NATIONAL HYDROLOGY PROJECT

NHP

Online Training on "Introduction to Projection, Datum, Contours, DEM and Creation of DEM"

12th September, 2022

At
National Geo-Spatial Data Centre,
Dehradun, Survey of India
(DEPARTMENT OF SCIENCE & TECHNOLOGY, GOVT OF INDIA)

National Geo-Spatial Data Centre
Hathibarkala Estate
Dehradun – 248 001
(Uttrakhand)

PREFACE

National Hydrology Project known as NHP-III is a World Bank assisted project and coordinated by Ministry of Jal Shakti. The aim of the project is to improve the planning, development and management of water resources as-well-as flood forecasting and reservoir observations in real-time.

Under NHP-III, SOI is providing updated digital topographical Geo-database and DEM of 3-5m accuracy of around 8,00,000 Sq. Km. area as–well-as DEM of 0.5m accuracy of approximately 58472 Sq. Km. area.

During various discussions at NPMU and with other State Implementing Agencies (IAs), it was felt that there is a need to create awareness among officers and staff of IAs, specifically regarding Projection System, Datum, Contours and creation of Digital Elevation Model(DEM) from various sources. Hence, an online training programme of 1 day was envisaged and conducted on 12th September, 2022 in which 50 participants participated from various IAs.

The response of online training on "Introduction to Projection, Datum, Contours and Creation of DEM" has been very encouraging and there is a demand for more training on the subject.

We expressed extreme gratitude to Surveyor General of India for his continuous support to NHP in general and conduct of training in particular. We are also thankful to Col S.K. Dwivedi, Director, NGDC & Nodal Officer NHP, for his support to conduct the training. Sincere thanks to Shri Ajay Kumar, OS, Shri Vivek Gupta, OS for delivering lectures. Thanks are also due to Shri Mahipal Singh, SS, other officers & staff of NGDC for organizing the online training as-a-whole.

At last but not the least we are extremely thankful to NPMU for their continuous guidance and state IAs for deputing various officers to participate in the training.

(S. V. Singh)
Project Director
National Hydrology Project-III

CONTENTS

Training Schedule Online Training on "Introduction to Projection, Datum, Contours and Creation of DEM"		
Time	**Topic**	**Lecture Taken By**
12th September, 2022		
1030 – 1130 Hrs	Introduction to Datum, Projecton, Heights & Contours	Shri Vivek Gupta OS, NGDC, Dehradun
1145– 1300 Hrs	Introduction to DEM & Creation of DEM	Shri Ajay Kumar OS, NGDC, Dehradun

Total List of participants for the online training on "Introduction to Projection, Datum, Contours and Creation of DEM"

SNo	Agency	Name	EmailID	MobileNo	Department Name	Designation
1	Andhra Pradesh GW	Ponnada Hari Prasad	ponnadahari@gmail.com	8106721084	Ground Water and Water Audit Department, Government of Andhra Pradesh	Sub Divisional Officer
2	Andhra Pradesh SW	Venkata Ramana U	venkataramana.uppala@ap.gov.in	8106340999	Water Resources Department, Government of Andhra Pradesh	Assistant Executive Engineer
3	Andhra Pradesh SW	Budharapu Subhashini	saisubhashinii@yahoo.com	9490080046	Water Resources Department, Government of Andhra Pradesh	Assistant Executive Engineer
4	Andhra Pradesh SW	Vasudevareddy Chamala	er.cvreddy18@gmail.com	9493219404	Water Resources Department, Government of Andhra Pradesh	Assistant Executive Engineer
5	Andhra Pradesh SW	Pinnapareddy Tejasri	shanmukha.pp@gmail.com	8886149968	Water Resources Department, Government of Andhra Pradesh	Assistant Executive Engineer
6	Andhra Pradesh SW	Nagabhushanam Basikonda	nagabhushanambasikonda@gmail.com	9618427123	Water Resources Department, Government of Andhra Pradesh	Assistant Executive Engineer
7	Andhra Pradesh SW	G Vinatha Vani	vinathavani.gorthi@ap.gov.in	9866662195	Water Resources Department, Government of Andhra Pradesh	Deputy Engineer
8	Assam	Pranab Baruah	pranabbaruah010@gmail.com	9952017929	Water Resources Department, Government of Assam	Assistant Engineer
9	Assam	Prajna Parmita	prajna.parmita15@gmail.com	8876707613	Water Resources Department, Government of Assam	Assistant Engineer
10	Bihar SW	Vikram Kumar	25.vikram@gmail.com	9161479906	Water Resources Department ,Government of Bihar	Senior Hydrogeologist
11	CGWB	Mohammad Danis Khan	mdkdaniya@gmail.com	8982358346	Central Ground Water Board (CGWB)	Hydrogeologist
12	CWC	Chanchala	chanchaladas@rocketmail.com	8144779792	Central Water Commission(CWC)	Research Officer
13	CWC	Atul Kumar Dwivedi	atulyahind@gmail.com	7415228571	Central Water Commission(CWC)	Sub Divisional Officer
14	CWC	Salana Gnaneswara Rao	vinaykumarsalana@gmail.com	9603930490	Central Water Commission(CWC)	Junior Engineer
15	Delhi	Ashutosh Mishra	ashujubilian@gmail.com	9140211807	Irrigation and Flood Control Department, Government of NCT Delhi	Hydrogeologist
16	Delhi	Jyoti Kushawaha	jyoti.vaishnavi@gmail.com	8800569927	Irrigation and Flood Control Department, Government of NCT Delhi	Hydrogeologist

17	Gujarat	Vasaikar Swarali	swaralihydro@gmail.com	9586149259	Water Resources Department , Government of Gujarat	Hydrogeologist
18	Gujarat	Ankitkumar Ranjitbhai Patel	arpatel972@gmail.com	9909429747	Water Resources Department , Government of Gujarat	Assistant Engineer
19	Himachal Pradesh	Er.Raj Kumar	rajnith008@gmail.com	9816533733	Jal Shakti Vibhag, Government of Himachal Pradesh	Assistant Engineer
20	Karnataka	Apoorva A	reddyapoorva02@gmail.com	9663933992	Water Resources Department, Government of Karnataka	Assistant Engineer
21	Karnataka	Shruthisri	shruthi1369@gmail.com	7829089377	Water Resources Department, Government of Karnataka	Assistant Research Officer
22	Karnataka	Navyashree M L	shreenavya444@gmail.com	9686410862	Water Resources Department, Government of Karnataka	Research Assistant
23	Karnataka	Shruti Halli	shruthi.shivaganga@gmail.com	6363209161	Water Resources Department, Government of Karnataka	Research Assistant
24	Karnataka GW	Sumit Kant	sumit.kant57@gmail.com	9889999992	Karnataka (GW)	Assistant Research
25	Maharashtra SW	Jitendra Hatwar	ENQUIRY.AEES@GMAIL.COM	9665930804	Water Resources Department, Government of Maharashtra	Consultant
26	Maharashtra SW	Suresh Bhima Bhange	bhangesuresh@gmail.com	7798093495	Water Resources Department, Government of Maharashtra	Junior Engineer
27	Maharashtra SW	Anil Ananda Patil	anilapatil007@gmail.com	7798423384	Water Resources Department, Government of Maharashtra	Junior Engineer
28	NCA	Nishi R Choudhary	nishi.pawar02@gmail.com	9479583561	Narmada Control Authority	Research Assistant
29	NIH	Ashwini Ranade	ranadeashwini@gmail.com	8294453890	National Institute of Hydrology (NIH)	Scientist D
30	NIH	Abhilash R	srscientist.abhi@gmail.com	9620302002	National Institute of Hydrology (NIH)	Scientist C
31	Punjab	Sukhdeep Kumar	sukhuk3610@gmail.com	8054003610	Department of Irrigation , Government of Punjab	Geo-Informatics Specialist
32	Tamil Nadu	Santhosh Raj	sanrani.raj@gmail.com	8122785879	Water Resources Department, Government of TamilNadu	Hydrogeologist Jr.
33	Tamil Nadu	Anand	anandb2205@gmail.com	9597227073	Water Resources Department, Government of TamilNadu	Research Assistant
34	Tamil Nadu	Thomas Chinnappan	thomas.j.1904@gmail.com	9659595612	Water Resources Department, Government of TamilNadu	Geologist
35	Tamil Nadu	Senthil Vel G	vel.senthil2391@gmail.com	9751009820	Water Resources Department, Government of TamilNadu	Assistant Engineer
36	Tamil Nadu	Suryaprakash I	suryaprakash.civil@gmail.com	8667273465	Water Resources Department, Government of TamilNadu	Assistant Engineer

37	Tamil Nadu	M Abdul Rahman	abrahwrd@gmail.com	9585688734	Water Resources Department, Government of TamilNadu	Assistant Engineer
38	Tamil Nadu	Kssenthil	outofboxcell@gmail.com	9444028737	Water Resources Department, Government of TamilNadu	Assistant Executive Engineer
39	Telangana SW	K.Shalini	shalini13579@gmail.com	9100790559	Irrigation & CAD Department, Government of Telangana	Assistant Executive Engineer
40	Telangana SW	A.R.N.Sharma	sharma.ome@gmail.com	7093320833	Irrigation & CAD Department, Government of Telangana	Executive Engineer
41	Telangana SW	Sri S.V.B. Patel	cehydrologyts@gmail.com	9989641526	Irrigation & CAD Department, Government of Telangana	Assistant Executive Engineer
42	Telangana SW	M.Vamshi Raj	iamvamshi.raj@gmail.com	9704997842	Irrigation & CAD Department, Government of Telangana	Assistant Executive Engineer
43	Telangana SW	P Kasi Viswanadham	ts.sehydrology@gmail.com	7673902441	Irrigation & CAD Department, Government of Telangana	Superintending Engineer
44	Telangana SW	P Shailaja	cehydrologyts@gmail.com	9848642573	Irrigation & CAD Department, Government of Telangana	Deputy Engineer
45	Telangana SW	Madaka Madhavi	madakamadhavi.dee2@gmail.com	9959026634	Irrigation & CAD Department, Government of Telangana	Deputy Engineer
46	Uttar Pradesh GW	Praveen Kumar Singh	pksingh1583@gmail.com	9532140854	Ground Water Department, Uttar Pradesh	Assistant Engineer
47	Uttar Pradesh SW	Shiv Narayan Maurya	snmaurya1977@gmail.com	9451096662	Irrigation and Water Resources Department, Government of Uttar Pradesh	Assistant Engineer
48	Uttar Pradesh SW	Sangharsh Rao	sangharshrao@gmail.com	8765977673	Irrigation and Water Resources Department, Government of Uttar Pradesh	Scientist D
49	Uttarakhand	Ajay Kumar	ajayukid@gmail.con	9411384113	Irrigation Department, Government of Uttarakhand	Superintending Engineer, Water Resources & GWSC
50	West Bengal GW	Vaswati Deb	vaswatiddeb@gmail.com	9432123778	Department of Water Resources Investigation & Development, Govt. of West Bengal	Geo-Informatics Specialist

Presentations

PRESENTATION ON

INTRODUCTION TO DATUM, PROJECTION, HEIGHT & CONTOURS

By Shri Vivek Kumar Gupta,
Officer Surveyor

VIVEK KUMAR GUPTA,
Officer Surveyor,
National Geo-spatial Data Centre,
Survey Of India,
Dehradun

Introduction to Datum, Projection, Heights & Contours

12-09-2022

- INTRODUCTION - SURVEY OF INDIA
- SURVEYING – Some Basics
  - Cordinates
- DATUM
- PROJECTION
- HEIGHT
- CONTOURS

INTRODUCTION - SURVEY OF INDIA

➢ Survey of India, the national survey and mapping agency of the country under the department of science & technology, is the oldest scientific department of the Govt. of India and was established in 1767.

➢ It is one of the Implementing Agencies among the Govt. Of India prestigious National Hydrology Project.

SOI - Mandate

- ➢ The Survey of India is the adviser to the Government of India on the all survey matters
- ➢ Deals with International Boundaries matters
- ➢ Geodetic Control (Horizontal and Vertical) & Geodetic surveys
- ➢ Tidal observation
- ➢ Topographical Control, Surveys and Mapping within India on 25K, 50K and 250K scales.
- ➢ Cantonments, Large Scale City Surveys, Guide Maps etc
- ➢ Surveys for Developmental Projects
- ➢ Mapping and Production of Geographical Maps and Aeronautical Charts.
- ➢ Survey and Mapping of special maps
- ➢ Toponomy
- ➢ Mapping in Antarctica

SOI- Services and Products

- Geodetic Survey
  - Satellite Geodesy - GPS Observations
  - Tidal Observations
  - High Precision Leveling
  - Geomagnetic Surveys
  - Gravity Surveys
  - CORS (Continuously Observed Referenced System)
- Topographic Survey
  - Topographical Survey on different scales
  - Large Scale Mapping
- Others
  - Project Surveys, expeditions etc
- Portal
  - SOI, G2G and India Map portal

Nation wide presence of SoI offices

MAP VS SKETCH

Sketch-

- It is just an imaginary image of a specific place/ area.
- It is a drawing mainly based on memory and spot observation.
- It is not to scale.
- It is a rough drawing & require no specific instrument.

Map-

- A map is a visual representation of an area.
- A symbolic depiction highlighting inter relationships in terms of distances & direction between details of that area.
- It has scale & require specific instruments to know exact direction & distances.

SCALE OF A MAP

- Map scale refers to **the relationship (or Ratio) between distances of objects on a map and the corresponding distances between same objects on the ground.**
- For example, on a 1:1,00,000 scale map, 1cm on the map equals 1km on the ground.

Types of Map Scales

- Large Scale 1:25,000 or larger (For small Area)
- Medium Scale 1:10,00,000 to 1:25,000
- Small Scale 1:10,00,000 or smaller (Covers large area)

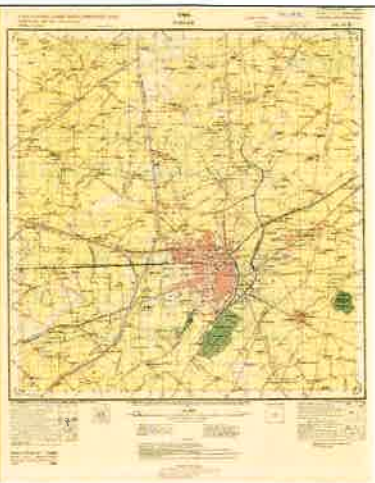
Topographical Maps are medium scale maps.

TOPOGRAPHICAL MAPS

TOPOGRAPHICAL MAPS

- **The maps on smaller than 1:1M scale are called Geo-graphical maps.**
- **Maps published on scale larger than 1:1M scale are called Topographical maps.**
- **SOI prepares topographical maps on 1:250K, 1:50K and 1:25K scales.**

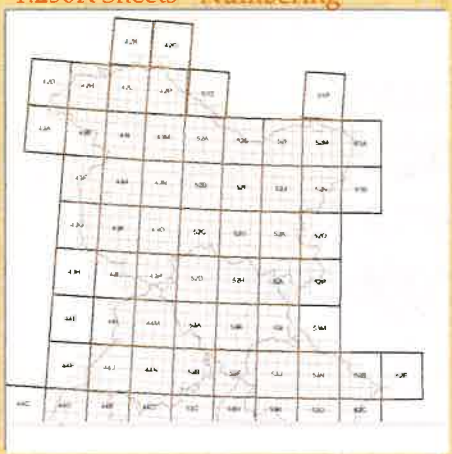
1:50,000 SCALE TOPO MAP



TOPOGRAPHICAL DATA - 1:250K

- **Entire India is covered by 394 sheets on 1:250,000 scale**
- **One 1:250 Sheet covers appx 110 Km * 110 Km area.**
- **The contour Interval for 1:250K sheets is generally 100m.**

1:250K Sheets - Numbering



Specimen of OSM

SOI- FEW LATEST WORK

- 3 D Mapping of entire Delhi on 1:1000 scale.. DSSDI (Delhi State Spatial Data Infrastructure)
- 152 Cities mapping on 1:2K and 1:10K scale. NUIS
- Mapping of all coal Mines of India on 1:4K Scale.. CMPDI (Central Mine Planning & Design Institute)
- Mapping of Coastal India with 0.5 contour Interval.. ICZM(Integrated coastal zone management)
- Redefinition of Indian Vertical Datum.. RIVD
- GPS data library, Tidal Observations, Gravity Obsn
- Open Series of Maps n Defence Series of Maps

SURVEYING
Some Basics

Surveying: Definition

- Surveying is the art and science of accurately determining 3-D position of points and the distances and angles between them.
- These points are usually on the surface of the Earth, and they are often used to prepare maps and boundaries for ownership or governmental purposes
- Points are (X,Y,Z) or (Long, Lat, Ht)

SURVEYING - Classification Of Surveying

Based on Extent of Area

- Plane Surveying (small area): **In this earth surface is assumed as a plane and curvature of the earth is ignored**
- Geodetic Surveying (large area): **In this curvature of the earth is taken into account and a higher degree of accuracy in linear as well as angular observation is achieved.**

SURVEYING - Classification of Ground Control:

- **The Ground Control are classifies as**
  - Horizontal Control
  - Vertical Control
- **Horizontal Control:**
  - A point or monument on surface of earth whose latitude and longitude with respect to some reference surface are known.
  - The reference surface is known as horizontal datum and for horizontal control it an ellipsoid (Everest, WGS84)
- **Vertical Control**
  - A point or monument on surface of earth whose height with respect to some reference surface is known.
  - The reference surface for vertical control is MSL or Geoid

Introduction

- Datum
- Height
- Contour
- Projection

What is Datum?

- A datum is a reference surface with respect to which measurements are made.
- Horizontal datums-
  - for describing a point on the earth's surface in Geographic Coordinates (latitude and longitude) or another coordinate system (Easting-Northing).
  - base measurement for 2-D coordinates (X-Y)
- Vertical datums
  - measure elevations or depths.
  - base measurement for 3rd Dimension (Height-Z)

WHY DATUMS :?

To deal with surveying and mapping a datum and coordinate system is required.

➢ **DATUM USED IN SURVEYING:**

- **Horizontal Datum- (Ellipsoid)**

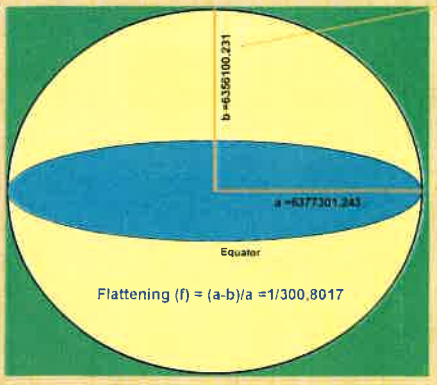
  The mathematical shape that best resembles with earth
- **Vertical datums – (Geoid/MSL)**

  Actual shape of earth after removing topographical surface

Horizontal Datum - The Ellipsoid

- The ellipsoidal surface is smooth & mathematical surface. Computations can be made on this surface.
  - Its centre coincides with the centre mass of the earth.
  - Its minor axis is parallel to the axis of rotation of the earth.
- Ellipsoid is used as the reference surface (datum) for horizontal coordinates in geodetic network.
- Everest ellipsoid was used as a Horizontal datum till year 2000. It was a local datum used in India and adjacent countries
- Post year 2000, we have started to use WGS84 as horizontal datum. It is a global datum.

Everest Ellipsoid (Local Datum)- The Realization



Everest Ellipsoid- The Realization

- Realised after observations of nearly 40 years and computations.
- The shape and radius best fit for Indian subcontinent was computed.

THE GREAT MERIDIONAL ARC

THE 1500 MILES LONG MERIDIONAL ARC OF INDIA ON THE 78[th] MERIDIAN STRETCHES FROM KANYA KUMARI TO THE FOOTHILLS OF THE HIMALAYAS IT IS ONE OF THE LONGEST ARC MEASURED IN THE 19[th] CENTURY

Horizontal Datum (Global) – GRS80/WGS84

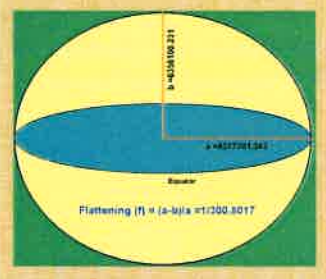
- Adopted by IUGG Canberra in December 1979.
- GRS 1967 was replaced by GRS 1980.
- For all practical purposes, the GRS80 and WGS84 ellipsoids are identical.
- WGS84 was designed to be a practical standard global, geocentric horizontal datum for:
  - Mapping
  - Charting
  - Geodesy and
  - Navigation

Horizontal Datum - Everest/WGS84

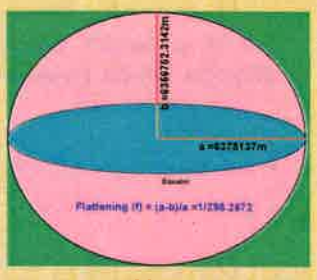
Everest Defining Parameters		
Parameter	Notation	Value
semi-major axis	a	6377301.243m
Reciprocal of flattening	1/*f*	300.8017

WGS84 Defining Parameters		
Parameter	Notation	Value
semi-major axis	a	6378137.0 m
Reciprocal of flattening	1/*f*	298.257223563

Horizontal Datum - Everest/WGS84

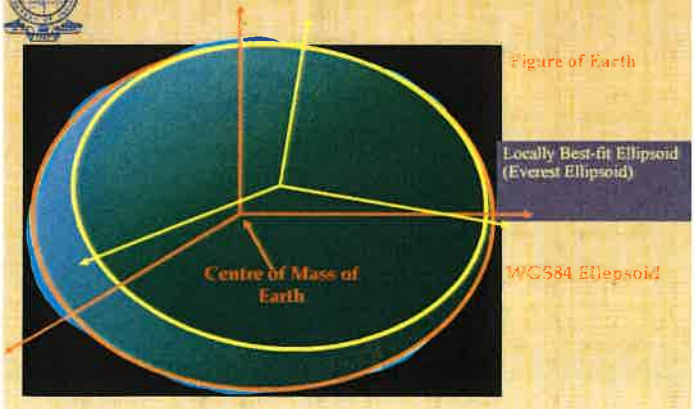


Everest Ellipsoid

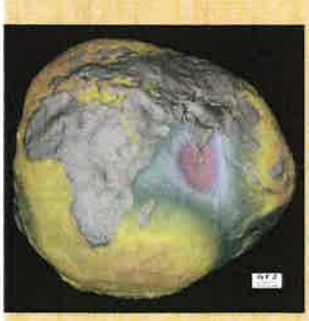


WGS-84

Horizontal Datum - Everest/WGS84



Geoid (Close to MSL)



Actual shape of earth

Figure of Earth

HEIGHT

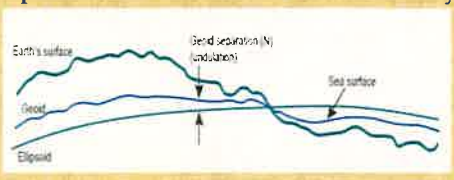
- **Height**
  - Length on Vertical direction
  - Water flow criterian
  - Different type of Heights
  - Issue of
    - Gravity
    - MSL
    - Geoid
    - Misc others

MSL (Mean Sea Level)

- Arithmetic Mean of all phase (high and low tides) of ocean tide (hourly heights) taken for 18.66 year (approx. 19yrs) at a place is called as Mean Sea Level of that place.
- MSL of nine tide gauge station namely Karachi, Bombay, Karwar, Beypore, Cochin, Nagapattinam, Madras, Vishakhapatnam, and False point with the assumption that the Mean Sea Level at all these stations represent the same level surface.
- The Indian vertical datum(IVD) was realized over a century ago in 1909 on the basis average MSL of nine tide gauge station with the assumption that Mean Sea Level measured at each of these nine observatories represents the same water level.

MSL (Mean Sea Level)

- The vertical datum for all surveying operation is taken as MSL which is natural surface. So all the heights are measured with respect to MSL which is taken as ZERO surface for height. The MSL is more precisely defined as Geoid.
- Mean Sea Level adopted by survey of India for reference, is located at Mumbai High (Before independence it was in Karachi but after the independence we have shifted it to the Bombay High).

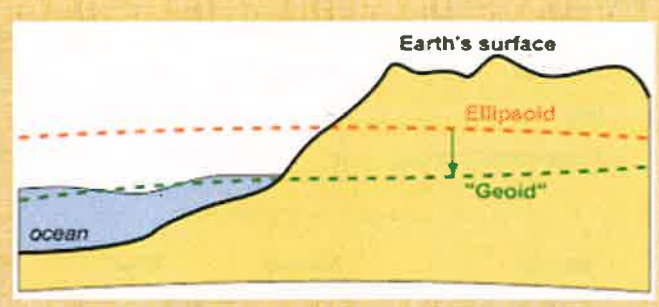


Geoid

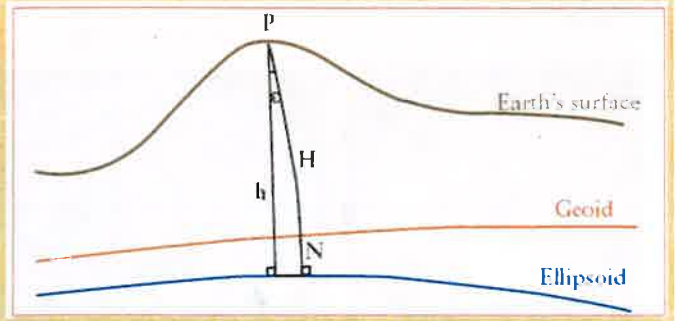
- An equipotential surface of the Earth's gravity field which corresponds most closely with 'mean sea level (MSL)'
- it is a datum which conforms to the laws of physics which says water must flow from higher potential to lower potential.
- Points are (X,Y,Z) or (Long, Lat, Ht)

Vertical Datum - Height

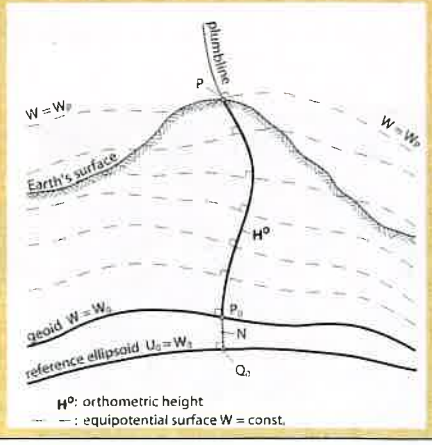
Geoid and Ellipsoid



Height



Direction of Vertical



Vertical Datum - Geoid

Figure of Earth

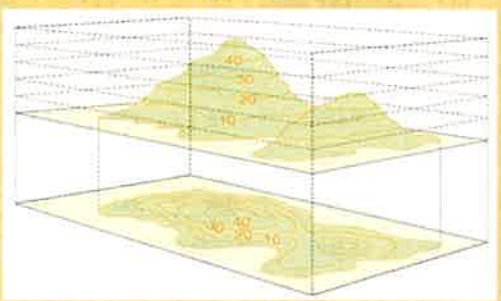
Geoid (Close to MSL)

INTRODUCTION TO CONTOURS

Contour Farming in Hilly Terrain

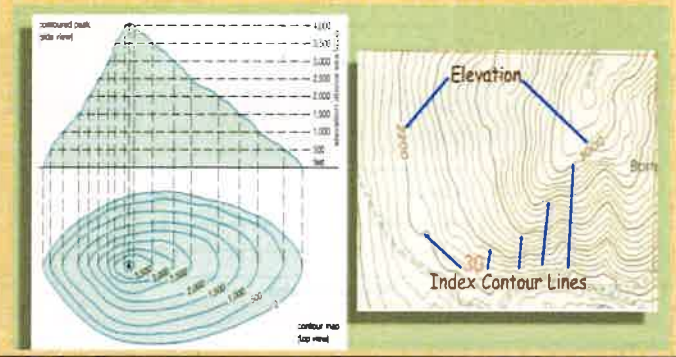
Contours -

A Contour is an imaginary line on the ground joining the points of equal elevation or reduced level.



Contour line

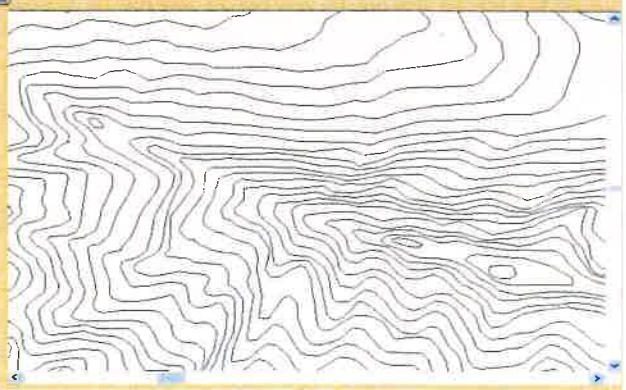
A Contour line is an imaginary outline of the terrain obtained by joining its points of equal elevation.



Normal Contour file looks like this

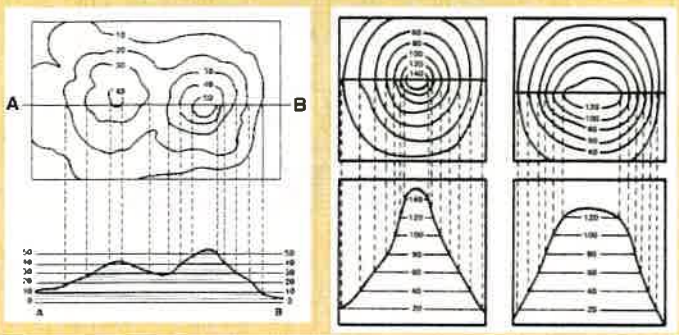
Heavy Contour (in High Hills) file looks like this

Zoom view



Contour interval

The vertical distance between two successive contours is known as 'Contour interval'. It remains constant for a given map.



Contour interval continued.....

- ✓ Contour Intervals for flat ground are generally small, e.g. 0.25m, 0.5m, 0.75m .
- ✓ The contour intervals for a steep slope in a hilly area is generally greater, e.g. 5m, 10m, 15m etc.
- ✓ Contour interval is kept large up to 2m for projects such as highways and railways, whereas it is kept as small as 0.5m for measurement of earthwork, building sites, dams etc.
- ✓ It is desirable to have a constant contour interval for a particular map.

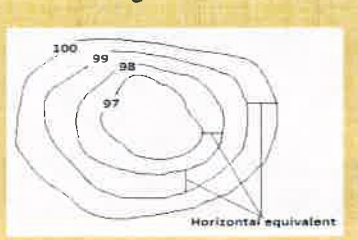
Contour interval for topo maps of SoI

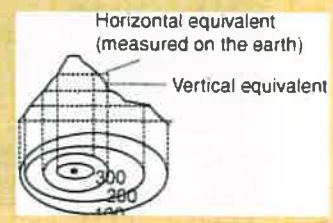
SCALE	POSITIONAL ACCURACY (1/4 of the scale)	CONTOUR INTERVAL		CONTOUR ACCURACY (1/2 of the contour interval)	
		for Plain	for Hills	for Plain	for Hills
1:50,000	12.5M	10/20M	40M	5/10M	20M
1:25,000	6.25M	5M	10M	2.5M	5M
1:10,000	2.5M	2M	4M	1M	2M
1:5,000	1.25M	1M	2M	0.5M	1M
1:1,000	0.25M	0.25/0.5M	0.5M		

(CI BELOW 0.5M IS RARELY USED)

Horizontal equivalent

The horizontal distance between two successive contours is known as 'Horizontal equivalent'. It is not constant for a given map, it varies according to the steepness of the ground.

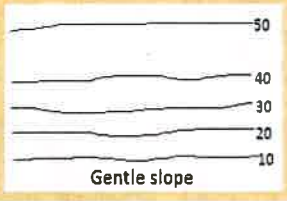


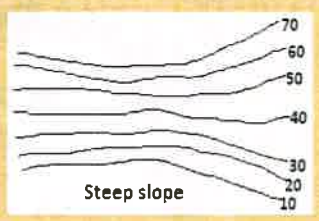


CHARACTERISTICS OF CONTOURS

i) All points in a contour line have the same elevation.

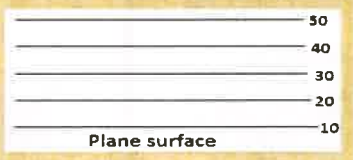
ii) Flat ground is indicated where the contours are widely separated and steep- slope where they run close together.



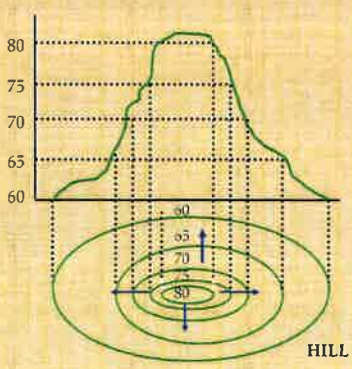


iii) A uniform slope is indicated when the contour lines are uniformly spaced and

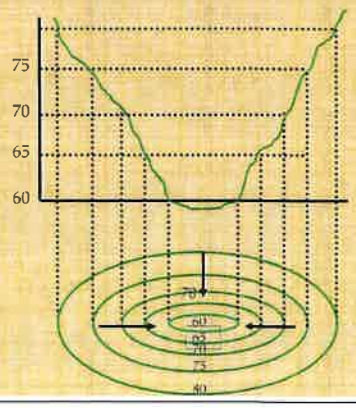
iv) A plane surface when they are straight, parallel and equally spaced.



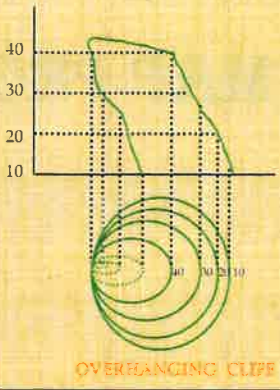
v) A series of closed contour lines on the map represents a hill , if the higher values are inside



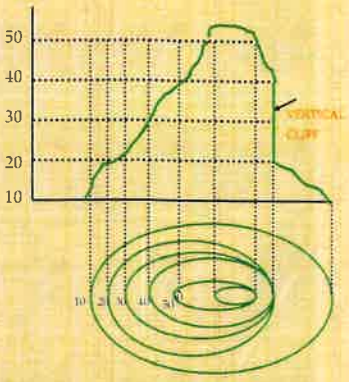
vi) A series of closed contour lines on the map indicates a depression if the higher values are outside



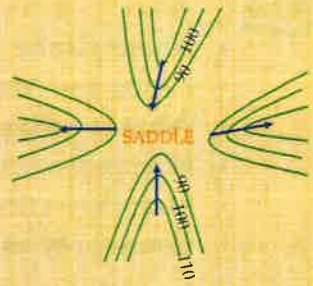
vii) Contour lines cannot merge or cross one another on map except in the case of **an overhanging cliff.**

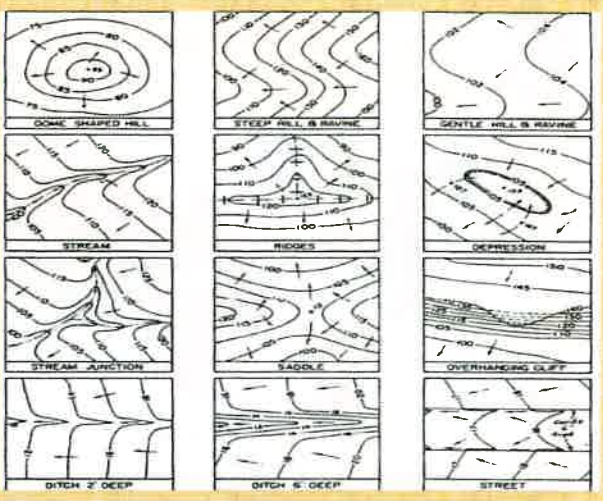


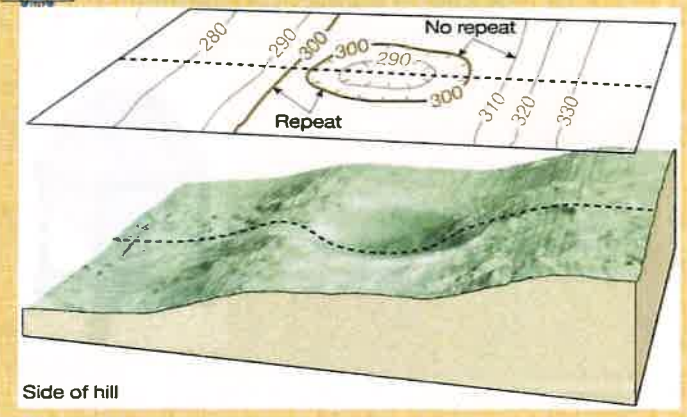
ix) Contour lines never run into one another except in the case of a vertical cliff. In this case, several contours coincide and the horizontal equivalent becomes zero.



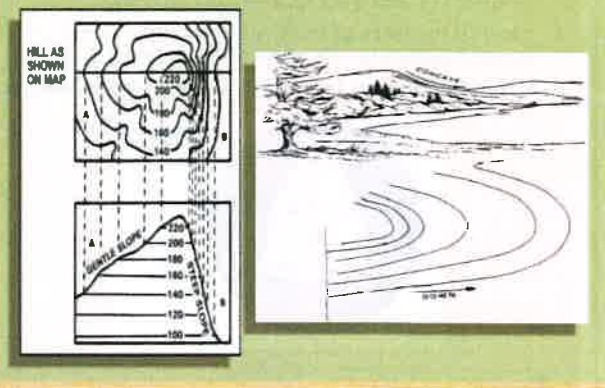
iX) Depressions between summits is called **a saddle**. It is represented by four sets of contours as shown. It represents a dip in a ridge or the junction of two ridges.



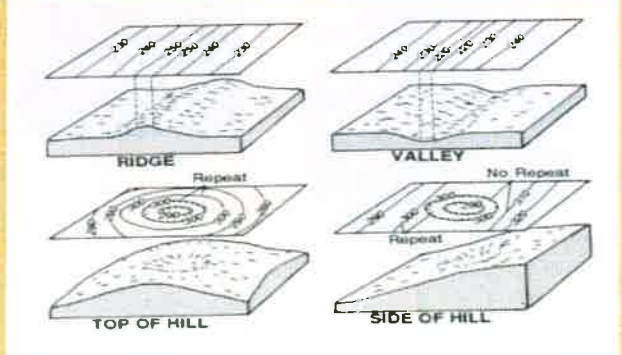




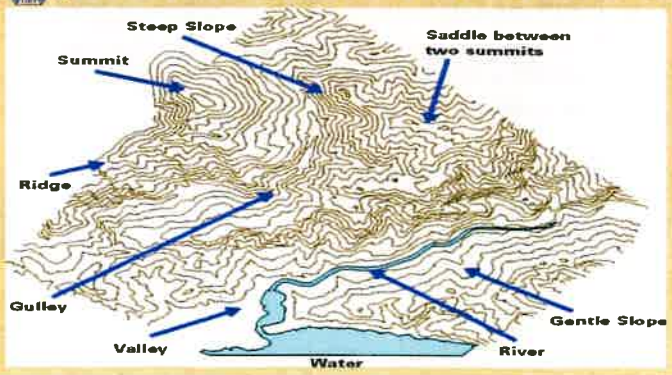
Characteristics of Contours



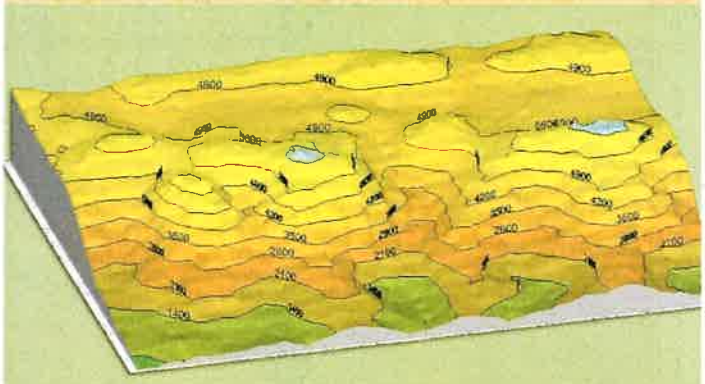
Typical Land Features and their contour forms



Typical Land Features and their contour forms



CONTOURS with TERRAIN



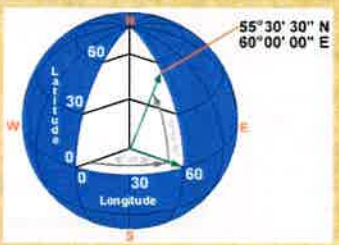
MAP PROJECTION

Map Projections

Contents

About Globe

- Spherical Earth's surface -radius 6371 km
- Meridians (lines of longitude) – Prime Meridian or 0° longitude passing through Greenwich, England.
- Parallels (lines of latitude) - using equator as 0° latitude

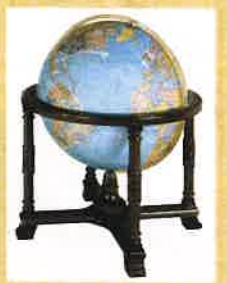


Globe and Map

- The earth is a spheroid/Ellipsoid
- The best model of the earth is a globe

Drawbacks of Globe:

- not easy to carry
- not good for making planimetric measurement (distance, area, angle)



Globe and Map .....Contd.

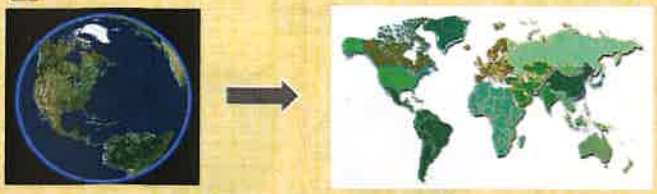
- Maps are flat
  - easy to carry
  - good for measurement
  - scaleable
- Map projections are used to "project" data from a sphere onto a planar surface

Globe and Map

(N,E) = F (Lat, Lon)

→distortions

What is a Map Projection?



Map projection is the process to represent a three dimensional Earth on a flat piece of paper

However...
The process of transferring information from the Earth to a map causes distortion either in shape, area, distance, or direction.

Map Projections - Distortions

- An orange's peel provides a classic demonstration of distortion in map projection
- It cannot be completely flattened unless compressed, stretched or torn apart.

Map Projection

Curved Earth
Geographic coordinates: ϕ, λ
(Latitude & Longitude)

Flat Map
Cartesian coordinates: x,y
(Easting & Northing)

Map Projections: Definition

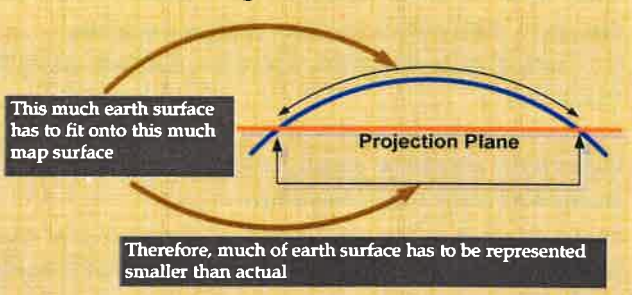
- A map projection is a mathematical model for conversion of locations from a three-dimensional earth surface to a two-dimensional map representation.
- This conversion necessarily distorts some aspect of the earth's surface, such as area, shape, distance, or direction.

Map Projections (Contd.)

- Every projection has its own set of advantages and disadvantages.
- There is no "best" projection for every area
- Some distortions of conformality (shape), scale, distance, direction, and area always results from this processes.
- Some projections minimize distortions in some of these properties at the expense of maximizing errors in others.

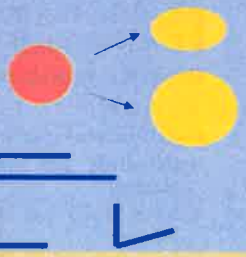
Distortion.

Fitting sphere to plane causes stretching or shrinking of features

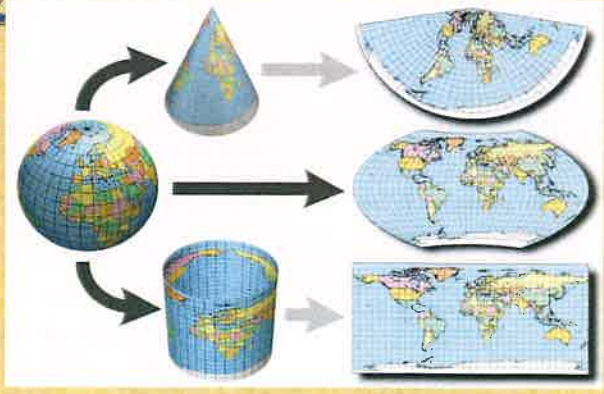


Map Projections-Distortions

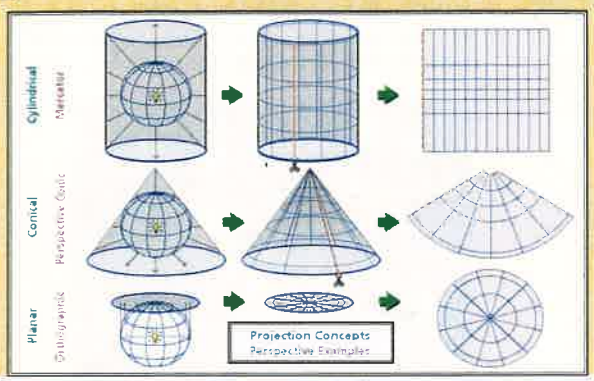
- **Projecting Earth's surface *always* involves distortion:**
  - –shape
  - –area
  - –distance
  - –direction



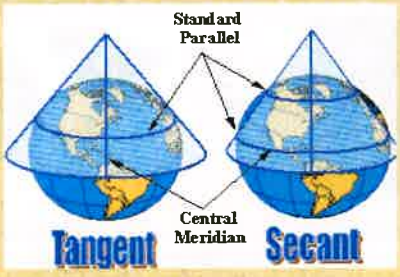
Physical Model:



Types of Projections



Conic Projections
(Albers, Lambert)



The lines where the cone is tangent or secant are the places with the least distortion.

Planar or Azimuthal
(Lambert)

Cylindrical Projections
(Mercator)

The lines where the cylinder is tangent or secant are the places with the least distortion.

Transverse

Oblique

Types of Projections

Equal Area: maintains accurate relative sizes. Used for maps that show distributions or other phenomena where showing area accurately is important. Examples: Lambert Azimuthal Equal-Area

Conformal: maintains angular relationships and accurate shapes over small areas. Used where angular relationships are important, such as for navigational or meteorological charts. Examples: Mercator (Cylindrical), Lambert Conformal Conic.

Types of Projections

Equidistant: maintains accurate distances from the center of the projection or along given lines. Used for radio and seismic mapping, and for navigation. Examples: Equidistant Conic

Azimuthal or Zenithal: maintains accurate directions (and therefore angular relationships) from a given central point. Used for aeronautical charts and other maps where directional relationships are important. Examples: Gnomonic projection, Lambert Azimuthal Equal-Area.

Azimuthal projection produces a circular map with a chosen point

Commonly Used Projection

Lambert Conformal Conic Projection (LCC)

* Projection surface	- Cone
* Coincidence	- Tangent for one standard parallel
	- Secant for two standard parallel
* Position	- Normal
* Properties of Projection	- Conformal as the name suggests

UTM projection (Universal Transverse Mercator)

* Projection surface	- cylinder
* Coincidence	- Tangent
* Position	- Transverse (cylinder touch the datum at poles)
* Properties of Projection	- Conformal

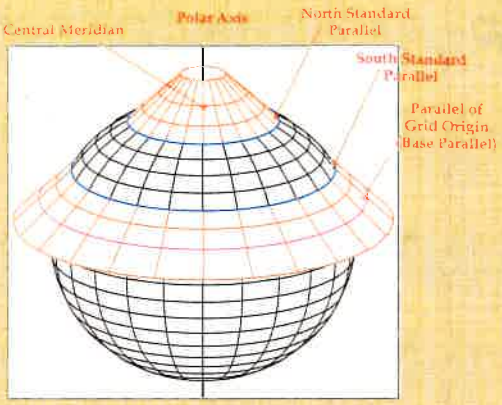
LAMBERT CONFORMAL PROJECTIONS

- J. H. Lambert developed the mathematics for conformal conic projection with standard parallels, and presented in 1772.
- Later it was fully described by Gauss
- Its main features are:
  - Conical
  - Conformal (preserves local angles and shape)
  - Parallels are unequally spaced arcs of concentric circles,
  - Meridians are equally spaced radii of the same circles, thereby cutting parallels at right angles
  - Scale is true along two standard parallels.

LAMBERT CONFORMAL PROJECTIONS (Contd.)

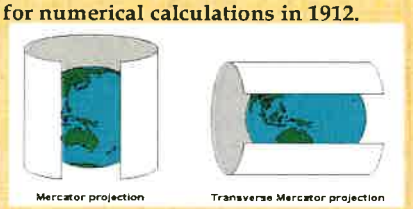
- Used for maps of countries and regions with east-west extent
- Used in India extensively for Geographical maps, grid in respect of topographical maps, and by coalfield companies

Lambert's Conformal Conic Projection



TRANSVERSE MERCATOR PROJECTION

- Mathematician and cartographer Johann Heinrich Lambert invented the widely used conformal projection in 1772.
- Carl F. Gauss analyzed the projection in 1882.
- L Kruger completed the development of the projection by developing the formulae further in order to make it suitable for numerical calculations in 1912.



Main Features of TRANSVERSE MERCATOR PROJECTION

- Cylindrical (Transverse)
- Conformal
- Meridian convergence increases with longitude away from central meridian.
- Meridian and parallel intersect at right angle.
- The origin of the ordinate y is at equator.
- The origin of abscissa x at central meridian.

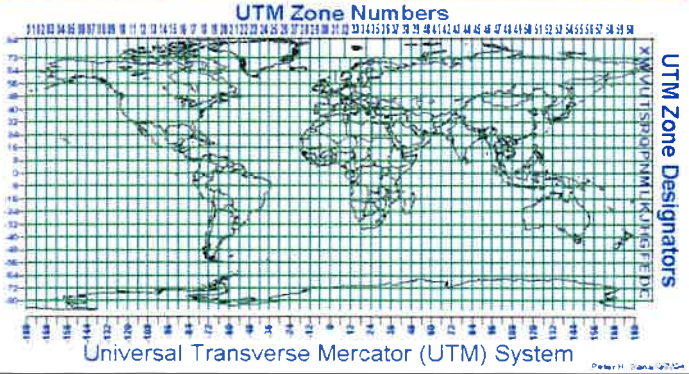
UNIVERSAL TRANSVERSE MERCATOR PROJECTION

- The Universal Transverse Mercator Projection is a particular case of Transverse Mercator Projection
- This is a world wide coordinate system brought up by the military during World War II
- This was adopted by US Army in 1947 for designating rectangular coordinates on large scale military maps of the entire world.

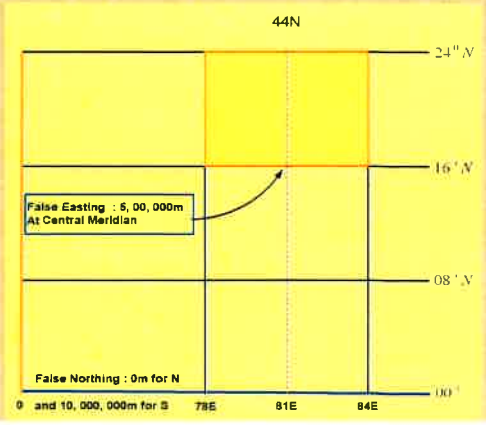
Specifications of UTM

- The world (Universe of UTM) is divided into 6° E-W equal parts from 180° W through 0° to 180° E and each UTM grid zone is numbered from 1 to 60.
- Zone number 1 starts from 180° W to 174° W, zone 2 from 174° W to 160°W and so on. Zone 30 from 6° W to Greenwich zone 60 from 174° E to 180° E.
- The N-S subdivision is from 80° S to 84° N and 8° apart except the last one, which is 72° N to 84° N.
- The geographical location in UTM projection is given x and y coordinates but in meters not feet.
- Scale factor at central meridian of UTM grid zone is 0.9996.

UTM Zone Numbers



UTM ZONE:



THANK YOU

PRESENTATION ON

INTRODUCTION TO DEM & CREATION OF DEM FROM VARIOUS SOURCES

By Shri Ajay Kumar,
Officer Surveyor

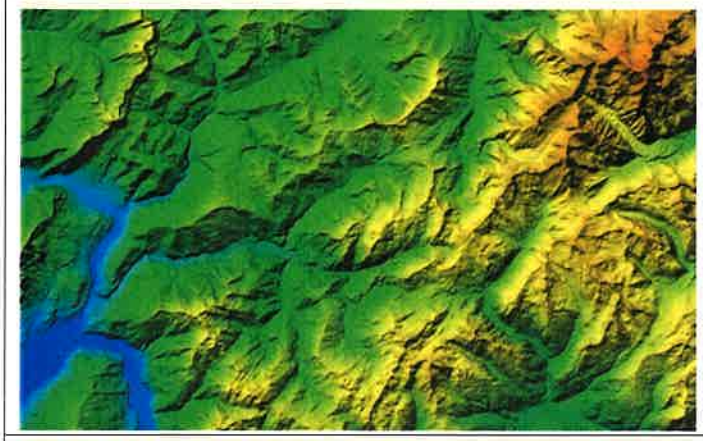
Introduction to DEM & Creation of DEM

By:

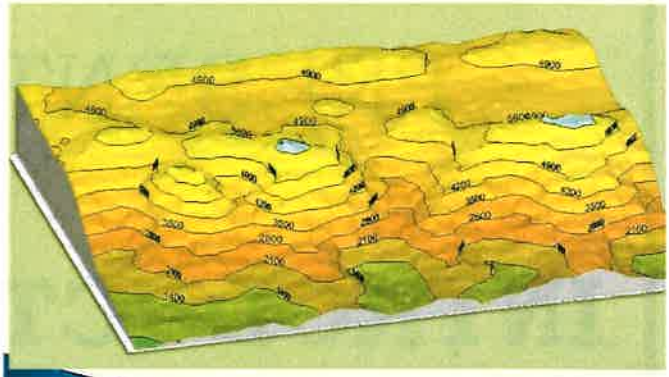
Ajay Kumar, Officer Surveyor
National Geospatial Data Centre,
Survey of India .

Digital Elevation Model

Digital Elevation Model looks like this

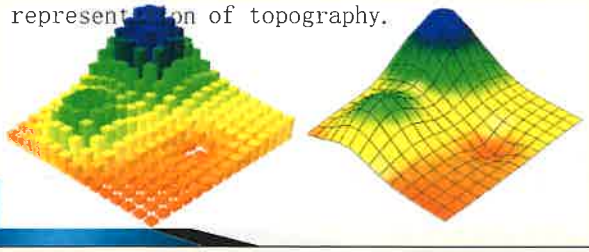


CONTOURS with TERRAIN



Introduction - Digital Elevation Model (DEM)

- Digital Elevation Model (DEM) is the digital representation of the land surface elevation with respect to any reference datum.
- DEM is the simplest form of digital representation of topography.



Uses of DEM

Uses of DEM-

- ✓ DEMs are used to determine terrain attributes such as elevation at any point, slope and aspect.
- ✓ Terrain features like drainage basins and channel networks can also be identified from the DEMs.
- ✓ DEMs are widely used in hydrologic and geologic analyses, hazard monitoring, natural resources exploration, agricultural management

Uses of DEM-

Hydrologic applications of the DEM include –

- ✓ Groundwater modeling
- ✓ Estimation of the volume of existing/proposed reservoirs
- ✓ Determining landslide probability
- ✓ Flood prone area mapping etc

DEM STRUCTURES

-DEM STRUCTURES -

A DEM can be represented as

- A raster (a grid of squares, also known as a height map when representing elevation)

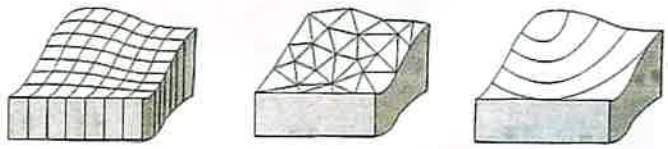
or

- A vector-based Triangular Irregular Network (TIN).

The TIN DEM dataset is also referred to as a Primary (measured) DEM, whereas the Raster DEM is referred to as a Secondary (computed) DEM.

Three main type of DEM structures used are the following.

a) Regular Square Grids (Gridded structure)
b) Triangulated Irregular Networks (TIN structure)
c) Contour based structure



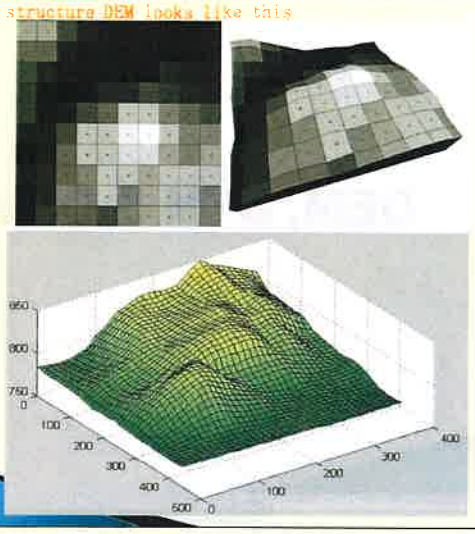
(a) Grid Cell DEM (b) TIN (c) Contour Lines

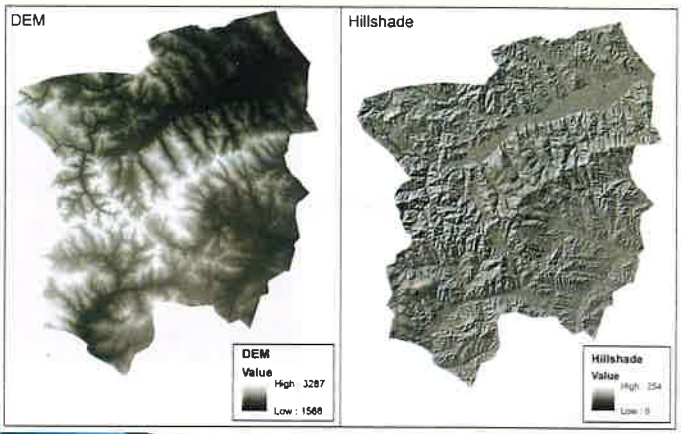
a) Regular Square Grid (Gridded structure DEM) :

➢ Gridded DEM (GDEM) consists of regularly placed, uniform grids with the elevation information of each grid.

➢ The GDEM thus gives a readily usable dataset that represents the elevation of surface as a function of geographic location at regularly spaced horizontal (square) grids.

Gridded structure DEM looks like this





Measure of quality:

➢ The quality of a DEM depends on its horizontal and vertical accuracy.

➢ Accuracy of the GDEM and the size of the data depend on the grid size.

b) TIN structure :

TIN structure looks like this

Zoom view of TIN structure

b) TIN structure :

➢ TIN is a more robust way of storing the spatially
varying information.

➢ It uses irregular sampling points connected through non-overlapping triangles.

➢ The vertices of the triangles match with the surface elevation of the sampling point and the triangles (facets) represent the planes connecting the points.

c) Contour-based structure :

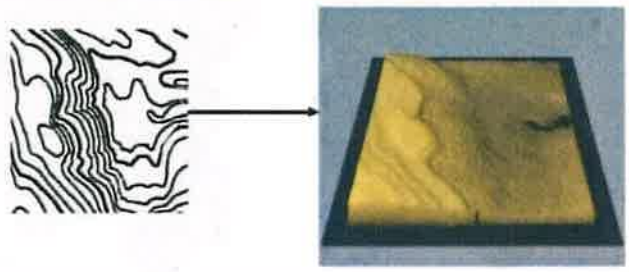
➢Contours represent points having equal heights/ elevations with respect to a particular datum such as
Mean Sea Level (MSL).

➢In the contour-based structure, the contour lines are
traced from the topographic maps and are stored with their location (x, y) and elevation (z) information.

➢These digital contours are used to generate polygons,
[illegible] each polygon is tagged with the elevation [illegible] the bounding contour.

Contour-based structure DEM :

Contour-based structure DEM :



DEM, DTM & DSM

There are three similar names as DEM, DTM & DSM-

➢ **Digital Elevation Model (DEM)**

A DEM is a representation of the elevation of the Earth's surface above a certain datum (e.g. mean sea level) in digital form. This is achieved taking elevation measurements at regular or irregular spaced points over the Earth's surface.

There are various acronyms used to describe digital elevation models. Two very popular ones are **Digital Terrain Model (DTM)** and **Digital Surface Model (DSM)**.

➢ **Digital Terrain Model (DTM)**

A DTM is a DEM that represents the elevation of the **bare earth** without taking into account any overground features (e.g. trees, buildings).

➢ **Digital Surface Model (DSM)**

A DSM is a DEM that represents the elevation of the surface to which a remote sensing system will first meet (i.e. when aerial photography is undertaken the top of a building, forest, etc.). Thus, the resulting DSM includes the elevation of the bare earth terrain plus the natural (e.g. trees, shrubs) and man-made features (e.g. buildings).

DSM & DTM

Digital Surface Model

Digital Terrain Model

Creation of DEM

Creation of DEM-

Several methods are available to create DEM.

a) Conversion of printed contour lines

- ✓ The first method is conversion of printed contour lines and use it in raster or vector form.
- ✓ The elevation contours are "tagged" with elevations.
- ✓ Any other additional elevation data are created from the hydrography layer.
- ✓ Finally, an algorithm is used to interpolate elevations at every grid point from the contour data.

b) Photogrammetry

This can be done manually or automatically:

i) Manually, an operator looks at a pair of stereophotos through a stereoplotter and must move two dots together until they appear to be one lying just at the surface of the ground.

ii) Automatically, an instrument calculates the parallax displacement of a large number of points.

Production:

Mappers may prepare digital elevation models in a number of ways, but they frequently use remote sensing rather than direct survey data.

DEMs are commonly built using data collected using remote sensing techniques, but they may also be built from land surveying.

Various methods for obtaining elevation data used to create DEMs:

- LiDAR-Light Detection And Ranging (sometimes Light Imaging, Detection, And Ranging)
- Stereo Photogrammetry from aerial surveys
- Multi-view stereo applied to aerial photography
- Interferometry from RADAR data
- Real Time Kinematic GPS
- Topographic maps
- Theodolite or total station
- Doppler RADAR
- Surveying and mapping Drones range imaging
- Other open source DEM -SRTM, ASTER etc.

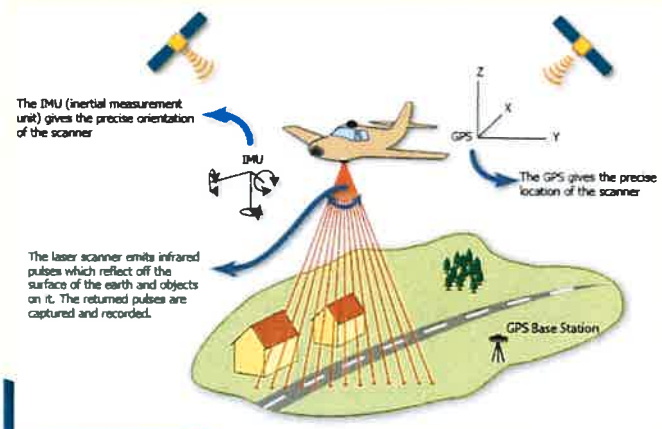
LIDAR and DEM:

➢Light Detection and Ranging (LiDAR) sensors operate on the same principle as that of laser equipment.

➢Pulses are sent from a LASER onboard on aircraft and the scattered pulses are recorded.

➢The time lapse for the returning pulses is used to determine the two-way distance to the object.

LIDAR Scanning -



LIDAR Aircraft, UAV / Drone –

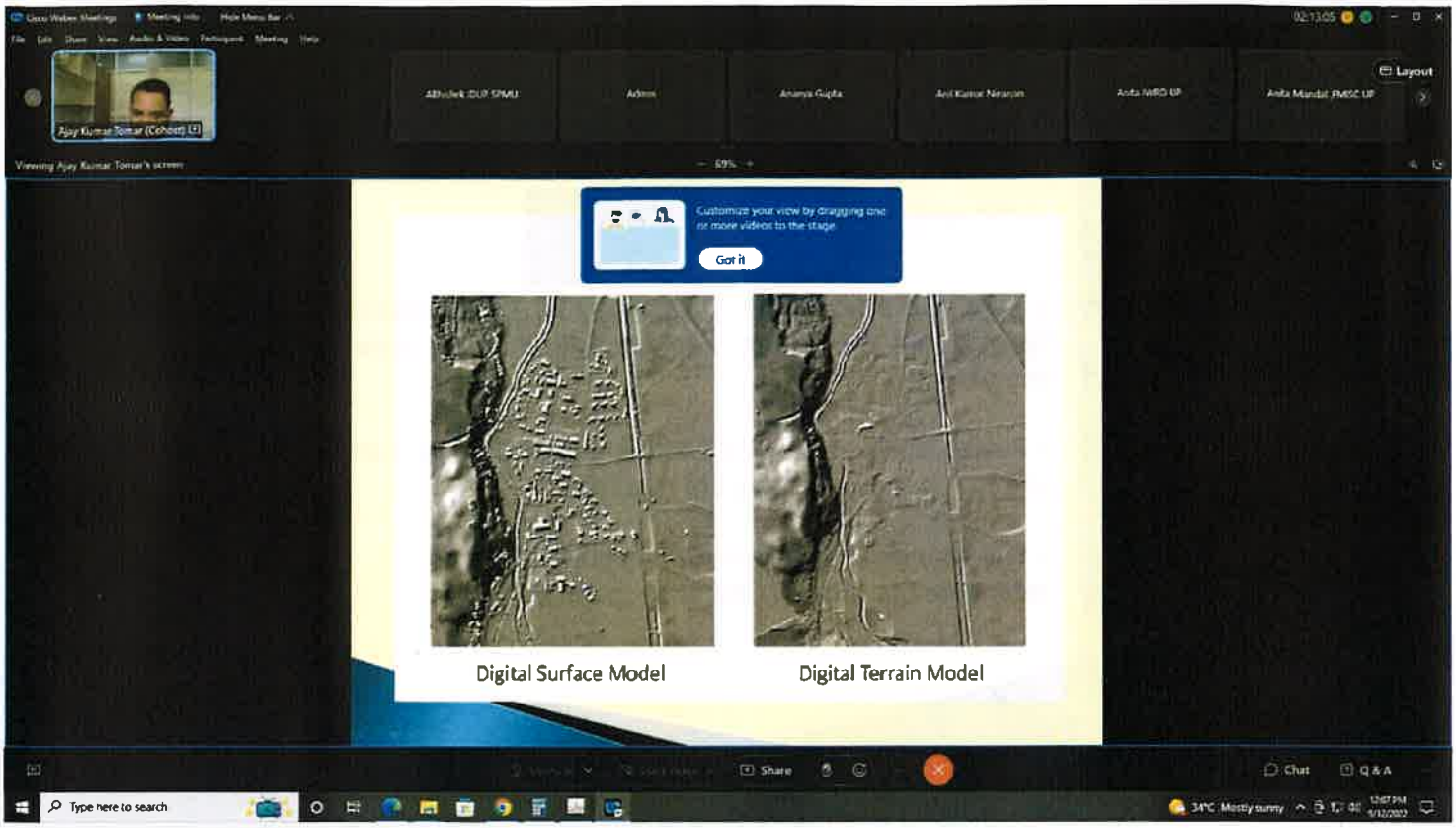
✓ The advantages of LIDAR DEM-

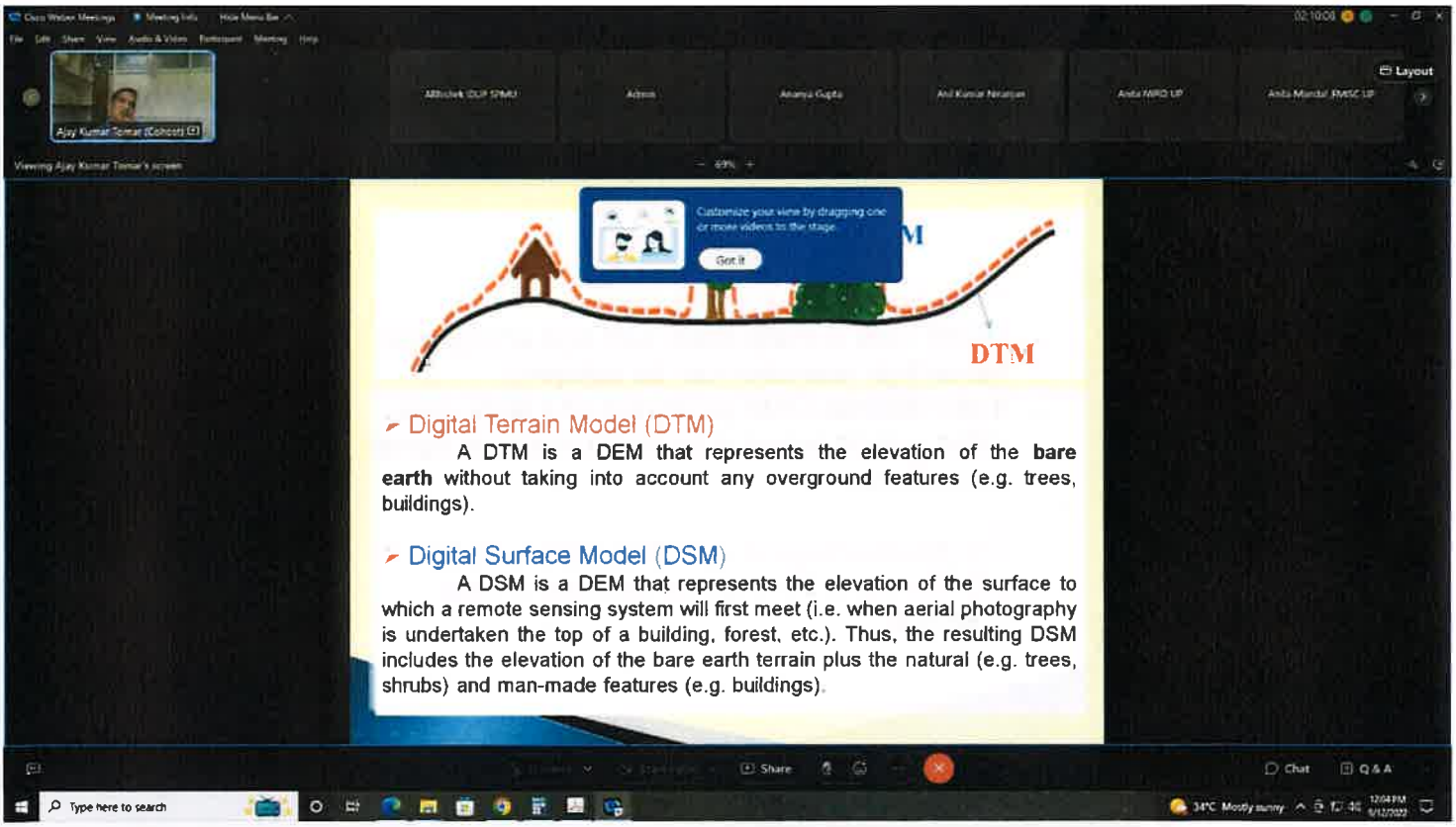
- LiDAR uses a sharp beam with high energy and hence high resolution can be achieved.
- It also enables DEM generation of a large area within a short period of time with minimum human dependence.

✓ The disadvantage of procuring high resolution LIDAR data is the expense involved in data collection.

Thank you ...

TRAINING GLIMPSES



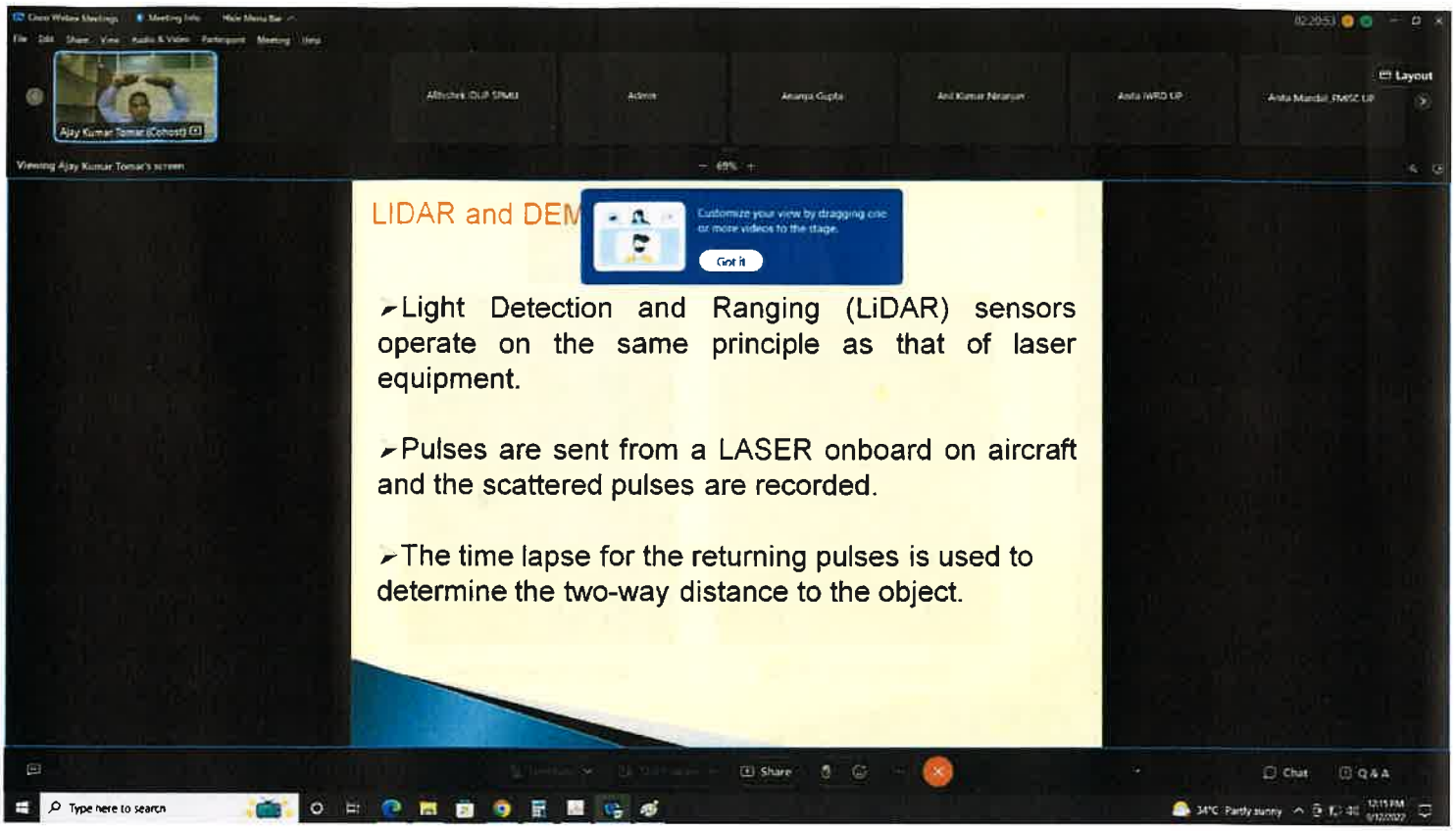


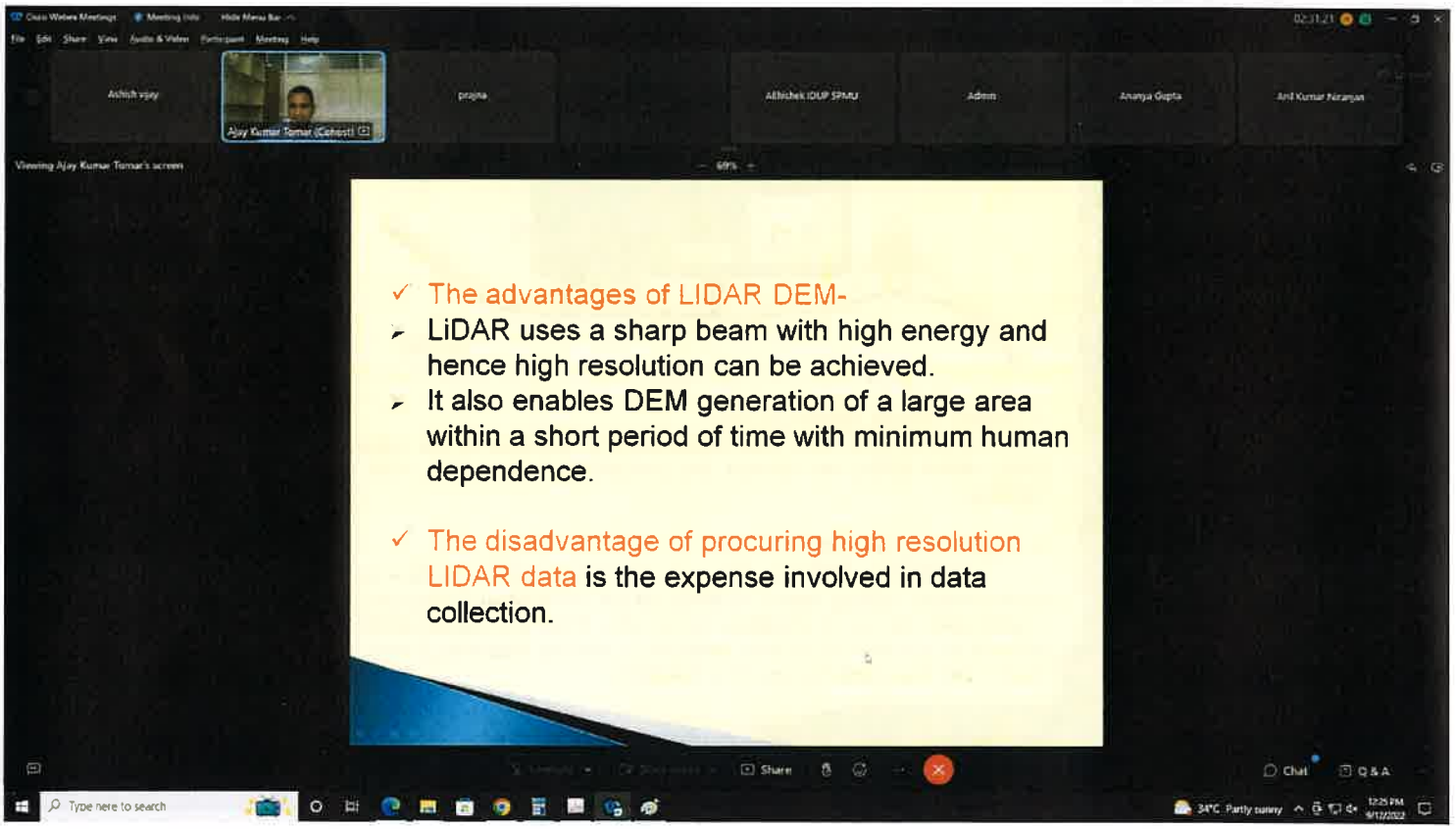
- Digital Terrain Model (DTM)

A DTM is a DEM that represents the elevation of the **bare earth** without taking into account any overground features (e.g. trees, buildings).

- Digital Surface Model (DSM)

A DSM is a DEM that represents the elevation of the surface to which a remote sensing system will first meet (i.e. when aerial photography is undertaken the top of a building, forest, etc.). Thus, the resulting DSM includes the elevation of the bare earth terrain plus the natural (e.g. trees, shrubs) and man-made features (e.g. buildings).


LIDAR and DEM
Customize your view by dragging one or more videos to the stage.
Got it
➢Light Detection and Ranging (LiDAR) sensors operate on the same principle as that of laser equipment.
➢Pulses are sent from a LASER onboard on aircraft and the scattered pulses are recorded.
➢The time lapse for the returning pulses is used to determine the two-way distance to the object.


✓ The advantages of LIDAR DEM-
➢ LiDAR uses a sharp beam with high energy and hence high resolution can be achieved.
➢ It also enables DEM generation of a large area within a short period of time with minimum human dependence.
✓ The disadvantage of procuring high resolution LIDAR data is the expense involved in data collection.

ABSTRACT OF THE TRAINING

The online training on "Introduction to Projection, Datum, Contours and Creation of DEM" was organized at NGDC, Survey of India, Dehradun on 12th September 2022. The aim of the training was to familiarize the officers from various Implementing Agencies under NHP about the technical aspects and use of height, map projection, datum and Creation of DEM. It includes the general introduction about horizontal and vertical control, ellipsoidal, map reading assigning different projections, datum and creation of DEM from various sources.

ONLINE LECTURE ORGANIZED

SNO	TOPIC	LECTURE BY	DATE
1	Introduction to Datum, Projecton, Heights & Contours	Shri Vivek Gupta OS, NGDC, Dehradun	12.09.2022
2	Introduction to DEM & Creation of DEM	Shri Ajay Kumar OS, NGDC, Dehradun	12.09.2022