everyone is paying attention to keeping waste from taking hold, then you have a good chance of sustaining production flow. There are four important methods you can use for maintaining a waste-free production environment:

- Standardization
- Visual controls
- Auditory controls
- 5W and 1H Sheet

16.5.2 Total Productive Maintenance Concept and Its Pillars

Total means all individuals in the organization working together. Productive means Production of goods that meet or exceed customer's expectations. Maintenance means keeping equipment and plant in good condition at all times.

Total Productive Maintenance (TPM) can be considered as the medical science of machines. It is a maintenance program which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction. TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum.

The Eight Pillars of TPM

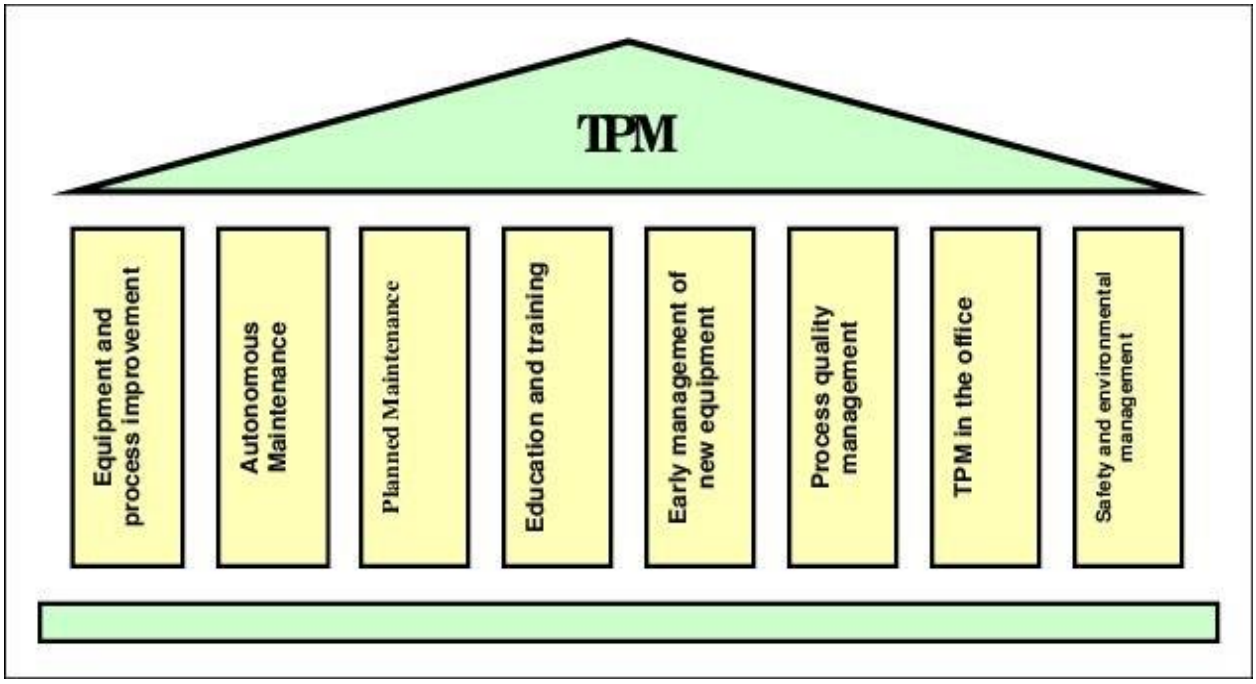


Figure 49: The eight Pillars of TPM

16.6 Summary

Dear trainee! Waste/MUDA is any activity which consumes resources, such as money, time, energy and materials that does not create value and can be eliminated. The most well-known category of wastes is the "seven deadly wastes," which captures the essence of all the ideas discussed above and simplifies them to help you root out waste throughout your production process. You will need strongly motivated people with an instinct for seeing and removing waste. Identifying and eliminating these seven types of waste will forge the path to lean production. Basically, conveyance waste is corrected by redesigning equipment layout to create a flow between operations. Then you will be able to take out much of the complexity in the conveyance system and decrease material handling to a minimum.

There are seven categories of waste under MUDA that follow the abbreviation TIMWOOD. The seven wastes are Transport i.e. excess movement of product, Inventory i.e. stocks of goods and raw materials, Motion i.e. excess movement of machine or people, Waiting, Overproduction, Over-processing, and Defects.

16.7 Self-Check Exercises

**Short Answer Items**

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

1) List out the three categories of operation?
2) Define the three categories of operation?
3) Describe the 3MU's and their relationships?
4) Describe the seven deadly wastes/MUDA
5) Write at least two causes and effects of each type of the seven deadly wastes/MUDA
6) Write at least four out of the ten basic principles of improvement?
7) Write at least two methods how to eliminate each of the seven deadly wastes?
8) What are the four methods for maintaining a waste free production environment?
9) What are the eight pillars of TPM?
10) What are the aims of each pillars of TPM?

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