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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Table of Contents

List of Tables x
List of Figures xi
List of Abbreviations xii
Preface xiii
CHAPTER ONE: READING AND INTERPRETING MAPS AND PLANS 1
1.1 Introduction 1
1.2 Learning Objectives 1
1.3 Types of Maps, Plans and Drawings, and their Functions 2
1.3.1 Types of Maps and Their Functions 2
1.3.2 Types of Plans and their Functions 4
1.3.3 Types of Drawing and Their Functions 6
1.3.4 Basic Concepts of Map Reading 7
1.3.5 Identifying and Interpreting Unique Parcel Identification Number 7
1.3.6 Basic Manual Computations on Maps 9
1.4 Recognizing Amendments in Project Documentation 9
1.4.1 Introduction 9
1.4.2 Checking Title Panel of Project Documentation 10
1.4.3 Project Objective, Scope and Specifications 10
1.5 Cartographic Representations 11
1.5.1. Introduction 11
1.5.2 Interpreting Symbols, Abbreviations on Plans and Maps 11
1.5.3 Spatial Reference System and its Use 13
1.6 Reading and Interpreting Specifications 14
1.7 Summary 15
1.8 Self-Check Exercise 15
CHAPTER TWO: ORGANIZING AND MAINTAINING EQUIPMENT AND SUPPLIES/ACCESSORIES 16
2.1 Introduction 16
2.2 Learning Objectives 16
2.3 Selecting Equipment and Supplies/Accessories 17
2.3.1 Specifications and Principal Work Activities 17
2.3.2 Selecting and Preparing Tools, Equipment and Supplies/Accessories 17

2.3.3 Contingencies and Risk Management Processes 18
2.3.4 Checking Equipment 19
2.3.5 Identifying Professional Code of Ethics 19
2.3.6 Personal Protective Equipment 20
2.4 Surveying Equipments and Accessories 20
2.4.1 Care and Maintenance of Surveying Equipment and Tools 20
2.4.2 Adjustments of Surveying Instruments 21
2.5 Maintaining and Organizing Equipment 22
2.6 Summary 22
2.7 Self-Check Exercises 23
CHAPTER THREE: CONDUCTING BASIC LAND SURVEYS 24
3.1 Introduction 24
3.2 Learning Objectives 24
3.3 Land Survey Preparations 25
3.3.1 Introduction 25
3.3.2 Checking Operation of Equipment and Accessories 26
3.3.2 Procedures of Land Surveying 27
3.4 Land Surveying 31
3.4.1 Taping 31
3.4.2 Field Booking 37
3.5 Conducting Quality Assurance of Survey Works 37
3.6 Summary 38
3.7 Self-Check Exercise 38
CHAPTER FOUR: PERFORM SURVEYING COMPUTATIONS 39
4.1 Introduction 39
4.2 Learning Objectives 39
4.3 Introduction to Traverse 40
4.4 Traverse Computation 44
4.4.1 Traverse Computation Procedures 44
4.4.2 Balancing and Finding Adjusted Coordinates of Closed Traverse 45
3.3.5 Area Computation 49
4.6 Summary 60
4.7 Self-Check Exercises 60

CHAPTER FIVE: PERFORMING BASIC AERIAL PHOTOGRAPHY AND IMAGE INTERPRETATION....61
5.1 Introduction....61
5.2 Learning Objectives....61
5.3 Basic Principles of Image Data....62
5.3.1 Remote Sensing Data Imaging....62
5.3.2 Photogrammetry....63
5.3.3 Classification of Photographs....64
5.3.4 Scale Measurement From Aerial Photograph....65
5.3.5 Applications of Photogrammetry....66
5.4 Identifying Features Using Stereoscopy....66
5.5 Interpreting Image Data....67
5.5.2 Elements of Image Interpretation....69
5.6 Summary....72
5.7 Self-Check Exercises....73
CHAPTER SIX: COLLECTING SPATIAL AND SOCIO-ECONOMIC DATA....74
6.1 Introduction....74
6.2 Learning Objectives....74
6.3 Data Collection Preparations....75
6.4 Conduct Data Collection....76
6.4.1 Methods of Spatial Data Collection....76
6.5 Information Review and Correlation....78
6.6 Summary....79
6.7 Self-Check Exercise....79
CHAPTER SEVEN: OPERATING BASIC APPLICATION SOFTWARE PACKAGES....80
7.1 Introduction....80
7.2 Learning Objectives....81
7.3 Introduction to Computer....81
7.3.1 Computer Hardware....81
7.3.2 Computer Software....82
7.4 Introduction to Desktop and its Components....83
7.5 Glossary of Icons....85
7.6 Working with Files....86
7.7 Working on Microsoft Application Packages....87

7.7.1 Microsoft Word 87
7.7.2 Microsoft Excel 88
7.7.3 Microsoft PowerPoint 88
7.7.4 Microsoft Access Databases 89
7.8 Printing Documents 90
7.9 Summary 91
7.10 Self-Check Exercise 91
CHAPTER EIGHT: APPLYING BASIC LAND AND LAND RELATED PROPERTY LAW 92
8.1 Introduction 92
8.2 Learning Objectives 93
8.3 Land and Land Related Property Laws 93
8.4 Land Adjudication and Registration 94
8.4.1 Land Adjudication 95
8.4.2 Land Registration 95
8.5 Acquisition of Land and Landed Property 96
8.5.1 Types of Land Acquisition 96
8.5.2 Procedures for Land Acquisition 96
8.5.3 Land Sales/Transfer Modalities 97
8.6 Summary 98
8.7 Self-Check Exercise 99
CHAPTER NINE: APPLYING STREET ADDRESSING 100
9.1 Introduction 100
9.2 Learning Objectives 100
9.3 Street Addressing 101
9.3.1 Basic Concept of Street Addressing 101
9.3.2 Guidelines for Assigning Street Names 101
9.3.3 Posting/Locating Street Address 102
9.3.4 House Numbering 102
9.4 Prepare Resources, Materials and Equipment 103
9.6 Summary 105
9.7 Self-Check Exercise 105
CHAPTER TEN: MAINTAIN EFFECTIVE RELATIONSHIP WITH CLIENT/CUSTOMERS 106

10.1 Introduction 106
10.2 Learning Objectives 106
10.3 Maintain Clean and Hygienic Environment 107
10.3.1 Maintaining Uniform Personal Grooming 107
10.3.2 Understanding Employer Standards 107
10.3.3 Maintaining Personal Presence, Organizing and Keeping Visible Work Area 108
10.4 Identify and Meet Client/Customer Requirements 108
10.5 Summary 109
10.6 Self-Check Exercise 109
CHAPTER ELEVEN: PARTICIPATING IN ENVIRONMENTALLY SUSTAINABLE WORK PRACTICES 110
11.1 Introduction 110
11.2 Learning Objectives 110
11.3 Principles of Sustainable Development 111
11.3.1 Environmental Sustainability 111
11.3.2 Sustainable Development Dimensions 112
11.3.3 Environmental Regulations 112
11.4 Environmental Sustainability Policies and Principles 113
11.5 Seeking Opportunities to Improve Resource Use Efficiency 114
11.6 Summary 116
11.7 Self-Check Exercise 116
CHAPTER TWELVE: APPLYING 5S PROCEDURES 117
12.1 Introduction 117
12.2 Learning Objectives 117
12.3 Preparing for a Work 118
12.3.1 Job Instruction and Requirements 118
12.3.2 Occupational Health and Safety (OHS) Requirements 119
12.3.3 Tools and Equipment Used to Implement 5S 120
12.4 Sorting all Items in Order 3
12.4.1 Implementation of 5S 121
12.5 Setting all items in Order 121
12.6 Shine all items 123
12.7 Standardizing 5S 123
12.7.1 The 4th Pillar Explanation and How to Implement Standardize 5S 123

12.8 Sustaining 5S 124
12.8.1 The Fifth Pillar Explanation and how to Implement Sustain 124
12.9 Summary 125
12.10 Self-Check Exercises 125
Bibliography 126

List of Tables

Table 1: Relationship of Bearing and Azimuth *44*
Table 2: Interpreting image data *68*
Table 3: Glossary of Icon *85*

List of Figures

Figure 1: Topographic and thematic maps *3*
Figure 2: Cadastral map *4*
Figure 3: Site Plan *5*
Figure 4: Site Plan with main features, contours and datum *5*
Figure 5: Location Plan *6*
Figure 6: Freehand Sketch *6*
Figure 7: Location of the four margins and frame work of a given map *7*
Figure 8: Features representation used on maps *12*
Figure 9: Commonly used map elements (Marginal Information) *13*
Figure 10: Accuracy and Precision *30*
Figure 11: Basic Principles of GPS Positioning *33*
Figure 12: GPS Errors and Biases *37*
Figure 13: Examples of closed traverses *41*
Figure 14: Open traverse *41*
Figure 15: Rectangular coordinate *42*
Figure 16: Principles of Imaging *62*
Figure 17: Photo Theodolite *64*
Figure 18: Scale of a vertical photograph over variable terrain *65*
Figure 19: Principle of stereoscopic principle *67*
Figure 20: Satellite view of a part of a city *69*
Figure 21: Image of an area *69*
Figure 22: Shadow of objects used for interpretation *70*
Figure 23: Satellite image of area in gray scale and in standard false color composite *71*
Figure 24: High resolution image showing different textures *71*
Figure 25: High resolution image showing different Pattern *71*
Figure 26: Image of associated relationships *72*
Figure 27: Desktop Icons *83*
Figure 28: Start button *84*
Figure 29: How to create table, insert pictures and charts in MS Word *88*
Figure 30: MS Excel interface *88*
Figure 31: MS PowerPoint interface *89*
Figure 32: MS Access interface *90*
Figure 33: Street addressing plate *104*
Figure 34: House No. plate *104*
Figure 35: Implementation of 5S *121*
Figure 36: Tools kept at hand and stored in the order used *122*
Figure 37: Implementation of Set-in order *122*
Figure 38: Implementation of Shine *123*

List of Abbreviations

CAD	Computer Aid Drawing
CD	Compact Disc
DBMS	Database Management System
DGPS	Deferential Global Positioning System
DN	Digital Numbers
DoD	Department of Defense
EDM	Electronic Distance Measurement
EDMS	Environmental Data Management Systems
EME	Electromagnetic Energy
FIG	International Federation of Surveyors
GCS	Geographic Coordinate Systems
GIS	Geographical Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
JPEG	Joint Photographic Experts Group
MSL	Mean Sea Level
MSS	Multi Spectral Spectrum
NOI	Net Operating Income
ODBC	Open Database Connectivity
OHS	Occupational Health Safety
OS	Occupational Standards
PCS	Projected Coordinate Systems
PDF	Portable Document Format
PIN	Parcel Identification Number
PVT	Position velocity Time
ppm	Part Per Million
RRR	Right, Restriction and Responsibilities
RTK	Real Time Kinematic
TIFF	Tagged Image File Format
TVET	Technical and Vocational Education and Training
UPIC	Unique Parcel Identification Code
UTM	Universal Transverse Mercator projection
WGS 84	World Geodetic System 1984

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 **II** 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 **12** competences which includes the following areas: Read and Interpret Maps and Plans, Organize and Maintain Equipment and Supplies/Accessories, Conduct Basic Land Surveys, Perform Surveying Computations, Perform Basic Aerial Photography and Image Interpretation, Collect Spatial Socio-Economic Data, Operate Basic Application Software Packages, Apply Basic Land and Landed Property Law, Apply Street Addressing, Maintain Effective Relationship with Client/Customers, Participate in Environmentally Sustainable Work Practices and Apply 5S Procedures.

CHAPTER ONE: READING AND INTERPRETING MAPS AND PLANS

1.1 Introduction

Dear trainee! This chapter introduces you about the concept of reading and interpreting plans, maps and specifications relevant to land related operations. It includes the identification of types of plans, maps and drawings and their functions, the recognition of commonly used symbols and abbreviations, the identification of key features and specifications on a site plan, the comprehension of written job specifications and the recognition of document status and amendment detail. Within this, there are detail information you need to know about maps, plans and drawings.

Maps and Plans are two common terms used in the geospatial industry. A map is a visual representation of an area with symbolic depiction highlighting relationships between elements of that space such as objects, regions, and themes. Although most commonly used to depict geography, maps may represent any space, real or imagined, without regard to context or scale; for example: Brain mapping, DNA mapping, and extra-terrestrial mapping. Plans are a set of two-dimensional diagrams or drawings used to describe a place or object, or to communicate building or fabrication instructions. Usually plans are drawn or printed on paper, but they can take the form of a digital file. Plans are often for technical purposes such as architecture, engineering, or planning. Their purpose in these disciplines is to accurately and unambiguously capture all the geometric features of a site, building, product or component.

1.2 Learning Objectives

After completing this chapter, you will be able to:

- Read and interpret plans, maps, and drawings
- Explain the key features and functions of maps, plans and drawings
- Identify the marginal items used to convey information about the features represented on maps
- Identify commonly used and conventional symbols and abbreviations in maps



Dear trainee! Before reading the following section take ten minutes and try to describe the terms and concepts such as real world, map, plan, marginal information and conventional signs/symbols or colors.

1.3 Types of Maps, Plans and Drawings, and their Functions

1.3.1 Types of Maps and Their Functions

Maps are an essential land information sources which exist in different documents and websites in digital and analog form. They appear in books, newspapers, magazines, on television screens etc. Some are of great details while others appear as simple sketches of places, even some depicts the whole world while others represent a small portion of the land. All these maps that appear as mentioned above may differ in their purpose, content or scale. However, no matter what their purpose, content or scale are, they have things in common that makes them similar. For this reason, almost all maps share a single general definition.

Maps are a two-dimensional representation of the real world at a known scale. All things portrayed on a map exist in space in the actual world as a three dimensional. Hence, all maps involve geometrical transformations to represent the 3D features onto a flat sheet of paper as a 2D feature. Such a transformation is called map projection. Therefore, maps are defined as a 2D graphic representation of the whole/parts of the earth's surface (either the man-made or natural phenomena or both such as rivers, farm lands, mountains, roads, etc.) on a flat piece of paper as if that area is viewed vertically from above (bird's eye view). So far what has been said, one can understand that although maps could seem different from each other, they have in fact many things in common.

Globes are the best model of the earth on which the relative distances, angles, and areas, as well as azimuths, and great circles are all retained without any additional distortion. However, they are expensive to make, difficult to produce, cumbersome to handle, awkward to store, and difficult to measure and draw on.

The number of maps that are in use worldwide is unlimited. Maps are greatly differing to each other in their purpose, content or scale. They can be prepared with varied scales that comply to depict the earth's surface containing certain elements for some specific purpose.

On the basis of their scale at which they are prepared maps can be categorized into:

a) **Large scale maps:** that can be drawn at the scale >1:50,000
b) **Medium scale maps:** which can be drawn at the scale between 1:50,000-1:500,000
c) **Small scale maps:** those maps prepared at the scale < 1:500,000

Note: There is no complete agreement on the quantitative limits of the terms small, medium and large scale. But most scholars would agree with the above classification. The larger the scale the smaller the area it represents and the vice versa.

In terms of the purpose they provide maps can be classified into:

- **General reference maps**: - can provide multiple uses at a time and which depicts both the manmade and natural phenomena such as relief, settlement, water bodies, roads, etc. For example: topographic map (See Figure 1.1)
- **Thematic maps**: - gives us detailed information about a specific theme/topic. For that reason, they are also known as topical maps/special purpose maps. These map types concentrate on the distribution of a single attribute. For example: Injury mortality rate map (See Figure 1.2)



Figure 1: Topographic and thematic maps

Based on their content/subject matter, maps can be divided into unlimited number of classes. One among these kinds of maps is a cadastral map. (See Figure 1.3)

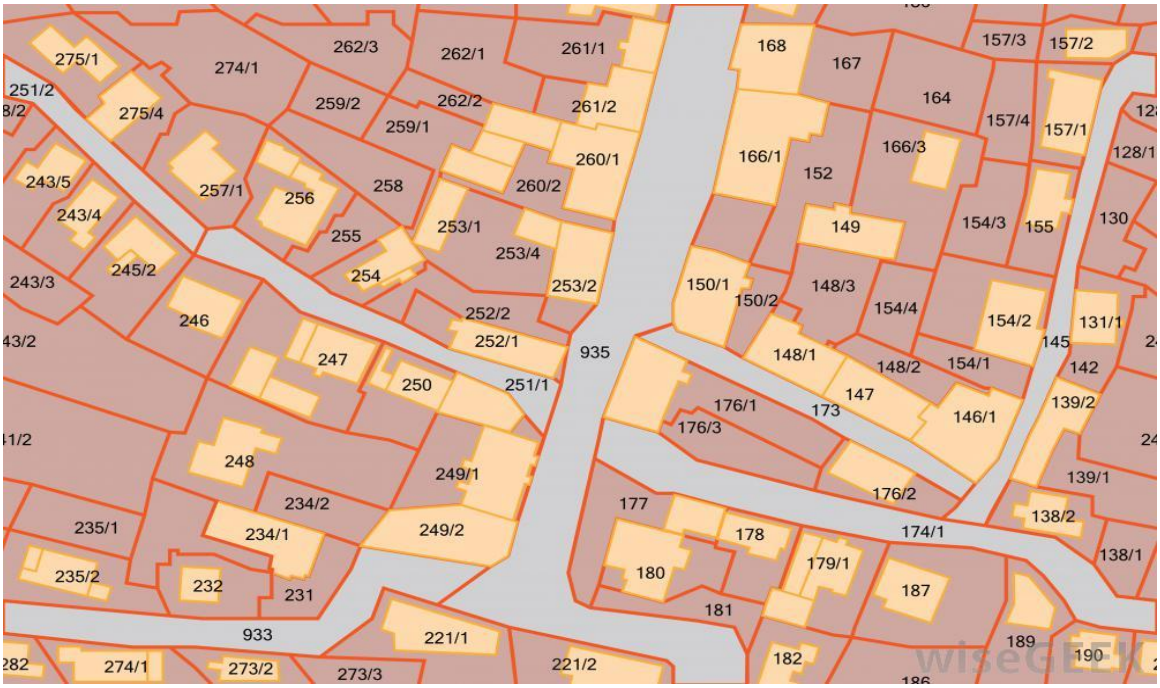


Figure 2: Cadastral map

A **cadastral map** shows the boundaries of every plot of land (Parcel). It indicates the relationship of legal boundaries (the spatial extents) of a given parcel and ownership right of the property. It is the basis for legal aspects like ownership as well as fiscal aspects like taxation of land. The cadaster also provides data for planning (For example, boundaries of constructions, land use, and soil). Cadaster also gives answers for the questions 'where' that refers to the location of the land parcel and its boundaries; and 'how much' to refer the size of the land parcel.

Activity	Explain the difference between the following terms: • Map and globe • Large, medium and small-scale maps • General reference map and thematic map

1.3.2 Types of Plans and their Functions

Plans are a set of drawings or two-dimensional diagrams used to describe a place or object, or to communicate design or construction instructions. Usually plans are drawn or printed on paper, but they can take the form of a digital file. Most planning applications require both a site plan and location plan.

Site plan: Site plan is also known as a 'block plan' shows the proposed development in relation to the property boundary. (See Figure 3) It includes:

- The size and position of the existing building in relation to the property boundary
- The position and use of any other buildings within the property boundary
- The position and width of any adjacent streets.

Site plan shows the aerial view of the site including property lines, easements and is the first type of drawing in a complete Construction Document. Site plans provides information about the site's topography, landscaping utilities, and site work. The main function of site plan is to illustrate the existing natural and built features (see Figure 4).

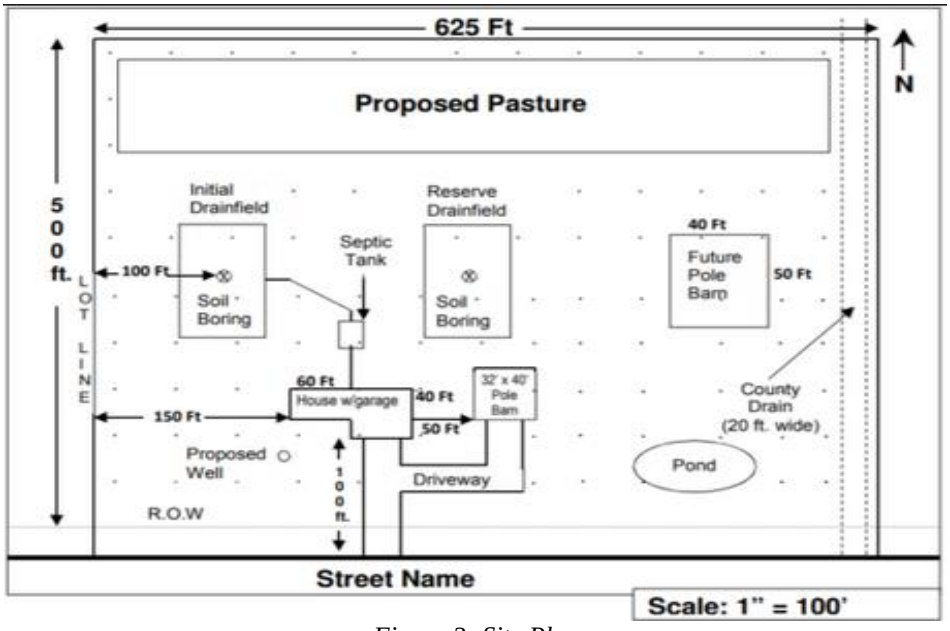


Figure 3: Site Plan

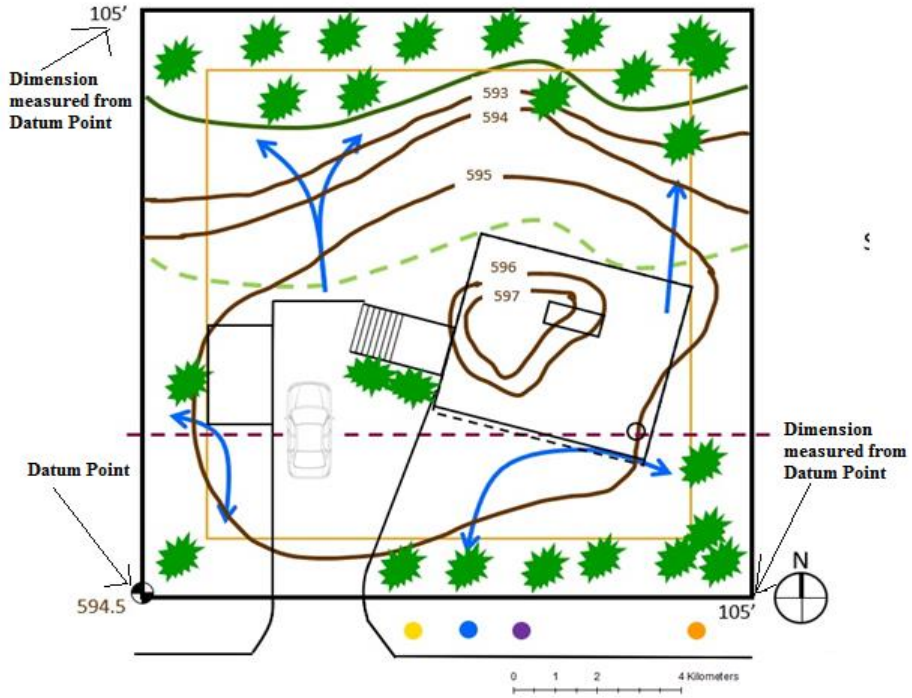


Figure 4: Site Plan with *main features, contours and datum*

Location Plan: Location plan shows the proposed development in relation to its surrounding properties. Location plan (See Figure 5) is prepared based on an up-to-date base map and produced at the scale of either 1:1,250 for the urban areas and small properties or 1:2,500 for rural areas and large properties.



Figure 5: Location Plan

1.3.3 Types of Drawing and Their Functions

Drawing is a form of visual art used to represent the visual world with no definite scale by making of dots, lines and areas onto paper or other materials like walls. It is the oldest forms of human expression within the visual art.

There are several categories of drawing. Some of these include freehand sketch (See Figure 6), cartooning, doodling, figure drawing etc.



Figure 6: Freehand Sketch

1.3.4 Basic Concepts of Map Reading

Map reading is the activity of recognizing the features and phenomena represented on a map. Reading a map is not a simple task without the understanding of cartographic conventions such as marginal information, signs and symbols that are used to represent real features on the map.

Every map conveys varied types of information through the use of a language of its own which universally conventional. Every map has a standard format in which compulsory and optional information is included in the margins. The specific locations of each piece of information may vary from one map to another. Whatever location it takes all the information included in any of the four margins (See Figure 7) of a given map are collectively called as marginal information. Some of these include are the title of the map; north arrow, legend/key, scale, projection system, date of production, serial number, sheet number: contour lines, etc.

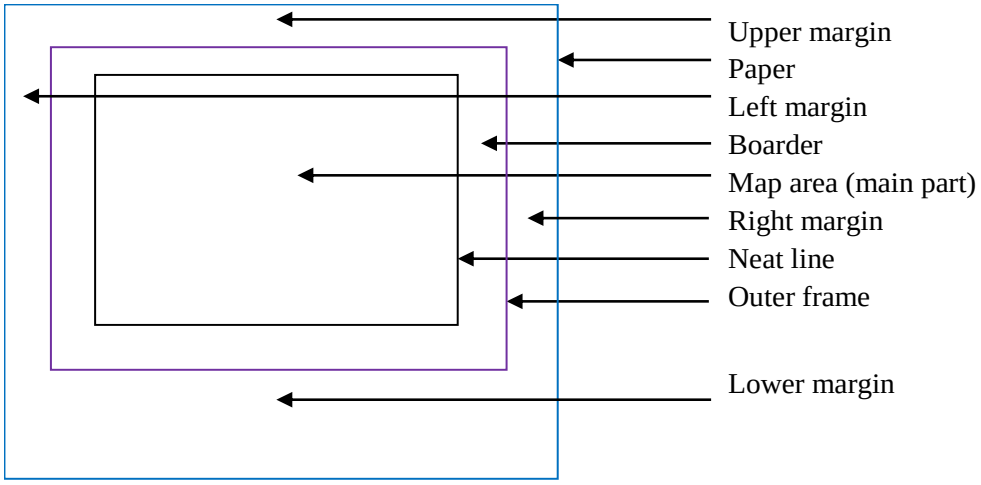


Figure 7: Location of the four margins and frame work of a given map

1.3.5 Identifying and Interpreting Unique Parcel Identification Number

For the proper management of the land resource, each land holding/parcel should be uniquely identified and coded in the manner that meets the legal acts. Countries have their own mechanism of coding their land resource.

The Unique Parcel Identification Number (UPIN) shall meet the following principles:

a) **Uniqueness**: is the most important attribute of a PIN. It refers to a one-to-one relationship between a parcel and its identifier. An identifier should be assigned to one and only one parcel.

b) **Permanent:** Parcel identifiers should be permanent and change only when absolutely necessary. This is especially important when stakeholders such as planning

departments or tax payment tracking services link their own databases to the assessor's.

c) **Simple:** Parcel identifiers should be easy to understand and use quarter-quarter-section numbers, along with individual parcel and have as few digits as possible. A parcel identifier that is uncomplicated and easily understood helps to reduce errors in its use.

d) **Easily Maintainable:** The parcel identification system should be easy to maintain and should efficiently accommodate changes, such as splitting or merging parcels.

e) **Flexible:** The parcel identification system should be reasonably flexible. It should be capable of serving a variety of uses: not just land parcels, but multi-story condominiums, sub-surface rights, leases, easements, and so on.

f) **Accessibility:** the description about the parcel shall be accessible to the user.

Prior to the declaration of urban land holding registration proclamation number 818/2014, identifying land holdings was so difficult due to the fact that information about the holding was kept with owners. This way of managing land resource was so tedious to identify the parcel at its exact location i.e. parcels were identified not by location. The identification/search for the parcel was done by questioning who owns it rather than where it is geographically situated (based on the known location defined by coordinates). Nowadays, by the standard set to code land holdings, providing UPIC for each and every parcel have been started. According to the proclamation 818/2014 Article 8, each parcel shall have a UPIC which may not be duplicated on another parcel in any urban center in the country. For this purpose, a national standard was set to assign a code for each parcel. According to the standard the UPIC shall take the following form:

Region code	+	City/town code	+	Woreda code	+	Neighborhood code	+	City block code	+	Parcel code

- Region code → 2 character (For Example: OR = Oromia)
- City/town code → 3 digits (For Example: 014 = Ambo)
- Woreda/Kebele code → 2 digits (For Example: 01= Kebele 01)
- Neighborhood code → 2 digits (For Example: 01= the first neighborhood with in the section)
- City block code → 2 digits (For Example: 01 = the first block within given neighborhood)
- Parcel ID → 3 digits (For Example: 001 = the first parcel within the block)

With this way of coding the total digit number UPIC will be 14 (OR014010101001) with an exception for the condominium site. For the condominium it will be 20 digits. The reason behind this is there are additions of code for the condominium block unit code, floor code and house number code where each of them are coded with a 2-digit numeric code.

Note:

- Except for the region code which is alphabetic all others should be coded numerically. The region code shall take the two alphabetical letters of the region name.
- Except for the city/town code and parcel code, which is three digits, the rest all should be coded with two digits

1.3.6 Basic Manual Computations on Maps

Distance on maps should always be measured with a pair of dividers, straight edge of paper or ruler. String nearly always gives an inaccurate result and should only be used for rough calculations. First of all, you have to know your scale at which features are represented on the map. When you measure a distance on the map, just compare it to the scale, and it will instantly tell you the ground distance. Then measure a straight-line distance on a map with a ruler and calculating distance using the scale. In order to calculate the ground distance, you need to multiply the map distance by the map scale, and convert it to meters or kilometers or miles.

For example: if the map distance obtained through measurement using a ruler on a given map whose scale is 1: 25,000 is 8.5 cm so the ground distance will be calculated in the following manner.

Multiply distance by scale: 8.5cm x 25,000 = 212,500 cm
Convert to meters: 212,500 / 100 =2,125 m
Convert to km:2,125 / 1,000 =2.125 km

1.4 Recognizing Amendments in Project Documentation

1.4.1 Introduction

An amendment is a formal or official change that made after the plans, maps or drawings have been finalized. They are sometimes called revisions. These changes might happen because the client requests or because the builder realizes something will work well if it is done a little differently.

Part of the process of monitoring and controlling project performance is regular comparison between planned project document and actual results achieved. Examining planned vs. actual technical, schedule, and cost performance may lead to a need for project amendments with in the project documents. Project documentation is the types of documents created and their content are dictated by the needs of the project. It is a brief description describing the content and purpose of the project.

Some scope amendments are critical and may reflect a shift in the direction of the project to accommodate transforming project objectives. Others may be unnecessary to the primary functionality of your end solution but they may be required to mitigate future risks. Given the impact that these types of adjustments have on the project schedule and requirements, it is helpful to have a process in place to help team leads decide whether or not a change should be adopted.

1.4.2 Checking Title Panel of Project Documentation

Naming and describing documents makes it easier to find relevant documents and to use them when the document is looks relevant for some purpose at any time. Consistent file names allow documents to be sorted alphabetically in order. The following are major considerations while naming documents:

- Naming should relate to the business activity the document supports
- Avoid including personal names
- Avoid terms such as miscellaneous, general
- Avoid acronyms and abbreviations, etc.

1.4.3 Project Objective, Scope and Specifications

A project objective describes the desired results of a project, which often includes a tangible item. It is a basic description of the purpose of the project. It should reflect positive changes in the set of conditions desired by the community after the problem is addressed.

Project specifications are the detailed technical description of a project and its requirement. The requirements may vary depending on the project or the job at hand. Specifications, particularly the “general conditions” form the rule of how project will be administered and costs. Project specifications also form the contract and need to be gone over before a project is bid. .

Requirements answer the following questions regarding the as-is and to-be states of the project: who, what, where, when, how much, and how does a project process work? Requirements may include attributes like dimensions, ease of use, colour, specific ingredients, and so on.

1.5 Cartographic Representations

1.5.1. Introduction

Cartography is the discipline dealing with the conception, production, dissemination and study of maps. It is also about representation of the map. This means that cartography is the whole process of mapping. Viewed in the broadest sense, this process includes everything from the gathering, evaluation and processing of source data, through the intellectual and graphical design of the map, to the drawing and reproduction of the final document.

Cartography, being an art and science of map-making, does include a series of processes that are common to all the maps. These processes that may also be referred to as elements of maps are: scale, map projection, map generalization, map design, map construction and production. In cartography, our dealing is more with graphics and the use of graphics to capture the spatial structure of the environment is the subject matter of Cartography. Graphic methods extend from drawing and painting to construction of maps, charts, plans, diagrams etc.

1.5.2 Interpreting Symbols, Abbreviations on Plans and Maps

A map uses its own language expressed with the help of its conventional signs and symbols to convey its messages in a summarized form. When drawing a map to scale, it is important to include as much details as possible. However not all detail will fit on the map, so we use map symbols that could be a diagram, image, sign or letter or abbreviation to represent the main items on the map.

The symbols in the legend or key help you to read a given map. Whenever you read a map you should consult the key or legend carefully so that you can understand what each symbol, sign or abbreviation representing on the map (See Figure 8). While using symbols, signs, diagrams, abbreviations; for representing the real features of the earth's surface they should satisfy the following requirements.

- Uniform throughout a map or a series of maps.
- Comprehensible so as not to lead to guesswork.
- Legible or easily distinguishable on the map.

- Sufficiently precise in terms of location, distribution or space occupied.

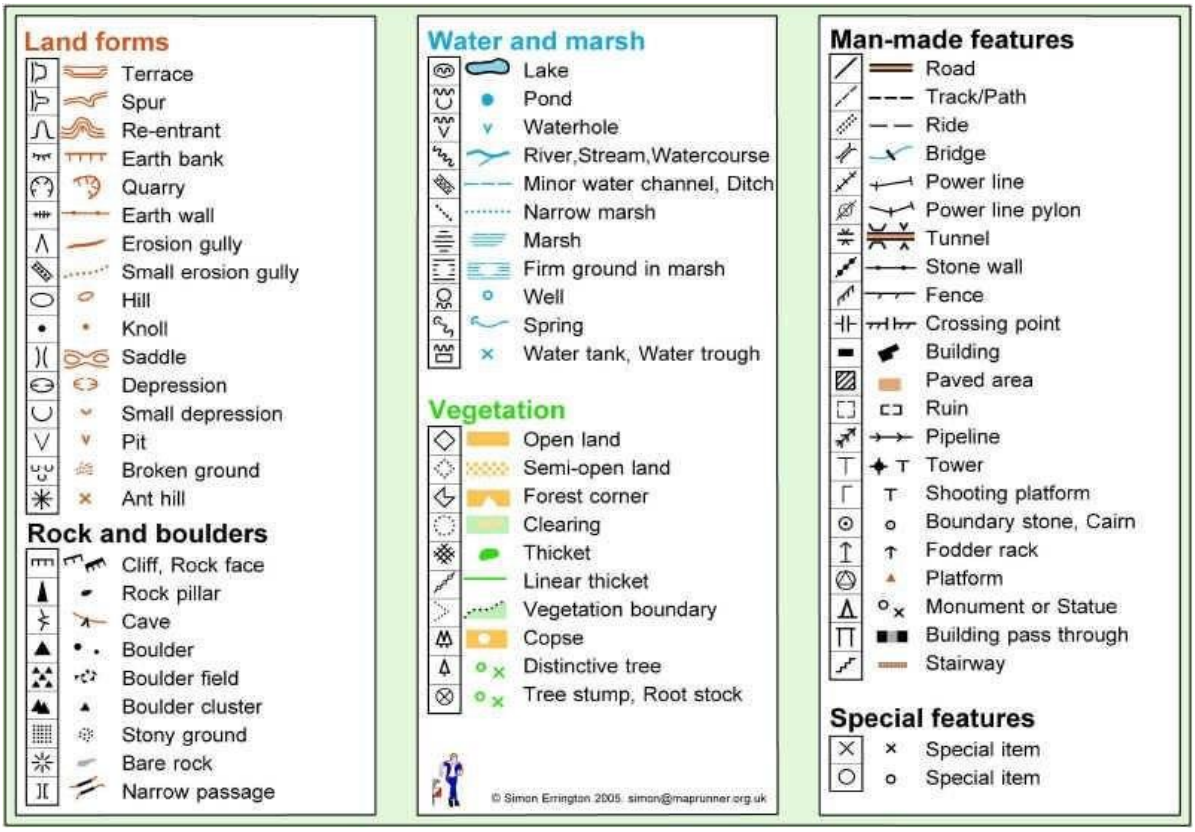


Figure 8: Features representation used on maps

As you have seen from the above figure, legend is a decoder for all the symbols used on a map. Remember it is not always intuitive as to what a symbol represents, so give sufficient information to ensure that your map is not misread. For example, a tree (draw a tree symbol) symbol could represent a single tree, a forest, a plant nursery, a city park, a lawn cemetery or even something totally unrelated to plants. The legend is therefore a symbolic interpretation of both natural and man-made features as represented in the map. Therefore, in a simple term legend refers to putting meaning to symbols.

Reading a map to utilize it for different functions is not a simple task without the understanding of how to use signs and symbols to interpret features represented on the map. A good map must have a key or legend which gives clue to the user what different symbols in that map represent. For instance, a square with a flag on top usually represents a school, while roads are represented by a variety of widths and a combination of line types and colors. Often dashed lines are used to depict boundaries of jurisdictions and administrative units.

In the map making process, there are standardized color, sign and symbol conventions in the representation of various categories of geographic features. For instance

- Blue – water bodies such as rivers, ponds, seas, etc.
- Black / grey – man-made features including buildings, paths, slope, etc.
- Brown – contour lines and sands.
- Green – natural vegetation; park; farmland
- Red/ pink – roads

There are conventions in cartography which allow a map to be read efficiently and quickly. A good map must have a key or legend which shows the user what different symbols, signs and colors in that map represent so that everyone can read the map. Other additional information about the map is kept in the margins of the map referred as marginal information.

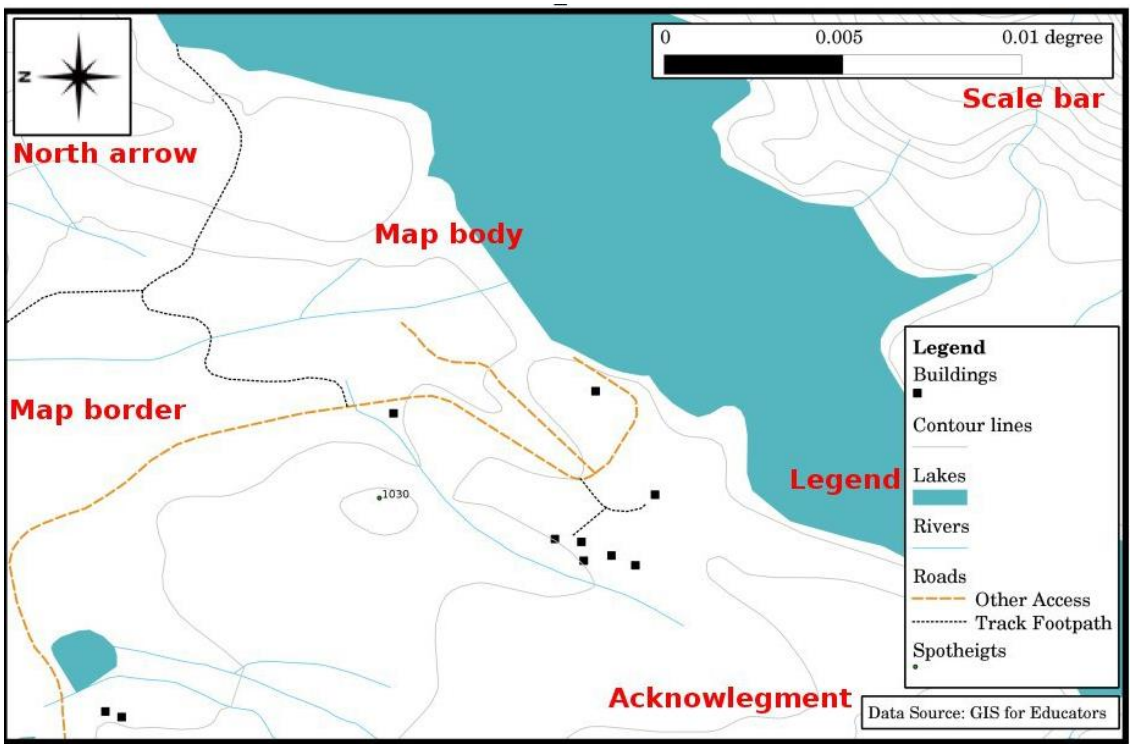


Figure 9: Commonly used map elements (Marginal Information)

1.5.3 Spatial Reference System and its Use

We understand that we are somewhere there, but how can we know where we are? While trying to answer this question we try to search for some reference point from our surrounding. Space is essential to Geography and geographic Information provides us information about where is what is located and why/where is about the location of feature, what is the kind of an attribute and why the analytical spatial reference system is. It is the concept used to uniquely define the position of a point. It is typical that all datasets for the same area (and in the same geo-database) use a common spatial reference point. Spatial reference systems consist of different physical and mathematical models and constants. The parameters are used in

identifying one coordinate system from the other to assign relative position of every spatial point.

Coordinate System

Coordinate systems enable geographic datasets to use common locations for integration. A coordinate system is a reference system used to represent the locations of geographic features, imagery, and observations such as GPS locations within a common geographic framework. There are two types of coordinate systems:

i) **Geographic Coordinate Systems (GCS):** uses a three-dimensional spherical surface to define locations on the earth in the form of: Latitude and Longitude (For example: World Geodetic System 1984 (WGS 84))

ii) **Projected Coordinate Systems (PCS):** is defined on a flat, two-dimensional surface. It is always based on a GCS that is based on a sphere or spheroid and include a map projection. (For example: Universal Transverse Mercator projection (UTM))

1.6 Reading and Interpreting Specifications

Detailed drawings, notes and descriptions help to clarify certain parts of the drawing. Notes are classified as either specific or general. General notes apply to the entire drawing. They are usually placed in a horizontal position above or to the left of the title block. General notes are not referenced in the list of materials or from specific areas of the drawing. Specific notes (or callouts) apply to certain features or areas. They are positioned near the feature or area to which the notes apply.

Specifications (sometimes called as specs) refer to an explicit set of requirements to be satisfied by a design, material or service. A specification is a type of technical standard. In engineering it is vital for suppliers, users of materials, products, or services to understand and agree up on all requirements. It is also a type of standard which is often referenced by a contractor procurement document. A specification may include:

- Descriptive title, number, identifier
- Date of last effective revision.
- A logo or trade mark
- Test methods
- Targets and tolerances
- Safety considerations
- Environmental considerations
- Signatures of approval, if necessary

1.7 Summary

Dear trainee! All maps are reduced at an established scale, selective, symbolized representation of the real world as viewed vertically from above. Map is a powerful tool of communication and it adds a lot to your geographical understanding of the land. Although, there is no limit to the number of maps that are in use, all maps can be categorized into a number of identifiable types based on their scale at which they are reduced to represent real features of the earth, the functions/purposes they provide to us and their subject matter or the content they convey in them.

Every map conveys varied types of information through the use of colors and symbols. Thus, map reading requires you to comprehend these symbols and signs used so that you will able to easily communicate with the map and the information included in the map. The symbols, signs, colors, abbreviations and other items, which represent and convey messages of the features and phenomena represented on maps are contained in the margins and borders of the map. Such important contained in the margins of maps include: title, scale, legend, direction reference, etc.

A map symbol could be a diagram, sign, letter, color or abbreviation which may be conventional or otherwise, and which by reference to a legend is understood to represent a specific feature or phenomena. The symbols used on a map should be uniform throughout a map, comprehensible, legible and sufficiently precise.

1.8 Self-Check Exercise

**Short Answer and Fill the Blank Space Items**

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

1) What do we mean by reading and interpreting plans?
2) How can an individual read and interpret plans?
3) Explain the similarity and differences between site plan and location plan.
4) What makes a map basically different from a globe?
5) List the three groups into which maps are classified based on scale.

CHAPTER TWO: ORGANIZING AND MAINTAINING EQUIPMENT AND SUPPLIES/ACCESSORIES

2.1 Introduction

Dear trainee! This chapter introduces you the basic concepts of organizing and maintaining equipment and supplies/accessories. Organizing and maintaining equipment and supplies/accessories are required before starting principal work activities according to the specifications and organizational guidelines. It is very important for every surveyor to have all of their equipment ready for the job ahead. One missing item could cost the organization time and money.

The surveyor should select appropriate tools, equipment and supplies/accessories for a given project and check the equipment to ensure as it is in safe working. contingencies and risk management processes shall be considered when using equipment and supplies/accessories. Arrangements are made for the transport of equipment and supplies/accessories. Personnel are instructed to operate equipment according to manufacturer specifications and user manual. Adjustment, calibration and maintenance of equipment are arranged. Unsafe or faulty equipment is identified and arrangements are put in place for the operational maintenance of equipment. Repair work is organized for unsafe or faulty equipment under direction of relevant personnel and according to organizational guidelines. Tools, equipment and batteries are stored safely in an appropriate location and according to manufacturer's specifications.

2.2 Learning Objectives

After completing this chapter, you will able to:

- Identify and prepare required surveying equipment and supplies/accessories
- Describe how to adjust and care surveying equipment and supplies/accessories
- Maintain and organize equipment for field wok

Dear trainee! Before reading the following section, take ten minutes and try to identify the basic surveying equipment's and their adjustment.

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2.3 Selecting Equipment and Supplies/Accessories

2.3.1 Specifications and Principal Work Activities

All tools, equipment, and accessories must be properly checked and maintained so that workers are not endangered. Before using an instrument for the principal work activities, make a visual inspection for any damages. Check for any exposed machine surfaces including the polished faces of lenses. The instrument motions should be checked to ensure they have a smooth operation. The interior of the instrument should be cleaned regularly in accordance with the specifications given by the manufacturer.

Specifications are a written description of the instrument's performance in quantifiable terms and apply to the population of instruments having the same model number. Since specifications are based on the performance statistics of a sufficiently large sample of instruments, they describe group behavior rather than that for a single, specific instrument. The initial selection of prospective equipment is usually based on its written specifications.

2.3.2 Selecting and Preparing Tools, Equipment and Supplies/Accessories

Modern surveying instruments provide faster and more precise surveying than conventional instruments. In conventional surveying, chain and tape are used for making linear measurements while compass and ordinary theodolites are used for making angular measurements. Leveling work is carried out using a Dumpy level and a leveling staff. With such surveying instruments, survey work will be slow and tedious.

The surveyor should regularly do adjustment to the equipment to ensure that the equipment is properly functioning and the accuracy of the intended work is maintained. The following are good practices while using the surveying instruments:

- Tape should be straight when used and avoid shrinks. Clean it regularly.
- The instrument should be removed and returned to its box carefully.
- Survey chain should be checked for its links, rings and length before its use.
- The instrument with mechanical parts should be protected from vibration and impact.
- Dirty and dust should be regularly cleaned from movable parts of the instrument.
- The clamping and adjusting screws should not be tightened far more than necessary.

- The objective and eye piece lens should not be touched with fingers.
- Raise the magnetic needle off the pivot of the instrument when not in use.
- Recharge the battery after its use in the field. Also, carry a spare battery for field work.
- Shelter total station against harsh weather elements using an umbrella.
- Charge the GPS batteries after a day's work.
- When transporting a total station/theodolite for long distances, return carefully into casing box. For medium distances, release from tribach clamp and carry from top handle. For short distances, move it holding it vertically upright.
- Select instrument stations that won't put instrument man, instrument or team at danger during field work.
- Conduct daily inspection on the equipment used.
- Never leave the instruments unattended.
- Never point the total station/ theodolite directly at the Sun.
- Keep the shoes of the tripods clean and dirt free.

2.3.3 Contingencies and Risk Management Processes

Risk contingency plan in a surveying field work project allows for flexibility and effective responses to change in fields, equipment related problems and unforeseen risks arising at field. A poor risk contingency allowance can result in cost, in terms of budget and time of the project as well as quality of surveyed data. However, a good risk contingency plan can be tailored based on the previous similar projects, project standards, and organizational guidelines while taking into consideration the individuality of that particular project.

Survey equipment should be taken care of with utmost caution and in the correct manner. The chief party is responsible for his party's equipment. Care must be taken against some of the following potential risks that may affect the equipment adversely:

- Adverse weather conditions e.g. rain, strong winds and high temperatures
- Wrong use of the equipment, for example sitting on the equipment cover case
- Setting up the equipment at dangerous positions e.g. near the edge of a valley, river bank or next to a busy road.
- Leaving equipment in an unsecured location.

- Transporting the equipment in the wrong way.
- Lack of routine care practices e.g. inspecting, cleaning and safely storing the equipment.

2.3.4 Checking Equipment

A checklist of the equipment is therefore prepared before embarking on further field work procedures. The checklist details the following items:

- Date/ time of picking the item
- Return date/time of the item
- Name of team party leader in charge of the equipment
- Equipment name and number of items collected from storage
- Officer in charge of the storage room
- Condition of the item taken

2.3.5 Identifying Professional Code of Ethics

A professional code of ethics is a set of principles designed to help professionals distinguish right from wrong in order to govern their decision-making. Often referred to as an ethical code, these principles outline the mission and values of an organization, how the professionals within the organization are supposed to approach problems and the standards to which the employees are held.

Professional land surveyors shall:

- Hold paramount the safety, health and welfare of the public in the performance of their professional duties.
- Make sure you perform services only in the areas of their competence.
- Issuance of public statements in line with its objective and truthful manner.
- Act in professional matters for each employer or client as faithful agents or trustees, and shall avoid conflicts of interest.
- Build their professional reputations on the merit of their services.
- Act in such a manner as to uphold and enhance the honor, integrity, and dignity of their profession.
- Continue their professional development throughout their careers and provide opportunities for the professional development of those under their supervision.

2.3.6 Personal Protective Equipment

Personal Protective Equipment (PPE) is the term used to describe protective clothing, helmets, goggles, or other garments or equipment designed to protect the wearer's body from injury or infection. The hazards that are mitigated by protective equipment can include physical, electrical, heat, chemicals, biohazards, and airborne particulate matter. PPE is mandatory on many job-sites and under many conditions.

2.4 Surveying Equipments and Accessories

Surveying equipment is being used under most stressful conditions. The equipment is exposed to extreme weather conditions, used in dusty construction areas and is subject to bumpy transportation. Proper care in the methods by which equipment is used, stored, transported, and adjusted is a major factor in the successful completion of the survey. Lack of good maintenance practices not only causes unjustified replacement costs, but also can seriously jeopardize the efficiency and accuracy of the entire survey.

2.4.1 Care and Maintenance of Surveying Equipment and Tools

Surveying instruments, which include tapes, levels, compass, theodolites, total stations, GNSS receivers and others are designed and constructed to provide years of reliable use. The shafts, spindles, pendulums, and electronics of precision instruments, although constructed for rugged field conditions, can be damaged by one careless act, or continued inattention to 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 instrument, 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.

The following general principles of care and servicing should be applied as a routine matter for all survey equipment and supplies:

- All equipment and tools should be kept as clean and dry as practicable, particularly if they are to be transported or stored for any length of time.

- Wooden surfaces should be wiped clean of caked mud or moisture prior to returning the equipment to the vehicle. The original painted or varnished surfaces should be repaired as often as needed to keep moisture from entering the wood.
- Metal surfaces should be cleaned and wiped as dry as practicable. A coat of light oil should be applied to tapes and the metal parts of tools to prevent rusting during storage. Excess oil should be wiped off.
- Keeping during transportation, because of the major portion of damage to equipment and tools occurs when they are being placed into or taken out of the survey vehicle.
- Before removing an instrument, study the way it is placed and secured in the case.
- Whenever possible, select instrument stations where operation is not dangerous to the instrument operator, the crew, or the instrument and Select stable ground for the tripod feet.

2.4.2 Adjustments of Surveying Instruments

The crew leader should develop a set of test procedures to be used frequently for elimination of gross errors. Such tests should include a check of items such as the levels, optical plummet, and tripod. In the field, adjustments should only be made when the instrument results are poor or require excessive manipulation.

Normally, each instrument should be periodically checked at a facility where the best conditions for testing are possible. Only the adjustments described in the manual for the instrument should be made in the field or shop. Do not field strip (dismantle) instruments.

When an instrument has been damaged or otherwise requires major adjustments, it will need to be sent to an authorized repair shop. The instrument should be accompanied by a written statement indicating the types of repairs needed. In the case of electronic devices, the request should describe conditions under which the instrument does not function properly, i.e., coldness, dampness, etc. If a loaner is needed, this should also be indicated. Wherever possible, the instrument should be double cased for shipping, with its case packed inside a cardboard container.

Improperly maintained tools can be a source of annoyance, as well as being a safety hazard. Each employee is responsible for keeping his or her tools and equipment in good condition. To prevent loss of small equipment and tools, avoid laying them on the ground, on vehicles,

or on equipment which might be moved. When not in use, carry them in scabbards and pouches.

- Repair or replace any driving tool that is burred or fractured on any part of the striking or driving face. Many surveyors have been injured by the "shrapnel" effect from gads and sledges which had ragged edges. The same is true for "bull points" or other tools which are driven.
- Crooked or warped handles can cause injury as well as mishitting and damage to the tool. Promptly replace such handles and those that are cracked or broken. Handles should be firmly secured in all cutting and driving tools.

2.5 Maintaining and Organizing Equipment

Based on the detail checking, unsafe or faulty equipment will be identified and arranged for the operational maintenance of the equipment. Operational maintenance is the care and minor maintenance of equipment using procedures that do not require detailed technical knowledge of the equipment's or system's function and design. Lack of good maintenance practices not only causes unjustified replacement costs, but also can serious the efficiency and accuracy of the entire survey. Then, repair work will be organized for unsafe or faulty equipment under direction of relevant personnel and according to organizational guidelines. Finally, the tools, equipments and batteries shall be stored safely in an appropriate location and according to manufacturer’s specifications.

2.6 Summary

Dear trainee! Many surveying equipment’s are found in the world as well as in our country for different purpose. Each surveying equipment has many suppliers/accessories. Before doing the field work you should select the right equipment with its supplier/accessories. When selection activities take place, you should consider the specification, use check list, use personal protective, identifying professional code of ethics and etc. Surveying equipment is being used under most stressful conditions. The equipment is exposed to extreme weather conditions, used in dusty construction areas and is subject to bumpy transportation. Proper care in the method by which equipment is used, stored, transported, and adjusted is a major factor in the successful completion of the survey. Lack of good care, adjustment and proper maintenance practices not only causes unjustified replacement costs, but also can serious the efficiency and accuracy of the entire survey.

2.7 Self-Check Exercises



Short Answer Items

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

1) Discuss the care and adjustments made for distance, angle and elevation measuring instruments.
2) Why it is necessary to maintain and organize surveying equipment before field work?
3) Explain the importance of equipment specification for selecting the equipment.
4) What is the difference between accuracy and precision?
5) List down the source of error and their classification as well.

CHAPTER THREE: CONDUCTING BASIC LAND SURVEYS

3.1 Introduction

Dear trainee! This chapter introduces you about the basic concept theoretical and practical concept of land surveying, specifically the concepts related to pre-surveying work, the operational aspect of land surveying and tasks after the land survey. Land surveying is the determination of the relative spatial location of points on or near the surface of the earth. It is the art of measuring horizontal and vertical distances between objects, of measuring angles between lines, of determining the direction of lines, and of establishing points by predetermined angular and linear measurements. Along with the actual survey measurements are the mathematical calculations. Distances, angles, directions, locations, elevations, areas, and volumes are thus determined from the data of the survey. Survey data is portrayed graphically by the construction of maps, profiles, cross sections, and diagrams.

3.2 Learning Objectives

After completing this chapter, you will be able to:

- Explain the basic concepts of Land surveying
- Identify procedures to conduct Land surveys
- Perform Land surveying activities
- Organize and prepare the surveyed data

Dear trainee! Before reading the following section, take ten minutes and try to explain concepts basic land surveying and preparation for land surveying.

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3.3 Land Survey Preparations

3.3.1 Introduction

Surveying can be defined as the science, art, and technology of determining the relative positions (distances and angles) of points above, on, or beneath the Earth's surface, or of establishing such points. It consists of the following four basic measurements that can be categorized in to linear and angular measurement:

- **Horizontal distance:** measured by tapes, chains, EDM, pacing, odometer, etc.
- **Vertical distance:** measured by levels, altimeter, and clinometer.
- **Horizontal angles:** measured by theodolites, total station, compasses, etc.
- **Vertical angles:** measured by theodolites, total station, and etc.

Types and Classification of Surveying

On the basis whether the curvature of the earth is considered or whether the earth is assumed to be a flat plane, surveying is divided in to two:

i) **Plane Surveying:** is type of surveying which assumes that the Earth is flat (plane), which is the most commonly, practiced form of surveying. Curvature is ignored and calculations are performed using the formulas of plane trigonometry and the properties of plane geometry. These may be considered accurate for limited areas (below 250m^2). These are mostly used in any engineering work like highway, canal, and bridge etc.

ii) **Geodetic Surveying:** is type of surveying which consider the shape of the earth as spherical or ellipsoid of revolution. As in plane surveying all height are referenced to the surface of mean ellipsoid or mean sea level (MSL). For the sake of plotting on the paper map their projection length is calculated and curvature correction is applied for every length. Geodetic surveys are precise over large areas.

Moreover, surveying can be classified based on:

- **Their field:** Land Surveying, Hydrographic Surveys and Astronomical Surveys.
- **Purpose:** Engineering Surveying, Cadastral Surveying, Geological Survey, Military Survey, Control Surveying, Route Surveying, Mine Surveying, Archeological Survey, Astronomical Surveys, and Hydrographic Surveys.
- **Instruments used:** Chain Surveying, Compass Surveying, Levelling Surveying, Theodolite Surveying, Tacheometer Surveying, Photogrammetric Surveying, and EDM Surveying.

Units of Measurement

A unit of measurement is a definite magnitude of a quantity, defined and adopted by convention or by law that is used as a standard for measurement of the same kind of quantity. There are two systems of measurements:

- **Metric System:** M.K.S (meter, kilogram, second): Because of its widespread adoption, the metric system is called the International System of Units, and abbreviated SI.
- **British/English System:** F.P.S (foot, pound, second). The system most commonly used in distance and angle measurements are in system international (SI).

3.3.2 Checking Operation of Equipment and Accessories

During land surveying works, some of the required instruments are tape, level, theodolite, compass, total station, GNSS and required materials such as sketching papers, checklist papers (which enables the land surveyor monitors his/her activities), field book (which helps for taking notes) need to be considered in advance. Organizational guidelines are those documents which are in-line with the legislation of that specific organization. To be followed and act according to these guidelines are mandatory, and tasks or activities contrary to these will be void. In purchasing, for instance, the surveying instruments should meet the specifications required by that specific organization. Specifications should be checked for their originality. After purchasing the required instruments, the supplier is expected to deliver with user manual and operational training.

Before you go to field surveying, you need to check out the instruments for their safety and operability. In addition to this, professionals need to check the purchased instrument if it is working properly. While planning to go to survey, the packages (set of equipment) should be fulfilled; this may include checking the status of batteries, required accessories, etc. which are necessary for accomplishing the planned land survey, should be packaged. Any organization 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 and specified quality.

3.3.2 Procedures of Land Surveying

Before leaving your office for land survey, in your plan you need to delimit the scope of your work. This task can be aided by the use of reconnaissance survey. Reconnaissance means the method of making measurements ready before the actual operational work. The land surveyor goes to the area, where is to be surveyed, and observes if all physical and environmental situations are conformable for the work. For instance, selecting points, benchmarks, monumenting points, observing obstructions for GPS measurement, etc. are some of the tasks to be ensured before the actual measurement.

Land surveying needs the most care while defining the boundary under investigation. Adjoining neighbors may disagree by the demarcation points and may reach disputes. In order to avoid these issues, awareness creation, prior to demarcation, plays the prominence role in dispute resolutions. For instance, public notice is the major requirement during land adjudication and registration activities conducted by either private or government institutions. Ethiopia's land adjudication and registration policies (Urban Land Registration Proclamation No. 818/2014 and the respective lower level laws) declare this vital procedure (awareness creation) prior to the actual work. Mobilizing is an activity, whereby, team leaders facilitate required activities for the effective accomplishment of the task. Mobilizing professionals, in this case, refers to land surveyors, who perform land survey. And these professionals need to be mobilized or prepared for the actual work in a good manner. In general, the procedures of land surveying are:

A. Reconnaissance

The term reconnaissance means the first inspection of the target area in terms of existing control points, possible sites for new observation stations, as well as the permanent marking of those stations, detection of possible obstacles and possible solutions to overcome them etc. Gathering information about the existing ground reference points, benchmarks and their coordinates and elevations respectively. At this stage a reconnaissance survey of the area to be mapped is absolutely indispensable/crucial and should therefore be carried out thoroughly/systematically, Sketch map is showing manmade features and natural features clearly.

B. Establishing Control Stations

Establishing of horizontal and vertical control points is the most essential part and is the first step in the field work process in most land surveying operations (For example, for cadastral

and topographic surveying), since the three-dimensional coordinates (X, Y, Z) of each point to be surveyed can only be determined with respect to well established reference points.

C. Detail Surveying

Through referring the established control points (Bench marks), detail surveying for the required surveying tasks will be conducted. It can be carried out to locate all the required natural and man-made features on a piece of land. Natural features include topography of the earth surface, vegetation, rocks, trees, stumps and so on. Man-made structures include anything built above the ground – buildings, walls, driveways, utilities and so on.

D. Setting out

Lastly, setting out survey may be required to locate the features found on the map or plan to the ground, setting out is the process of locating points for parcel corners, columns, site boundary level, pile position and other necessary features or structural parts according to the map, plan and drawing. A setting out should be made to full fill the requirements such as length, angle and level.

Errors

All measurements, no matter how carefully executed, will contain error, and so the true value of a measurement is never known. It follows from this that if the true value is never known, the true error can never be known and the position of a point known only with a certain level of uncertainty. The sources of error fall into three broad categories, namely:

- **Instrumental errors:** Surveying error may arise due to imperfection or faulty adjustment of the instrument with which measurement is being taken. For example, a tape may be too long or an angle measuring instrument may be out of adjustment. Such errors are known as instrumental errors.

- **Personal Error:** may also arise due to want of perfection of human sight in observing and of touch in manipulating instruments. For example, an error may be there in taking the level reading or reading and angle on the circle of a theodolite. Such errors are known as personal errors.

- **Natural Error:** in surveying may also be due to variations in natural phenomena such as temperature, humidity, gravity, wind, refraction and magnetic declination. If they are not properly observed while taking measurements, the results will be incorrect.

For example, a tape may be 20 meters at 20ºC but its length will change if the field temperature is different.

Classification of errors

(1) **Mistakes:** are sometimes called gross errors, but should not be classified as errors at all. They are blunders, often resulting from fatigue or the inexperience of the surveyor. Typical examples are omitting a whole tape length when measuring distance, sighting the wrong target in a round of angles, reading '6' on a levelling staff as '9' and vice versa. Mistakes are the largest of the errors likely to arise, and therefore great care must be taken to obviate them. However, because they are large they are easy to spot and so deal with.

(2) **Systematic errors:** can be constant or variable throughout an operation and are generally attributable to known circumstances. Systematic errors, in the main, conform to mathematical and physical laws; thus, it is argued that appropriate corrections can be computed and applied to reduce their effect. Careful calibration of all equipment is an essential part of controlling systematic error.

(3) **Random errors:** are those variates which remain after all other errors have been removed. They are beyond the control of the observer and result from the human inability of the observer to make exact measurements, for reasons already indicated above. Random errors should be small and there is no procedure that will compensate for or reduce any one single error. The size and sign of any random error is quite unpredictable. Although the behavior of any one observation is unpredictable the behavior of a group of random errors is predictable and the larger the group the more predictable is its behavior. This is the basis of much of the quality assessment of survey products. Random variants are assumed to have a continuous frequency distribution called normal distribution and obey the law of probability. A random variant, x, which is normally distributed with a mean and standard deviation, is written in symbol form as $N(\mu, \sigma^2)$. Random errors alone are treated by statistical processes.

Accuracy and Precision

Accuracy refers to the correctness of a measurement or prediction. The results can vary a lot, but what matters is the difference between the measurements or predictions to what is considered to be the real or accepted value. In reality, there is no true value rather an established value through repeating measurements. When the average of the repeated

measurements is taken, it is considered as true value. Thus, accuracy in short, is the closeness of measurements towards the true value.

Precision is often contrasted with accuracy by emphasizing on the frequency of repeatability of the same measurement. This is most applicable to measurements, but can be applied to modeling too (For example, stochastic models). When measuring something, we want some confidence that if we were to measure the same thing again, we would get a similar answer. In this situation, precision describes the degree of this similarity.

Accuracy and precision are both highly desirable characteristics for our measurements and predictions, but they are usually independent. For example, most models should produce the same results when based on the same algorithms and inputs, but this has nothing to do with the accuracy of the model's predictions. Measurements can also be precise without being accurate. When this situation occurs, the difference between the measurements and the true value is called the bias (i.e., bias of an estimator). If we can quantify the bias, then it is possible to adjust for the bias to improve the accuracy.

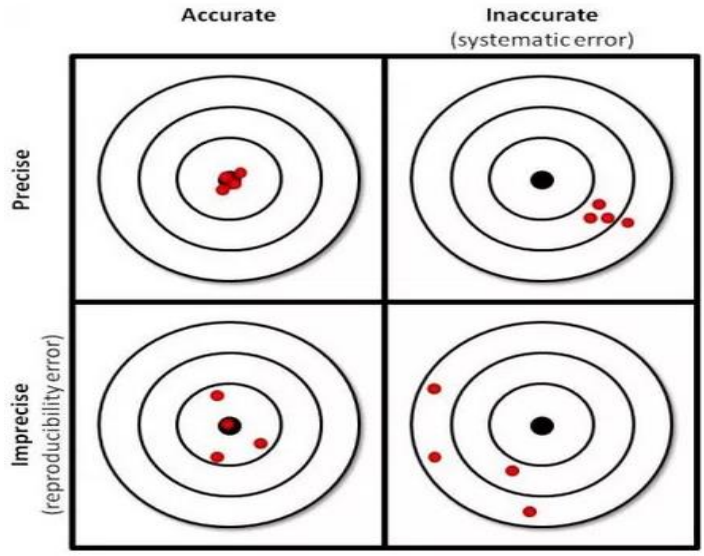


Figure 10: Accuracy and Precision

The concepts of accuracy and precision are also illustrated in the following example.

Example: A building wall known to be 157.22 m long is measured by two methods. In the first case, the wall is measured very carefully using a fiberglass tape graduated to the closest 0.01 m. The result of this operation is a measurement of 157.23 m. In the second case, the wall is measured with the same care, but with a more precise steel tape graduated to the

closest 0.001 m. The result of this operation is a measurement of 157.225 m. In this example, the more precise method (using the steel tape) resulted in the more accurate measurement:

	True Distance	Measured Distance	Error
Cloth tape	157.22	157.23	0.010
Steel tape	157.22	157.225	0.005

It is conceivable, however, that more precise methods can result in less accurate answers.
In the preceding example, if the steel tape had previously been broken and then incorrectly repaired (say, that an even foot had been dropped), the results would still be relatively precise but very inaccurate.

3.4 Land Surveying

There are different land surveying activities for measuring distance, height, angle and coordinates. Steel tapes or wires are used to measure distance very accurately, Level are used to measure vertical distance, Angle (direction) are measured by theodolite and compass instrument and GPS were used to determine position, velocity and time (PVT) .

3.4.1 Taping

Taping is the linear measurement of the horizontal distance between two points using a surveyor's tape depending up on the conditions under which the measurements have been made. Taping requires a minimum of two people. Using range poles, the line to be measured should be marked at both ends (in a vertical position), and at intermediate points where necessary, to ensure the unobstructed sight lines.

3.4.2 Measuring Angle

Angle is defined as the difference in direction between two convergent lines. Measurement of angles can also use to locate the position of a point. The measurement of the angles or directions can be made by the use of compass or a theodolite.

3.4.3 Leveling

Leveling is an operation in surveying performed to determine the difference in levels of two points. By this operation the height of a point from a datum, known as elevation, is determined. Differential leveling or spirit leveling is the most accurate simple direct method of determining the difference of level between two points using an instrument known as level with a leveling staff. A level establishes a horizontal line of sight and the difference in the

level of the line of sight and the point over which the leveling staff is held, is measured through the leveling staff.

3.4.4 Compass Survey

Compass surveying is a type of surveying in which the directions of surveying lines are determined with a magnetic compass, and the length of the surveying lines are measured with a tape or chain or laser range finder.

3.4.5 Conduct land Survey Activities

The land survey process includes a number of steps. Land surveyors need to find county records of property maps, collect data of the property, do calculations, restore lost corners, and prepare accurate descriptions of the property.

3.4.5 Operation of GPS

Global Navigation Satellite Systems or the most popular system which is the Global Positioning System (GPS) instrument is used to determine the position of points on Earth surface with respect to WGS 84 datum. Global Positioning System (GPS) is one of a satellite-based navigation system which developed by the U.S Department of Defense (DoD) in the early 1970s. Its primary mission is to provide passive, real-time, 3-D positioning, navigation, timing and velocity data for land, air, and sea-based strategic and tactical forces operating anywhere in the world.

GPS consists, nominally, of a constellation of 24 operational satellites. To ensure continuous worldwide coverage, GPS satellites are arranged so that four satellites are placed in each of six orbital planes. With this constellation geometry, four to ten GPS satellites will be visible anywhere in the world, if an elevation angle of 10° is considered. GPS satellite orbits are nearly circular (an elliptical shape with a maximum eccentricity is about 0.01), with an inclination of about 55° to the equator. The semi-major axis of a GPS orbit is about 26,560 km (i.e., the satellite altitude of about 20,200 km above the Earth surface). The corresponding GPS orbital period is about 12 sidereal hours (~11 hours, 58 minutes).

Principles of GPS

The basic principle behind how GPS determines a position of point on the earth is conceptually simple. If the distances from a point on the Earth (a GPS receiver) to three GPS satellites are known along with the satellite locations, then the location of the point (or

receiver) can be determined by simply applying the well-known concept of resection. But, how can we get the distances to the satellites as well as the satellite locations? Each GPS satellite continuously transmits a microwave radio signal composed of two carriers, two codes, and a navigation message. When a GPS receiver is switched on, it will pick up the GPS signal through the receiver antenna. Once the receiver acquires the GPS signal, it will process it using its built-in software. The partial outcome of the signal processing consists of the distances to the GPS satellites through the digital codes (known as the pseudoranges) and the satellite coordinates through the navigation message. Theoretically, only three distances to three simultaneously tracked satellites are needed. In this case, the receiver would be located at the intersection of three spheres; each has a radius of one receiver-satellite distance and is centered on that particular satellite. From the practical point of view, however, a fourth satellite is required in order to resolve timing variations (receiver clock offset). Adding more satellite ranges will provide redundancy and more accuracy in the position solution. The user should also be well aware of the positioning mode and GPS receiver quality, location, and length of observation time.

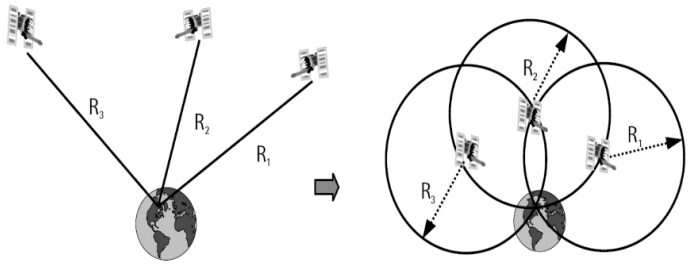


Figure 11: Basic Principles of GPS Positioning

GPS Signal Structure

GPS satellite transmits a microwave radio signal composed of two carrier frequencies (or sine waves) modulated by two digital codes and a navigation message.

GPS carrier frequencies

The two carrier frequencies are generated at 1,575.42 MHz (referred to as the L1 carrier) and 1,227.60 MHz (referred to as the L2 carrier). The corresponding carrier wavelengths are approximately 19 cm and 24.4 cm, respectively, which result from the relation between the

carrier frequency and the speed of light in space. The availability of the two carrier frequencies allows for correcting a major GPS error, known as the ionospheric delay. All of the GPS satellites transmit the same L1 and L2 carrier frequencies. The code modulation, however, is different for each satellite, which significantly minimizes the signal interference.

GPS codes

The two GPS codes are called coarse acquisition (or C/A-code) and precision (or P-code). Each code consists of a stream of binary digits, zeros, and ones, known as bits or chips. The codes are commonly known as PRN codes because they look like random signals (i.e., they are noise-like signals). But in reality, the codes are generated using a mathematical algorithm. Presently, the C/A-code is modulated onto the L1 carrier only, while the P-code is modulated onto both the L1 and the L2 carriers. This modulation is called biphase modulation, because the carrier phase is shifted by 180° when the code value changes from zero to one or from one to zero.

The C/A-code is a stream of 1,023 binary digits (i.e., 1,023 zeros and ones) that repeats itself every millisecond. This means that the chipping rate of the C/A-code is 1.023 Mbps. In other words, the duration of one bit is approximately 1 m/s, or equivalently 300m. Each satellite is assigned a unique C/A-code, which enables the GPS receivers to identify which satellite is transmitting a particular code. The C/A-code range measurement is relatively less precise compared with that of the P-code. It is, however, less complex and is available to all users.

The P-code is a very long sequence of binary digits that repeats itself after 266 days. It is also 10 times faster than the C/A-code (i.e., its rate is 10.23 Mbps). Multiplying the time, it takes the P-code to repeat itself, 266 days, by its rate, 10.23 Mbps, tells us that the P-code is a stream of about is 1 week long. Of these, 32 segments are assigned to the various GPS satellites. That is, each satellite transmits a unique 1-week segment of the P-code, which is initialized every Saturday/Sunday midnight crossing. The remaining six segments are reserved for other uses. It is worth mentioning that a GPS satellite is usually identified by its unique 1-week segment of the P-code. For example, a GPS satellite with an ID of PRN 20 refers to a GPS satellite that is assigned the twentieth-week segment of the PRN P-code. The P-code is designed primarily for military purposes. It was available to all users until January 31, 1994. At that time, the P-code was encrypted by adding to it an unknown W-code. The resulting encrypted code is called the Y-code, which has the same chipping rate as the P-code. This encryption is known as the anti-spoofing (AS).

GPS navigation message

The GPS navigation message is a data stream added to both the L1 and the L2 carriers as binary bi phase modulation at a low rate of 50 bps. It consists of 25 frames of 1,500 bits each, or 37,500 bits in total. This means that the transmission of the complete navigation message takes 750 seconds, or 12.5 minutes. The navigation message contains, along with other information, the coordinates of the GPS satellites as a function of time, the satellite health status, the satellite clock correction, the satellite almanac, and atmospheric data. Each satellite transmits its own navigation message with information on the other satellites, such as the approximate location and health status.

GPS Receivers

A GPS Receiver is L-band radio processor capable of solving the navigation equations in order to determine the user Position, Velocity, and Time (PVT), by processing the signal broadcasted by GPS satellites. There are two general types of GPS receivers: Code Phase and Carrier Phase.

A code receiver: is also called a code-correlating receiver because it requires access to the satellite navigation message of the P or C/A code signal to function. This type of receiver relies on the satellite navigation message to provide an almanac for operation and signal processing. Because it uses the satellite navigation message, this type of receiver can produce real-time navigation data. Code receivers have anywhere fix capability and consequently, a quicker start up time at survey commencement. Once locked onto the GPS satellites, an anywhere fix receiver has the unique capability to begin calculations without being given an approximate location and time.

A carrier phase receiver: utilizes the actual GPS signal itself to calculate a position. There are two general types of carrier phase receivers:

- **Single frequency receiver** tracks the L1 frequency signal. A single frequency receiver can be used effectively to develop relative positions that are accurate over baselines of less than 20 km or where ionospheric effects can generally be ignored.
- **Dual Frequency receiver** tracks both the L1 and L2 frequency signal. A dual frequency receiver will more effectively resolve baselines longer than 20 km where ionospheric effects have a larger impact on calculations. Dual frequency receivers

eliminate almost all ionospheric effects by combining L1 and L2 observations. All geodetic quality receivers are multichannel, in which a separate channel is tracking each satellite in view. Most manufacturers of dual frequency receivers utilize codeless techniques, which allow the use of the L2 during anti spoofing.

GPS receivers may also be divided into the following types based on their receiving capabilities, though the discussion on receiver types is thwarting, because of the rapid technological advancements.

- **Single frequency code receiver:** measures the pseudoranges with the C/A code only. No other measurements are available. It is the least expensive and the least accurate receiver type, and is mostly used for recreation purposes.

- **Single frequency carrier smoothed code receiver:** also measures the pseudoranges with the C/A code only. However, with this receiver type, the higher resolution carrier frequency is used internally to improve the resolution of the code pseudorange, which results in high precision pseudorange measurements.

- **Single frequency code and carrier receiver:** (output the raw C/A code pseudo ranges, the L1 carrier phase measurements, and the navigation message).

GPS Errors and Biases

GPS pseudorange and carrier-phase measurements are both affected by several types of random errors and biases (systematic errors). These errors may be classified as those originating at the:

- **Satellites:** The errors originating at the satellites include ephemeris, or orbital, errors, satellite clock errors, and the effect of Selective Availability (SA). SA was intentionally implemented by the U.S. DoD to degrade the autonomous GPS accuracy for security reasons. It was, however, terminated at midnight (eastern daylight time) on May 1, 2000.

- **Receiver:** This include receiver clock errors, multipath error, receiver noise, and antenna phase center variations.

- **Due to signal propagation (atmospheric refraction):** Include the delays of the GPS signal as it passes through the ionospheric and tropospheric layers of the atmosphere.

In fact, it is only in a vacuum (free space) that the GPS signal travels, or propagates, at the speed of light.

In addition to the effect of these errors, the accuracy of the computed GPS position is also affected by the geometric locations of the GPS satellites as seen by the receiver. The more spread out the satellites are in the sky, the better the obtained accuracy.

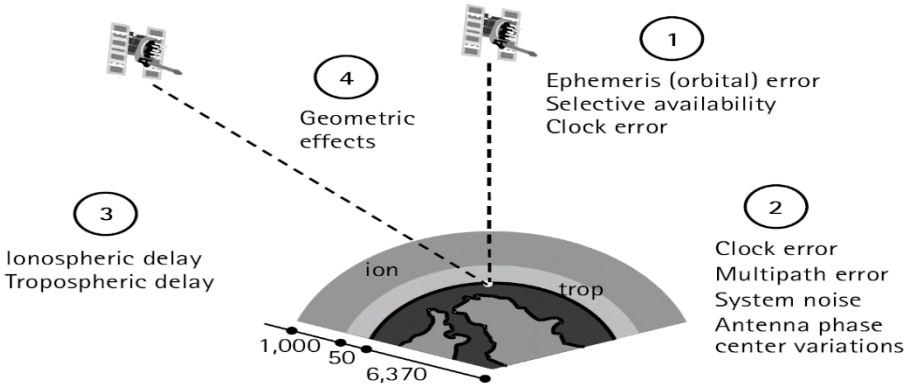


Figure 12: GPS Errors and Biases

Anyone can compute the distance and direction of a given points from the coordinates acquired with GPS using the following formula respectively:

$$AB = \sqrt{(X_B - X_A)^2 + (Y_B - Y_A)^2} \quad \text{and} \quad Az_{AB} = \tan^{-1}\left(\frac{\Delta X}{\Delta Y}\right)$$

3.4.2 Field Booking

Accomplishing and submitting field notes to the expert who is responsible for mapping is mandatory. Since this information gives pertinent information to mapping expert. Any ambiguous information committed in the instrument (such as personal errors), can be corrected using this filed note. 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.

3.5 Conducting Quality Assurance of Survey Works

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.

3.6 Summary

Dear trainee! Land surveying provides the foundation and continuity for land management, boundary location, land development, and all other preliminary works. Land Surveying has to do with the determination of the relative spatial location of points on or near the surface of the earth. It is the art of measuring horizontal and vertical distances between objects, of measuring angles between lines, of determining the direction of lines, and of establishing points by predetermined angular and linear measurements. The surveyor may be called on to determine heights and distances; to set out property boundary; to determine areas and volumes and to draw plans at a predetermined scale.

Land surveying activities require instruments like tape, level, theodolite, compass, total station, GNSS and also required materials like sketching papers, checklist papers, field book and others. All those activities should be in line with organizational guideline which is a document that gives direction on how to perform activities required. Nowadays, the traditionally distances are measured with tape, foot, odometer and others replaced EDM as a result of geospatial technology advancement. Angles can be measured with theodolites and total stations where as elevations can be measured with level instruments. Compass is an instrument used to measure directions of lines with azimuths or bearing. GPS is also an instrument that uses satellites to measure the location of a specific place.

3.7 Self-Check Exercise

**Short Answer Items**

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

1) Define and explain what land surveying mean?
2) Explain the land surveying work procedures.
3) Discuss the basic land surveying measurements with their working principles.

CHAPTER FOUR: PERFORM SURVEYING COMPUTATIONS

4.1 Introduction

Dear trainee! This chapter introduces you the concepts performing surveying computations. Cadastral data need to be checked for their correctness and reliability before proceeding to detail data collection. In cadastral surveying, the next step after reconnaissance is traverse establishment, which controls detail points to be collected. This traverse needs to be adjusted for its correctness through least square adjustment. A traverse is a continuous series of connected lines of known lengths related to one another by known angles. The lengths of the lines are determined by direct measurement of horizontal distances, slope measurement, or by indirect measurement using the methods of stadia or the sub tense bar. The line courses run between a series of points are called traverse stations. The angles at the traverse stations, between the lines are measured by tape, transit, theodolite, compass, plane table, or sextant. These angles can be interior angles, deflection angles, or angles to the right. The lengths and azimuths or bearings of each line of the traverse are estimated through field measurements. The lengths are horizontal distances, and the azimuths or bearings are true, magnetic, assumed, or grid.

There are two types or classes of traverses. An open traverse, which starts at a point of known or assumed horizontal position with respect to a horizontal datum, and terminates at an unknown horizontal position. Whereas, a closed traverse starts at a known or assumed horizontal position and terminates at that point (i.e., loop traverse), or it starts at a known horizontal position and terminates at another known horizontal position (i.e., connecting traverses). Both the measured angles and lengths in a closed traverse may be checked.

4.2 Learning Objectives

After completing this chapter, you will able to:

- Describe types of traverse
- Explain steps required to compute traverse
- Explain the difference between bearing and Azimuth

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

_____

_____

_____

_____

4.3 Introduction to Traverse

A traverse is a series of consecutive lines whose ends have been marked in the field and whose lengths and directions have been determined from observations. In traditional surveying by ground methods, traversing, the act of marking the lines, that is, establishing traverse stations and making the necessary observations, is one of the most basic and widely practiced means of determining the relative locations of points.

There are two kinds of traverses: closed and open. Two categories of closed traverses exist: polygon (or loop/ring) and link (or route). In the polygon traverse, as shown in Figure 4.1(a), the lines return to the starting point, thus forming a closed figure that is both geometrically and mathematically closed. Link traverses finish upon another station that should have a positional accuracy equal to or greater than that of the starting point. The link type (geometrically open, mathematically closed), as illustrated in Figure 4.1(b), must have a closing reference direction, for example, line E-Az Mk_2. Closed traverses provide checks on the observed angles and distances, which is an extremely important consideration. They are used extensively in control, construction, property, and topographic surveys.

If the distance between stations C and E in Figure 4.1(a) were observed, the resultant set of observations would become what is called a *network*. A network involves the interconnection of stations within the survey to create additional redundant observations. Networks offer more geometric checks than closed traverses. For instance, in Figure 4.1(a), after computing coordinates on stations C and E using elementary procedures, the observed distance CE can be compared against a value obtained by inversing the coordinates.

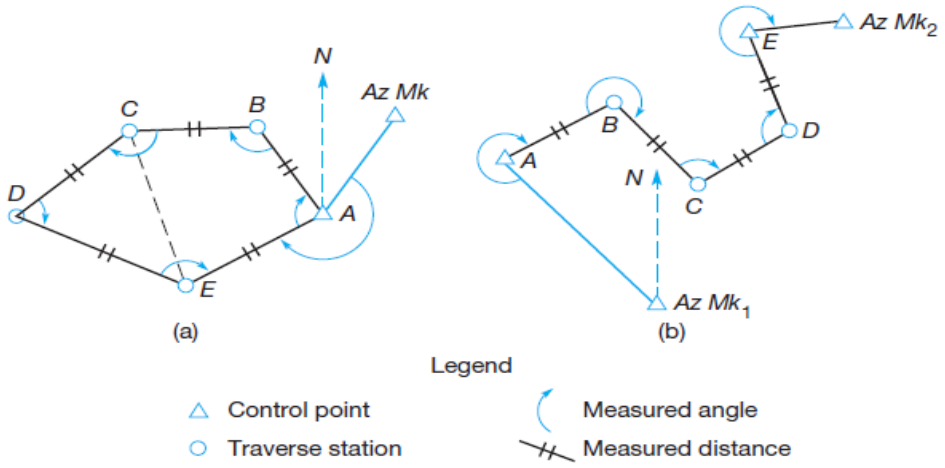


Figure 13: Examples of closed traverses

An open traverse (geometrically and mathematically open) (Figure 1.2) consists of a series of lines that are connected but do not return to the starting point or close upon a point of equal or greater order accuracy. Open traverses should be avoided because they offer no means of checking for observational errors and mistakes. If they must be used, observations should be repeated carefully to guard against mistakes.

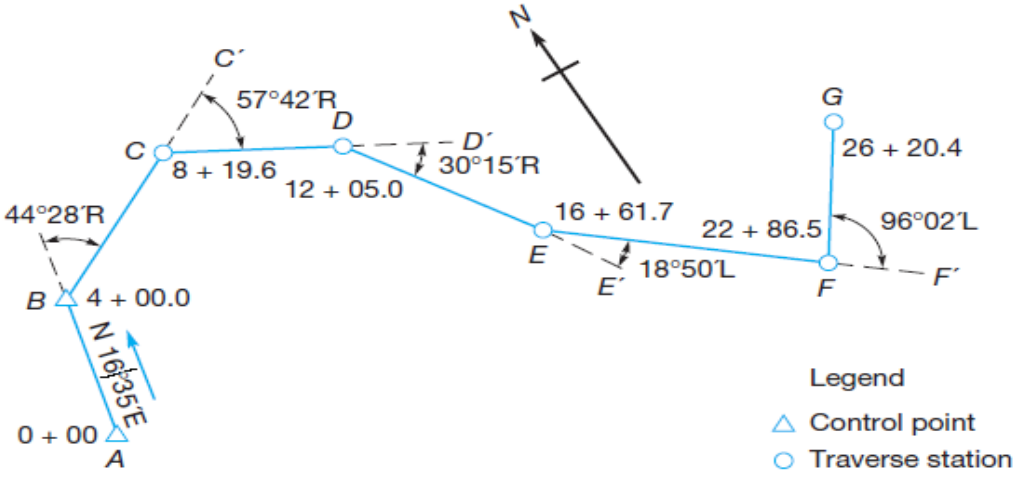


Figure 14: Open traverse

Traverse surveys are made for many purposes which may include:

- To determine the positions of exiting boundary markers.
- To establish the positions of boundary lines.
- To determine the area encompassed within a boundary.
- To determine the positions of arbitrary points from which data may be obtained for preparing various types of maps (i.e., establish control for map making).
- To establish ground control for photographic mapping.

- To establish control for gathering data regarding earthwork quantities in railroad highway, utility, and other construction work.
- To establish control for locating railroads, highways, and other construction work.

Conventionally, traverse has been established using theodolite, compass and tape. The theodolite is used to measure angles, the compass is to measurer bearing, and the tape is used to measure distances of the legs. Angles, distances and bearing altogether can be used to calculate coordinates of the traverse manually. With the advancement of surveying technology, Total Station has replaced theodolite to perform an automatic computation of coordinates by measuring distances and angles. Based on the required accuracy of the traverse, legs are measured directly on the ground either by chaining or taping of the traverse. Angles, the angle between consecutive traverse legs are measured with a theodolite by setting up the instrument at each station in turn. If the coordinate of one station and the true bearing of the traverse legs connected to it are known, the coordinate of the other traverse station may be calculated with the following formula.

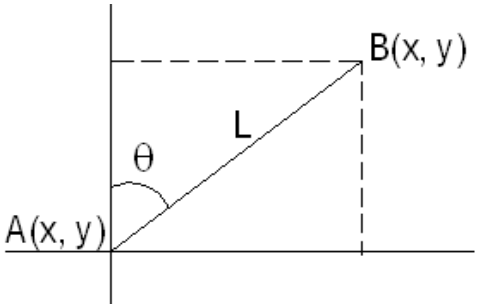


Figure 15: Rectangular coordinate

The coordinate can be computed as

$$X \text{ coordinates of } B = X \text{ coordinates of } A + L \sin \theta$$

$$Y \text{ coordinates of } B = Y \text{ coordinate of } A + L \cos \theta$$

On the basic of measuring the relative direction of the traverse legs, the method of theodolite traverse, may be divided in two to groups.

1) By measuring the angles between the two consecutive traverse legs
2) By measuring the direct bearing of traverse legs

The first method is generally adopted for long traverse, when higher degree of accuracy is required. In this method, the bearing of the starting and closing traverse legs are generally determined by making astronomical observation to either pole star or sun. The second method is used when it is not possible or desirable to make an astronomical observation obtaining the

true bearing of the starting and the closing traverse legs and also when higher accuracy is not required.

Traverse field work consists of the following steps:

- Select station positions as close as possible to the objects to be located.
- Mark the stations with stakes with tacks or with stone or concrete monuments set flush with the ground with a precise point marked on the top by a chiseled cross, drilled hole, or bronze tablet.
- Make angle and distance measurements.
- Place signals at each station such as a range pole to be used for taping and angle measurement.

The forward and backward directions for any traverse needs to be defined. The order in which measurements are made usually is called the forward direction. Loop traverses should be measured counterclockwise around the loop. The angles of the traverse should be measured clockwise from the backward direction to the forward direction. Most highway surveys and other connecting or open traverses are based on measurement of deflection angles. Either interior or deflection angles can be used for a closed traverse. If angle and distance measurements are done separately, the field notes for each operation will be kept separately. If both measurements are done together, you might want to keep the field notes together.

Closed loop traverse computation procedures

a) The sum of measured interior angles should be equal to (n-2) *180, where n= the number of sides of traverse
b) If the exterior angles are measured, their sum should be equal to (n+2) *180 where n=number of side traverse legs.

The angular error of closure is the difference between the sums of measured angles and their theoretical sum. The discrepancies are equally distributed among all the angles.

Azimuth and Bearing

The azimuth of a line can be converted to bearing by reducing it to an angle less than 90º which has the same numerical value of the trigonometric functions. Rule of conversion of azimuth into bearing.

Bearing (Quadrantal bearings) system bearings of a line is measured from either the north or the south, clock wise or counter clockwise whichever is nearer to the line towards the east or west.

Table 1: Relationship of Bearing and Azimuth

Q.No.	Azimuth (W.C.B)	Bearing (Q.B)	Relationship
1	Between 0º to 90º	N.E	Q.B = Azimuth
2	Between 90º to 180º	S.E	Q.B = 180º - Azimuth
3	Between 180º to 270º	S.W	Q.B = W.C.B -180º
4	Between 270º to 360º	N.W	Q.B = 180º -W.C.B

4.4 Traverse Computation

4.4.1 Traverse Computation Procedures

The procedures for adjusting closed loop traverse can be summarized in the following five (5) steps

1. Sum up all observed angle and check the sum with the **$(n-2) * 180^0$**

   Where, $(n-2) *180^0$ = Nominal sum or theoretical sum

   n = Number of stations

   Sum (observed) = Actual (practical)

   Then, Error = Nominal – Actual

   Correction = $\frac{\text{Error}}{n}$

2. By using the given azimuth of the first line find the azimuth of all lines.

If it is *right hand traverse*, which means the direction of progress is clockwise);

Az of (23) = Az12 + 180^0 - < ß at point '2'

Az of (34) = Az 23 + 180^0 - < ß at point '3' and follows for the other as looks like this.

If it is *left hand traverse***,** which means the direction of progress is counter clockwise);

Az of (23) = Az 12+ < ß at point '2'- 180^0

Az of (34) = Az 23 + < ß at point '3'- 180^0 Where; ß is adjusted angle

3. Find the latitude and departure of all lines and sum up to get closure error of departure and latitude.
4. Balance the departures and latitudes.
5. Compute the coordinates.

4.4.2 Balancing and Finding Adjusted Coordinates of Closed Traverse

Balancing the traverse means making adjustment to remove any visible error. For balancing the traverse, the underlying objective is to adjust the traverse in such a way that the sum the latitude and departure should each equal to zero in closed loop traverse. The closing error, however it is distributed throughout the traverse such that the above-mentioned objective is achieved this operation is called balancing the traverse.

There are different methods of balancing the traverse, however two of them are recommended at this stage.

1. Bowditch rule
2. Transit rule

According to the Bowditch rule error is proportional to the length of the side

Correction lat /dep = $\frac{\text{Closure error in lat/dep}}{\text{Perimeter of the traverse}}$ * length of the side *Note: Lat= latitude; dep= departure*
Correction lat/dep = $\frac{\text{Closure error in lat/dep}}{\text{Total sum of lat/dep}}$ * lat/dep of the side

Illustrative Example

The following data is observed for a closed loop traverse ABCDEF. Using the given data calculate the coordinates of stations B, C, D, E, F.

Included clockwise angle	**Line**	**Distance (m)**
<FAB = $115^0$11’20”	AB =	429.37
<ABC = $95^0$00’20”	BC =	656.54
<BCD = $129^0$49’20”	CD =	301.83
<CDE = $130^0$36’20”	DE =	287.40
<DEF = $110^0$30’00”	EF =	526.72
<EFA = $138^0$54’40”	FA =	372.47

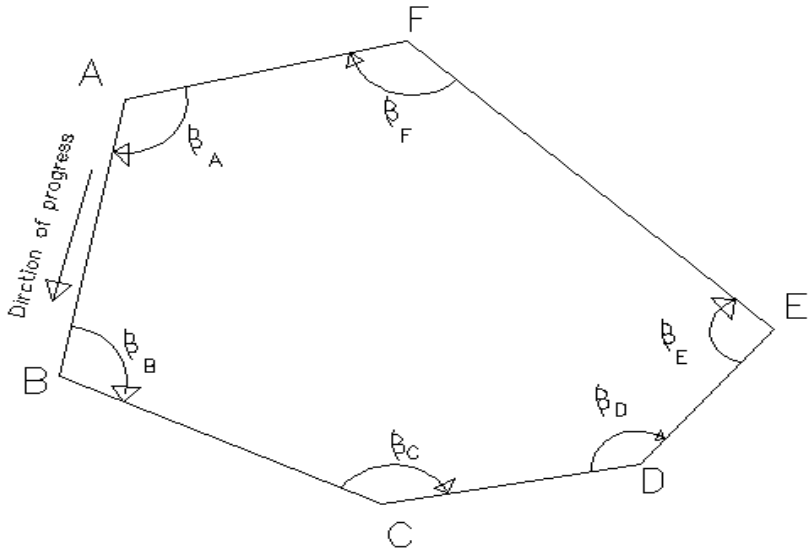
Coordinates

XA = 500.00

YA = 1000.00

Azimuth

AB = $191^0$11’00”



Solution:

1. **Computation of error, correction and adjusted angles**

$\sum ß_{practical} = ß_A + ß_B + ß_C + ß_D + ß_E + ß_F$

$= 720^0\ 02'00"$

$\sum ß_{Nominal} = (n-2) * 180^0$

$= (6-2) * 180^0$

$= 720^0\ 00'00"$

Error $= \sum ß_{Nominal} - \sum ß_{practical} = -2'00"$

Correction= Error/ n = -20"

If allowable error = 1' (n) 1/2

= 2'27" since error is less than allowable error the measurement is **ok!**

Therefore; the adjusted angles are

<FAB = $115^0 11'20" - 20" = 115^0 11'00"$

<ABC = $95^0 00'20" - 20" = 95^0 00'00"$

<BCD = $129^0 49'20" - 20" = 129^0 49'00"$

<CDE = $130^0 36'20" - 20" = 130^0 36'00$

<DEF = $110^0 30'00" - 20" = 110^0 29'40"$

<EFA = $138^0 54'40" - 20" = 138^0 54'20"$

$\sum 720^0\ 00'00"$

2. Computation of azimuths

Az AB = $191^0 11'00"$

Az BC = Az AB + ßB - 180^0

= $106^0 11'00"$

Az CD = Az BC + ßC - 180^0

= $56^0$00’00“

Az DE = AzCD + ßD - 180^0

= $6^0$36’00“

Az EF = AzDE + ßE - 180^0

= 297005’40“

Az FA = AzEF + ßF -180^0

= $256^0$00’00“

3.Computation of latitude and departure

Side	**Azimuth**	**Distance(m)**	**Departure**	**Latitude**
AB	$191^0$11’00“	429.37	-83.276	-421.217
BC	$106^0$11’00“	656.54	630.524	-182.985
CD	$56^0$00’00“	301.83	250.228	168.781
DE	$6^0$36’00“	287.40	33.033	285.495
EF	$297^0$05’40“	526.72	-468.916	239.899
FA	$256^0$00’00“	372.47	-361.406	-90.109
∑		**2574.33**	**+0.187**	**-0.136**

Closure error of a traverse = [cldep2 + cllat2]1/2

= [0.1872 + -0.1362]1/2

= 0.231

Relative accuracy of a traverse = [Cl $_{traverse}$ / perimeter (Total length of a traverse)]

= 0.231/2574.33 = (0.231/0.231)/ (2574.33/0.231)

= 1: 11,144 ~ 1:11,000

4. Balancing (Adjusting) the departure and latitude by using Bowditch rule.

Let A = [closure error of latitude]
Total length of a traverse

And B = [closure error of departure]
Total length of a traverse

Since the summation of latitude is negative, the correction should be positive. And the summation of departure is positive, the correction should be negative.

Therefore;

Line	Adjusted departure	Adjusted latitude
AB	-83.276 – [B*429.37] = -83.307	-421.217 – [A*429.37] = -421.240
BC	630.524 – [B*656.54] = 630.476	-182.985 – [A*656.54] = -182.950
CD	250.228 – [B* 301.83] = 250.206	168.781 – [A* 301.83] = 168.797
DE	33.033 – [B*287.40] = 33.012	285.495 – [A*287.40] = 285.510
EF	-468.916 – [B*526.72] = -468.954	239.899 – [A*526.72] = 239.927
FA	-361.406 – [B* 372.47] = -361.433	-90.109 – [A* 372.47] = -90.090

5. Compute the coordinates.

$X_B = X_A$ + dep AB
= 500 + -83.307
= 416.693
$X_C = X_B$+ dep BC
= 416.693 + 630.476
= 1047. 169
$X_D = X_C$ + dep CD
= 1047.169 + 250.206
= 1297.375
$X_E = X_D$ + dep DE
= 1297.375 + 33.012
= 1330. 387
$X_F = X_E$ + dep EF
= 1330.387 + - 468.954
= 861.433
Checking, $X_A = X_F$ + dep FA
= 861.433 + -361.433 = 500.000 …**OK!**

$Y_B = Y_A$ + lat AB
= 1000 + (- 421.194)
= 578. 806
$Y_C = Y_B$ + lat BC
= 578.806 + - 182.950
= 395.856
$Y_D = Y_C$ + lat CD
= 395.856 + 168 .797
= 564.653
$Y_E = Y_D$ + lat DE
= 564.653 + 285.510
= 650. 165
$Y_F = Y_E$ + lat EF
= 650.165 + 239.927

= 1090.09

Checking, $Y_A = Y_F$ + lat FA

= 1090.09 + -90.090 = 1000.000 …**OK!**

3.3.5 Area Computation

A) Area by Coordinates

In geometry, the area can be defined as the space occupied by a flat shape or the surface of an object. The area of a figure is the number of unit squares that cover the surface of a closed figure. Area can be measured in square units such as square centimeters, square meter, square kilometer, hectares and others.

In cadastral surveying, the area of a closed non-crossing plane polygon can be computed from the coordinates of the parcel or polygon's vertices. The area equations, depending on coordinate format used, are shown as:

In terms of X and Y coordinates

$$2(\text{Area}) = X_A(Y_E - Y_B) + X_B(Y_A - Y_C) + X_C(Y_B - Y_D) + X_D(Y_C - Y_E) + X_E(Y_D - Y_A)$$

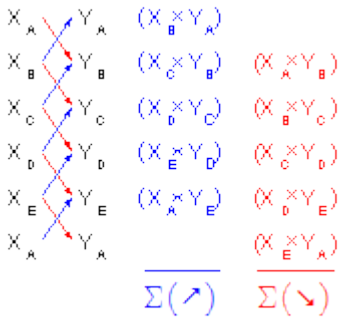
In terms of N and E coordinates

$$2(\text{Area}) = E_A(N_E - N_B) + E_B(N_A - N_C) + E_C(N_B - N_D) + E_D(N_C - N_E) + E_E(N_D - N_A)$$

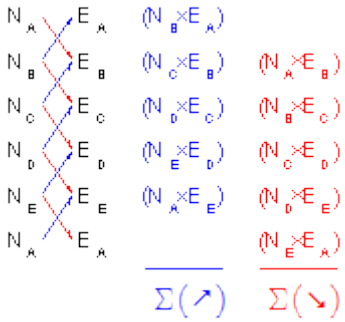
These equations look complex, more so if you expand all the terms. Rather than memorize each equation, it's easier to remember their *pattern* and determine the area in tabular fashion. To accurately compute the traverse area:

- Select a start point (it doesn't matter where you start)
- Going in sequence around the exterior list each coordinate pair vertically. Direction of travel around the traverse (clockwise or counter-clockwise) doesn't matter; nor does coordinate precedence, for example, (X, Y) or (Y, X).
- The first coordinate pair must be repeated at the bottom of the list. In Figure G-5, the surveyor started at point A and then ended on point A.
- Cross multiply the coordinates and sum the products, Figure G-6. Arrows indicate "direction" of multiplication.

Using X,Y cords



Using N,E cords



The units of the cross products are square linear units, if coordinates are in meter, cross products are sq ft.

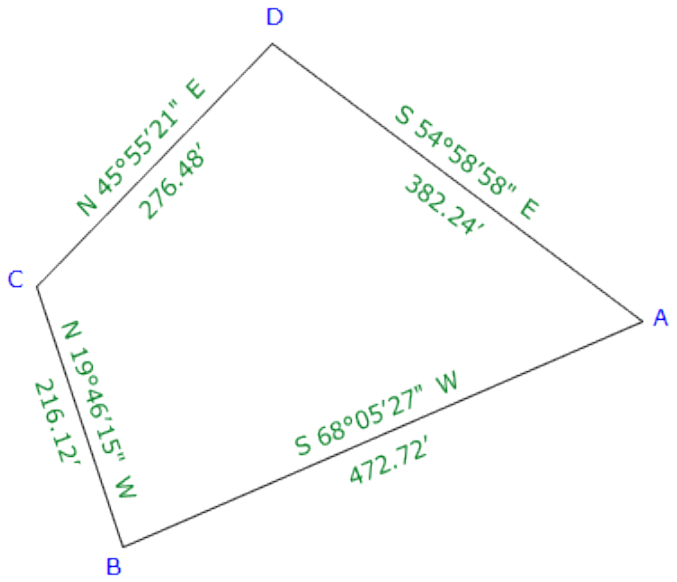
- Compute the traverse area: Sum each column (↗) and (↘)

$$\text{Area} = \frac{\left|\sum(\nearrow) - \sum(\searrow)\right|}{2}$$

The absolute value is used since the area could be negative depending on the combination of direction around the traverse, coordinate precedence (for example, X,Y vs Y,X), and cross multiplication order. Just as the square root of 4 can be either +2 or -2, so can the area be positive or negative. Because we're generally interested in the magnitude of the answer, we use the absolute value of the area computed.

Example

Compute the area of the following figure by coordinate method.



Point	*North (ft)*	*East (ft)*
A	500.000	2000.000
B	323.614	1561.426
C	526.996	1488.321
D	719.336	1686.956

Step 1: Start at point A and going clockwise around the traverse list the coordinates:

Step 2: Cross multiply in one direction:

Point	N (m)	E (m)	(↗), m^2
A	500.000	2000.000	647,228.0
B	323.614	1561.426	822,865.2
C	526.996	1488.321	1,070,602.9
D	719.336	1686.956	843,478.0
A	500.000	2000.000	

Step 3: Cross multiply in the other direction

Point	N (ft)	E (ft)	(↗), sq ft	(↘), sq ft
A	500.000	2000.000	647,228.0	
B	323.614	1561.426	822,865.2	780,713.0
C	526.996	1488.321	1,070,602.9	481,641.5
D	719.336	1686.956	843,478.0	889,019.1
A	500.000	2000.000		1,438,672.0

Step 4: Add up the columns

Point	N (ft)	E (ft)	(↗), sq ft	(↘), sq ft
A	500.000	2000.000	647,228.0	
B	323.614	1561.426	822,865.2	780,713.0
C	526.996	1488.321	1,070,602.9	481,641.5
D	719.336	1686.956	843,478.0	889,019.1
A	500.000	2000.000		1,438,672.0
		sums:	3,384,174.1	3,590,045.6

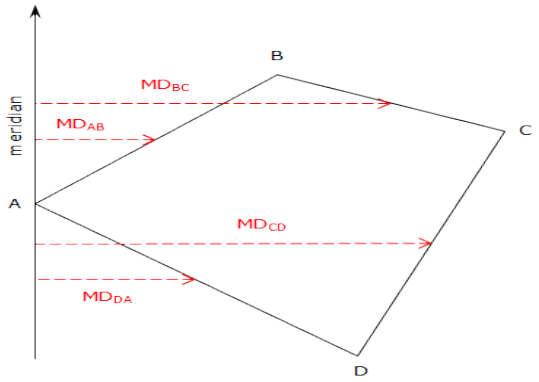
Step 5: Compute the area

$$\text{Area} = \frac{\left|\sum(\nearrow) - \sum(\searrow)\right|}{2} = \frac{|3,384,174.1 - 3,590,045.6|}{2}$$

$$= \frac{|-205,871.5|}{2} = 102,935.8 \text{ sq ft}$$

B) Area by DMDs

Most software uses coordinates for area determination. However, a Double Meridian Distances (DMD) which is a traditional method of computing area of a closed polygonal traverse can be used. A Meridian Distance (MD) is the distance from a reference meridian to the center of a line; it is measured in the East (X) direction,



The reference meridian used can be placed anywhere, but generally, it passes through the first point of the traverse. Triangular and trapezoidal areas can be computed by multiplying a meridian distance by the latitude of the respective line. The base of each triangle or trapezoid coincides with the meridian. Adding the areas, some of which are negative based on the latitude and meridian distance, results in the area of the polygon.

Compute the *Double* Meridian Distance

$$MD_{AB} = \tfrac{1}{2}(Dep_{AB})$$
$$MD_{BC} = Dep_{AB} + \tfrac{1}{2}(Dep_{BC})$$
$$= \tfrac{1}{2}(Dep_{AB}) + \tfrac{1}{2}(Dep_{AB}) + \tfrac{1}{2}(Dep_{BC})$$
$$MD_{CD} = \cdots$$

By multiplying both sides of each MD equation by 2, the 1/2's all go away and we're left with *Double* Meridian Distances (DMDs) on each left side,

$$DMD_{AB} = Dep_{AB}$$
$$DMD_{BC} = DMD_{AB} + Dep_{AB} + Dep_{BC}$$
$$DMD_{CD} = DMD_{BC} + Dep_{BC} + Dep_{CD}$$
$$DMD_{DA} = DMD_{CD} + Dep_{CD} + Dep_{DA}$$
$$= -Dep_{DA} \qquad \textit{math check}$$

Notice that, the DMD of the last line is the same as the Departure of that line except with an opposite math sign. That's the math check. Multiplying each line's DMD by its Latitude and summing the results will give us double the area.

General Step for a Link traverse

A) Angular Stage

i) Computing the azimuth of the two-known line of traverse:

- Azimuth of the traverse first line (known line)
- Azimuth of the traverse last line (known line)

$$\text{Bearing}_{(A-B)} = \tan \frac{\Delta x}{\Delta y} \quad \text{and Bearing}_{(C-D)} = \tan \frac{\Delta x}{\Delta y}$$

$$\Delta x_{(A-B)} = x_B - x_A \quad \Delta y_{(C-D)} = y_D - y_C$$

After knowing bearing of both lines, the azimuth is determined according to the bearing quadrant regarding:

$+\frac{\Delta x}{+\Delta y}$ First quadrant $+\frac{\Delta x}{-\Delta y}$ Second quadrant

$-\frac{\Delta x}{-\Delta y}$ Third quadrant $-\frac{\Delta x}{+\Delta y}$ Fourth quadrant

ii) First azimuth calculates

$$A_{2-1} = A_{1-2} + \alpha \pm 180^0$$

iii) Computing the angular closure error

The angular error is the difference between the last line azimuth by data (previously calculated) and the last line azimuth by calculate. Then:

$$ec = \text{Azimuth of Known line}_{(\text{by data})} - \text{Azimuth of Known line}_{(\text{by calculus})}$$

iv)Determining the angular permissible error = **1' √n** or 30''√**n**or **10''√n'**

v) Determining the angular correction $\mathbf{c = \frac{ec}{N}}$

vi) Appling the angular correction to interception angles $\boldsymbol{\alpha_{(corrected)} = \alpha \pm c}$

(the correction is introduced into the angle with the error appositive sign)

vii) Computing the azimuth of every line $\mathbf{A_{2-3} = A_{1-2} + \alpha_{(corrected)} \pm 180^0}$

(Second azimuth calculate)

viii) Checking angular correction: Azimuth: A C – D = A C – D

$$A_{(\text{last line by calculate})} = A_{(\text{last line by previously calculated})}$$

ix) Determining the bearing upon the azimuth of every line.

B) Linear Stage

i) Computing the differences in X and Y: ΔX1 = dist1 * sin Azimuth1-2

ΔY_1 = dist1 * cos $Azimuth_{1-2}$

ii) Determining the total error in X :X e = Known ΔX – Previous ΔX

Known ΔX = X of first known point – X of last known point

Known $\Delta X = X_B - X_C$ and Previous $\Delta X = \sum \Delta X$

Y_e = Known ΔY – Previous ΔY

Known ΔY = Y of first known point – Y of last known point

Known $\Delta Y = Y_B - Y_C$ and Previous $\Delta Y = \sum \Delta Y$

iii) Determining the linear absolute error $Ae = \sqrt{(Xe2 + Ye2)}$

iv) Computing the Precision or liner relative error: $\mathbf{P = \frac{1}{\frac{D}{Ae}}}$

v) Comparing the achieved Precision with the expected Precision or Project Precision, It must to be fulfilled that: P > PP (otherwise the field data are not acceptable)

vi) Computing the correction for ΔX and Δy: $C = \frac{Xe * dist}{D}$

$C = \frac{ye}{D} * dist$

vii) Appling the correction to ∑ΔX and ∑ΔY:

$\sum \Delta X$ (corrected) = ΔX ± C $\quad \sum \Delta Y_{(corrected)} = \Delta Y \pm C$

viii) Checking the linear correction now it must be fulfilled that:

$\mathbf{\sum \Delta X_{(corrected)} = Known\ \Delta X}$

$\mathbf{\sum \Delta Y_{(corrected)} = Known\ \Delta Y}$

ix) Computing the final coordinate of every traverse vertex:

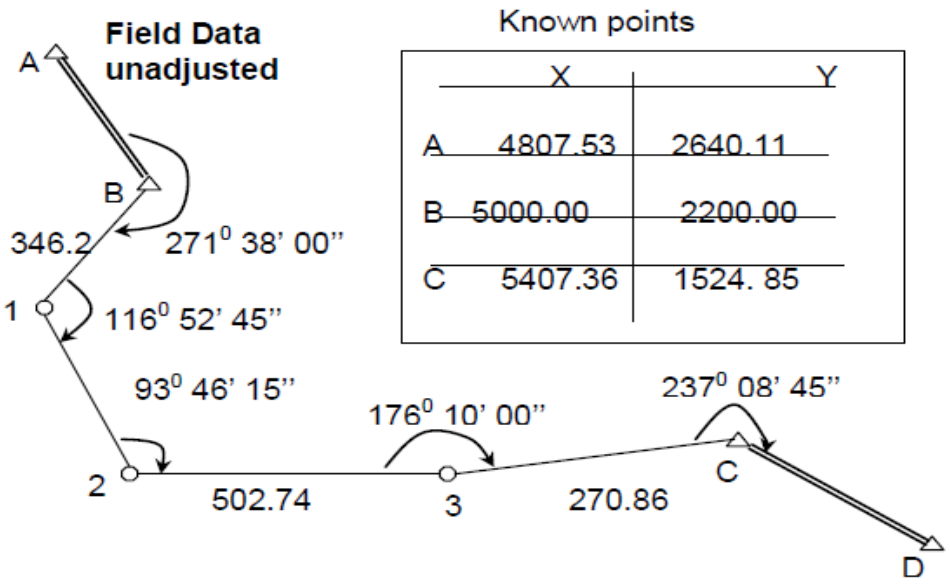
$\mathbf{X_2 = X_1 \pm \sum \Delta X_{(corrected)}}$

$\mathbf{Y_2 = Y_1 \pm \sum \Delta Y_{(corrected)}}$

x) Filling out the calculus compendium

Example:

Pp = 1: 2000 (Project's Precision)



Solution: Angular Stage

i) Computing the azimuth of the two-known line of traverse:

- Azimuth of the traverse first line (known line)
- Azimuth of the traverse last line (known line)

Tan of Bearing $_{(A-B)} = \frac{\Delta x}{\Delta y}$ and Tan of Bearing $_{(C-D)} = \tan \frac{\Delta x}{\Delta y}$

$\Delta x_{(A-B)} = x_B - x_A \quad \Delta y_{(C-D)} = y_D - y_C$

Bearing $_{(A-B)} = \tan \frac{\Delta x}{\Delta y} = \tan \frac{5000 - 4\,807.53}{2200 - 2640.11} = \frac{192.47}{-440.11} = 0.4373224$

Bearing $_{(A-B)} = 23.620836 = 23^0\ 37'\ 15'' \text{ SE}$

Azimuth $_{(A-B)} = 180^0 - \text{Bearing} = 180^0 - 23^0\ 37'\ 15'' = \mathbf{156^0\ 22'\ 45''}$

Tan of Bearing $_{(C-D)} = \tan \frac{\Delta x}{\Delta y} = \frac{X_D - X_C}{Y_D - Y_C} = \frac{5651.71 - 5407.36}{1066.26 - 1524.85}$

Tan of bearing $= \frac{244.35}{-458.59} = 0.5328288 = 28.04998 = 28^0.03'\ 00'' \text{ SE}$

Azimuth$_{(C-D)} = 180^0 - 28^0\ 03'\ 00'' = \mathbf{151^0\ 57'\ 00''}$

The bearing of line C – D is on second quadrant since Δx is positive and Δy is negative. Now the angle whose tan = 0. 5328288 is found by means of calculator.

ii) First azimuth calculates

$A_{B-1} = A_{A-B} + \alpha_B \pm 180^0 = 156^0\,22'\,45'' + 271^0\,38'\,00'' - 180^0 = 248^0\,00'\,45''$

$A_{1-2} = A_{B-1} + \alpha_1 \pm 180^0 = 248^0\,00'\,45'' + 116^0\,52'\,45'' - 180^0 = 184^0\,53'\,30''$

$A_{2-3} = A_{1-2} + \alpha_2 \pm 180^0 = 184^0\,53'\,30'' + 93^0\,46'\,15'' - 180^0 = 98^0\,39'\,45''$

$A_{3-C} = A_{2-3} + \alpha_3 \pm 180^0 = 98^0\,39'\,45'' + 176^0\,10'\,00' - 180^0 = 94^0\,49'\,45''$

$A_{C-D} = A_{3-C} + \alpha_C \pm 180^0 = 94^0\,49'\,45'' + 237^0\,08'\,45'' - 180^0 = 151^0\,58'\,30''$

The angular error is the difference between the last line azimuth by data (previously calculated) and the last line azimuth by calculate. Then:

ec = Azimuth of Known line $_{(\text{by calculus})}$ - Azimuth of Known line $_{(\text{by data})}$

ec = $151^0\,58'\,30''$ - $151^0\,57'\,00''$ = **1' 30''**

iii) Determining the angular correction $c = \frac{ec}{n}$

$c = 1'\,30'' = \frac{90''}{5} = 18''$

iv) Appling the angular correction to interception angles $\alpha_{(\text{corrected})} = \alpha \pm c$

(the correction is introduced into the angle with the error appositive sign)

$\alpha_{(\text{corrected B})} = \alpha_B - c = 271^0\,38'\,00'' - 18'' = 271^0\,37'\,42''$

$\alpha_{(\text{corrected 1})} = \alpha_1 - c = 116^0\,52'\,45'' - 18'' = 116^0\,52'\,27''$

$\alpha_{(\text{corrected 2})} = \alpha_2 - c = 93^0\,46'\,15'' - 18'' = 93^0\,45'\,57''$

$\alpha_{(\text{corrected 3})} = \alpha_3 - c = 176^0\,10'\,00' - 18'' = 176^0\,09'\,42''$

$\alpha_{(\text{corrected C})} = \alpha_C - c = 237^0\,08'\,45'' - 18'' = 237^0\,08'\,27''$

v) Computing the azimuth of every line $A2_{-3} = A_{1-2} + \alpha_{(\text{corrected})} \pm 180^0$

(Second azimuth calculate)

$A_{B-1} = A_{A-B} + \alpha_B \pm 180^0 = 156^0\,22'\,45'' + 271^0\,37'\,42'' - 180^0 = 248^0\,00'\,27''$

$A_{1-2} = A_{B-1} + \alpha_1 \pm 180^0 = 248^0\,00'\,27'' + 116^0\,52'\,27'' - 180^0 = 184^0\,52'\,54''$

$A_{2-3} = A_{1-2} + \alpha_2 \pm 180^0 = 184^0\,52'\,54'' + 93^0\,45'\,57'' - 180^0 = 98^0\,38'\,51''$

$A_{3-C} = A_{2-3} + \alpha_3 \pm 180^0 = 98^0\,38'\,51'' + 176^0\,09'\,42'' - 180^0 = 94^0\,48'\,33''$

$A_{C-D} = A_{3-C} + \alpha_C \pm 180^0 = 94^0\,48'\,33'' + 237^0\,08'\,27'' - 180^0 = 151^0\,57'\,00''$

vi) Checking angular correction: Azimuth: $A_{C-D} = A_{C-D}$

$A_{(\text{last line by calculate})} = A_{(\text{last line by previously calculated})}$

$151^0\,57'\,00'' = 151^0\,57'\,00''$

vii) Determining the bearing upon the azimuth of every line.

Azimuth $_{(A-B)} = 156^0\,22'\,45''$

Bearing $_{A-B)} = 1800 - 156^0\,22'\,45'' = 23^0\,57'\,15''$ SE

Azimuth $_{(B-1)} = 248^0\,00'\,27''$

Bearing $_{B-1)} = 248^0\,00'\,27'' - 180^0 = 68^0\,00'\,27''$ SW

Azimuth $_{(1-2)} = 184^0\ 52'\ 54''$

Bearing $_{1-2)} = 1840\ 52'\ 54'' - 180^0 = 4^0\ 52'\ 54''$ SW

Azimuth $_{(2-3)} = 98^0\ 38'\ 51''$

Bearing $_{2-3)} = 180^0 - 98^0\ 38'\ 51'' = 81^0\ 21'\ 09''$ SE

Azimuth $_{(3-C)} = 94^0\ 48'\ 33''$

Bearing $_{3-C)} = 180^0 - 94^0\ 48'\ 33'' = 85^0 11''\ 27''$ SE

Azimuth $_{(C-D)} = 151^0\ 57'\ 00''$

Bearing $_{C-D)} = 180^0 - 151^0\ 57'\ 00'' = 290\ 03'\ 00''$ SE

Solution: Linear Stage

i) Computing the differences in X and Y: $\Delta X1$ = dist1 * sin Azimuth1-2

ΔY_1 = dist1 * cos Azimuth$_{1-2}$

ΔX_1 = dist $_{(B-1)}$ * sin Azimuth $_{(B-1)} = 346.21 * \sin 248^0\ 00'\ 27''$

0.927 = -321.017

ΔX_1 = **-321.017**

ΔX_2 = dist $_{(1-2)}$ * sin Azimuth $_{(1-2)} = 448.62 * \sin 184^0\ 52'\ 54''$

$\Delta X_2 = 448.62 * -0.085$

ΔX_2 = **-38.177**

ΔX_3 = dist $_{(2-3)}$ * sin Azimuth $_{(2-3)} = 502.74 * \sin 98^0\ 38'\ 51''$

$\Delta X_3 = 502.74 * 0.988$

ΔX_2 = **497.025**

ΔX_4 = dist$_{(3-C)}$ * sin Azimuth $_{(3-C)} = 270.86 * \sin 94^0\ 48'\ 33''$

$\Delta X_4 = 270.86 * 0.996$

ΔX_4 = **269.906**

$\sum \Delta \mathbf{X} = \mathbf{407.737}$ (previous ΔX)

Known ΔX = X of first known point – X of last known point

Known $\Delta X = X_C - X_B$ and Previous $\Delta X = \sum \Delta X$

Known $\Delta X = X_C - X_B = 5\ 407.36 - 5000.00 = 407.360$

ii) Determining the total error in X: X e = Previous ΔX - Known ΔX

$X_e = 407.737 - \mathbf{407.360} = + \mathbf{0.377}$

Computing ΔY: **ΔY_1 = dist1 * cos Azimuth$_{1-2}$**

ΔY_1 = dist $_{(B-1)}$ * cos Azimuth $_{B-1} = 346.21 * \cos 248^0\ 00'\ 27''$

$\Delta Y_1 = 346.21 * -0.374$

ΔY_1 = **-129.65**

ΔY_2 = dist$_{(1-2)}$ * cos Azimuth$_{1-2} = 448.62 * \cos 184^0\ 52'\ 54''$

$\Delta Y_2 = 448.62 * -0.996$

$\Delta Y_2 =$ **-446.990**

$\Delta Y_3 = dist_{(2-3)} * \cos Azimuth_{2-3} = 502.74 * \cos 98^0\ 38'\ 51''$

$\Delta Y_3 = 502.74 * -0.150$

$\Delta Y_3 =$ **-75.589**

$\Delta Y_4 = dist_{(3-B)} * \cos Azimuth_{3-B} = 270.86 * \cos 94^0\ 48'\ 33''$

$\Delta Y_4 = 270.86 * -0.083$

$\Delta Y_4 =$ **-22.708**

$\sum \Delta Y =$ **- 674. 937** (Previous ΔY)

Known ΔY = Y of first known point – Y of last known point

Known $\Delta Y = Y_C - Y_B$ and Previous $\Delta Y = \sum \Delta Y$

Known $\Delta Y = Y_C - Y_B = 1\ 524.85 - 2\ 200.00 =$ **- 675. 150**

Y_e = Previous ΔY - Known ΔY

$Y_e =$ 674. 937 – (- 675. 150) = **+ 0.213**

iii) Determining the linear absolute error Ae = √ (Xe2 + Ye2)

$Ae = \sqrt{-0.377^2 + +0.213^2}$

Ae = 0.433

iv) Computing the Precision or liner relative error: $P = \frac{1}{\frac{D}{Ae}}$

P = 1: $\frac{1\ 568.43}{0.\ 433}$ = 1: 3 622 ≈ **1: 3 600**

v) Comparing the achieved Precision with the expected Precision or Project Precision, it must to be fulfilled that: P > PP (otherwise the field data are not acceptable).

1: 3 600 > 1: 2000

vi) Computing the correction for ΔX and Δy: C = Xe/D* dist

$C = \frac{ye}{D} * dist$

$C_1 = \frac{-0.377}{1\ 568.43} * 346.21 = 0.0002403 * 346.21 = +0.083$

$C_2 = \frac{-0.377}{1\ 568.43} * 448.62 = 0.0002403 * 448.62 = +0.108$

$C_3 = \frac{-0.377}{1\ 568.43} * 502.74 = 0.0002403 * 502.74 = +0.121$

$C_4 = \frac{-0.377}{1\ 568.43} * 270.86 = 0.0002403 * 270.86 = +0.065$

$\sum C =$ **+ 0.377**

$C_1 = \frac{+ 0.213}{1\ 568.43} * 346.21 = 0.0001358 * 346.21 = 0.047$

$C_2 = \frac{+ 0.213}{1\ 568.43} * 448.62 = 0.0001358 * 448.62 = 0.061$

$C_3 = \frac{+ 0.213}{1\ 568.43} * 502.74 = 0.0001358 * 502.74 = 0.068$

$C_4 = \frac{+ 0.213}{1\ 568.43} * 270.86 = 0.0001358 * 270.86 = 0.037$

$\sum \mathbf{C = 0.213}$

vii) Appling the correction to $\sum\Delta X$ and $\sum\Delta Y$:

$\sum\Delta X$ (corrected) $= \Delta X \pm C$

$\mathbf{\sum\Delta Y_{(corrected)} = \Delta Y \pm C}$

$\Delta X_{1\ (corrected)} = \Delta X_{1\ (previous)} + C_1 = -321.017 - 0.083 = - 321.100$

$\Delta X_{2\ (corrected)} = \Delta X_{2\ (previous)} + C_2 = -38.177 - 0.108 = - 38.285$

$\Delta X_{3\ (corrected)} = \Delta X_{3\ (previous)} + C_3 = 497.025 - 0.\ 121 = + 496.904$

$\Delta X_{4\ (corrected)} = \Delta X_{4\ (previous)} + C_4 = 269.906 - 0.065 = + 269.841$

viii) Checking the linear correction now it must be fulfilled that:

$\sum\Delta X_{(corrected)}$ = Known $\Delta X = 407.360$

$\Delta Y_{1\ (corrected)} = \Delta Y_{1\ (previous)} - C_1 = -129.650 - 0.047 = - 129.697$

$\Delta Y_{2\ (corrected)} = \Delta Y_{2\ (previous)} - C_2 = - 446.990 - 0.061 = - 447.051$

$\Delta Y_{3\ (corrected)} = \Delta Y_{3\ (previous)} - C_3 = -75.589 - 0.068 = - 75.657$

$\Delta Y_{4\ (corrected)} = \Delta Y_{4\ (previous)} - C_4 = -22.708 - 0.037 = - 22.745$

$\mathbf{\sum\Delta Y_{(corrected)} = Known\ \Delta Y = - 675.\ 150}$

ix) Computing the final coordinate of every traverse vertex:

$X_2 = X_1 \pm \sum\Delta X_{(corrected)}$

$Y_2 = Y_1 \pm \sum\Delta Y_{(corrected}$

$X_B = 5000.00$

$X_1 = X_B - \Delta X_1 = 5000.00 - 321.100 = 4\ 678.900$

$X_2 = X_1 - \Delta X_2 = 4\ 678.900 - 38.285 = 4\ 640.615$

$X_3 = X_2 + \Delta X_3 = 4\ 640.615 + 496.904 = 5\ 137.519$

$X_C = X_3 + \Delta X_4 = 5\ 137.519 + 269.841 = 5\ 407.36$

$Y_B = 2\ 200.00$

$Y_1 = Y_B - \Delta Y_1 = 2\ 200.00 - 129.697 = 2\ 070.303$

$Y_2 = Y_1 - \Delta Y_2 = 2\ 070.303 - 447.051 = 1\ 623.252$

$Y_3 = Y_2 - \Delta Y_3 = 1\ 623.252 - 75.657 = 1\ 547.595$

$Y_C = Y_3 - \Delta Y_4 = 1\ 547.595 - 22.745 = 1\ 524.\ 85$

4.6 Summary

Dear trainee! A traverse is a continuous series of connected lines of known lengths related to one another by known angles. The lengths of traverses are measured by using tape and the angles are measured by theodolites. The azimuth for the first line is given by compass. Traverse may be classified into two: those are open and closed. Computation can be performed for closed traverse one by using three given data (length, angles and first azimuth angles). If there is a difference on angles between summation of included angles and theoretical angle that is within allowable error limit, then equal distribution of errors should be done among all included angles. On the other side, if the summation of latitude or longitude is not equal to zero, there is some adjustment on lengths that can be done through Bowditch or transit rule.

4.7 Self-Check Exercises

**Short Answer Items**

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

1) Define the term of traverse
2) What is the difference between open and closed traverse?
3) Put the formula used in balancing in case of Bowditch rule and Transit rule?
4) What is the difference between azimuth and bearing?

CHAPTER FIVE: PERFORMING BASIC AERIAL PHOTOGRAPHY AND IMAGE INTERPRETATION

5.1 Introduction

Dear trainee! This chapter introduces you the concepts required to identify and interpret information from various types of image data to fulfill project requirements. The urge to view the earth from above has deep historic roots. With the advent of human civilization and the invention of photography, aerial images of the Earth's surface became an important tool in scientific, technical, and cartographic disciplines. Remote Sensing, which includes aerial photographs and satellite images, refers to data collection taken from a significant distance from the subject. This often refers to photographs and video taken from above at a significant altitude. Remote sensing produces images of a much larger area of the Earth's surface than a person on the ground can photograph. It also shows the position and relationship between objects and geographic features within the area in the image. Combining special sensors with remote imaging can help determine the health of forests, movement of camouflaged military vehicles, and study changes in geographic features.

Aerial photographs are produced by exposing film to solar energy reflected from Earth. Photographs and other images of the Earth taken from the air and from space show a great deal about the planet's landforms, vegetation, and resources. Aerial and satellite images, known as remotely sensed images, permit accurate mapping of land cover and make landscape features understandable on regional, continental, and even global scales. Transient phenomena, such as seasonal vegetation vigor and contaminant discharges, can be studied by comparing images acquired at different times. 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. This is called stereoscopy. Image interpretation is the extraction of qualitative and quantitative information in the form of a map, about the shape, location, structure, function, quality, condition, relationship of and between objects, etc. by using human knowledge or experience.

5.2 Learning Objectives

After completing this chapter, you will be able to:

- Explain the concepts of photogrammetry and photo interpretation

- Extract information from various types of image data
- Identify and interpret aerial photographs

Dear trainee! Before reading the following sections take a moment and try to explain the concepts photogrammetry and photo interpretation.

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5.3 Basic Principles of Image Data

5.3.1 Remote Sensing Data Imaging

Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information." In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements (Energy Source (A),Radiation and the Atmosphere (B),Interaction with the Target (C),Sensors (D),Transmission reception and processing (E),Interpretation and Analysis (F) and applications (G).

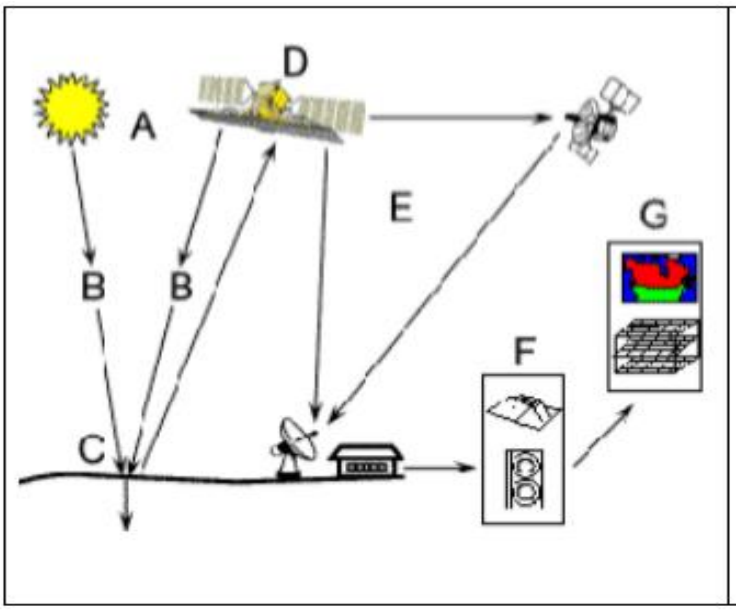


Figure 16: Principles of Imaging

Remote sensing image data are more than a picture; they are measurements of Electro Magnetic Energy (EME). Image data are stored in a regular grid format (rows and columns). A single image element is called a pixel, a contraction of 'picture element'. For each pixel, the measurements are stored as Digital Numbers (DN) values. Typically, for each measured wavelength range a separate data set is stored, which is called a band or a channel and sometimes a layer.

5.3.2 Photogrammetry

The photogrammetry has been derived from three Greek words: Phos or phot: means light Gramma: means something drawn or written whereas Metrein: means to measure. This definition, over the years, has been enhanced to include interpretation as well as Measurement with photographs. The art, science, and technology of obtaining reliable information about physical objects and the environment through process of recording, measuring, and interpreting photographic images. Originally photogrammetry was considered as the science of analyzing only photographs. But now it also includes analysis of other records as well, such as radiated acoustic energy patterns and magnetic phenomenon. Photogrammetry includes two aspects:

i) **Metric:** it involves making precise measurements from photos and other information source to determine, in general, relative location of points. Most common application: preparation of planimetric and topographic maps. Metric photogrammetry is classically divided into two, terrestrial photogrammetry and aerial photogrammetry. Photographs of terrain in an area are taken by a precision photogrammetric camera mounted in an aircraft flying over an area.
   - **a) Terrestrial Photogrammetry:** photographs of terrain in an area are taken from fixed and usually known position or near the ground and with the camera axis horizontal or nearly so.
   - **b) Aerial Photogrammetry:** photographs of terrain in an area are taken from air or airplane. It is a type used for surveying applications.

ii) **Interpretative:** It involves recognition and identification of objects and judging their significance through careful and systematic analysis. It includes photographic interpretation which is the study of photographic images. It also includes interpretation of images acquired in Remote Sensing using photographic images.

5.3.3 Classification of Photographs

Depending on the position of camera at the time of photography, photograph is broadly classified in to two.

- Terrestrial photograph and
- Aerial photograph

Terrestrial Photograph: When photograph is taken with ground-based cameras the position and orientation of which might be measured directly at the time of exposure, or with photo-theodolite (See Figure 15) having camera station on the ground and the axis of camera is horizontal or nearly horizontal.

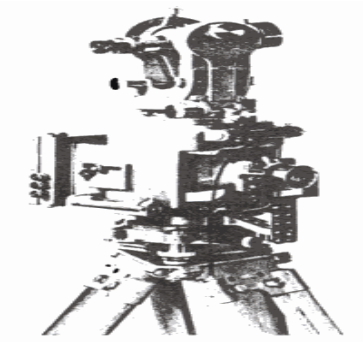


Figure 17: Photo Theodolite

Aerial photography: It is commonly classified as either vertical or oblique. *Vertical photos* are taken with the camera axis directed as nearly vertically as possible. The following paragraphs give details of classification of vertical photographs used in different applications on the basis of the alignment of optical axis:

a) **Truly Vertical:** If optical axis of the camera is held in a vertical or nearly vertical position.

b) **Oblique:** Photograph taken with the optical axis intentionally inclined to the vertical.

Following are different types of oblique photographs:

- High oblique: Oblique this contains the apparent horizon of the earth
- Low oblique: Apparent horizon does not appear.

c) **Trimetrogon:** Combination of a truly vertical and two oblique photographs in which the central photo is vertical and side ones are oblique. Mainly used for reconnaissance.

d) **Convergent:** A pair of low oblique taken in sequence along a flight line in such a manner that both the photographs cover essentially the same area with their axes tilted at a fixed inclination from the vertical in opposite directions in the direction of flight line so that the

forward exposure of the first station forms a stereo-pair with the backward exposure of the next station.

5.3.4 Scale Measurement From Aerial Photograph

The scale of the photographs is important to acquire information from photographs. The scale of a given photograph can be determined using following methods:

a) Measuring the distance between two well-defined points on the ground as well as on the photograph.

$$\text{Scale of Photograph} = \frac{\text{Photo Distance}}{\text{Ground Distance}}$$

b) Measuring the distance between two well-defined points on the available topographic map and aerial photograph. Then;

$$Photo\ scale\ = \frac{Map\ scale\ * Photo\ Distance}{Map\ Distance}$$

c) From average of the camera and the terrain above mean sea level with respect to the focal length (f) of the camera lens (See Figure 16).

$$Photo\ scale\ = \frac{(Focal\ length)}{Flying\ Height - Average\ Height}$$

Note: if the plane of the photographed object or area is exactly on the reference plane i.e., the plane of Mean Sea Level (MSL), the value for average height will be 0. Then;

$$Photo\ Scale\ = \frac{Focal\ length}{Height}$$

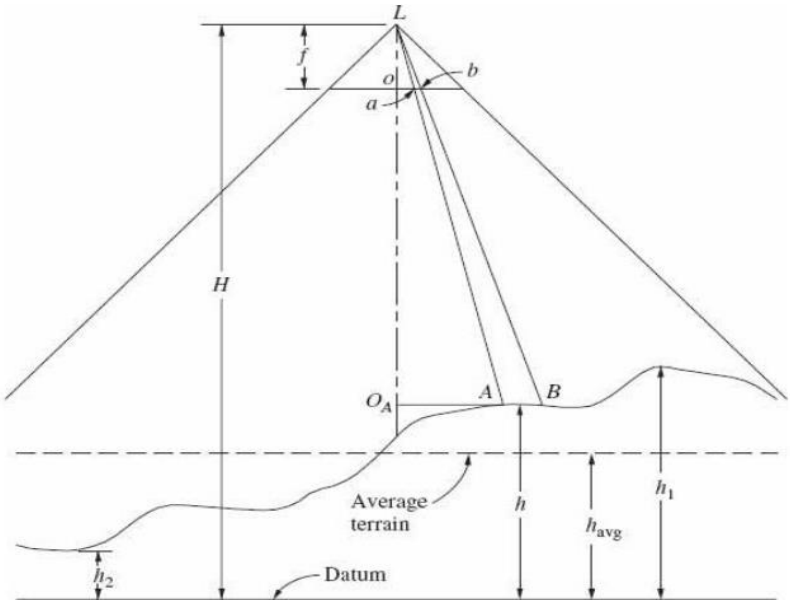


Figure 18: Scale of a vertical photograph over variable terrain

5.3.5 Applications of Photogrammetry

Photogrammetry has been used in several areas. The following descriptions give an overview of various applications areas of photogrammetry.

- **Geology**: Structural geology, investigation of water resources, analysis of thermal patterns on earth's surface, geomorphological studies including investigations of shore features.
- **Forestry:** Timber inventories cover maps, acreage studies
- **Agriculture:** Soil type, soil conservation, crop planting, crop disease, crop-acreage.
- **Design and construction:** Data needed for site and route studies specifically for alternate schemes for photogrammetry. Used in design and construction of dams, bridges, transmission lines, planning of cities and highways, new highway locations, detailed design of construction contracts, planning of civic improvements.
- **Cadaster:** Cadastral problems such as determination of land lines for assessment of taxes. Large scale cadastral maps are prepared for reapportionment of land.
- **Environmental Studies:** Land-use studies.
- **Exploration:** To identify and zero down to areas for various exploratory jobs such as oil or mineral exploration.
- **Military intelligence:** Reconnaissance for deployment of forces, planning maneuvers, assessing effects of operation, initiating problems related to topography, terrain conditions or works.
- **Miscellaneous:** Crime detection, traffic studies, oceanography, meteorological observation, architectural and archaeological surveys, contouring beef cattle for animal husbandry etc.

5.4 Identifying Features Using Stereoscopy

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. This is called stereoscopy. Stereoscopy is based on Porro-Koppe‘s principle that the same flight path will be generated through an optical system id 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. The eye-base and the photo-base must be parallel in order to view at a stereoscopic model.

Usually a stereoscope is used for image interpretation. There are several types of stereoscope, for example, portable lens stereoscope, stereo mirror scope, stereo zoom transfer scope etc. The process of stereoscopy for aerial photography is as follows. At first the centers of both aerial photographs, call the principle point, should be marked. Secondly the principle point of the right image should be plotted in its position on the left image. At the same time the principle point of the left image should be plotted on the right image. The principle points and the transferred points should be aligned a long a straight line, called the base line, with the appropriate separation (normally 25-30 cm in the case of a mirror stereoscope) as shown in the Figure 5.3 below. By viewing through the binoculars, a stereoscopic model can now be seen.

The advantage of stereoscopy is the ability to extract 3D for example, classification between tall trees and low trees, terrestrial features such as height of terraces, slope gradient, detailed geomorphology in flood plains, and dip of geological layers and so on.

The principle of height measurement by stereoscopic vision is based on the use of parallax, which corresponds to the distance between image points, of the same object on the ground, on the left and right image. The height difference can be computed if the parallax difference is measured between two points of different height using a parallax bar, as shown in the figure (See Figure 17).

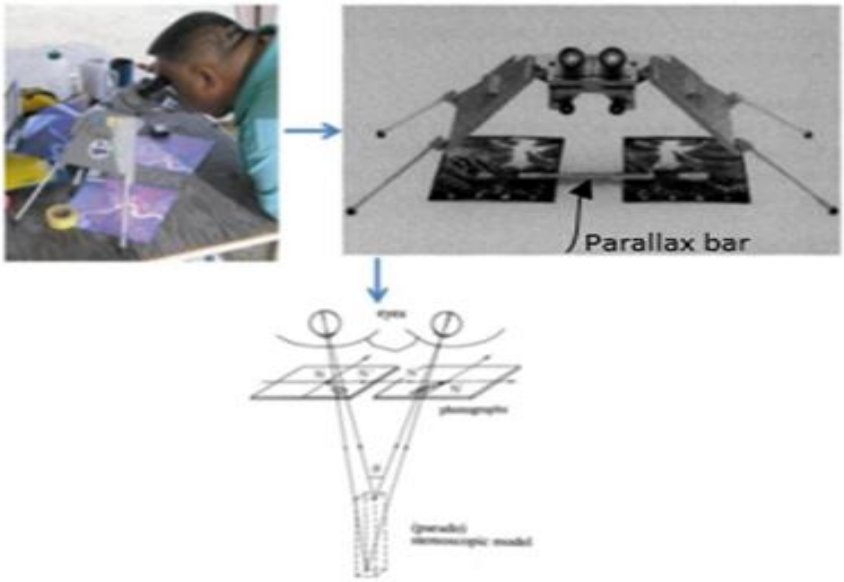


Figure 19: Principle of stereoscopic principle

5.5 Interpreting Image Data

Image interpretation is the extraction of qualitative and quantitative information in the form of a map, about the shape, location, structure, function, quality, condition, relationship

of/between objects, etc. by using human knowledge or experience. As a narrow definition, photo-interpretation is sometimes used as a synonym of image interpretation.

Image interpretation in satellite remote sensing can be made using a single scene of a satellite image, while usually a pair of stereoscopic aerial photography is used in photo-interpretation to provide stereoscopic vision using, for example, a mirror stereoscope. Such a single photo-interpretation is discriminated from stereo photo-interpretation.

Image reading is an elemental form of image interpretation. It corresponds to simple identification of objects using such elements as shape, size, pattern, tone, texture, color, shadow and other associated relationships. Image reading is usually implemented with interpretation keys with respect to each object. Image measurement is the extraction of physical quantities such as length, location, height, density, temperature and so on, by using reference data or calibration data deductively or inductively.

Table 2: Interpreting image data

S/N	Activity	Description
1	Image Preparation	To obtain image from the sources
2	Preliminary Procedures	To read annotation data and to orient images with base map
3	Image Reading	To apply image interpretation using common interpretation key elements
4	Image Measurement	To measure length and height ratio between different objects and to measure photo density
5	Image analysis	To evaluate objects and/or analyze phenomenon on images (classification, evaluation)
6	Thematic Mapping	To display the results of interpretation on a base map

Image analysis is the understanding of the relationship between interpreted information and the actual status or phenomenon, and to evaluate the situation. Extracted information will be finally represented in a map form called an interpretation map or thematic map. Generally, the accuracy of image interpretation is not adequate without some ground investigation. Ground investigations are necessary, first when the keys are established and then when preliminary map is checked.

5.5.2 Elements of Image Interpretation

The following eight elements are mostly used in image interpretation; size, shape, shadow, tone, color, texture, pattern and associated relationship or context.

a) **Size**: a proper photo-scale should be selected depending on the purpose of interpretation. Approximate size of an object can be measured by multiplying the length on the image by the inverse of the photo-scale.



Figure 20: Satellite view of a part of a city

b) **Shape**: the specific shape of an object as it is viewed from above will be imaged on a vertical photograph. Therefore, the shape looking from a vertical view should be known. For example, the crown of a conifer tree looks like a circle, while that of a deciduous tree has an irregular shape. Airports, harbors, factories and so on, can also be identified by their shape.



Figure 21: Image of an area

c) **Shadow** is usually a visual obstacle for image interpretation. However, shadow can also give height information about towers, tall buildings etc., as well as shape information from the non-vertical perspective such as the shape of a bridge.

Shadow is a helpful element in image interpretation. It also creates difficulties for some objects in their identification in the image. Knowing the time of photography, we can estimate the solar elevation/illumination, which helps in height estimation of objects. The outline or shape of a shadow affords an impression of the profile view of objects.

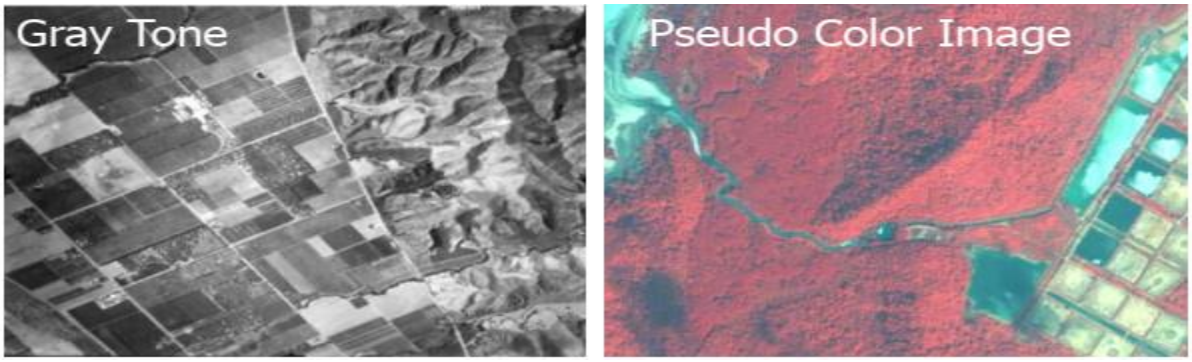


Figure 22: Shadow of objects used for interpretation

d) **Tone/Color**: Tone is the relative brightness of grey level on black and white image or color/F.C.C image. Tone is the measure of the intensity of the reflected or emitted radiation of the objects of the terrain. Lower reflected objects appear relatively dark and higher reflected objects appear bright.

Color is more convenient for the identification of object details. For example, vegetation types and species can be more easily interpreted by less experienced interpreters using color information. Sometimes color infrared photographs or false color images will give more specific information, depending on the emulsion of the film or the filter used and the object being imaged.

In panchromatic photographs, any object will reflect its unique tone according to the reflectance. For example, dry sand reflects white, while wet sand reflects black. In black and white near infrared photographs, water is black and healthy vegetation white to light gray.



(a) (b)

Figure 23: Satellite image of area in gray scale and in standard false color composite

e) **Texture** is a group of repeated small patterns. For example, homogeneous grassland exhibits a smooth texture; coniferous forests usually show a coarse texture. However, this will depend on the scale of the photograph or image.

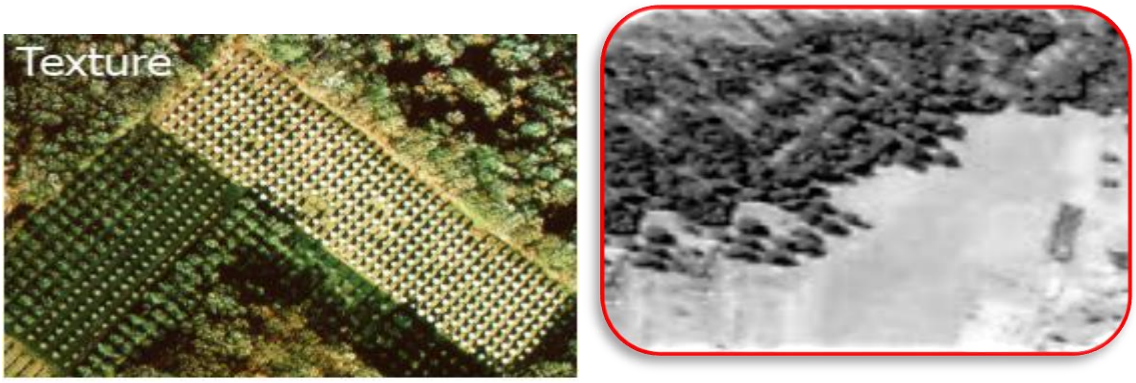


Figure 24: High resolution image showing different textures

f) **Pattern** is a regular usually repeated shape with respect to an object. For example, rows of houses or apartments, regularly spaced rice fields, interchanges of highways, orchards etc., can provide information from their unique patterns.



Figure 25: High resolution image showing different Pattern

g) **Associated relationships or context**: Associated combination of elements, geographic characteristics, configuration of the surroundings or the context of an object can provide the user with specific information for image interpretation.

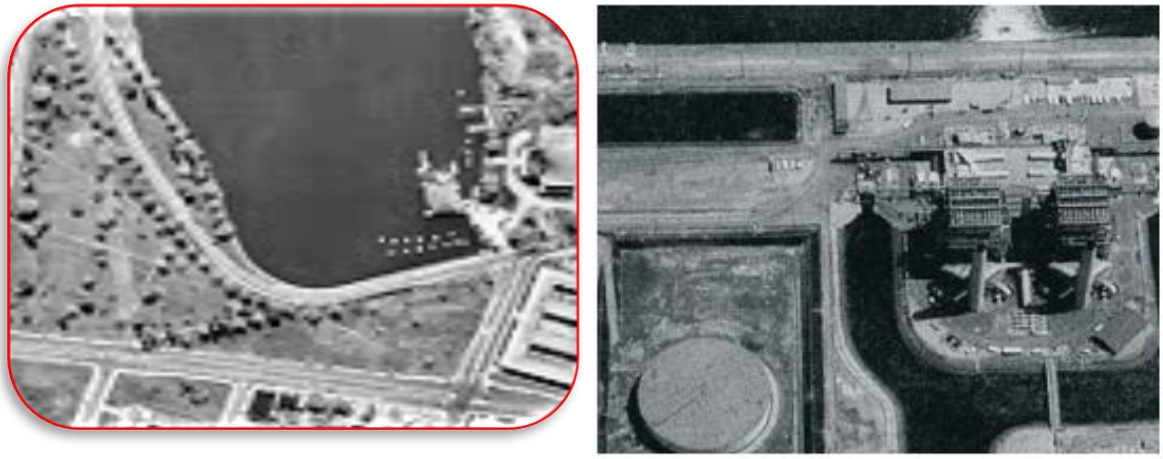


Figure 26: Image of associated relationships

5.6 Summary

Dear trainee! Photogrammetry with respect to the overall basic principles involves two aspect, measurement and interpretation of photo data. The applications of photogrammetry are widely spread. Principally, it is utilized for object interpretation (what is it? What's its type, quality, and quantity) and object measurement (where is it? What's its form and Size?). Different organization use the interpretative aspect of photogrammetry called Image interpretation, which is the extraction of qualitative and quantitative information in the form of a map, about the shape, location, structure, function, quality, condition, relationship of and between objects.

Photo-interpretation deals with the examination of photographic images for the purpose of identifying objects and deducing their significance. Everyone, to a certain degree, is a photo-interpreter. However, photo-interpretation as practiced by an expert, requires an interpretation key and element, otherwise the interpretation become liable to overlook or misinterpret small and subtle features on aerial photographs.

Depending on the position of camera at the time of photography, photograph is broadly classified in to two; Terrestrial photograph and Aerial photograph. 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. This is called stereoscopy. Usually a stereoscope is used for image interpretation. There are several types of stereoscope. The advantage of stereoscopy is the ability to extract 3D information. The following eight elements are mostly used in image interpretation; size, shape, shadow, tone, color, texture, pattern and associated relationship or context.

5.7 Self-Check Exercises



Short Answer Items

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

1) What are the basic principles of image Data?
2) What do we mean by photogrammetry and stereoscopy?
3) What are the classifications of photograph?
4) What are the advantages of stereoscopy?
5) List the elements of image interpretation.
6) How do we identify features from image/ photograph?

CHAPTER SIX: COLLECTING SPATIAL AND SOCIO-ECONOMIC DATA

6.1 Introduction

Dear trainee! This chapter introduces you about the concepts of spatial and non-spatial data, gathered through different data collection methods. It requires the ability in gathering information through techniques of data collection that leads to the formal record in the legal sense. Definitions, collection mechanisms and checking, validation mechanisms and correlations between layers are also covered by this chapter. Spatial data sets are primarily defined as those which are directly or indirectly referenced to a location on the surface of the earth whereas non-spatial data are attributes describing the spatial data such as numbers, characters or logical type. Within broad view of this theme, the following three core areas are covered.

Data includes both spatial and non-spatial data on which GIS operations are performed to derive new information. Spatial data acquired from various sources such as satellite images, aerial photographs, ground surveying or existing map data that can be integrated with corresponding non-spatial data in GIS environment. Spatial data is described by X, Y coordinates and descriptive data are best organized in alpha numeric fields. Normally, Spatial and attribute data are stored separately to a GIS and links are established between the two types of data. Broadly categorized, the basic data for any GIS application has two components. Spatial data is consisting of maps and which have been prepared either by field surveys or by the interpretation of remotely sensed data whereas, non-spatial data describes attributes complimentary to the spatial data and that describe what is at a point, along a line or in a polygon.

6.2 Learning Objectives

After completing this chapter, you will be able to:

- Identify tasks prior to data collection
- Conduct the spatial and non-spatial data collection
- Perform information review and correlation



Dear trainee! Before reading the following section, take ten minutes and try to describe concepts of spatial and non-spatial data collection.

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6.3 Data Collection Preparations

Data according to this context refers to both spatial and non-spatial data: Spatial data sets are primarily defined as those which are directly or indirectly referenced to a location on the surface of the earth. When a dataset cannot be related to a location on the surface of the earth is referred as non-spatial data. GIS technologies are unique in their capability to combine the two data sets thereby bringing a paradigm shift in thinking how the planning and monitoring system may work. The power and potential of such systems is unlimited thereby providing huge opportunity to process information which can be used effectively.

The non-spatial data are numbers, characters or logical type. The spatial data sets, however has primary data type as point, line or polygon and may be referenced to some specific grid system. Traditionally the information systems in past have created the huge data repositories which appear to be non-spatial in nature. However, these may indirectly be referring to specific locations.

The first step in data collection is planning: this includes preparations which give guidelines for the actual work. Planning mainly used to manage time properly, save resources from waste such as transportation, energy, cost, etc. So, these resources can be saved and used properly. There are various data planning preparations depending on the type of data and application required. Making data collection arrangements have to be performed if there are different crews. Team leaders in this case mobilize the resources required for the work. Materials needed for the work should be prepared including their accessories; safety covers or boxes; helmet, field shoe, etc. are parts of the planning mission. Enumeration area has to be defined and delineated on a day to day activity in order to avoid confusions.

For instance, if the required data is densified control point, DGPS is needed. Before going to the field measurement GPS mission planning need to be made in advance to know satellite availability and their obstruction level. The Satellite Availability tool of Leica Geo Office (LGO) helps you to plan your GPS field work. It provides you with graphical and numerical information on the satellite constellation for any location (Site) at a given time. To compute the satellite availability for a specific Site, Almanac information has to be provided. Define the site-specific obstructions. Obstructions may be defined for Rover and Reference. In the same manner, if the required data is the land tenure data of a given neighbor, it has to be prepared the legal document of the land holders and adjudication formats in line with the legislations and standards.

6.4 Conduct Data Collection

6.4.1 Methods of Spatial Data Collection

This is a procedure which the actual data collected is made. Depending on the required data for the specific application, both spatial and non-spatial (socio-economic) data are collected. Spatial data is collected in the field using land surveying instruments such as GPS, Total Station, Tape, Level, etc. or from remotely sensed data's like aerial photographs and satellite imageries. Mostly, the spatial data collection techniques can be broadly categorized as a ground and photogrammetric approaches.

Ground Survey Methods: are conducted using surveying instruments like Tape, Level, Theodolite, Compass, Total Station, GPS and others. This method is economical and suitable for relatively small areas.

GPS: Using GPS spatial data can be collected in two techniques; Static and RTK (Real Time Kinematics). Static GPS surveying is a relative positioning technique that depends on the carrier-phase measurements. It employs two (or more) stationary receivers simultaneously tracking the same satellites. One receiver, the base receiver, is set up over a point with precisely known coordinates such as a survey monument (sometimes referred to as the known point). The other receiver, the remote receiver, is set up over a point whose coordinates are sought (sometimes referred to as the unknown point). The base receiver can support any number of remote receivers, as long as a minimum of four common satellites is visible at both the base and the remote sites.

Real time kinematics data collection uses differential GPS corrections broadcast by a base receiver to solve for coordinates at a rover receiver in real time. There are several ways to transmit a correction signal from the base station to mobile station. The most popular way to achieve real-time transmission is radio communication. The accuracy of the resulting range measurement depends on the number of satellites in view, resolved ambiguities, satellite geometry, etc.

Total Station: Using Total Station angles (horizontal and vertical) and distance can be measured. Angle measurement is one of the fundamental measurements in surveying work, which is used to describe the relative orientation of points and properties with respect to each other. Basic terms used in angle measurement are: *Horizontal plane* is a plane that is perpendicular to the vertical line at a point; there can be only one horizontal plane through a given point but unlimited horizontal lines exist at the same point. *Horizontal angle* is the difference between two intersecting lines when they are projected onto the datum plane. *Vertical plane* is any plane that contains the vertical line at a given point; unlimited vertical planes exist at a given point. *Vertical angle (Elevation angle)* is the angle of elevation or depression between the line of collimation and the horizontal plane which passes through the horizontal axis of the theodolite.

Distance is one of the fundamental measurements in surveying. Although frequently measured as a spatial distance (sloping distance) in three-dimensional space, inevitably it is the horizontal equivalent which is required. Distance is required in many instances, for example, to give scale to a network of control points, to fix the position of topographic detail by offsets or polar coordinates, to set out the position of a point in construction work, etc. Having said this, different features can be measured and collected; trees, poles, buildings, roads, etc.

Remote Sensing Method: is a method of acquiring data without physical contact between the sensor and the target. Aerial photographs/satellite images are remotely sensed data that are used to show the necessary ground data. It is an economic method for larger areas and projects and it overcomes the sometimes-difficult access problems to the area to be mapped. The accuracy of photogrammetric mainly depends upon the scale of the aerial photographs. The ground work is only limited to establishing horizontal and vertical ground control points (For example, through traversing and leveling) that must be clearly defined and well-distributed over the target area and a final terrestrial field check should be made.

6.4.2 Methods of Non-spatial Data Collection

Any additional information, or attribute, that describes a feature is referred to as a non-spatial data. For example, you might have a map displaying buildings within a city's downtown region. Each of the buildings, in addition to their location, may have additional attributes such as the type of use (housing, business, government, etc.) and how many stories it has.

The name of the town, its population, settlement type, modes of transportation and communication, government structure, educational institutions, occupations, and facilities are among the non-spatial statistics of the town. It's worth noting that none of the town's data listed above are based on their physical location. As a result, non-spatial data is unaffected by location information.

Implies that non-spatial (socio-economic) data are acquired at the same time as geographical data. Depending on the nature of the project, some were developed during the analysis period and others were obtained from other organizations such as municipalities, statistics agencies, and so on.

6.5 Information Review and Correlation

The obtained data must be checked for correctness and completeness after the field measurement; this procedure is known as data review. Correlation can be used to review the data because it shows the degree and direction of a linear relationship between two random variables. In contrast, the term "connection" is used in everyday conversation to refer to any relationship, not necessarily linear. The departure of two random variables from independence is referred to as correlation or co-relation in standard statistical usage. There are numerous coefficients that measure the degree of correlation and are adapted to the nature of the data in this wide sense.

Correlation is a relation existing between phenomena or things or between mathematical or statistical variables which tend to vary, be associated, or occur together in a way not expected on the basis of chance alone.

6.6 Summary

Dear trainee! Preparing for data collection (measurement), doing the actual measurement, and chores following data collection are all examples of land surveying activities. Preparation work such as planning, coordinating, and mobilizing the workforce for the task is done in advance of the actual data collecting. The real data collection task will then be undertaken, based on the application requirements. Finally, the acquired data should be reviewed for accuracy and validated. Data can be classed as spatial or non-spatial in land surveying. Spatial data, or geographical data, is information about a physical item that may be represented numerically in a geographic coordinate system. The position, size, and shape of an object on the planet Earth, such as a building, lake, mountain, or township, is represented by spatial data. Non-spatial data includes properties such as numbers, characters, and logical types that describe spatial data. In general, spatial data describes the geometrical orientation, shape, size, and relative position of a feature in relation to other features using x, y coordinates, whereas attribute data qualifies information about numerous properties such as area, length, and population. The obtained data must be checked for correctness and completeness after the field measurement; this procedure is known as data review. We can utilize correlation during data analysis to determine the degree and direction of a linear relationship between two random variables.

6.7 Self-Check Exercise

Short Answer Items

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

1) What are the procedures and preparations for data collection in the field?
2) Define and explain spatial and non-spatial data.
3) How can be collected data checked for its correctness?
4) When and why correlation is required?

CHAPTER SEVEN: OPERATING BASIC APPLICATION SOFTWARE PACKAGES

7.1 Introduction

Dear trainee! This chapter introduces you the basic concepts of computer, working with file and operating basic software packages including a word-processing, spreadsheet. and database applications. A computer is a machine that is controlled by internally stored programmers and that can perform operations without human intervention. It is a collection of hardware and software components. The hardware parts consist of one or more processing units, memory units, and input and output devices. It is the equipment you see and the parts you can touch. The software is the set of instructions, called a program, which tells the computer what to do, when and how to do it. In its literal meaning, device or machine for making calculations or controlling operations that are expressible in numerical and logical terms. This literal meaning was attached because the inventors (mathematicians or physics) invent computers for making calculations only. But today's computers not only process numbers, they process texts, pictures, and multimedia and so on. Therefore, the meanings of the computer, nowadays, are broader than computing concepts.

Computer software is anything that can be stored electronically. The term is used to contrast with computer hardware (the physical objects); unlike hardware, software cannot be touched. Hardware and software require each other and neither has any value without the other. Application software is all the software that uses the computer system to perform useful work beyond the operation of the computer itself. Examples of common applications are: word processor, spreadsheet, database, Internet browser, email, games, etc. Data is all the documents and files that are created or manipulated by application software, including documents, spreadsheets, pictures, movies, etc.

Operating under the control of instructions stored in its own memory unit and that can accept data, process data, produce output and store the results for future use. So, in more general sense as described above a computer is a programmable electronic machine capable of accepting data, processing, storing and then displays the output to the user.

7.2 Learning Objectives



After completing this chapter, you will be able to:

- Define computer system
- Identify appropriate Microsoft Office package
- Customize basic settings and format documents
- Work with desktop environment
- Identify different types of extension formats



Dear trainee! Before proceeding to the following section, take ten minutes and try to explain the basic concepts of computer system and identify appropriate word-processing software.

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7.3 Introduction to Computer

A System is any collection of component elements (also called Subsystems) that work together to achieve some objective (s). The components collectively make the whole (the System). Each component has a specific task to accomplish. A Computer is not a single machine. It is a System and the System contains lot of subcomponents. A Computer System is made up of both hardware and software. Software is another term for computer program. Software is a series of instructions that tells a computer what to do and how to do it. Hardware refers to the physical components of a computer system.

7.3.1 Computer Hardware

The hardware of a computer system is made up of a number of electronic devices connected together. It is composed of a number of interacting physical parts based on the need of the information. Generally, the basic elements of the computer hardware are categorized in to five sections. These are input devices, output devices, system unit, secondary storage devices and a communication network called bus/cables, which links all the elements of the system and connects the system to the external world.

7.3.2 Computer Software

System soft ware primarily exists for the computer itself. System software consists of instructions or programs that are used to manage the hardware resources of a computer. It placed between the hardware and the application software, i.e. it is used as an intermediate for the communication between the hardware and the application software of a computer system.The system software can be of the following type:

- Operating system software and
- System development software (Language software)

A. Operating System Software

Operating system is a set of programs that controls and supervises the overall operation of the computer. All computers require the Operating system. It has the following functions in common:

- It manages the computer resources
- It interprets and processes commands
- It activates input/output devices
- It allows the system to understand application soft ware
- It schedules jobs

B. Language Software

The other sub-division of the system software is the system development software (the language software), which are used by the programmers to develop application programs. System development software (language software) includes the computer programming language translators that are used to convert written programs in to machine language for execution. Before we discuss about the major language software, namely the compilers, assemblers and Interpreters, that serve as translators, first let's see about programming languages and the major categories of programming languages.

C. Application Software

Application software is a type of software that placed between the user and the system software and allows the user to perform a certain activity- such as creating a document or editing a graphic image. They are also called application packages. Some important kinds of application software are: word processing programs (Ms Word), spreadsheet software (Ms Excel), database management Presentation programs (Ms Access), etc.

7.4 Introduction to Desktop and its Components

You should start thinking of your screen as your DESKTOP. Your DESKTOP is what you now see on the screen (as shown in Fig. 19). As you are logged into the University desktop, it will look a little different to your desktop if you have a computer at home.

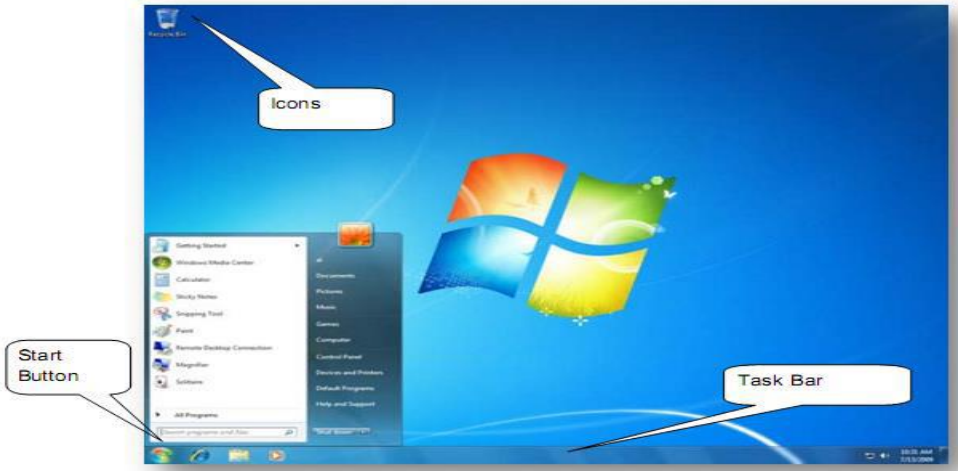


Figure 27: Desktop Icons

Let have a look at what is on your DESKTOP. You will have a few pictures on your desktop, these are called ICONS. To access the program the icon represents, or the contents of these icons they must be opened. To open an icon, you point to it with your mouse and then double-click on it using the left mouse button, or right-click and open. Components of Desktop may include:

The taskbar: The taskbar is the long horizontal bar at the bottom of your screen. Unlike the desktop, which can get obscured by open windows, the taskbar is almost always visible. It has three main sections:

- The Start button which opens the start menu.
- The middle section, which shows you which programs and files you have opened and allows you to quickly switch between them.
- The notification area, which includes a clock and icons (small pictures) that communicate the status of certain programs and computer settings

When a window is active (its taskbar button is highlighted), clicking its taskbar button minimizes the window. That means that the window disappears from the desktop. Minimizing a window doesn't close it or delete its contents, it temporarily removes or it from the desktop.

In the picture below, Calculator is minimized, but not closed. You can minimize a window by clicking the minimize button in the upper-right corner of the window. You can tell it's still running because it has a button on the taskbar.

The START Button: is located at the bottom of the screen on the left-hand side of the taskbar and gives you access to most things available on your computer. When you click on the START button, you will see a menu. Clicking on this item will run the application.

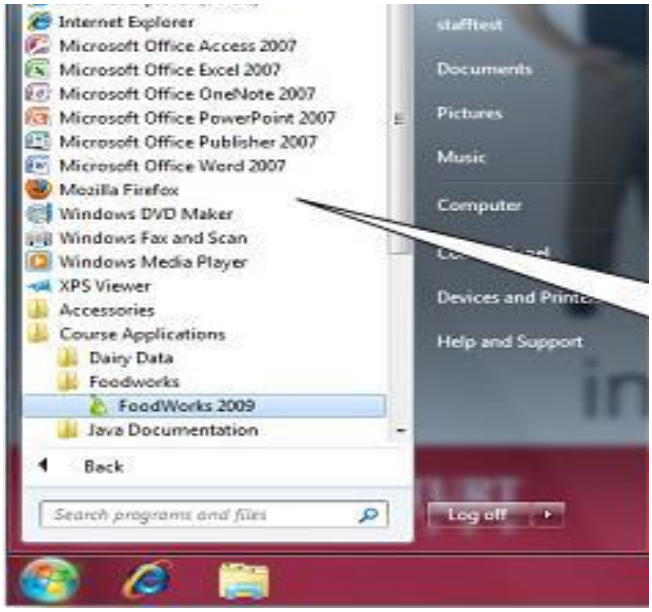


Figure 28: Start button

Some of the items you may see in the START Menu are:

- Documents: The DOCUMENTS menu links you to your documents.
- Pictures: This will link you to your pictures folder
- Music: This links you to a folder for storing music
- Computer: Clicking this link will show you the drives connected to this computer
- Control Panel: Allows you to make changes to the current settings on the computer.
- Devices and Printers:
- Search programs and files: Allows you to search for files, folders, printers, software applications etc. by entering search criteria
- Help and Support: Gives you access to a help facility where you can find out how to do certain things on your computer.
- Log Off: Allows you to log off as a User without turning off the computer and someone else can log on.

7.5 Glossary of Icons

Table 3: Glossary of Icon

	**My Documents** My document is the default storage folder for your files that you create. When you save or open a file, Microsoft Windows initially opens the My Documents dialog box. At this time, you can navigate to where you want to save your file.
	**My Computer** My computer displays information about your computer, such as the contents of your computer drives and which printers you have installed. It also allows you to find, view and organize files.
	**The Recycle Bin**: This is where you place files you no longer need. Your computers data files should be tidied up regularly and any unwanted files deleted from the system. Any file you delete from your hard drive will be placed first in the Recycle Bin. Files you delete from the University Network drives will not go into the recycle bin. You may decide to leave those files in the Recycle Bin if you think you might need to retrieve them later. However, you should empty the recycle bin so it does not fill up.
	**Internet Explorer:** With internet explorer and an Internet connection, you can search for and view information on the World Wide Web. You can search the Internet for people, businesses, and information about subjects that interest you, download music, copy graphics, stay in touch with or meet new friends, and a host of other activities.
	**Microsoft Outlook:** Microsoft Outlook is an e-mail program that lets you exchange mail with friends and colleagues as well as manage appointments through the calendar function.

	**Microsoft Excel:** Microsoft Excel is a spread sheet application which allows users to enter text and numbers into rows and columns. This data can be manipulated and analyzed by using formulas and functions and reporting and charting can be done on the results.
	**Microsoft PowerPoint** Microsoft PowerPoint is a presentation program. It turns text, numbers and graphics into a presentation which can be shown to an audience in a slideshow or printed off as handouts.
	**Microsoft Word** Microsoft Word is a word processing application used for creating documents such as reports, letters, business plans, and more.
	**My Personal Drive (P)** This is a network drive where you are able to save any files you create.
	**My Shared Drive (S)** This is a corporate or home network drive where you are able to save any files you create.

7.6 Working with Files

Files are documents which have been created using different software applications, for example, a letter you may have created in Microsoft Word or a spread sheet in Microsoft Excel etc. The programs you use (Word, Excel etc.) are also made up of many (sometimes hundreds) of files, each having instructions on how the program should work. A filename consists of a descriptive name to describe the contents and a three-letter file extension which

follows the name you have given the file. This extension indicates the type of application used to create the document. Some common file extensions are:

- .doc - Microsoft Word files
- .xls - Microsoft Excel files
- .pdf - Adobe Acrobat files
- .ppt - Microsoft PowerPoint files

These extensions are automatically added to your filename when you save your file. They are separated from the name you give the file by a full stop (period); therefore, you should not use full stops when you name a file as the program may think you are trying to add your own extension.

As there are so many files on your computer, a filing system must be maintained to keep some sort of order. For example, if you keep all your letters in a folder called LETTERS, then you will be able to locate them faster. Similarly budgets and financial files could be kept in a folder called ACCOUNTS. Files are kept separate from one another by keeping them in folders. Folders are located in drives (either hard drives, network drives, diskettes, CDs, thumb drives etc.).

All files have a path name. This gives you (and the computer) the exact details of which drive and which folder(s) the file(s) are located in. A path name may be as simple as C:\ or it can be many characters long. A path name starts with the drive the file is on, it is then followed by the folder and any subfolders where the file is stored. Each bit of information is separated with a backslash (\). For example, the path name P:\data\personal\timesheet.xls means that a file called *timesheet.xls* is stored on your P: drive under the folder named DATA and then under the sub folder named PERSONAL. It is important that you become familiar with path names.

7.7 Working on Microsoft Application Packages

7.7.1 Microsoft Word

Microsoft Word is a word-processing application perhaps the most widely used word-processing application in existence. You can use Word to write letters, memos, reports, and essays. Because it is so pervasive and allows you to save in a variety of file formats, there is an excellent chance you can create a version of a given Word document that can be opened by almost any recipient.

While being in Word, someone can create table, insert pictures and charts. (See figure 21)

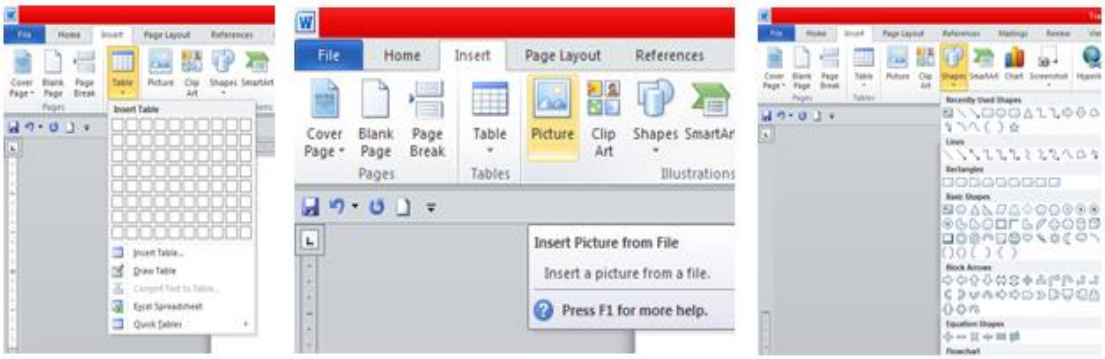


Figure 29: How to create table, insert pictures and charts in MS Word

7.7.2 Microsoft Excel

Microsoft Excel is a spread sheet application which allows users to enter text and numbers into rows and columns. This data can be manipulated and analyzed by using formulas and functions and reporting and charting can be done on the results.

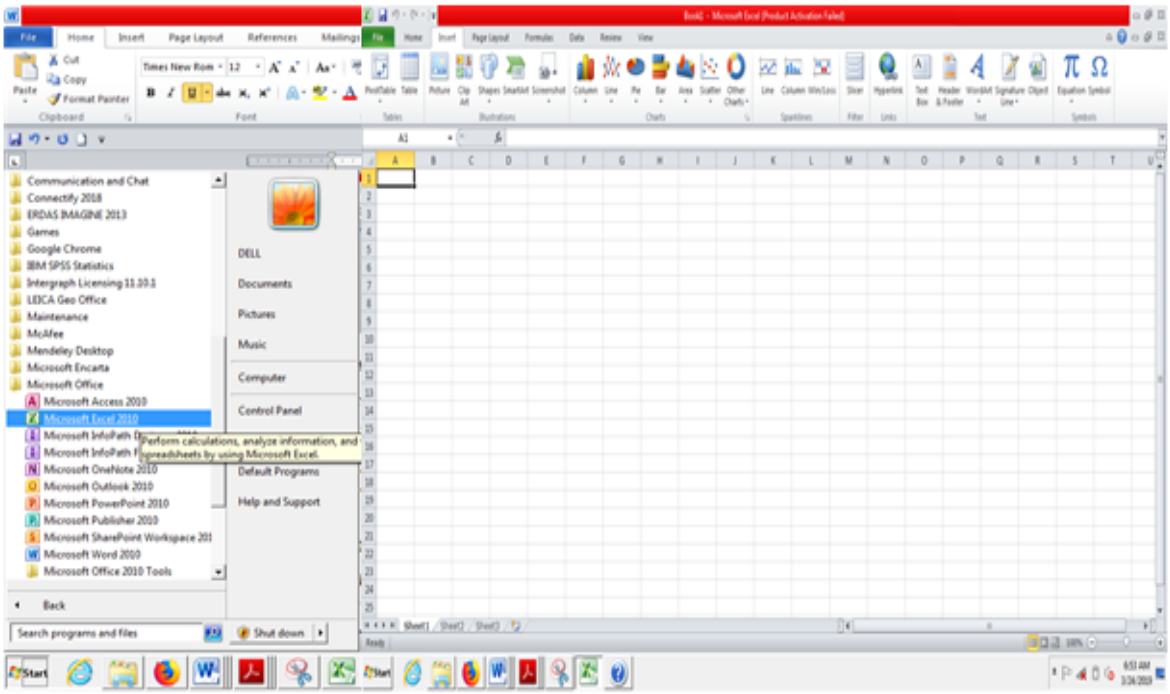


Figure 30: MS Excel interface

7.7.3 Microsoft PowerPoint

Microsoft PowerPoint is a presentation program. It turns text, numbers and graphics into a presentation which can be shown to an audience in a slideshow, or printed off as handouts.

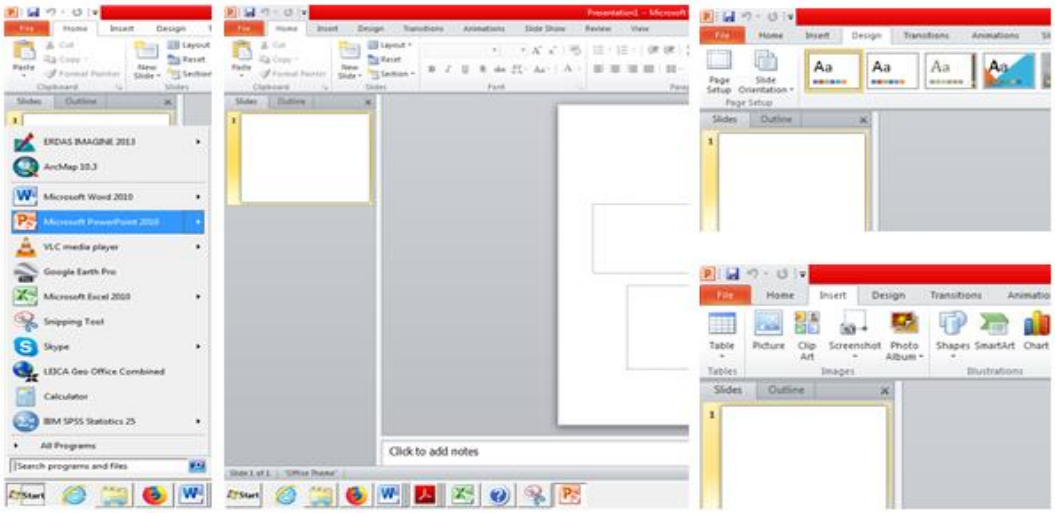


Figure 31: MS PowerPoint interface

7.7.4 Microsoft Access Databases

The database component of MS Office is designed to act as an "intelligent" electronic filing cabinet. Like a manual filing cabinet, it enables you to

- collect sets of related data and keep the data organized;
- update the data once you've collected them, by adding or deleting records and by changing existing records;

Microsoft Access is a Database Management System (DBMS) from Microsoft that combines the relational Microsoft Jet Database Engine with a graphical user interface and software development tools. It is a member of the Microsoft Office suite of applications, included in the professional and higher editions.

Access can also understand and use a wide variety of other data formats, including many other database file structures. It can export data to and import data from word processing files, spreadsheets, or database files directly. Access can work with most popular databases that support the Open Database Connectivity (ODBC) standard, including SQL Server, Oracle, and DB2. A database is a collection of information that's related. Access allows you to manage your information in one database file. Within Access there are four major areas: Tables, Queries, Forms and Reports

- **Tables** store your data in your database
- **Queries** ask questions about information stored in your tables
- **Forms** allow you to view data stored in your tables
- **Reports** allow you to print data based on queries/tables that you have created

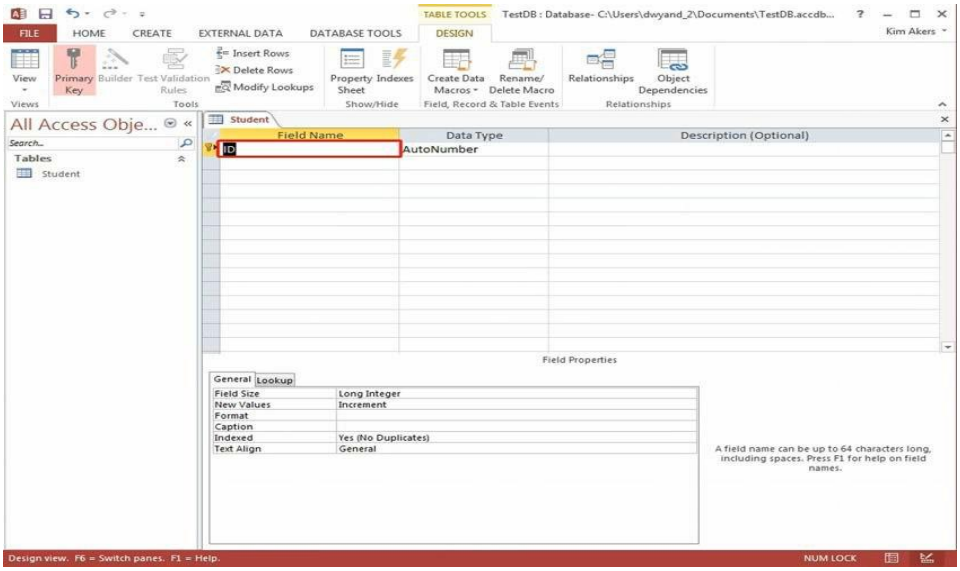


Figure 32: MS Access interface

7.8 Printing Documents

A printer is a device that produces a paper copy of the documents on your computer. You can use a printer to produce letters, invoices, newsletters, reports, labels, and much more. To print from your computer, you select a printer to which you would like to send the file. There are two different ways that a printer can be connected to your computer; it can be a local printer or a Network printer. A local printer is connected to your computer only and there will be a printer cable that runs from your computer to the printer. No-one else will have access to this printer unless they log on to your computer. A network printer is connected to your computer via the file server and will usually sit in a room away from your computer. Other people within your department will also have access to the printer from their computer.

The quickest way to print a document or file is to print using Windows. You don't have to open any programs or change any settings. Right-click the file you want to print, and then click Print. Doing so opens the Print dialog box. This is the place to change basic settings such as what printer to use or how many copies to print. (The dialog box you see might look different from the one shown here, depending on your software and printer.).

7.9 Summary

Dear trainee! Computer is an electronic device; operating under the control of instructions stored in its own memory unit and that can accept data, process data, produce output and store the results for future use. So in more general sense as described above a computer is a programmable electronic machine capable of accepting data, processing, storing and then displays the output to the user.

Every computer needs an operating system which let operate a computer. There are a few around and Microsoft Windows is just one of them, albeit one of the most popular ones. Some of the functions the Windows operating system allows you to do are: Access applications (programs) on your computer (word processing, games, spread sheets, calculators and so on); Load any new programs on to the computer; Manage hardware such as printers, scanners, mice, digital cameras; Manage how files are stored on your computer; and Change computer settings such as color schemes, screensavers, and the resolution of your monitor.

In our day today computer working activities, the most frequently used Microsoft Offices are: Microsoft Excel is a spread sheet application which allows users to enter text and numbers into rows and columns. This data can be manipulated and analyzed by using formulas and functions and reporting and charting can be done on the results. Microsoft PowerPoint is a presentation program. It turns text, numbers and graphics into a presentation which can be shown to an audience in a slideshow or printed off as handouts. Microsoft Word is a word processing application used for creating documents such as reports, letters, business plans, and more.

7.10 Self-Check Exercise

**Short Answer Items**

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

1) Describe computer system and components of computer system?
2) What is an Operating System? Mention its different types.
3) List and describe different types of extension formats.
4) What are the applications of Microsoft (Word, Excel and PowerPoint)?
5) How do you print documents?

CHAPTER EIGHT: APPLYING BASIC LAND AND LAND RELATED PROPERTY LAW

8.1 Introduction

Dear trainee! This chapter introduces you about the basic concepts of land and land related property laws, understanding these laws and complying in any organizational entities. In Ethiopia, there are various laws applicable in the land sector; proclamations, regulations, directives, standards, etc. Thus, within the context of this thematic area, the following issues will be addressed.

Land is the most vital resource on earth from which humankind derives almost all its basic needs. Land plays significant role through economic, social, political and cultural dimensions. In terms of economic use, it serves as basis for livelihood; in terms of social aspect, land is a space for interaction; in term of politics, land is the source for power; in terms of culture, land is a symbol for collective identity. Land related property is defined as, in this case, fixtures on the land such as buildings. Administration of these vital resources is a major issue underlying social, economic and cultural development. Its protection will be sustainable if there is proper land and Land related property laws.

Ethiopia has issued different land related laws in order to administer this vital resource properly. Some of them are: Proclamation 721/2011: Urban Land Lease Holding Proclamation, which is provided for the allocation of rights to use land through urban leases by prohibiting land possession and permission; Proclamation 818/2014: Urban Landholding Registration Proclamation. This proclamation provides for the registration of rights, restrictions and responsibilities relating to urban land; Proclamation 370/2003: Condominium Proclamation, which provides the use and allocation mechanisms; Proclamation 455/2005: Expropriation of landholdings for Public Purposes and Payment of Compensation Proclamation. This proclamation provides expropriation of landholdings and the payment of compensation. Under all these proclamations there are lower level laws in the form of regulations, directives and standards which are in line with the higher laws (in this case the proclamation). The intention of these lower level laws is to give details and execution guidance.

8.2 Learning Objectives

After completing this chapter, you will be able to:

- Explain concepts of land and land related property law
- Identify and apply real property registration laws
- Describe type of property laws

Dear trainee! Before reading the following section, take ten minutes and try to discuss the basic concepts of land and land related property law.

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8.3 Land and Land Related Property Laws

All laws emanate from the constitution, which is the highest law of all. Other laws such as proclamations, policies, regulations, directives, etc. are under this constitution. Any law contrary to this constitution will be void. Therefore, constitution is the source of all other laws. In the land sector there are a number of laws which are drafted and enacted in-line with the highest law. Some of the laws applicable in the land sector are:

Proclamation 721/2011: *Urban Land Lease Holding Proclamation*

This proclamation provides for the allocation of rights to use land through urban lease system, prohibits land possession and permission other than lease holding and provides for the administration of urban land lease holdings. Applies to all urban lands irrespective of how the lands were held previously.

Proclamation 818/2014: *Urban Landholding Registration Proclamation*

This proclamation provides for the registration of rights, restrictions and responsibilities relating to urban land. It also provides the principles of a legal cadaster and landholding adjudication and registration system. In addition, it defines the Legal Cadaster as an updated landholding information system containing a record of the rights, restrictions and

responsibilities on a defined legal boundary for each landholding demarcated as a parcel on a map.

Proclamation 370/2003: *Condominium Proclamation*
This Federal Proclamation applies only to Addis Ababa and Dire Dawa but has been used by the Regions as a basis for their condominium proclamations.

Proclamation 1161/2019: Expropriation of Land holdings for Public Purposes, Payments of Compensation and Resettlement of Displaced People Proclamation
It provides for the expropriation of landholdings and the payment of compensation, as well as complaints and appeals processes. It applies to both rural and urban landholdings. Currently, this proclamation had amended by expropriation of land holdings for public purposes, payments of compensation and resettlement with significant changes.

Regulation 323/2014: *Urban Cadastral Surveying*
Provides the principles of cadastral survey system implementation, specifies survey measurement and calculation activities and procedures.

Regulation 324/2014: *Urban Landholding Adjudication and Registration*
It provides the objectives and principles of landholding registration and adjudication, and further detail on the implementation of Proclamation 818/2014.

The main functions of these laws are to serve as fundamental roadmaps for the implementation of land and Land related properties. And there are procedures on their implementation; they are executed through the respective lower level laws. Their successfulness or effectiveness is measured in terms of an evaluation framework with a set of indicators. 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.

8.4 Land Adjudication and Registration

Land registration generally describes systems by which matters concerning ownership, possession or other rights in land can be recorded (usually with a government agency or department) to provide evidence of title, facilitate transactions and to prevent unlawful disposal. The information recorded and the protection provided will vary by jurisdiction.

8.4.1 Land Adjudication

Land registration is a process of official recording of rights in land through deeds or as title on properties. When title to land is brought onto the register for the first time, a special procedure may need to operate. This is procedure is known as adjudication, which is the process whereby existing rights in parcels of land are finally and authoritatively determined. According to UNECE, adjudication can be performed either sporadically or systematically.

Sporadic: this implies "here and there" or "now and then". Thus, in this type of adjudication, it takes place whenever or wherever there is intent to define the right owner and boundaries of individual parcels, while the later indicates a systematic and orderly sequence such as area by area, and all parcels are brought onto registration.

Systematic: this approach is the longer term less expensive because of economies of scale, safer because it gives maximum publicity to the determination of who owns what within an area, and more certain because detailed investigations take place on the ground with direct evidence from the owners of neighboring properties.

8.4.2 Land Registration

There are two types land registration systems; the deed and the title. Deed registration system means that the deed itself, being a document, which describes an isolated transaction, is registered. This deed is evidence that a particular transaction took place, but it is in principle not in itself proof of the legal rights of the involved parties and, consequently, it is not evidence of its legality. Thus, before any dealing can be safely effectuated, the ostensible owner must trace his ownership back to a good root of title. On the other hand, a title registration system is concerned about the legal consequence of transaction i.e. the right itself. So, the right itself together with the name of the rightful claimant and the object of that right with its restrictions and charges are registered.

Regardless of the differences between deeds and title registration systems, there are four basic legal principles that can generally be recognized. Booking principle implies that a change in interests on real property is not legally effectuated until the change right is booked or registered in the land register. Consent principle implies that the real entitled person who is booked as such in the register must give his consensus for a change of the inscription in the land register. Principle of publicity implies that the legal registers are open for public inspection, and also that the published facts can be supported as being more or less correct by third parties in good faith, so that they can be protected by law. Principle of specialty

concerned with the rightful subject (man) and object (real property) must be absolutely recognized.

8.5 Acquisition of Land and Landed Property

8.5.1 Types of Land Acquisition

Land acquisition is the process of buying/owning a piece of land. The motivation behind land acquisition can be varied; perhaps as an alternative investment to shares, as the starting point for a self-build project, to develop at a later date, and so on. Previously, in Ethiopia history different modes of acquiring land use was implemented some of them are Auction, Negotiation, Assignment, Lot and Award are well known. But most of this methods of land acquisition are open door for corruption and "rent seeking" behaviors. Because of this the current proclamation no 721/2011 stated that the means to acquire the land use is by lease system with two modalities: tender and allotment.

- Tender means a modality of transferring lease of urban land to a bid winner fulfilling the competition requirements issued based on the rule of market competition of urban land tenure;
- Allotment means a modality applied for providing urban lands by lease to institutions that could not be accommodated by way of tender;

8.5.2 Procedures for Land Acquisition

i) Procedures tender based land acquisition

- The appropriate body shall advertise lease tender and forthwith put bid documents on sale.
- The sale of bid documents shall be in a manner accessible to anyone willing to bid; provided, however, that no single bidder may be allowed to buy more than one bid document for the same plot.
- The amount of bid bond shall be determined by regulations of regions and city administrations; provided, however, that it may not be less than five percent of the land lease benchmark price.
- A bid shall be cancelled if less than three bidders participate in the first round of tender.
- The highest bidder shall be declared a winner on the basis of his bid price and the amount of advance payment he offers.

- The list of winners with the details of their scores shall be made public on a notice board.

ii) Procedures land acquisition in allotment

Urban land lease holding through allotment shall be accompanied by:

- Support letter from the supervising authority of the requesting institution or from pertinent sectoral bodies;
- Detailed study of the project to be implemented at the requested site; and
- Evidence showing the budget allocated for implementing the project.

8.5.3 Land Sales/Transfer Modalities

It is clearly indicated in the constitution of the Federal democratic republic of Ethiopia that land is public property, the government of Ethiopia designed land sales modalities to transfer land user rights from state to private developers and users. In article, 40 of the FDRE constitution it is provided that the right to ownership of rural, urban land as well as ownership of all natural resources is exclusively vested in the state and the peoples of Ethiopia. Land is a common property of the nation nationalities and peoples of Ethiopia and hence not subject to sale, exchange or mortgage. This signifies the state and the people have equal right in relation to the right to ownership of land. The land holders have other rights than sale or purchase right mainly Usufruct right. Usufruct is the right which is a real right to *enjoy* a thing belonging to another the same goes for holding right too. Usus (use right) refers to the right to avail ones of physically a thing for one pleasure or personal profit in accordance with the nature of the thing (Planiol). Sale is one of the most important transactions in the area of real property. Currently, land is not subject to sale; but buildings are. Sale of land is legally prohibited in Ethiopia. But this does not mean that all immovable or real properties are not subject to this type of transaction. Buildings are capable of being sold. Sale is the major means of transaction with building. This type transaction does not apply to land. Other means of transactions applicable both to land and buildings. These are: donation, land inheritance, court order, prescription/adverse possession and barter/exchange.

A. Donation

As per Art. 2427 of CCE, donation is a contract whereby a person, the donor, gives some of his property or assumes an obligation with the intention of gratifying another person, the donee. Donation is a voluntary transfer of title to property without payment or consideration by the donee. Donation is very important in connection with ownership because to some

extent it represents absolute power of an owner over his/her property. However, having ownership right over property is not a necessary requirement to transfer his/her interest through donation.

B. Land Inheritance

Inheritance is the passage of title and ownership of property from the one who dies to people whom the law designates because of blood or marriage relation as the deceased heir by operation of the law or by will of the deceased. In other words, it is the devolution of the property of the deceased to persons on the basis of close blood relation to the deceased. Save the case of buildings, in our case it is the passage of land use right from the deceased land holder to his/ her heirs.

C. Barter/Exchange

According to the civil code of Ethiopia Art.2408 of, No. (1) Each of the exchangers shall, as regards the things subject to the exchange, have the same rights and obligations as a seller. (2) The exchanger who is bound by the barter contract to pay a balance shall, as regards the payment of such balance, have the same obligations as a buyer. (3) Unless otherwise agreed, the exchangers shall share equally in the expenses of the barter contract.

D. Court order

A decree is for the delivery of any immovable property, possession thereof shall be delivered to the decree-holder, or to such person as he may appoint to receive delivery on his behalf, and, if necessary, by removing any person bound by the decree who refuses to vacate the property.

E. Adverse possession

The possessor who has paid for fifteen consecutive years the taxes relating to the ownership of an immovable shall become the owner of such immovable Provided that no land which is jointly owned by members of on family in accordance with custom may he acquired by usucapion and any member of such family may at any time claim such land.

8.6 Summary

Dear trainee! There are two major components of cadastral system: land registration and cadaster. The registration is generally maintained by legal or clerical personnel. The cadaster, on the other hand, is usually maintained by cadastral surveyors and draftsmen. In land registration systems, there are four basic legal principles: Booking principle implies that

a change in interests on real property is not legally effectuated until the change right is booked or registered in the land register. Consent principle implies that the real entitled person who is booked as such in the register must give his consensus for a change of the inscription in the land register. Principle of publicity implies that the legal registers are open for public inspection, and also that the published facts can be supported as being more or less correct by third parties in good faith, so that they can be protected by law. Principle of specialty concerned with the rightful subject (man) and object (real property) must be absolutely recognized. Land acquisition is the process of possessing a piece of land through lease system. The acquiring modalities are different from time to time and have its on advantage and disadvantages. But at this time according to proclamation 721/2011 tender and allotment are the two modalities to acquire land. Both modalities have a prerequisite and procedures to request land acquisition.

8.7 Self-Check Exercise



Short Answer Items

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

1) How do you define and explain property law?
2) What does land registration mean? And list the types of registrations.
3) When title to land is brought onto the register for the first time, a special procedure may need to operate. What is this procedure?
4) Briefly explain urban land registration laws and regulations.
5) State the differences between land registration and adjudication.

CHAPTER NINE: APPLYING STREET ADDRESSING

9.1 Introduction

Dear trainee! This chapter introduces you about the basic concepts of street signs, address and house numbering system. The addressing system involves naming streets and then numbering the properties along them. Street addressing is an exercise that makes it possible to identify the location of a plot or dwelling on the ground. That is, to assign an address‖ using a system of maps and signs that gives numbers or names of streets and buildings/parcels of land. Street Addressing as a system goes beyond the mere naming of streets and numbering of properties. It includes developing digitized maps for use in the management of settlements and urban communities. The maps with the information thereon can be developed into geographical information system (GIS) as a database. Thus, development of a street addressing system should not be viewed as a one-off activity, but as a process to be expanded and refined over time to address a range of needs. It therefore has a number of arms and processes which are elaborated in subsequent sections of this document.

9.2 Learning Objectives

After completing this chapter, you will able to:

- Read and interpret street addressing system
- Explain how and where street addressing should be posted
- Describe laws and guidelines applicable for street addressing

Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts of street addressing.

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9.3 Street Addressing

9.3.1 Basic Concept of Street Addressing

Street addresses are the location identifiers most widely used by state and local government and the public. Street addresses are critical information for administrative, emergency response, research, marketing, mapping, GIS, routing and navigation, and many other purposes. Because they have evolved over many decades, under the control of thousands of local jurisdictions, in many different record and database formats, and to serve many purposes, different address formats and types pose a number of complex geo-processing and modeling issues.

The standards set out the requirements to be complied with in implementing the two key dimensions of the addressing system; namely, the naming of streets and the numbering of properties. For the purpose of this document, Street has been used as a working definition for all access way types, excluding railways. The rationale behind the standards is to enhance the knowledge, communication and consistency of addressing information regarding interpretation of the implementation requirements of the Addressing System.

A street map is a map of a city or town, showing the positions and names of all the streets. Reading and interpreting street sign post and plaques depends on one's ability of interpreting and understanding maps. An accurate and easily visible address is vital for rapidly locating a home or business in any emergency requiring fire, life, and/or safety services. It also promotes efficient mail and parcel delivery to businesses and residences. During construction, an address that is posted where it can easily be seen also speeds up the inspection process. Having an address clearly posted and visible from the street will help emergency personnel locate a residence quickly.

9.3.2 Guidelines for Assigning Street Names

- Street names should not be duplicated in a Metropolitan, Municipal and District Assemblies or in any geographical region defined for the purpose of this exercise even if the street types are different.
- Street names along continuous collector and arterial streets with elbows shall not change.
- Names with similar pronunciations but different spelling shall be avoided
- Street names applied should effectively communicate to the public especially children. The names should be appropriate, easy to pronounce and not offensive.

- The street names should promote community image. The sources should cover such themes as local history, culture and traditions (including names of distinguished chiefs, queens and elders); fauna and flora; and landmarks.
- The range of streets in a community or city should be categorized into first, second and third order levels in terms of use and used as a guide for the naming exercise. With such categorization, the most important streets get to be given the most important names and followed through with the second order of names for the next level of important streets in that order.
- Names with the same theme, such as flowers should be applied in naming streets in an entire sector or area, as a means of providing general identification distinctions and easy public appreciation of the naming system.

9.3.3 Posting/Locating Street Address

Address numbers must be posted in a conspicuous place over or near the principal entrance or entrances. If the entrance(s) cannot be seen easily from the nearest adjoining street, the address numbers must be placed in another conspicuous place on the building or structure so that the address numbers can easily be seen from the nearest adjoining street. If the building or structure cannot be easily seen or is greater than 50 feet from the nearest adjoining street, the address numbers must be placed on a portion of the site that is clearly visible and no more than 20 feet from the street. The address numbers must be legible figures, not less than three inches high for residential uses, and not less than five inches high for commercial uses. Numbers must contrast with the color of the structure upon which they are placed and either is illuminated during periods of darkness, or reflective, so they are easily visible at night.

9.3.4 House Numbering

House numbering is the system of giving a unique number to each building in a street or area, with the intention of making it easier to locate a particular building. The house number is often part of a postal address. The term describes the number of any building (residential or commercial) with a mailbox, or even a vacant lot.

House numbering schemes vary by location, and in many cases even within cities. In some areas of the world, including many remote areas, houses are named but are not assigned numbers.

Problems of street naming and house numbering may confront planning commissions in relation to new subdivisions or new planned neighborhood developments or these problems may arise simply as a result from the difficulties that have come out of the accumulated inefficiencies of an outmoded system.

9.4 Prepare Resources, Materials and Equipment

Addressing involves assigning a number to each street in the urban center, until a future time when street names will be assigned. The number will be displayed at the street corner, mounted either on a panel on the wall of a building, or on a signpost. Each house will also be assigned a number.

Purpose of addressing

Addressing will make it easier for you to find your way around the city. It will also make it easier for the city to provide services such as ambulances, fire trucks, and utility services (like electricity, water and telecommunication). Mail, messengers and emergency assistance will be able to reach you faster and more directly. So for this purpose different civil works like excavation, concrete work and metal works need also different equipment's and tools can be used. From this some of they are:

Address Plates/Plaques

Plates on which round about names, avenue, street, sub-street, minor street and path numbers or some part of the above stated based on the given information shall be written on both sides. The surface of the plates shall be water and weather-proof enamel finishing. The list of names and numbers shall be provided by the client and shall be written in an appropriate reflecting lamination, in Blue background and White writing. Letter size shall be proportional to the size of the plate as per the drawing. In other words, the size of the letters shall be as big as possible to allow better visibility. There is an arrow between Amharic and English texts. The size of the arrow shall be as per the given drawing. According to Amended Street addressing standard the size of plaques is 700mm X 320mm X 2mm aluminum address.

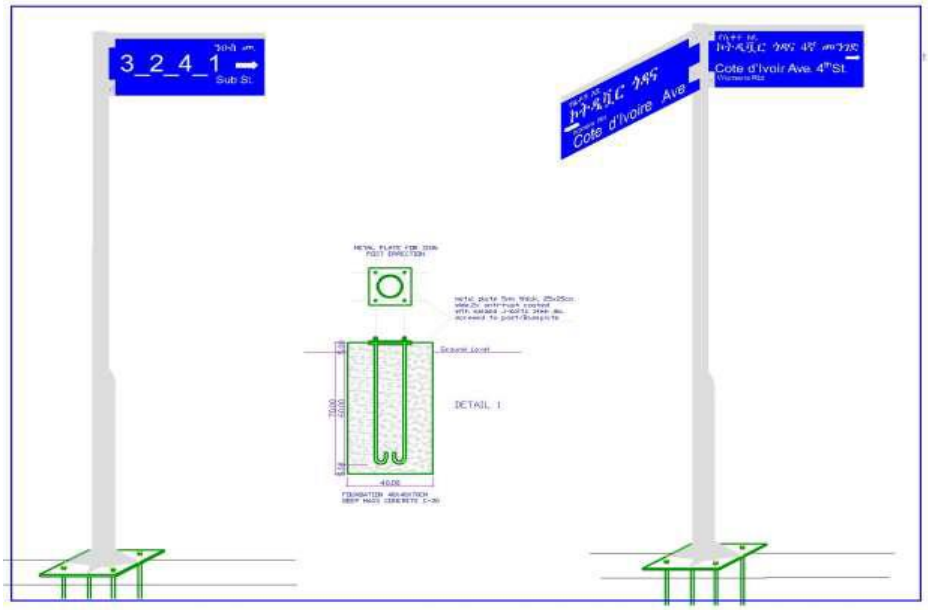


Figure 33: Street addressing plate

House number plates

A 3mm thick Mica sheet plate with Signage size of 200mm x 150mm includes signage printing and painting, rust free, water and weather-proof finishing on both sides, the interior writing to be done in an appropriate stove enameling according to the House number list provided by the client, plate material shall be reflector in Blue background and White writing. Letter size shall be proportional to the size of the plate as per drawing. In other words, the size of the letters shall be as big as possible to allow better visibility. The house number shall comprise of the top half of the plate.



Figure 34: House No. plate

Addressing System Database

An address database, a database that contains spatial and nonspatial addressing datasets which could describe and define the location of a particular parcel or house.

9.6 Summary

Daer trainee! Addressing makes it easier to locate residents and their homes by means of an address system that can be used by the people themselves and by government officials, concessionaires, and other service providers. Street address is a fundamental component of any service delivery system, it must be assigned through a logical and consistent procedure. The importance of proper addressing cannot be overstated; during an emergency it can mean, quite literally, the difference between life and death. Additionally, addressing helps define educational and political districts, and affects the quality of services available to citizens. A logical and consistent addressing system, therefore, can tangibly improve the quality of life in a community.

Today there are various tools to help implement a new addressing system or revamp an existing one. Although Geographic Information System (GIS) tools will not make the political process any easier, they certainly make technical implementation much simpler, faster, and more consistent. This document was written with GIS implementation in mind; most, if not all, of the applications described in this document will be applicable to the non-digital world, but the standards herein were developed primarily for electronic implementation.

9.7 Self-Check Exercise

**Short Answer Items**

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

1) Explain what is street addressing and housing number?
2) What is the advantage of street addressing and house numbering?
3) Where should be posted street address numbers?
4) How do you find new locations having street addresses?
5) What are the standards for street addressing?

CHAPTER TEN: MAINTAIN EFFECTIVE RELATIONSHIP WITH CLIENT/CUSTOMERS

10.1 Introduction

Dear trainee! This chapter introduces you about maintaining effective relationships with your clients or customers. When you communicate effectively with your clients/customers, it eliminates confusion and can foster a healthy and happy workplace. Effective communication with your clients/customers will also allow you to get work done more quickly and efficiently. Once you get the lines of communication open with your team, the process of completing tasks and projects will probably go by much more smoothly. At the end of this chapter, the following outcomes are expected to be achieved.

Clients are arguably one of the most important factors of starting and sustaining a successful organizational business. Without clients especially, those who return to request services of the organization would be non-existent. Most successful Organizations understand and prioritize their customer satisfaction and form strong relationships. Not only is developing relationships with your clients a smart move from a marketing standpoint, but it also helps you to anticipate client needs and perform ongoing adjustments so you can improve your business over time. To identify the needs of the organization customers, solicit feedback from the customers at every step of process. Organizations can identify customer needs in a number of ways, for example, by conducting focus groups, listening to customers or social media etc.

10.2 Learning Objectives

After completing this chapter, you will be able to:

- Maintain and Sustain a clean and hygienic environment
- Identify client/customer satisfaction requirements
- Describe organization employer standard



Dear trainee! Before reading the following section, take ten minutes and try to discuss the concepts of effective relationship with client.

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10.3 Maintain Clean and Hygienic Environment

10.3.1 Maintaining Uniform Personal Grooming

Personal grooming refers to an art which helps individuals to clean and maintain their body parts. Human beings need to wash, clean their body parts to look good and for personal hygiene as well. It is the process of making yourself looks neat and attractive. It is the things which you do to make yourself and your appearance tidy and pleasant. Grooming is important for a positive self-image and to encourage and assist the resident to maintain a pleasing and attractive appearance. Personal grooming is a mechanism whereby someone coaches his/her self so as to enhance working in teams. And you, as an individual, need to maintain this character. The characteristics of personal grooming can be expressed in the following behaviors:

- Appreciate how an organization operates in different client sectors.
- Tailor your approach to align with the client goals and circumstances.
- Respect the client need for information, commitment and confidentiality.
- Listen and respond effectively, and check understanding.
- Adapt your personal style to empathize with a whole range of clients.
- Build and maintain rapport over sustained periods.
- Invite a two-way exchange of information and feedback with clients and others.

10.3.2 Understanding Employer Standards

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. Employer standards are part of the institutional legislations governing that specific organization and are requirements to be followed.

10.3.3 Maintaining Personal Presence, Organizing and Keeping Visible Work Area

Personal presence is actually a state of being and when mastered, it can allow you to tap into your higher choices, reduce fears and greatly influence the people around you. Personal presence in this context refers to the physical appearance/character of a person in which his/her operates in his/her work environment. This physical expression may be reflected in the form of; personal stance, posture, body language, grooming, etc.

The work environment should be maintained so that it remains in a clean and safe condition. Broken or damaged furniture, fixtures and fittings, including chairs, plumbing, air-conditioning and lighting should be repaired promptly. Facilities should be clean, safe, accessible and in good working order. Workplaces and facilities should be cleaned regularly, usually on a daily or weekly basis. The cleaning schedule of facilities such as dining areas, toilets, hand basins and showers should consider shift work, the type of work performed, the likelihood of contamination and the number of workers using them. Working equipment/tools, which we are working on, should be kept in a safe and good environment. There are various equipment/tools which need special care while handling and keeping them in store. Unless otherwise we care them properly in the required manner, they can be exposed to damage and lose their vitality.

10.4 Identify and Meet Client/Customer Requirements

The ultimate goal of our products and services is delivering quality services to our clients/customers which satisfy them. To achieve sustained success, an organization needs strong leadership and clear strategic direction. They need to develop and improve their people, partnerships and processes to deliver value-adding products and services to their customers.

Excellent organizations consistently add value for customers by understanding, anticipating and fulfilling needs, expectations and opportunities. To ensure sustainable quality services, we need to keep our customers satisfied. To do this, we need to develop and deliver products and services that add value to them. We also need to deliver excellent service to maximize retention, loyalty and our reputation. Clients/customers' requirements are optimizing satisfaction through quality services and products. This can be ensured through setting satisfaction measure indicators and evaluating in that respect. Additionally, getting direct feedbacks from the users (customers/clients) and evaluate and revisit delivering services.

Therefore, appropriate action would be taken which results in building credibility by customers/clients.

10.5 Summary

Dear trainee! Organization needs clear standard, which considered as a guiding document that needs to be fulfilled by the employee and customers of each organization. In most Organizations employer standards are part of the institutional legislations governing that specific organization. One of standard has to consider that, the work environment should be maintained so that it remains in a clean and safe condition. Broken or damaged furniture, fixtures and fittings, including chairs, plumbing, air-conditioning and lighting should be repaired promptly. Facilities should be clean, safe, accessible and in good working order.

Successful organization that handling cases and score low compliments consistently add value for customers by understanding, anticipating and fulfilling needs, expectations and opportunities. Such organizational success can be achieved through teamwork.

Good client relationships make you feel like a true partner to your client. They trust and listen to you, and you feel good about the work you do for them. As a result, your relationship builds and expands into bigger and better things, either through longevity, additional projects or business, or the biggest compliment referrals to other clients. The success of any human endeavor depends on the quality of the relationships between those involved. A good working relationship, just like a good friendship, builds rapport and understanding between the parties. To achieve such a relationship takes more than clear and regular communication, although this certainly contributes. It requires investing time and effort into understanding the client and his or her business and situation.

10.6 Self-Check Exercise

**Short Answer Items**

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

1) What does an effective client relationship mean?
2) What are the requirements to maintain clean and hygiene environment?
3) How does teamwork can be enhanced? What is the advantage?

CHAPTER ELEVEN: PARTICIPATING IN ENVIRONMENTALLY SUSTAINABLE WORK PRACTICES

11.1 Introduction

Dear trainee! This chapter introduces you the concepts required to participate in environmentally sustainable work practices. It includes identifying current resource use, complying with environmental regulations and seeking opportunities to improve resource efficiency. An environment is a set of physical circumstances and/or conditions, including both natural and man-made phenomena. Environment is the things that surround a person or organization including physical features, economic and market conditions, attitudes and climate. Implementing the 3S principles creates a work environment in which space, time, money, energy, and other resources can be managed and used most effectively, and leads to a much safer workplace. By clearing out the items you no longer need (sorting), people will have more room to work and things like trip hazards and items falling off shelves will be greatly reduced.

The world is faced with challenges in all three dimensions of sustainable development economic, social and environmental. Over the past years, the global challenges to sustainable development have been driven by a broad set of “megatrends”, such as changing demographic profiles, changing economic and social dynamics, advancements in technology and trends towards environmental deterioration. The overall goal of sustainable development (SD) is the long-term stability of the economy and environment; this is only achievable through the integration and acknowledgement of economic, environmental, and social concerns throughout the decision-making process.

11.2 Learning Objectives

After completing this chapter, you will be able to:

- Explain environmental sustainability
- Identify the current resource use
- Practice environmental regulations in the organization
- Improve on how to use resources efficiently


Dear trainee! Before reading the following section, take ten minutes and try to define environmental sustainability, sustainable development (SD) in work practices.

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11.3 Principles of Sustainable Development

11.3.1 Environmental Sustainability

Linking environmental sustainability initiatives with employee engagement makes good business sense. Employee engagement or the practice of creating supportive, stimulating, collaborative and rewarding work environments is nothing new. Good workplaces have always motivated and involved their workers to gain operational efficiency, better relations and strengthen communities.

Putting sustainability into practice requires an engaged workforce doing the work, and synchronizing employee engagement with sustainability strategy is key to building an innovative, environmentally responsible, and socially conscious organization.

The increasing pressure people put on natural resources and the environmental systems does not seem long lasting. Everything seems to cease soon and people's life seems endangered. The wasteful and unwise utilization of natural resources together with ever-growing population, threaten and scared the ability of the earth to feed and provide sustainability. In order to ensure sustainable development, there are many issues to be considered. Among these are:

- engaging people in sustainable issues
- developing their capacities to contribute to development
- utilize the diversity represented by all people.

Natural resources are the foundation of the economy. Environmental sustainability is the first pillar of sustainable development. It requires a change from "business as usual approach" to Sustainable Development approach of using natural resources wisely, minimizing waste and limit damage to atmosphere and check harmful climate change. This involves the responsible

use of raw materials; energy, water etc. and awareness of the impacts of production processes and environmental auditing system. Economic Sustainability is the second pillar of sustainable development. It requires a different and wider, set of economically related knowledge, skill and attitude regarding economic literacy, sustainable production and consumption and management of small enterprise. Social Sustainability is the third pillar of sustainable development. On both the global and local scale, social sustainability involves ensuring that the basic needs of all people are satisfied and all, regardless of gender, ethnicity or geography, have an opportunity to develop and utilize their talents in ways that enable them to live happy, healthy and fulfilling lives.

11.3.2 Sustainable Development Dimensions

The concept of sustainable development combines three principal dimensions:

A. Economic dimension:

An economically sustainable system must be able to produce goods and services on a continuing basis. It focuses on the development of the economic infrastructure, in which the efficient management of our natural and human resources is important.

B. Environmental dimension:

An environmentally sustainable system must maintain a stable resource base, avoiding over-exploitation of renewable resource systems, and depleting non-renewable maintenance of biodiversity, atmospheric stability, and other ecosystem functions not ordinarily classed as economic resources.

C. Social dimension:

A socially sustainable system must achieve distributional equity, adequate provision of social services including health and education, gender equity, and political accountability and participation.

11.3.3 Environmental Regulations

Environmental compliance means conforming to environmental laws, regulations, standards and other requirements such as site permits to operate. In recent years, environmental concerns have led to a significant increase in the number and scope of compliance imperatives across all global regulatory environments. Being closely related, environmental concerns and compliance activities are increasingly being aligned with corporate performance goals and being integrated to some extent to avoid conflicts, wasteful overlaps, and gaps.

Compliance with the above requirements and obligations requires meeting certain conditions. Typically, these include:

- Managing monitoring programs or schedules, ensuring that the monitoring required in the permit has been done, at the correct locations, for the correct parameters, and at the correct frequency
- Pre-processing, performing calculations and validating the data for compliance with any alert or reporting levels
- Generating routine compliance reports for authorities.

The management of the above can be complex and time-consuming, leading to an increasing uptake of software systems designed to manage environmental compliance. These are often referred to as 'Environmental Data Management Systems' (EDMS). Criteria must be considered when selecting environmental compliance software: proven capability, high performance, transparent, traceable data handling, a robust calculation engine, advanced factor handling, simple integration, automated workflows and QA, and flexible reporting and data extraction.

Environmental Compliance

Compliance can be defined "conformity in fulfilling official requirements". That's pretty much it. If you put the word environmental in there, you'll have a great definition of what environmental compliance is. It's conformity in fulfilling official environmental requirements. It's a great question, simply because if you aren't sure what it means, then chances are you're probably not in compliance. The biggest risk of not complying is violations, penalties, monetary fines, and other bad things you don't want happening to your company. Not complying is not good.

And simply put, conformity means getting it right and meeting the requirements. It means doing everything that is required, and not picking and choosing what to do with your regulatory requirements. It means doing everything you have to do, completely, and correctly. In order to put compliance, there should be policies and principles of environmental sustainability.

11.4 Environmental Sustainability Policies and Principles

The Overall Policy Goal

The overall policy goal of environmental sustainability is to improve and enhance the health and quality of life of citizens and to promote sustainable social and economic development through the sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

The Key Guiding Principles

- Every person has the right to live in a healthy environment;
- Sustainable environmental conditions and economic production systems are impossible in the absence of peace and personal security. This shall be assured through the acquisition of power by communities to make their own decisions on matters that affect their life and environment;
- The development, use and management of renewable resources shall be based on sustainability;
- The use of non-renewable resources shall be minimized and where

11.5 Seeking Opportunities to Improve Resource Use Efficiency

Improvements on resource use efficiency can be made to:

- Measure and track your usage rates for energy, water and ingredients.
- Ensure that your suppliers measure, and are accountable for, the quality of their product or service, including environmental impacts.
- Define the optimum start up conditions for each process, and train staff to minimize startup losses.
- Measure what you sell or package and ensure you do not give your product away.
- Assess your environmental performance regularly.
- Keep maintenance/material safety data sheet manuals in an easily accessible place (and keep them up-to date).
- Keep current records up to date and manage your historical records effectively.
- Devise reports in terms of products that you sell. For example: liters of water per ton of product, or kilograms of waste per ton of product.
- Track usage rates of raw materials, for example: product yields, number of spills and waste output rates.
- Develop a system to record your measurements, and determine full cost attribution for each waste product (that is, know how much each waste really costs).

- Be consistent when taking and recording measurements.
- Establish regular reports for major resource consumables including water and energy. Report all consumption by a per unit production basis, not by time (for example, liters of water/unit of production not liters of water/minute)

The hints and tips have been grouped for ease of reference and the broad categories are listed below. They are intended to help you focus on specific areas in your business and guide your subsequent actions.

- Waste assessment
- Improve purchasing
- Improve storage
- Conserve energy
- Conserve water
- Preserve waterways
- Reduce waste
- Reduce risk
- Improve information
- Improve systems
- Reduce odor and air emissions

11.6 Summary

Dear trainee! The key to creating a vibrant and sustainable environment in organizations is to find ways to get all employees from top executives to assembly line workers, which can be emphasized though employee engagement in day-to-day business. Employee engagement is the practice of creating supportive, stimulating, collaborative and rewarding work environments. Good workplaces have always motivated and involved their workers to gain operational efficiency, better relations and strengthen community ties. Putting sustainability into practice requires an engaged workforce doing the work, and synchronizing employee engagement with sustainability strategy is key to building an innovative, environmentally responsible, and socially conscious organization.

Sustainable Development (SD) is an elusive term, which many people misunderstand to only refer to environmental protection or economic development. Sustainable Development is more than that. It is about maintaining and improving the quality of life without compromising the ability of future generations to meet their own needs. It is not limited to a concern for the natural environment or focused exclusively on economic development. Rather, SD is a concept based on integrating socio-cultural, environmental and economic considerations. Moving towards the goal of sustainable development requires fundamental changes in human attitudes and behavior-in our personal lives, in our community activities and in our places of work. Successfully making these changes is critically dependent on education and training.

Sustainable development is about maintaining and improving the quality of life without compromising the ability of future generations to meet their own needs. It is a concept based on integrating socio-cultural, environmental and economic considerations.

11.7 Self-Check Exercise

**Short Answer Items**

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

1) Identify current resource use?
2) Explain how to comply with environmental regulations?
3) Explain how to seek opportunities to improve resource efficiency?

CHAPTER TWELVE: APPLYING 5S PROCEDURES

12.1 Introduction

Dear trainee! This chapter introduces you about the concept of continuous improvements through Kaizen elements. The requirements for a job vary according to the nature of the job itself. However, a certain work ethic must be refined to succeed in any job and this is fundamental to an individual's sense of himself as a worker, as part of production relations and a fundamental economic being.

5S is an abbreviation of Sort, Set in Order, Shine, Standardize, and Sustain. Sort is a simple method for identifying potentially unneeded items in the factory or workshop, evaluating their usefulness and dealing with them appropriately. Set in order is the method used to examine method of storage that is effective and efficient. Shine refers to the method used to properly and thoroughly clean the workplace every day. In order to apply the 3S, there are required tools and equipment to implement sort, set in order and shine activities in to your work station. In line with these instruments, OHS is required; Occupational Health and Safety (OHS) are legislation/regulations/codes of practice and enterprise safety policies and procedures. This may include protective clothing and equipment, use of tooling and equipment, workplace environment and safety, handling of material, use of firefighting equipment, enterprise first aid, hazard control and hazardous materials and substances.

5S is defined as a methodology that results in a workplace that is clean, uncluttered, safe, and well organized to help reduce waste and optimize productivity. It's designed to help build a quality work environment, both physically and mentally. The 5S helps to eliminate waste, streamline production, and optimize efficiencies. When you adopt these principles, you make a commitment to put safety, organization, and effectiveness ahead of production deadlines, profit and output. The end product is always, an increase in overall success, though growing pains will occur as the processes are implemented.

12.2 Learning Objectives

At the end of the module the trainee will be able to:

- Prepare for work
- Sort items
- Set all items in order.

- Perform shine activities.
- Standardize 5S.
- Sustain 5S



Dear trainee! Before reading the following section, take ten minutes and try to describe the concepts such as understanding of quality system, Sort needed items from unneeded, set workplace in order, Shine work area, Standardize activities and Sustain 5s system

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12.3 Preparing for a Work

Being prepared in the workplace means that not only will employees be better able to recognize an incident, but they will also be able to report it to the relevant department. This may not seem that important, but internal communication is actually extremely necessary should a threat arise.

12.3.1 Job Instruction and Requirements

Job Instruction Training (JIT) is a step-by-step, relatively simple technique used to train employees on the job. It is especially suitable for teaching manual skills or procedures; the trainer is usually an employee's supervisor but can be a co-worker. The four steps of job instruction training are prepare, present, try out, and follow up. Preparation by the supervisor or instructor is for motivation of the employee or trainee.

The requirements for a job vary according to the nature of the job itself. However, a certain work ethic must be cultured to succeed in any job and this is fundamental to an individual’s sense of himself as a worker, as part of production process and a fundamental economic being. The basic requirements for a job remain the same no matter what the job is, where it is located or what professional and educational qualifications are required for it. These are as follows:

Discipline: Nothing is possible without discipline. Any job requires a fundamental core of discipline from the worker or the employee and this is a quality which is independent of age, post, stature, job and so on. Discipline is absolutely indispensable and provides the impetus for work that can be strenuous, repetitive, boring and even unsatisfactory at times.

Enthusiasm: Enthusiasm for work is also a pre-requisite for any job. An innate love for the job, which in modern parlance is known as job satisfaction, is a core requirement for any job. The drive to succeed, to innovate, to do well and to make one's profession into one's livelihood is a critical drive which needs to be present in the employee or cultivated as soon as possible. No job, however perfectly carried out, can evoke the feeling of satisfaction of a job well done without the instinct for success.

Qualifications: This is a more material, tactile need for a job which can be conveyed through degrees and certificates. However, education is not limited to what is taught in colleges or vocational training courses. It is the burning desire to learn more, to reach the depths of knowledge about a particular field of interest, to complete the job and learn from it that marks the true enthusiast and the truly learned.

Soft Skills: Soft skills include those skills which ensure that a job is executed well, and the employee can carry himself in the proper manner too. For example, good and smooth communication, computer skills, proficiency in language if needed, presentable appearance, the ability to manage crises are all soft skills which are fundamentally important in any job and which must be cultivated consciously.

12.3.2 Occupational Health and Safety (OHS) Requirements

Occupational Health and Safety (OHS) requirements are legislation/regulations/codes of practice and enterprise safety policies and procedures. This may include protective clothing and equipment, use of tooling and equipment, workplace environment and safety, handling of material, use of firefighting equipment, enterprise first aid, hazard control and hazardous materials and substances.

Personal protective equipment includes those prescribed under legislation/ regulations/codes of practice and workplace policies and practices. Safe operating procedures include the conduct of operational risk assessment and treatments associated with workplace organization. Emergency procedures include emergency shutdown and stopping of equipment, extinguishing fires, enterprise first aid requirements and site evacuation.

12.3.3 Tools and Equipment Used to Implement 5S

You are required to prepare and use tools and equipment to implement sort, set in order and shine activities in to your work station. The following are some tools and equipment that help you in the implementation of 5S.

A. Tools and Materials Used to Implement Sort Activity

Tools and materials are required to implement sort, set in order and shine activities in work stations. The following are some tools and materials used to implement the first pillar of 3S-Sort.

- Red tags
- Sticker
- Hook
- Nails
- Shelves
- Chip wood
- Sponge
- Broom
- Pencil
- Shadow board/ tools board
- Formats (for recording necessary and unnecessary items, plans etc.)

B. Tools and Materials Used to Implement Set in Order

The goal of this step is to examine methods of storage that are effective and efficient, sometimes referred to as "visual management," and then create a work environment that is organized, ergonomic, uncluttered and easily navigable. Some questions to ask during this step might be: Which specific items are needed to perform a task? How many items need to be readily accessible and where should they be located?

The methodical storage of materials means that every item has a predetermined location where it will remain until it used, and then it will be returned immediately following its use. Labels and colour coding are also helpful techniques to use in this step. With an organized and efficient use of storage, everyone is easily able to locate important items and enjoy a less stressful work environment. Depending on your facility's needs, you may find one approach easier than another:

- Draw up a map, and then implement it
- Physically arrange the workplace first, and then map it out
- Map as you go, testing ideas and writing down what works well

C. Tools and Materials Used to Implement Shine

The following are some tools and materials used to implement the third pillar of 3S-Shine.

- Sponges
- Brooms
- Brushes
- Spades
- Vacuum cleaners
- Waste baskets
- Dust bins
- Gloves
- Dust masks
- Detergents
- Containers
- Oils
- Bolts
- Screws
- Boots shoes, etc.

5S Implementation

Remove all items from the workplace that are not needed for current production or administrative operation. Keep "only what is needed, only in the amount needed, and only when it is needed".

12.4 Sorting all Items in Order

Overview of Red Tagging

The Red-Tag Strategy is a simple method for identifying potentially unneeded items in the factory or workshop, evaluating their usefulness and dealing with them appropriately. Red-tagging means putting red tags on items in the factory or workshop that need to be evaluated as being necessary or unnecessary. A Red tag is a red colored tag used to identify items no longer needed in a particular work area. The red tags catch people's attention because red is a color that stands out. An item with a red tag is asking three questions:

- Is this item needed?
- If it is needed, is it needed in this quantity?
- If it is needed, does it need to be located here?

Once these items are identified, they can be held in a "Red Tag Holding Area" for a period of time to see whether they are needed, disposed of, relocated, or left exactly where they are.

Steps in Red tagging

The red-tagging process in a department or work area can be broken down into seven steps.

- Step 1: Launch the red-tag project.

- Step 2: Identify the red-tag targets.
- Step 3: Set red-tag criteria.
- Step 4: Make red tags.
- Step 5: Attach red tags.
- Step 6: Evaluate red-tagged items.
- Step 7: Document the results of red-tagging.

12.4.1 Implementation of 5S

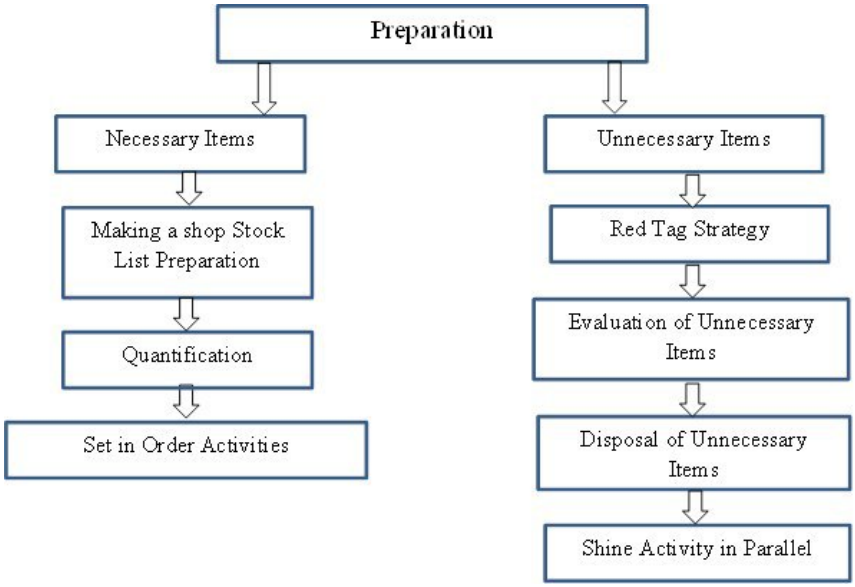


Figure 35: Implementation of 5S

12.5 Setting all items in Order

There are some principles for deciding best locations for tools and equipment's. Jigs, tools and dies differ from materials, equipment's, machinery and parts in that they must be put back after each use. Some of the principles for jigs, tools and dies also apply to parts, equipment's, and machinery. These are:

- Locate items in the workplace according to their frequency of use. Place frequently used items near the place of use. Store infrequently used items away from the place of use.
- Store items together if they are used together, and store them in sequence in which they are used.

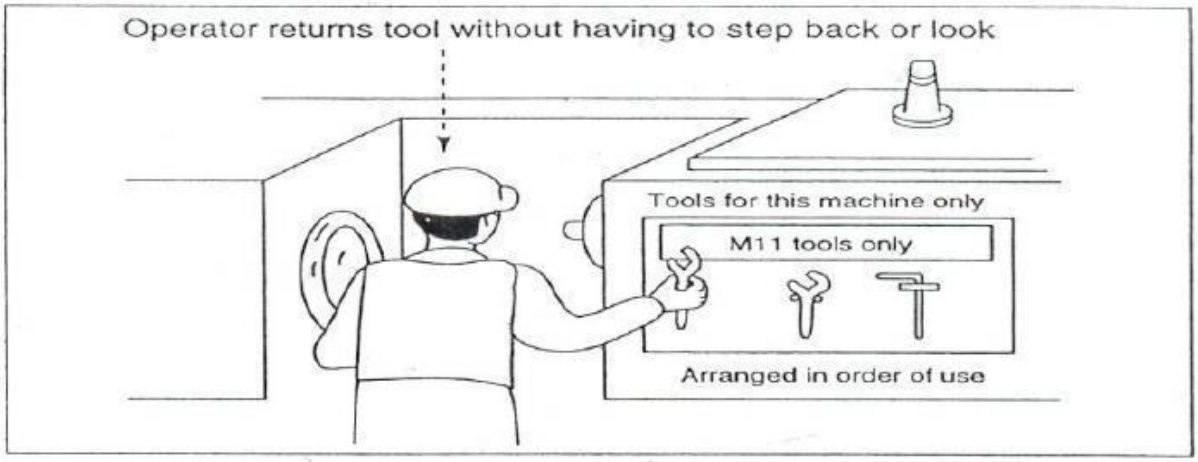


Figure 36: Tools kept at hand and stored in the order used

- Device a "just let go" arrangement for tools. This approach involves suspending tools from a retractable cord just within reach so that they will automatically go back in to their correct storage position when released.
- Make storage places larger than the items stored there so that they are physically easy to remove and put back.
- Eliminate the variety of jigs, tools and dies needed by creating a few jigs, tools and dies that serve multiple functions.
- Store tools according to function or product. Function-based storage means storing tools together when they have similar functions. This works best for job-shop production. Product-based storage means storing tools together when they are used on the same product. This works best for repetitive production.

Implementation Stage

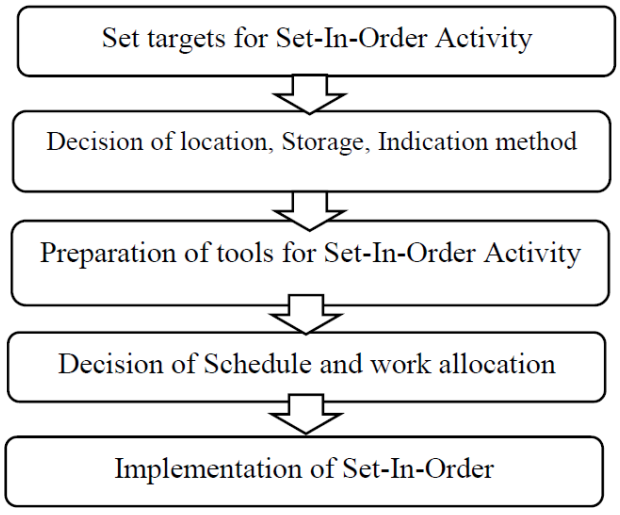


Figure 37: Implementation of Set-in order

12.6 Shine all items

Shine activities should be taught as a set of steps and rules that employees learn to maintain with discipline.

- Step 1: Determine shine target areas
- Step 2: Determine Shine Assignments
- Step 3: Determine shine methods
- Step 4: prepare tools
- Step 5: Start to shine

Implementation stage

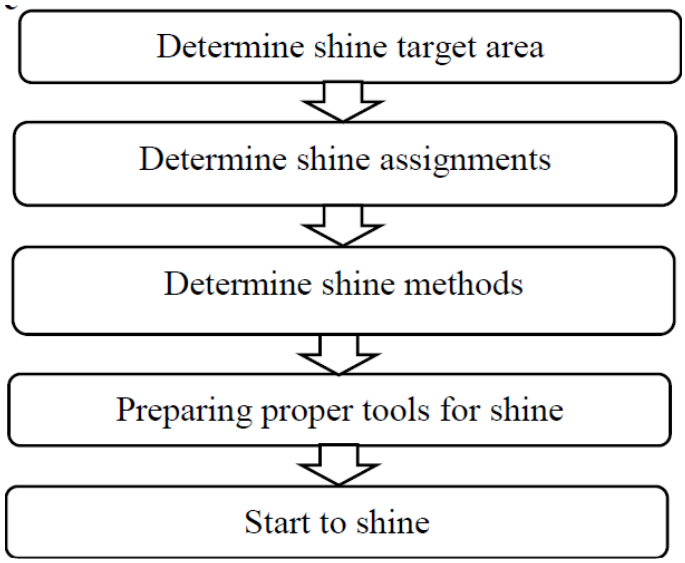


Figure 38: Implementation of Shine

12.7 Standardizing 5S

12.7.1 The 4th Pillar Explanation and How to Implement Standardize 5S

Standardize is the fourth pillar of our visual workplace, which differ from Sort, Set in Order, and Shine. This is because it is the method you use to maintain the first three pillars of 5S. Building on this definition, we may define Standardize the result that exists when the first three pillars-Sort, set in order and Shine-are properly maintained.

Benefits from Standardize

1. Lead to workplace standardization

    - Prevent setbacks in the first three pillars

- Make implementing them a daily habit
- Ensure that all the three pillars are maintained in their fully implemented state.

2. Lead to work standardization

- Muda elimination
- Quality improvements
- Cost improvements
- Delivery time improvements
- Process improvements

Tools and Techniques to Standardize 5S

- 5S Job Cycle Charts
- Visual 5S
- The Five Minute 5S
- Standardization level checklist
- 5S checklist
- The five Whys and one How approach (5W1H)
- Suspension
- Incorporation
- Use Elimination

12.8 Sustaining 5S

12.8.1 The Fifth Pillar Explanation and how to Implement Sustain

The fifth pillar is Sustain. In the context of the five pillars, to sustain means to make a habit of properly maintaining correct procedures. In your life in general, what do you mean when you talk about sustaining something? Usually, you think of it as drawing on something from inside yourself in order to maintain a course of action-even when forces in your life challenge in this effort. Means making a habit of properly maintaining correct procedures.

Tools and techniques to sustain 5S

There are many tools and techniques your company can use to help sustain commitment to 5S implementation. We offer these below so you will be aware of them. At some point in your 5S implementation work, you may be called upon to use or even coordinate the use of these techniques. These are:

- 5S slogans; 5S posters; 5S photo exhibits & storyboards; 5S newsletter

- 5S maps; 5S pocket manuals; 5S department/benchmarking tours
- 5S months; 5S audit; Awarding system; Big cleaning day; Patrolling system
- Top management Patrol; 5S Committee members and Promotion office Patrol
- Mutual patrol; Self-patrol; Checklist patrol; Camera patrol

12.9 Summary

Dear trainee! The basic requirements for a job remain the same no matter what the job is, where it is located or what professional and educational qualifications are required for it. OHS requirements are legislation/regulations/codes of practice and enterprise safety policies and procedures. This may include protective clothing and equipment, use of tooling and equipment, workplace environment and safety, handling of material, use of firefighting equipment, enterprise first aid, hazard control and hazardous materials and substances. The fourth pillar is Standardize, which is the result of properly maintaining the first three pillars Sort, Set in Order, and Shine. The basic purpose of Standardize is to prevent setbacks in the first three pillars to make them a daily habit, and to make sure they are maintained in their fully implemented state. The fifth pillar, sustain, means to make a habit of properly maintaining correct procedures over time. No matter how well implemented the first three pillars will not work for long without a commitment to standardize and sustain it.

12.10 Self-Check Exercises

**Short Answer Items**

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

1) Describe the 5S concepts.
2) What are the common tools and techniques to sustain 5S?
3) How 5S slogans are used to sustain 5S?
4) Why 5S photo exhibits and storyboards are used to implement sustain activities
5) What is the result of implementing 5S without standardization?
6) List at least five tools and techniques used to standardize the 5S.
7) What are the tools used to assign 5S responsibilities

Bibliography

Abbas, F. (2006). Image Interpretation for Soil Survey accessed on April 15, 2019 from http://www.charim.net/sites/default/files/handbook/datamanagement/3/3.6/Geopedology/Air_photo_interpret.pdf.

Aerial photography: accessed from https://en.wikipedia.org/wiki/Aerial_photography on April 01, 2019.

Ann Dobson, Communication at work, How To Books Ltd, 1995

Antohny G.King : Effective Communication, Blackstone press limited,1992

Bonn, George S. (1971). Literature of Science and Technology. McGraw Hill Encyclopedia of Science and Technology,7, 614.

Chandra, M. A. (2005). *Surveying: Problem Solving with Theory and Objective Type Questions*, book, Originally published in 2005.

Charles D. Ghilani and Paul R. Wolf (2012*). Elementary Surveying* (13th Edition) 14th Edition.

CDC (Centers for Disease Control and Prevention), "The National Institute for Occupational Safety and Health (NIOSH)," CDC,

Chris Simons and Blenda Naylor-Stables ,Effective Communication for Managers,1997

Cooper, D. 2007. "*Behavioral Safety Approaches: Which Are the Most Effective?*" White Paper, B-Safe Management Solutions Inc., Franklin, Indiana

Dhiman, Anil K. &Yashoda Rani (2005). *Learn Information and Reference Sources andServices*. New Delhi: Ess Publication.

Examples of different site location plans: accessed on April 01, 2019 fro https://www.southnorfolk.gov.uk/sites/default/files/Examples of supporting_applications.pdf

FDRE,(2011). Urban Land Lease Holding Proclamation, Federal Democratic Republic of Ethiopia, Proclamation No. 721/2011, Negarit gazetta. Addis Abeba, Ethiopia.

FDRE,(2014).Urban Cadastral Surveying, Federal Democratic Republic of Ethiopia, Regulation No. 323/2014, issued by the Council of Ministers, Ethiopia.

FDRE,(2014).Urban Landholding Adjudication and Registration, Federal Democratic Republic of Ethiopia, Regulation No. 324/2014, issued by the Council of Ministers, Ethiopia.

FDRE,(2014).Urban Landholding Registration, Federal Democratic Republic of Ethiopia, Proclamation No. 818/2014, Negarit gazetta. Addis Abeba, Ethiopia.

FIG (1995). Statement on the Cadastre. Report Prepared for the International Federation of Surveyors by Commission 7 (Cadastre and Land Management), FIG Publication No. 11, and pp. 22.

Geller, E. S. 2004. "Behavior-Based Safety: A Solution to Injury Prevention: Behavior-Based safety „Empowers" Employees and Addresses the Dynamics of Injury Prevention." *Risk & Insurance* 15 (12): 66.

Guidotti, T. L., ed. 2011. *Global Occupational Health*. New York: Oxford.

HSE (Health and Safety Executive). 1997. *Successful Health and Safety Management*. Suffolk, UK: HSE Books,

Hutchins, Margaret (1974*). Introduction to reference work* (p.10-15). Chicago: American Library Association,

Indra Gandi National Open University, Organization Theory and Behavior handout,2005

Kragh, Helge (1989). *An Introduction to The Historiography of Science*. Cambridge University Press.

Krishan Kumar. *Reference Service* .5th rev ed. (p.115-127). NewDelhi: Vikas Publishing House.

Land Surveying and Conventional Techniques for Measuring Positions on the Earth's Surface accessed on April 15, 2019 from https://www.e-education.psu.edu/geog160/node/1926

MoUDH, (2013). Ethiopian Land Administration Domain Model (ELADM), No.02/2015. Federal Democratic Republic of Ethiopia, Ministry of Urban Land Development and Housing

MoUDH, (2013). Urban Land Development and Management Policy. Federal Democratic Republic of Ethiopia, Ministry of Urban Land Development and Housing

MoUDH, (2014). Urban Cadastral Surveying. Ministry of Urban Land Development and Housing, Directive No. 44/2014, issued by the Ministry of Urban Development and Housing, Ethiopia.

MoUDH, (2014). Urban Cadastral Surveying. Ministry of Urban Land Development and Housing, Standard No. 03/2014, issued by the Ministry of Urban Development and Housing, Ethiopia.

MoUDH, (2014). Urban Landholding Adjudication and Registration. Ministry of Urban Land Development and Housing, Directive No. 45/2014, issued by the Ministry of Urban Development and Housing, Ethiopia.

MoUDH, (2014). Urban Landholding Adjudication and Registration. Ministry of Urban Land Development and Housing, Standard No. 05/2014, issued by the Ministry of Urban Development and Housing, Ethiopia.

Remote Sensing & GIS: Knowledge Resource for Remote Sensing & GIS accessed on April 02, 2019 from http://rsgislearn.blogspot.com/2007/05/gis-data-type.html.

Photo Interpretation Student Handbook: Photo Interpretation Principles. Unclassified, 1996.

Principals and Elements of Image Interpretation theory: accessed on April 15, 2019 from https://www.edc.uri.edu/nrs/classes/NRS409509/RS/Lectures/409509PhotoInterpretationClass3_Update.pdf.

Rezaldi, Y., Kadir R. Mohamad, A. (2017). Review of Spatial and Non-spatial Data Transformation to 3D Geo-visualization for Natural Disaster. Book, DOI: 10.1007/978-3-319-70010-6_32.

Rinker, J. and P.A. Cori, P. (1984) Air Photo Analysis, Photo Interpretation Logic, and Feature Extraction: accessed from https://apps.dtic.mil/dtic/tr/fulltext/u2/a153926.pdf on April 02, 2019.

Schofield, W. and Mark Breach (2007). Engineering Surveying, Sixth Edition 6th Edition.ISBN-13: 978-0750669498, ISBN-10: 0750669497