Data acquisition and integration 2.

Surveying (Geodesy)

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Abstract

Summary: In this chapter, we are discussed on the breakdown of geodesy, brief history of geodesy, types of survey networks, leveling, important measuring tools and equipments, point position methods, and finally the map making, which is an important step of surveying.

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Chapter 2. Surveying (Geodesy)

1. 2.1 Introduction

The definition of the surveying (geodesy) is the "science of measurement and mapping the earth's surface”. This includes determining the geometric shape of the Earth, its gravity field and the orientation of the Earth in space. According to Robert Friedrich Helmert, it is the science of measurement and mapping of the earth's surface (including the determination of Earth's gravity field and sea floor).

In scientific classification the surveying means mainly to surveying engineering. This is particularly evident at the technical universities or universities, which is assigned to the surveying study often differ from the Faculty of Natural Sciences, but the civil engineering. In addition the surveying represents the link between astronomy and geophysics.

2. 2.2 Breakdown of Geodesy

The Geodesy was divided to about 1930 in two areas: - The Higher Geodesy includes (as Physical, Mathematical and Astronomical geodesy), surveying and astronomical methods. - The Geodesy (which works with flat surfaces processing) includes simple construction and cadastral surveying, it is now known more general as a surveying, Applied geodesy, Practical Surveying and property surveying.

The engineering geodesy used depending on the required accuracy of methods in both areas. By 1950, the aerial measurement established as a separate compartment under the name of Photogrammetry - since the 1990s, usually recognized as remote sensing. Starting in 1958, introduced the satellite geodesy.

The databases of the national land surveys developed into geographic information systems (GIS) and Land Information Systems (LIS)further . All these sub-subjects are, however, usually brings in a high school program, which includes the mapping, or at least parts thereof, and a number of other major and minor subjects (such as land tenure). In North America (and the English literature), however, distinguish between Geodesy and Surveying, which is local curricula any more. The name corresponds to our word geodesy is surveying.

The European university-trained surveyors, in addition to the above tasks often take in land valuation, construction, computing, cartography, navigation and spatial information systems. Other training more prevalent - in the real estate industry - with the exception of the land registry.

3. 2.3 Basics and subjects

Geodetic surveying supplies with their results (for example, of cadastral and land surveying, engineering geodesy, photogrammetry and remote sensing), the foundations for many other disciplines and activities: - In geosciences and natural sciences, for example, in astronomy, physics and oceanography, Geoinformatics and land, for maps (in addition to topographic and thematic maps) in geology, geophysics and cartography, as well as for various documentation, such as archeology. - In the technology primarily for building and architecture, for a variety of civil engineering, civil engineering, the geotechnical engineering and related databases and information systems.

The so-called Higher Geodesy (Mathematical Geodesy, Geodesy and Physical Geodesy) deals inter alia with the Earth's figure mathematical, precise references and of the determination of geoid and gravity field. To Geoid determination different measurement techniques is used: gravimetry, geometric and dynamic methods of satellite geodesy and the astrogeodesy. The knowledge of gravity is needed to establish an accurate height system, including on the North Sea or the Adriatic level. The official height system embodies in Hungary the Hungarian head height network (EOMA).

The geoid (or its gradient, the deflection of the vertical) also serves to define and reduce long-range measurements and coordinates on the earth's surface. To triangulate and longer connection lines approached the sea level by a reference ellipsoid and calculates by means of geodetic lines, which are also used in mathematics (differential geometry), and the navigation application. Geoid and gravity field are also important for the Applied Geophysics and the calculation of satellite orbits. Also of Higher Geodesy is the area assigned to the national survey, including regional surveys and their reference systems. These tasks were previously dissolved terrestrial, now growing with the GPS satellites and other methods. The so-called Low Geodesy or Geodesy include the recording of site plans for building design, documentation and creation of digital models for technical projects, the topographical view of the site, the cadastral surveying and areas of facility management.

During time, the ownership of land have complicated (dividing by the purchase and sale or inheritance), then a so-called land readjustment was necessary. The most important instrument is the land consolidation, land improvement. It also serves the uniform distribution of charges where land for large projects (highways, railways) must be applied.

With engineering surveying refers to the technical, non-official survey (such as building layout, establishment of large machines, etc.). In the performance of survey tasks in underground and above ground mining is called mine surveying or mountain surveying. Among the specialized areas of Geodesy also includes the marine surveying, hydrographic surveying and recording hydrographic profiles of rivers, the oceanographic altimetry satellite, and cooperation in the field of navigation.

4. 2.4 Brief History of Geodesy

Geodesy originates the need to allocate land and property boundaries and to document the country's borders. Its history dates back to the "hydraulic society" of ancient Egypt, where the profession of surveyors was after the Nile floods every year for a few weeks to the most important of the country. Man has also given attention since time with the stars and in particular the shape of the earth. At first it was thought the earth was a disk surrounded by the ocean. Pythagoras of Samos (c. 500 BC) said though that the earth is a sphere, but he could not prove his thesis. This was first Aristroteles (c. 350 BC). He proved the theory in the following three practical examples: 1. Only one ball can throw at lunar eclipse is always a round shadow on the moon. 2. When traveling in a north-south direction, the emergence of new stars can be explained only by the spherical shape of the earth. 3. All falling objects are striving for a common focus, namely the center of the earth.

There was a remarkable degree of measurement of the Hellenistic scholar Eratosthenes between Alexandria and Syene (now Assuan) at 240 BC. It states the Earth's circumference to 252 000 Stadium (the ancient measuring unit), which came close to the true value, despite the uncertain distance (estimate 5000 stadium) to about ten percent. The scientist and Alexandrian library director estimated the circumference of the earth by 7.2 degrees from different stages of the Sun. As in Egypt, the surveying requirements of the Maya were amazing, where the Geodesy was apparently strong in astronomy and calendar calculations. Even difficult-tunnel measurements are made from the 1st Millennium BC such as in the 6th Century BC, the tunnel of Eupalinos on Isle of Samos. Important landmarks of the ancient geodesy were also the first world maps of Greece, the observatories in the Middle East and various measuring instruments in a few centers in the eastern Mediterranean. 1023 identified Abu Reyhan Biruni - a universal genius of the then Islamic world - with one he invented new methods of measurement, the radius of the earth on the banks of Kabul river, called Indus pretty much to 6339.6 km (the radius at the equator of the earth is actually 6378, 1 kilometer). At that time in Arabia in the 11th Century, the construction of sun clocks and astrolabes driven to maximum flowering, what in 1300 were able to build by European scientists such as Peuerbach.

With the dawn of modern times ensured the needs of mapping and navigation for a new burst of development, such as the watch and instrument production of Nuremberg or the measurement and calculation methods of the sailors of Portugal. This era also saw the discovery of the trigonometric functions (India and Vienna) and triangulation (Snellius in 1615). New measuring instruments such as the measuring table (Praetorius, Nuremberg 1590), the "Pantometrum" of the Jesuit Athanasius Kircher and the telescope / microscope allowed of the first truly accurate national surveying.

From about 1700 improved the maps again by exact calculation methods (Mathematical Geodesy) and the beginnings of large-scale Geodesy, which saw 1740 with the determination of the ellipsoidal Earth radii by the French Bouguer and Maupertuis. To combine the better results of various projects and land surveying, Roger Joseph Boscovich, Carl Friedrich Gauss, and others developed gradually the equalization.

For the 19th and 20 Century, the most important stages of Geodesy:

- The introduction of the meter, the Greenwich Prime Meridian in 1950 and a global time system based on wireless technology and quartz watches
- The geoid and gravity measurements and cross-links to geophysics

- Iincrease the measurement accuracy to about one hundred times (dm ⇒ mm per km), including further development of theodolite and angle measurement, optical, and later the computer helped electro-optical / electronic distance measurement
- From 1960, the increasing use of satellites and the enormous development of satellite geodesy, which allowed the first intercontinental measurements and realized by 1990, the global systems such as GPS
- From about 1980 through radio astronomy interferometry (VLBI) as the basis of high-precision reference systems such as ITRF, ETRS89 for Global Geodesy and Geodynamics of the Earth's crust.

5. 2.5 Types of the Survey work

- Benchmark fields for position, height
- Horizontal and vertical coordinates of object points and survey points
- Engineering Geodesy
- Geodynamics
- Dimensions and orientation of objects
- Deformation monitoring of objects
- Maps and plans
- Orthophotos
- Data for Geographic Information Systems
- digital terrain models based on representations, such as perspective views
- Visualization of artificial objects

5.1. 2.5.1 Geodetic network

Network (geodetic network) in geodesy is meant an array of measurement points, which are created "net-like" by observations (measurements). Networks can, for example, the area covering one or more countries or being developed for a specific field of work (construction, excavation). These points forms a fixed point as the basis for further field surveys, which are connected to the network and be determined to within a single coordinate system. Depending on whether the location or level of the fixed points is determined, it is called a ground control point field or vertical control network.

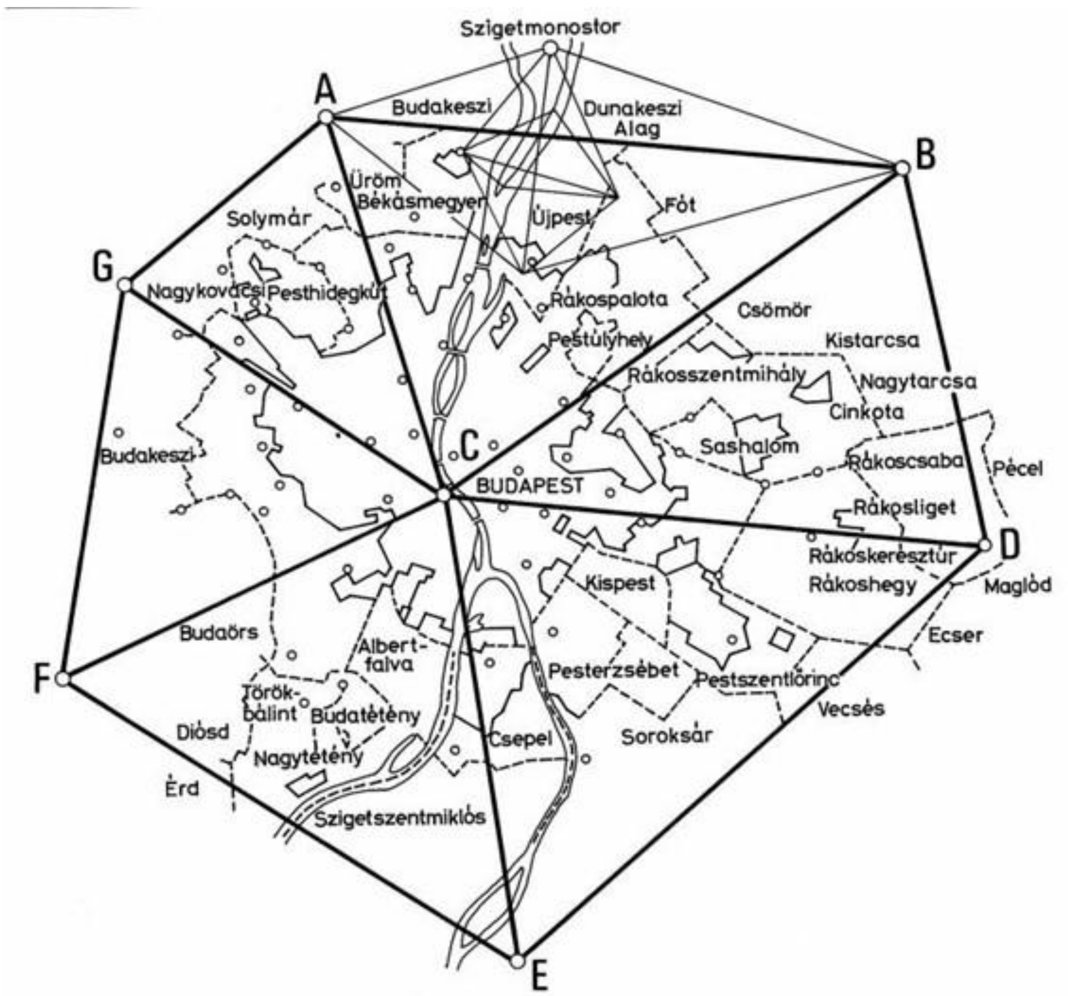


Figure 1. Network around Budapest

1

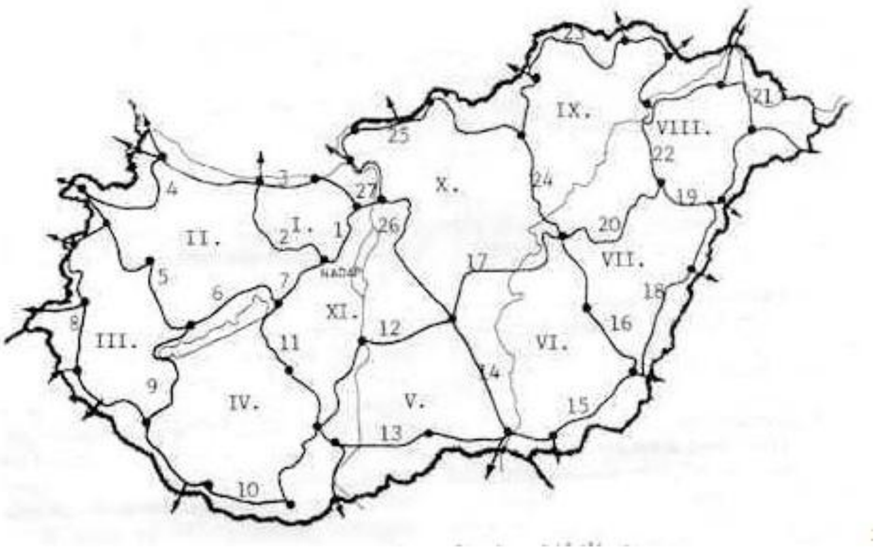


Figure 2. First order Hungarian levelling network

2

[1] http://mek.oszk.hu/02100/02185/html/img/4_104a.jpg
[2] http://www.fomi.hu/honlap/magyar/szaklap/1999/02/1991_02_4.htm

A geodetic network is determine the coordinates of survey points in a chosen reference system. These observations may be:

- directions
- distances
- zenith or elevation angle
- height differences
- three-dimensional vectors in space, derived from GPS measurements (GPS vectors)

Types of geodetic networks

- Triangulation: from every point the directions or angles are measured to adjacent points. To determine the size of the network must be measured along at least one side of the triangle, the length, which was done earlier by basic measurements.
- Trilateral network: for the three side, which are formed between the points of the network are only measured the distances.
- Leveling networks: if only the height to be determined for the measurement points, it is sufficient to calculate the height differences.
- GPS Networks: between points are GPS measurements, the spatial vectors determined (i.e., the coordinate differences in the direction of the x-, y-and z-axis).
- Combined networks: two or more of the above methods are used.

To have control over the measurements are made, the measurements are should be redundant. That means it made more measurements (extra or redundant measurements) than to determine the geometry of the network are necessary. This allows the qualitative statements about the network and performed measurements. The mathematical optimization of the network structure is called the network design.

Surveying monuments:

Monuments are marks on the ground that defines location. This survey control point could me temporary, or permanent.

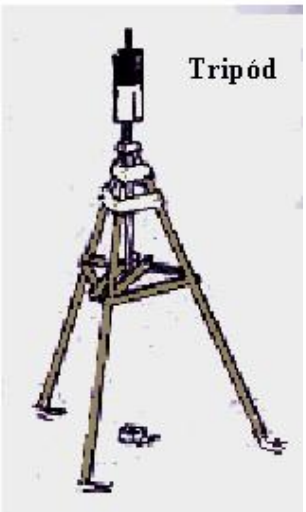


Figure 3. Temporary monument

[3]

[3] http://eki.sze.hu/ejegyzet/ejegyzet/ottofi/7fejezet.htm

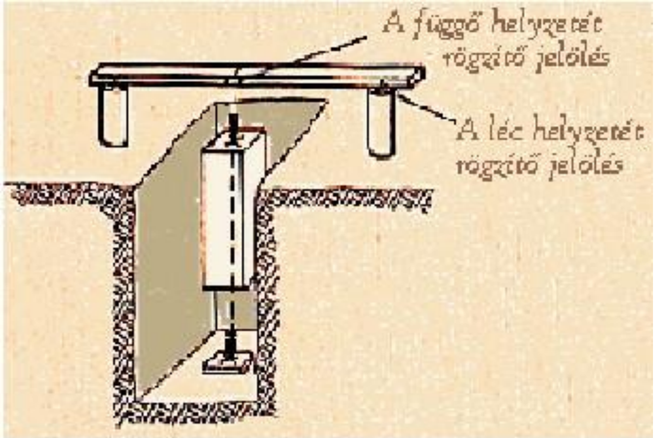


Figure 4. Permanent survey control point

[4]

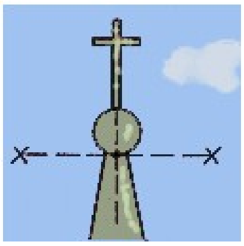


Figure 5. The survey monument could be a church

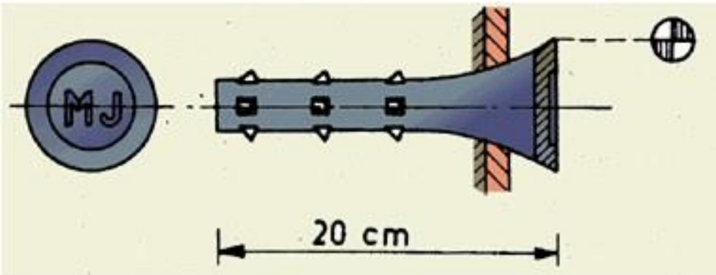


Figure 6. Levelling survey control

[5]

Pegs are commonly used to mark boundary corners, and nails in bitumen, small pegs in the ground (dumpys) and steel rods are used as instrument locations and reference marks, commonly called survey control.

Marks should be durable and long lasting, stable so the marks do not move over time, safe from disturbance and safe to work at. The aim is to provide sufficient marks so some marks will remain for future re-establishment of boundaries. Examples of typical man-made monuments are steel rods, pipes or bars with plastic, aluminum or brass caps containing descriptive markings and often bearing the license number of the surveyor responsible for the establishment of such. The material and marking used on monuments placed to mark boundary corners are often subject to state laws.

5.2. 2.5.2 Leveling

Levelling or leveling is a branch of surveying, the object of which is 1) To find the elevation of a given point with respect to the given or assumed Datum. 2) to establish a point at a given elevation with respect to the given or assumed Datum. Levelling or leveling is the measurement of geodetic height using an optical levelling instrument and a level staff or rod having a numbered scale. Common levelling instruments include the spirit level, the dumpy level, the digital level, and the laser level.

The geometric leveling

[4] http://eki.sze.hu/ejegyzet/ejegyzet/ottofi/7fejezet.htm
[5] http://eki.sze.hu/ejegyzet/ejegyzet/ottofi/9fejezet.htm

The level instrument is at an arbitrary observation point situated between the measurement points. To eliminate systematic influences the earth's curvature and refraction, will be respected. At each measuring point, a leveling rod is placed vertically. For a height difference of greater distance over large height differences, the measurement is divided into sections. A section is a result of each measurement from the known point to the new point. The leveling device is placed between two leveled points.

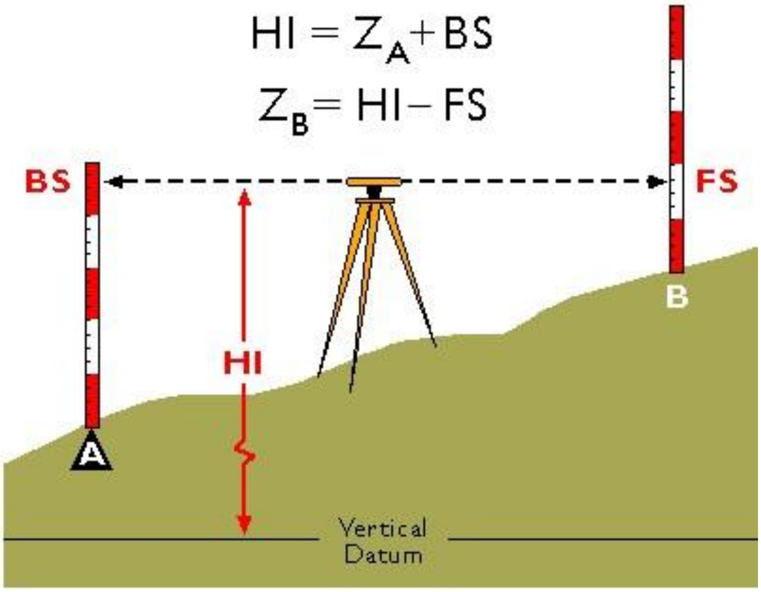


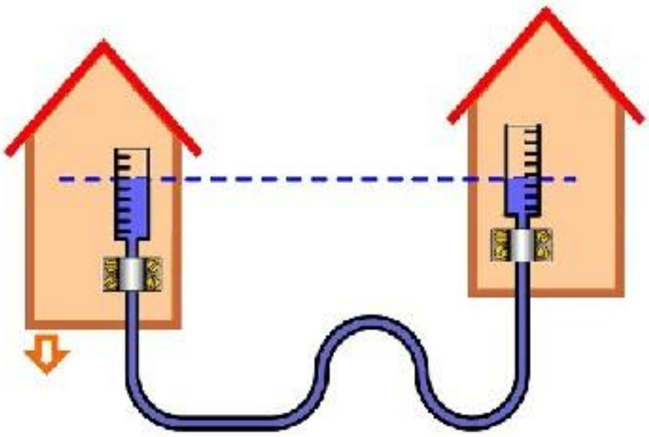
Figure 7. Schema of geometric leveling

[6]

The surveyor first reads a backsight measurement (BS) off of a leveling rod held by his trusty assistant over the benchmark at A. The height of the instrument can be calculated as the sum of the known elevation at the benchmark (ZA) and the backsight height (BS). The assistant then moves the rod to point B. The surveyor rotates the telescope 180°, then reads a foresight (FS) off the rod at B. The elevation at B (ZB) can then be calculated as the difference between the height of the instrument (HI) and the foresight height (FS).

The hydrostatic leveling

Principles of hydrostatic leveling have been known for a long time. The Egyptians are known to have filled ditches with water to transfer elevations. The hydrostatic leveling works on the principle of communicating vessels: are associated with water-filled container at the lowest point through tubes to each other, it turns into an all containers of the same water level. For the practical application of a transparent tube is free of bubbles filled with water almost completely. Now if the two hose ends must be kept about the same height, this raises the water level one at both ends.



[6] https://www.e-education.psu.edu/natureofgeoinfo/c5_p13.html

Figure 8. Principle of hydrostatic leveling

[7]

It is suitable for example for measurements in buildings. For accurate reading offers the precision measurement technology (such as glass cylinder) with a corresponding reading device or electronic data capture. Thus, the hydrostatic leveling is handy for the computer-based remote monitoring of building movement. The hydrostatic leveling can bridge distances up to 20 km between the measuring points. The accuracy is better than 0.02 mm, the overall accuracy for distances of several kilometers better than 1 mm. To achieve such high accuracy over long distances, however, have influences such as temperature differences in the liquid.

Trigonometric leveling

In the trigonometric leveling is with surveying instruments (theodolites, total stations, etc.) the zenith angle (Z) and slope distance (S') measured at the measuring point. The height difference is then a simple approximation to the geometric formula

$dh = s' * \cos z$

is calculated.

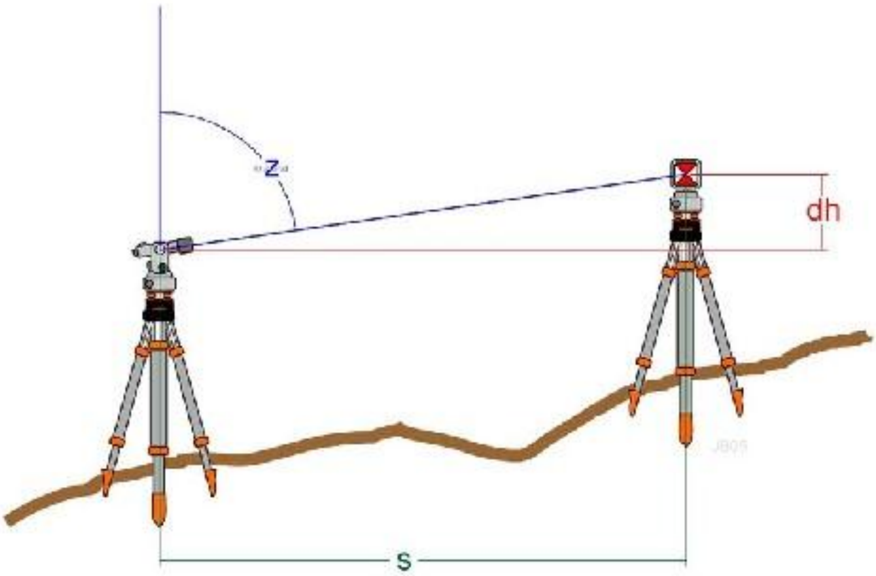


Figure 9. Trigonometric leveling For target distances over 200 m, the curvature of the earth and terrestrial refraction is taken into account.

[8]

With the barometric height determination, the air pressure difference is measured and used to calculate the height difference.

[7] http://de.wikipedia.org/w/index.php?title=Datei:Hydrostatisches_Nivellement.jpg&filetimestamp=20051208121124
[8] http://de.wikipedia.org/w/index.php?title=Datei:Trigonometrisches_Nivellement.jpg&filetimestamp=20051208142927

Engineering Geodesy

The engineering geodesy means that part of applied geodesy, with the precise survey work in connection with the planning, building and monitoring of technical objects (machinery and equipment) and structures. The engineering geodesy therefore always in close contact with neighboring disciplines such as geology, construction and mechanical engineering. Almost all the tasks of engineering geodesy can be attributed to the determination of geometrical parameters (position, shape, dimensions) and their changes over time. This is usually through the measurement of individual, or a really distributed measurement points. The main task to be considered here also be modeling the measurements and their adjustment.

Examples from the machinery and equipment

- Operate electron synchrotron (such as CERN and DESY)
- Control of industrial robots in the automotive industry
- Quality control, surface inspection
- Aircraft - and shipbuilding

Examples from the construction

- The engineering survey will be used at the planning stage of these objects. In this phase, the creation of a basic network in the foreground, on the basis of the subsequent demarcation (i.e. the transfer of the plan as survey points in nature). During construction, and the final measurement for quality control and building inspection is carried out. Continuous or periodic monitoring measurements are adequate for large projects (e.g. dams) and bridges. This area of engineering surveying is also referred to as deformation monitoring.
- Engineering navigation: machine control e.g. of tunnel boring machines, sliding machines (concrete pavers and pavers).

Examples from the Geomonitoring

In unstable conditions of the mountain slopes are also monitoring for the protection of man and nature. Depending on the knowledge of the rates of movement such monitoring measurements are done periodically or permanently. The permanent monitoring enjoy the benefit from the technical development of sensors and communication systems, automatic monitoring systems).

6. 2.6 Important measuring tools and equipments

Theodolite

A theodolite is a precision instrument for measuring angles in the horizontal and vertical planes. Theodolites are mainly used for surveying applications, and have been adapted for specialized purposes in fields like meteorology and rocket launch technology. A modern theodolite consists of a movable telescope mounted within two perpendicular axes — the horizontal axis, and the vertical axis. When the telescope is pointed at a target object, the angle of each of these axes can be measured with great precision, typically to seconds of arc.

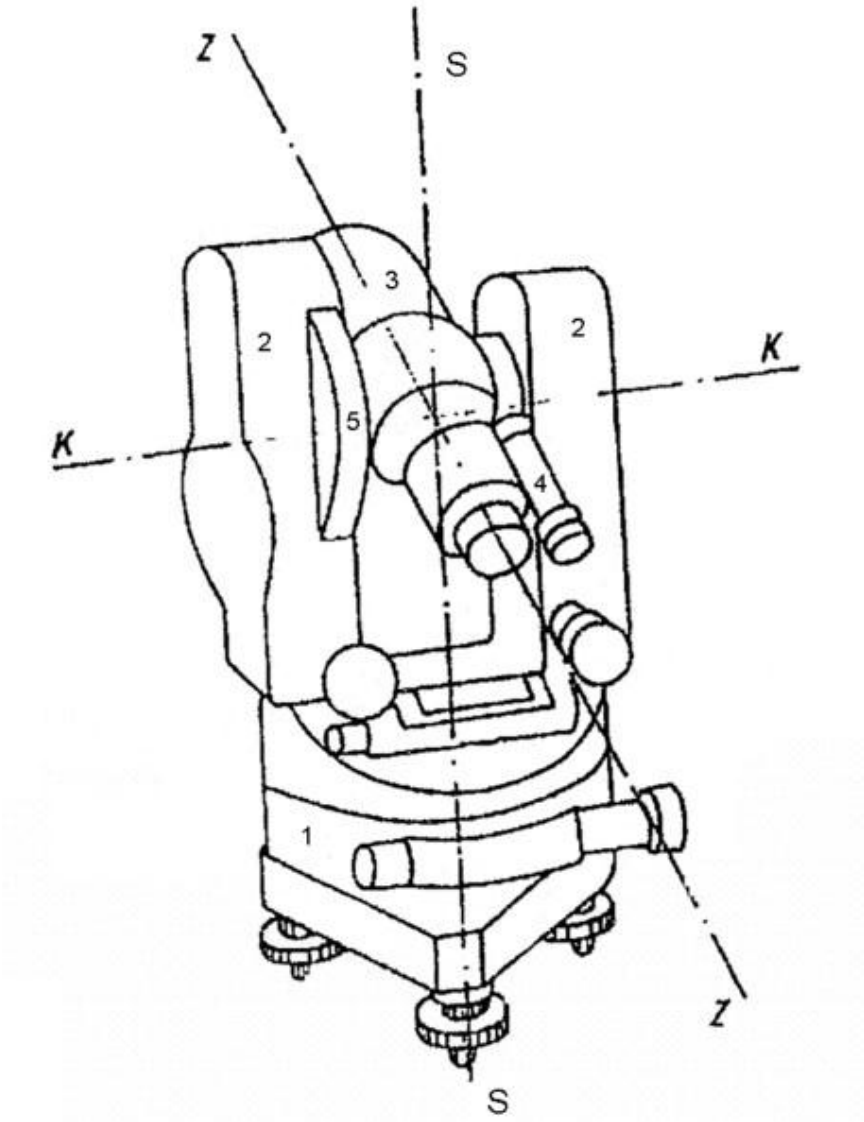
Figure 10. The soviet optical theodolite built in 1958

[9]

Depending on the accuracy and purpose, a distinction is made between

- Theodolite (robust and light, about ± 10 " precision)
- Tachymeter (including analogue distance measurement, since ~ 1990 mostly digital readout and automatic tilt compensation of the vertical axis)
- Precision or Sekundentheodolit (± 1 ", for engineering geodesy)
- And the universal instrument (± 0.1 ", for example DKM3 and wild T4) for astro-geodesy.

[9] http://en.wikipedia.org/wiki/File:SovietTheodolite.jpg



[10]

The basic plate or limbus contains the horizontal circle (1) and the vertical axis (S). He wears the alidade (Arabic), the top of theodolite consists of two supports (2), the horizontal tilt axis (K), the telescope (3), the circle reading (4) and the vertical circle (5). The telescope has a reticule (reticule in the eyepiece), by which the target axis (Z) is defined, and an internal lens to focus.

The base sits on the base plate which is mounted on a tripod and leveled with three leveling screws and spirit level. The centering of the measuring point is made by moving the instrument to the horizontal tripod plate, then tight by the mounting screw of the tripod from the bottom.

[10] http://de.wikipedia.org/w/index.php?title=Datei:Theodolit_Schema.PNG&filetimestamp=20051123023705

Figure 11. The surveyor's tripod

[11]

The main Theodolite errors:

- The trunnion axis is not perpendicular to the vertical axis.
- The line of sight is not perpendicular to the trunnion axis.
- The vertical axis is not plumb.
- The vertical angle collimation is out of adjustment.

Total station

A total station is an electronic/optical instrument used in modern surveying. The total station is an electronic theodolite integrated with an electronic distance meter (EDM) to read slope distances from the instrument to a particular point.

[11] http://en.wikipedia.org/wiki/File:Surveyors_tripod.jpg

Figure 12. Total station

[12]

Modern total stations are equipped with optional laser rangefinder that can measure on almost any reflector surface. Range and accuracy of this so-called DR measurement (direct reflex) are somewhat lower than that of the infrared measurements on triple mirror, so both methods are used side by side. The accuracy is mainly depend on the nature of the targeted surface in terms of its reflection properties (so the bright areas are far better than dark). The different tachometer models of the various manufacturers offer depending on the device class ranges from 15 to just over 2000 m.

Data processing

The measurement of destination (direction and distance) is fully automatic. For data storage are usually connected peripheral computer. In modern total stations are processors and corresponding memory often integrated. The data (three-dimensional measuring points) can now be exported in two dimensions using appropriate computer programs (such as architectural survey of facade / floor plans) and also mapped in three dimensions and as a dxf file.

Robotic total station

The latest generation of total stations has electrically driven lateral and vertical axes. These include allowing the automatic sighting of the triple mirror and target tracking. In addition, a total station can survey a series of

[12] http://en.wikipedia.org/wiki/File:Teodolit_nikon_520.jpg

several pre-defined points automatically. In this way, for example, the deformations of the arch dam or other constructions can be monitored.

Figure 13. The robotic total station with GPS receiver equipped

13

GPS is a "Global Positioning System." It is a technique for determining positions and elevations on earth. For maximum accuracy, a GPS total station takes help of a number of satellites. Depending upon the quality of the GPS survey equipment, the accuracy can differ from about +/- 30 meters for inexpensive hand held receivers, to only +/- 1 centimeter for sophisticated systems using a base station located at a known position on earth to give a reference signal. This technique is known as "differential processing".

Imaging total station

The total stations of the future rely on the use of visual information during the measurement. The test image is a partly used for documentation purposes, on the other hand, it can be actively integrated into the measurement process. The sighting of the points must no longer take the eyepiece, but can be made directly in the image. Digital zoom or optical zoom functions allow even the exact fine sighting. The measurement can to run from the tachymeter directly or via WLAN to the field computer or PC. Built-in scanning features allow the planar scanning of targets and thus help in creating photo-realistic 3D models.

[13] http://www.thetestequipment.com/articles/gps-total-station.html

Figure 14. The imaging total station

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GPS and Laser scanner

Because the next chapter is fully about GPS and Laser scanner, we don’t discussing on it anymore.

Gyrotheodolite

A gyrotheodolite is used when the north-south reference bearing of the meridian is required in the absence of astronomical star sights. This mainly occurs in the underground mining industry and in tunnel engineering. A gyrotheodolite can be operated at the surface and then again at the foot of the shafts to identify the directions needed to tunnel between the base of the two shafts. Unlike an artificial horizon or inertial navigation system, a gyrotheodolite cannot be relocated while it is operating. It must be restarted again at each site.

[14] http://www.siteprepmag.com/Articles/Products/2010/10/05/Leica-Reveals-Viva-TS15-Robotic-Imaging-Total-Station

Figure 15. Upper mounted gyrothedolite

[15]

The gyrotheodolite comprises a normal theodolite with an attachment that contains a gyroscope mounted so as to sense rotation of the Earth and from that the alignment of the meridian. The meridian is the plane that contains both the axis of the Earth's rotation and the observer. The intersection of the meridian plane with the horizontal contains the true north-south geographic reference bearing required. The gyrotheodolite is usually referred to as being able to determine or find true north.[16]

Leveling instruments

A dumpy level, builder's auto level, leveling instrument, or automatic level is an optical instrument used in surveying and building to transfer, measure, or set horizontal levels. This has the leveling a telescopic sight, the target axis by means of a precision spirit level or similar device - now mostly a pendulum compensator - is aligned perpendicular to the perpendicular direction. The telescopic sight is perpendicular to the vertical axis free to rotate, therefore can be looked round with a horizontal line of sight. Any two points located in this horizon have the same height. A **dumpy level** is an older-style instrument that requires skilled use to set accurately. The instrument requires to be set level in each quadrant, to ensure it is accurate through a full 360° traverse. Some dumpy levels will have a bubble level ensuring an accurate level.

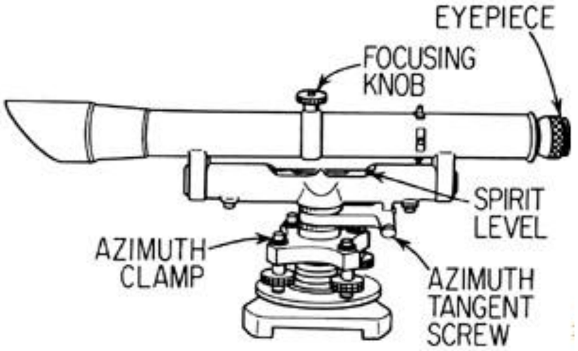

Figure 16. The functionality of dumpy level

[15] http://www.ismdhanbad.ac.in/depart/mining/facility.htm
[16] http://en.wikipedia.org/wiki/Theodolite

17

The **self-leveling** instrument instead of the telescope level has a compensator (for the automatic leveling control of sight line). This consists of optical-mechanical components, which are inserted into the beam of the telescope. Through these components, the sight line is automatically horizontally in a small range. Because of the limited workspace of the expansion joints with a compensator, the bubble is required.

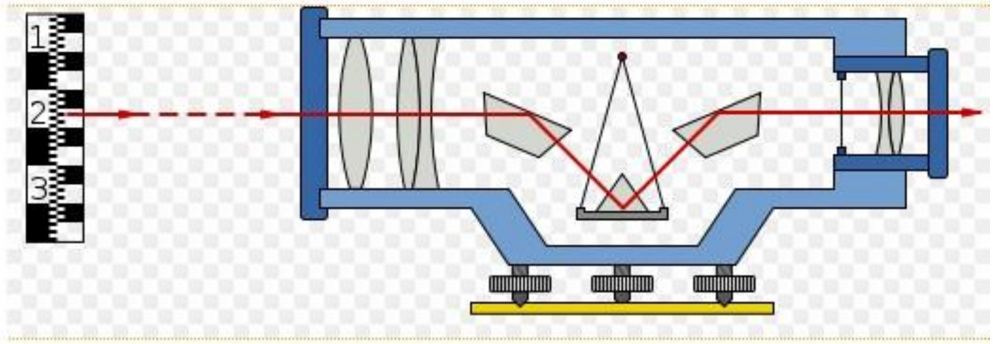

Figure 17. The principle of compensator

18

A **digital electronic level** is also set level on a tripod and reads a bar-coded staff using electronic laser methods. The height of the staff where the level beam crosses the staff is shown on a digital display. This type of level removes interpolation of graduation by a person, thus removing a source of error and increasing accuracy.

Figure 18. Digital electronic level instrument

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[17] http://www.answers.com/topic/dumpy-level
[18] http://en.wikipedia.org/wiki/File:Automatic_Level.svg
[19] http://www.surveyequipment.com/levels/digital-levels

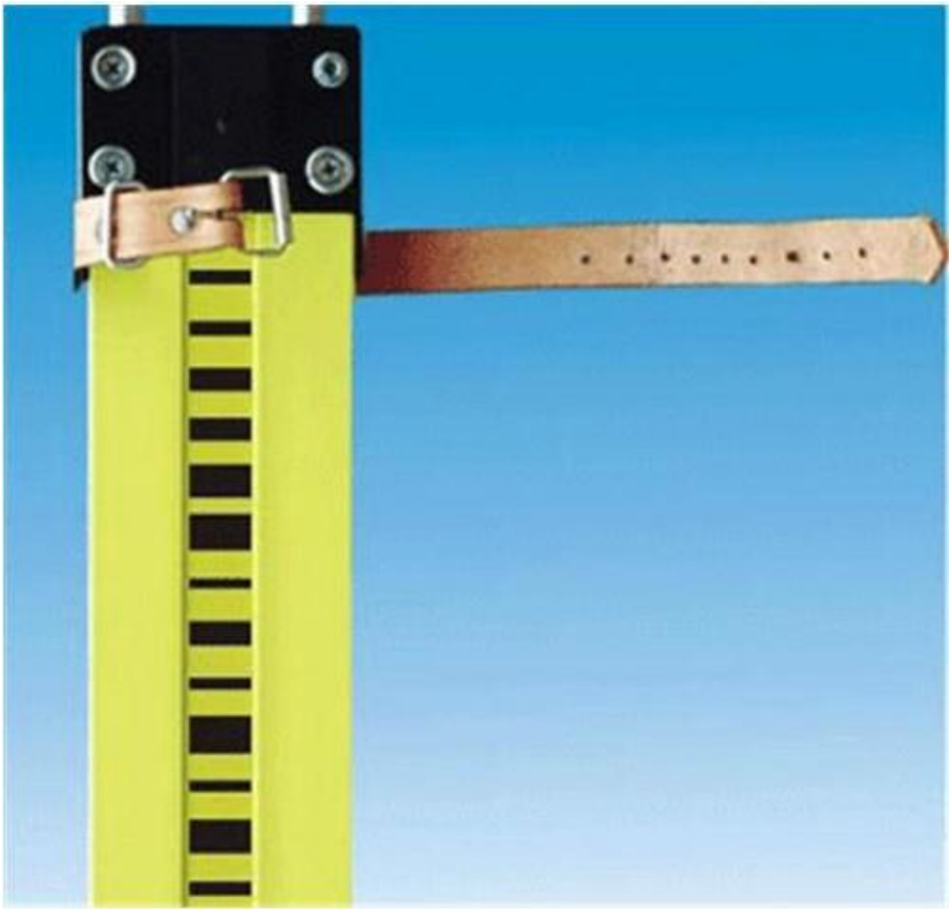


Figure 19. Accurate invar bar code leveling staff

[20]

7. 2.7 Main point position methods of geodesy

Point positioning is the determination of the coordinates of a point on land, at sea, or in space with respect to a coordinate system. Point position is solved by computation from measurements linking the known positions of terrestrial or extraterrestrial points with the unknown terrestrial position. This may involve transformations between or among astronomical and terrestrial coordinate systems. One purpose of point positioning is the provision of known points for mapping measurements, also known as (horizontal and vertical) control. In every country, thousands of such known points exist and are normally documented by the national mapping agencies. Surveyors involved in real estate and insurance will use these to tie their local measurements to.[21]

The direction measurement is a fundamental task of geodesy, geometry, navigation, and other areas of technology. It means the angle measured to determine the horizontal angle measuring beams oriented courses or in a reference system. Directions and distances are the most important metrics for tracking of vehicles and for the determination of points in a coordinate system. The distance measurement or length measurement means to measure the distance between two points in space by direct or indirect comparison with a length unit such as the meter.

Geodetic network

In geodesy the network is meant an array of measured points. Networks can, for example, covering one or more countries or being developed for a specific field of work (construction, excavation). The points forms a fixed point as the basis for further field surveys, which are connected to the network and be determined to within a single coordinate system. Depending on whether the location or level of the fixed points is determined, it is called a ground control point field or vertical control point field.

[20] http://www.tradevv.com/chinasuppliers/zfyqyb_p_1716e8/china-Accurate-invar-bar-code-leveling-staff-top-shell.html
[21] http://en.wikipedia.org/wiki/Geodesy

A geodetic network is used to determine the coordinates of survey points in a chosen reference system. The observations between the points is determined by the figure of the network.

These observations may be:

- directions
- distances
- zenith or elevation angle
- height differences
- three-dimensional spatial vectors, derived from GPS measurements (GPS vectors)

To have control over the measurements taken to make qualitative statements about the network and performed measurements, the measurements are made redundant. That means it made more measurements (supernumerary measurements) than to determine the geometry of the network are necessary. The mathematical optimization of the network structure is called network design.

Traverse

Traverse is a method in the field of surveying to establish control networks.[1] It is also used in geodesy. Traverse networks involved placing survey stations along a line or path of travel, and then using the previously surveyed points as a base for observing the next point.[22]

Traverse networks have many advantages, including:

- Less reconnaissance and organization needed;
- While in other systems, which may require the survey to be performed along a rigid polygon shape, the traverse can change to any shape and thus can accommodate a great deal of different terrains;
- Only a few observations need to be taken at each station, whereas in other survey networks a great deal of angular and linear observations need to be made and considered;
- Traverse networks are free of the strength of figure considerations that happen in triangular systems;
- Scale error does not add up as the traverse is performed. Azimuth swing errors can also be reduced by increasing the distance between stations.

The types of traverses:

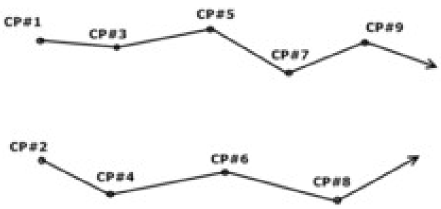


Figure 20. Open / free traverse

[23]

[22] B. C. Punmia, Ashok Kumar Jain (2005). Surveying. Firewall Media
[23] http://en.wikipedia.org/wiki/Traverse_%28surveying%29

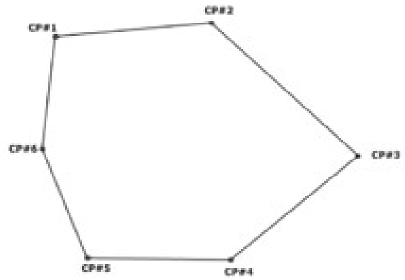


Figure 21. Closed / compound traverse

[24]

There is several rules of right traversing.

To ensure accurate results, the following should be considered:

- The distances to the traverse points should not be larger than the distances to the given points.
- All measurements should be carried out controlled:

o There should be more given point measurements are performed at least as necessary.

o traverse points should be adequate from multiple viewpoints

o be controlled the sum of angles.

Resection

The resection has become a popular method for quickly creating measured points by total stations, because these instruments can observe both angles and distances, and their built in computer can provide the least-squares solution for the instrument's position.

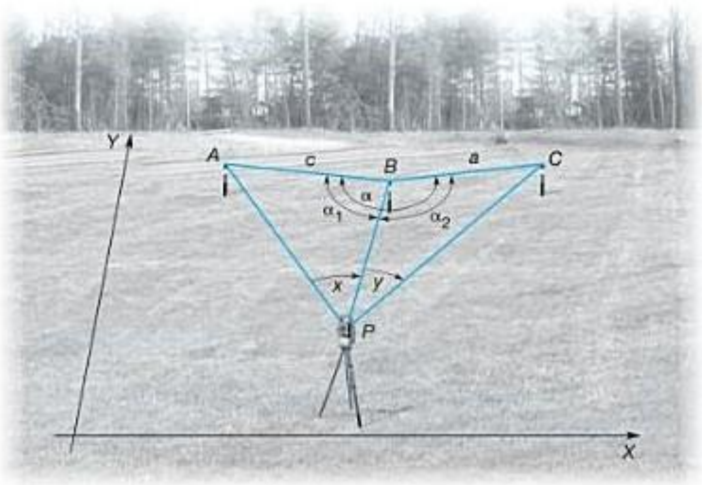


Figure 22. The situation of resection

[25]

The calculation is made of the coordinates of the point and the object points are from polar coordinates (direction and distance). It is performed usually with a computer program in the field by a coordinate transformation. The Helmert transformation can be used. Because of the mathematical overdetermination in the transformation resulting in the deviations in the coordinates (residuals) between the coordinates of the connection points (ground control point field) and the coordinates in the system of measurement. It should be noted, that the resection problem will not have a unique solutions if points A,B,C and P define a circle (i.e.

[24] http://en.wikipedia.org/wiki/Traverse_%28surveying%29
[25] Charles D. Ghilani,Paul R. Wolf Elementary Surveying: An Introduction to Geomatics

dangerous circle). Another problem, that the accuracy of the position P will decrease, when the observed angles x and y are less than 30˚.

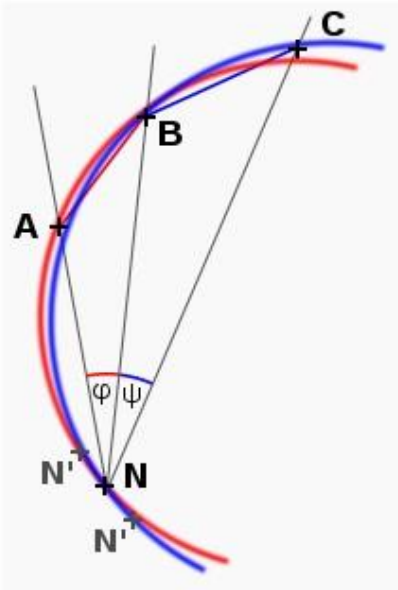
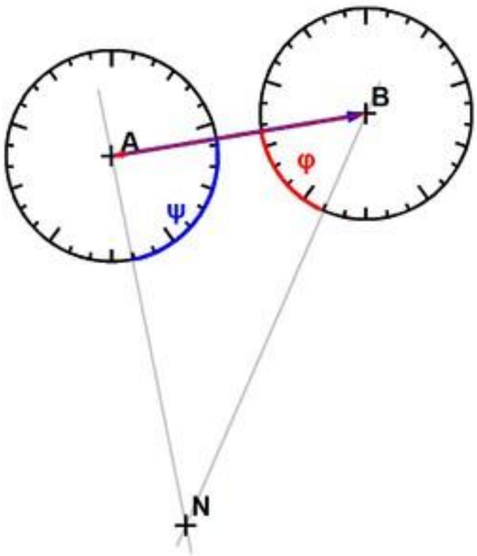


Figure 23. The dangerous circle

[26]

Forward section

The forward section is a trigonometric method of determining point in geodesy. This is done by directional measurements from two locations A and B to a new point N. The coordinates of the two points A and B must be known.



[27]

The calculation is made by resolution of the triangle ABN or by calculating the intersection of the two N distance that extend from the respective position of A and B to the new point.

8. 2.8 Map making (cartography)

A map is a digital or analog medium for representing the earth or other celestial body. There are two main types of maps: topographic maps (maps of Earth, maps of the Moon ...) and thematic maps. Representation spaces of a

[26] http://de.wikipedia.org/wiki/R%C3%BCckw%C3%A4rtsschnitt
[27] http://de.wikipedia.org/wiki/Vorw%C3%A4rtsschnitt

map are, above all the earth and the continents. The science and technology to represent the earth's surface in topographic and thematic maps, is the cartography. Traditionally, a map is printed on paper, with its thematic layers, such as terrain, rivers, roads, forests, etc. are applied in multiple colors.

Figure 24. The traditional form of map

28

Today, the layers are not archived as print films, but in a database (geographic information system) is stored. The map can be presented on a screen and are updated more easily. A digital map also allows the inclusion of other visual and acoustic media to the interactive communication with the user.

Figure 25. Dynamic digital map

29

[28] http://printscreen.eastway.hu/news/analog-zoom-terkepen
[29] http://ddm.geo.umass.edu/ddmmappage.html

The map is the result of a complex workflow. The map made from available spatial data, so-called geodetic data or spatial data.

Types of the maps

Maps are used for orientation and navigation on land, water and air. They are also used for planning. It can be using measure or estimate distances, angles or surfaces. Map can serve as an aid compass, divider line, area meter or ruler. Since the map is a flat image of the curved surface, it cannot be both equal area, length and angle-preserving true - only one world makes such a realistic representation of the geometric relationships. Maps can be classified according to various criteria.

Data storage and presentation

They allow a distinction between analog maps and digital maps. Analog maps are called „classical maps" on an original character holder (copper plate, engraved glass, engraved foil) and are usually printed on paper or any other suitable character carrier.

Figure 26. Engraved map of Hungary by Lazarus

[30]

Digital maps are in raster format or vector format electronically stored on a disk. This type of maps can be using electronic equipment spending in various forms, for example, a touch screen in the "computer to plate" process on a screen or display of a navigation system or a mobile phone.

[30] http://lazarus.elte.hu/hun/dolgozo/jesus/970117/images/lazar.jpg

Figure 27. Car navigation system

[31]

Scale ratio

You can classify maps according to their scale. There is talk of a large scale if the scale denominator is small, however, from a small scale when the scale denominator is large. Map scale is the relationship between distance on a map and distance in the real world. There are several ways to specify map scale. Often we find the scale of a map expressed in words like, "one centimeter equals one kilometer". You've most likely seen map scale depicted with a graphic, like a bar divided up into segments. The length of a segment represents some distance on the earth.

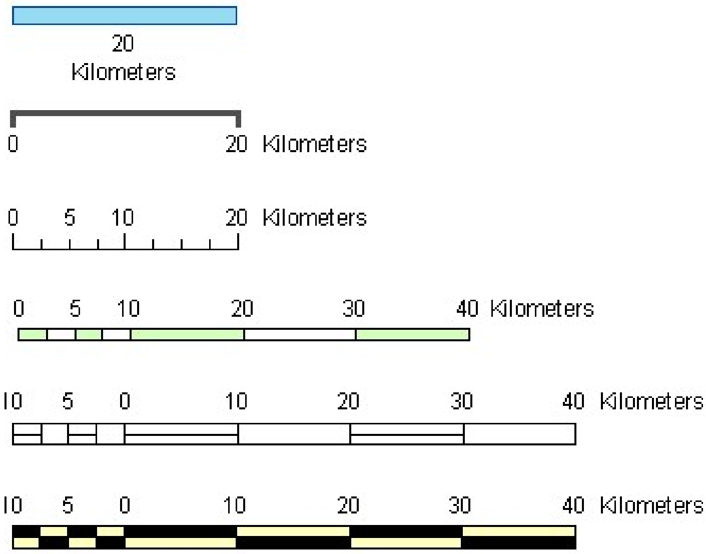


Figure 28. Different scale bars

[32]

We can specify scale as a representative fraction as well. These fractions often appear as follows: 1:10000. The fraction means that one unit of measurement on a map represents 10000 units in the real world. It's important to remember that the same units of measurement are on either side of the colon. That is, 1 centimeter represents 10000 centimeters, or 1 decimeter represents 10000 decimeters. To calculate the distance between two points, one simply measures the map distance and multiplies it by the number of "real world" units. For example, if the measured distance between two points on a map with a scale of 1:25000 is 1.5 centimeters, then the real world distance is 1.5 times 25000 or 375 meters (37500 centimeters). The topographic maps is called up to a scale of

[31] http://www.smh.com.au/news/security/hackers-could-give-you-a-bum-steer/2007/08/03/1185648154676.html
[32] http://www2.bc.cc.ca.us/cs/cmesel/Carto_Design/lesson1/mod01_les01_top02_1.html

1:10,000 as a large scale or as a topographic base maps, such as medium scale with a scale of 1:25,000 to 1:100,000. Topographic maps with a scale of 1:200,000 or smaller designated as an overview topographic map.

Figure 29. Large scale topographic map

[33]

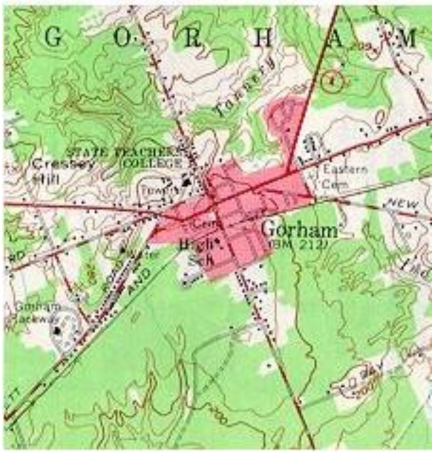


Figure 30. Medium scale map of the same area

[34]

Figure 31. Small scale map

[35]

Thematic maps

[33] http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/essentials/scale.html
[34] http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/essentials/scale.html
[35] http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/essentials/scale.html

The main theme of the represented spatial phenomena is a common distinguishing feature for this type of maps. In a first approximation, we have so different topographic maps of thematic maps. A more sophisticated approach instead of talking about topographic maps and base maps and thematic maps allowed for the further distinctions, such as aeronautical charts, nautical charts, geoscientific maps, business maps, political maps, historical (history) maps. (The term historical map is not unique, since it is used colloquially for obsolete, outdated maps.) The representation area of a map is another distinguishing factor.

Figure 32. Thematic map of ozone concentration

36

Space or area

There are, for example, world maps, maps of Europe, country maps, city maps and sky maps, maps of the moon, Mars maps, etc.

Figure 33. World map

37

[36]http://mapcatalog2008.blogspot.com/2008_08_01_archive.html

Figure 34. Lunar map

[38]

Historical map

After the specified degree of compliance of map content and real world we can distinguish between current map and outdated maps (old maps). The name historical map reserved and should not be used for old maps**.**

Figure 35. Historical map of central Europe

[39]

User groups or applications They allow a distinction of maps, for example in car (driver) maps, biker maps, navigation charts, school cards, etc. This category includes blank cards that are designed as tactile maps of army.

[37] http://www.mapsofworld.com/world-political-map.htm
[38] http://www.georgeglazer.com/maps/celestial/homann/homannmoon.html
[39] http://www.lib.utexas.edu/maps/historical/history_europe.html

Figure 36. Mountain bike map

[40]

Figure 37. Tactical map

[41]

By the editor of the map

After the editor of a map is divided into official maps and maps of the commercial cartography. Official map issued by a public institution in public affairs. They serve the public interest and security is often based on a law or regulation. The commercial maps issued are for the market and business to consumers (in the tourism sector, leisure maps, tourist maps etc. This distinction is not always as well as many national surveying authorities hand over the market for the specific maps. There is also a large number of scientific special cards that are produced by universities and other scientific institutions in the research and a limited group of users are usually provided.

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[40] http://www.redfoxcabin.com/mountain_bike_map.html
[41] http://www.blackcatstudio.net/sstorm.html

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