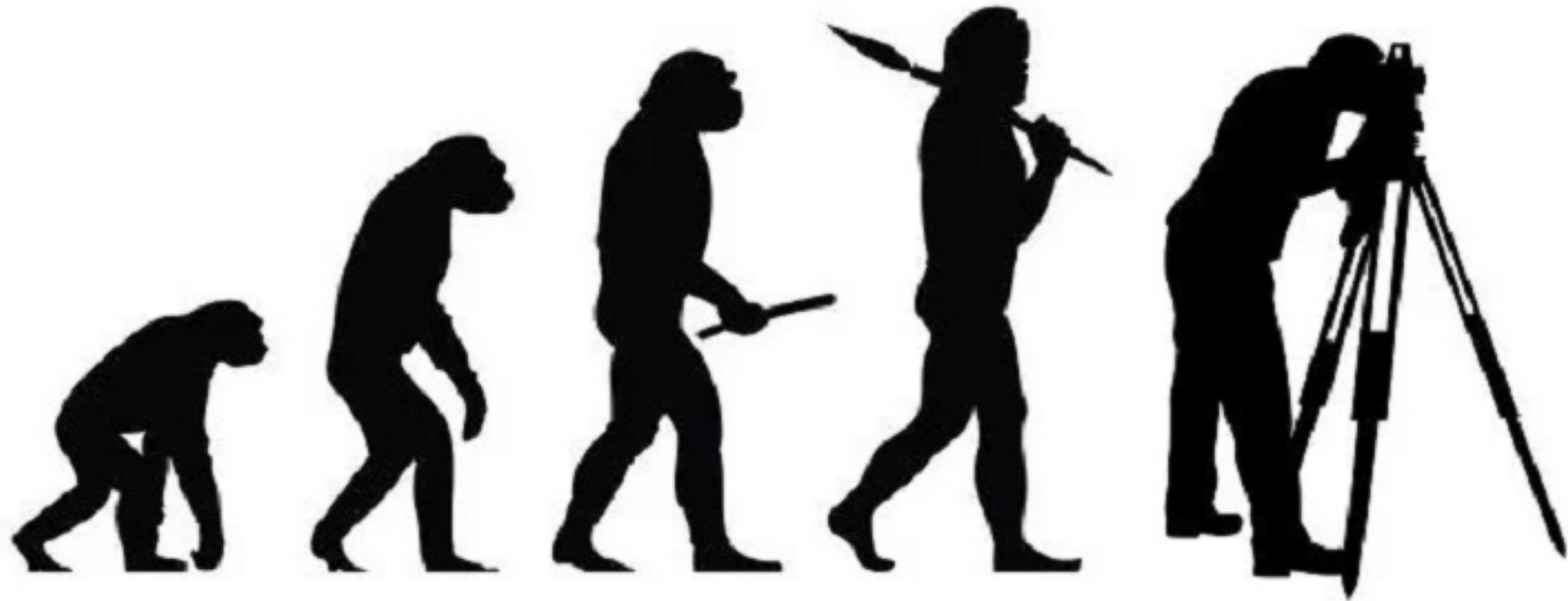


Lecture 7: Digital Surveying



<https://www.satpalda.com/blogs/evolution-in-surveying-techniques>

Assessment

Submission
deadline:

9th December 2019

Return date of provisional
marks & written feedback:

27th Jan 2020

Essay (2000 words)

There are two parts to be considered for the essay and these are to be approached in equal weighting.

Part 1

Outline a **brief history of surveying**, describing different measurement and surveying techniques from antiquity to the modern era.

Part 2

Consider **two forms** of current digital surveying technologies in detail, giving examples of appropriate applications within the Construction Industry.

The essay can incorporate the use of diagrams and figures to illustrate the text.

A list of references is required and all referencing is to be clearly indicated throughout the essay.

Assessment

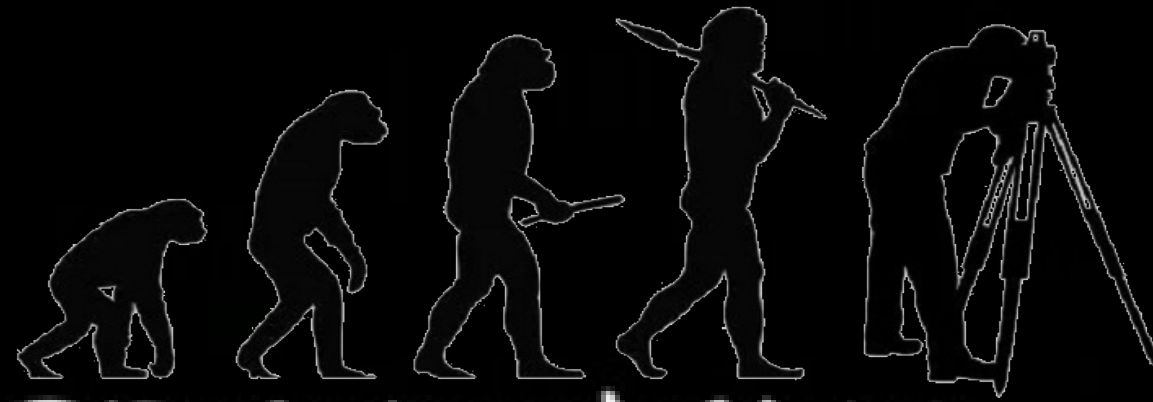
Submission
deadline:

9th December 2019

Return date of provisional
marks & written feedback:

27th Jan 2020

- *Use appropriate sources and compile make sure to reference any material.*
- *Demonstrate your understanding of the methods and techniques of surveying over time.*
- *Show how the techniques are used on site. Give real life examples.*
- *Demonstrate through your examples, practical application and be sure to indicate limitations where appropriate.*
- *The essay should be presented in a professional manner with all work clearly labelled and referenced.*



PREVIOUSLY . . .



surveying in British

(sɜːˈveɪɪŋ 🔊)

Word Frequency 🔴 🔴 🔴 🔴 🔴

noun

1. the study or practice of measuring altitudes, angles, and distances on the land surface so that they can be accurately plotted on a map
2. the setting out on the ground of the positions of proposed construction or engineering works

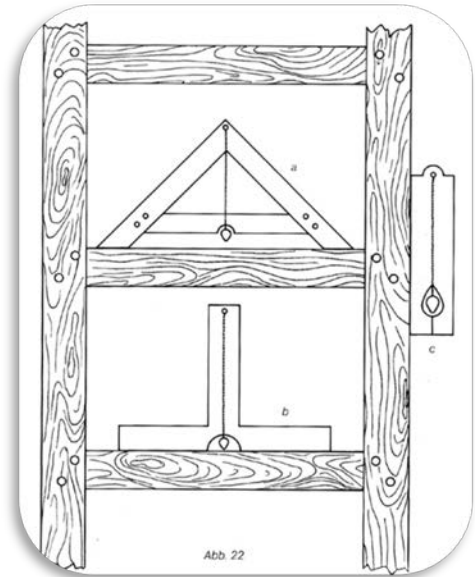
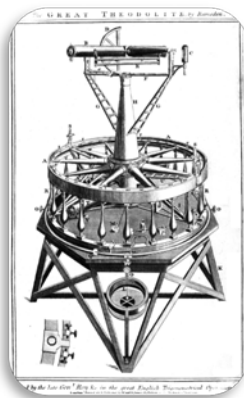
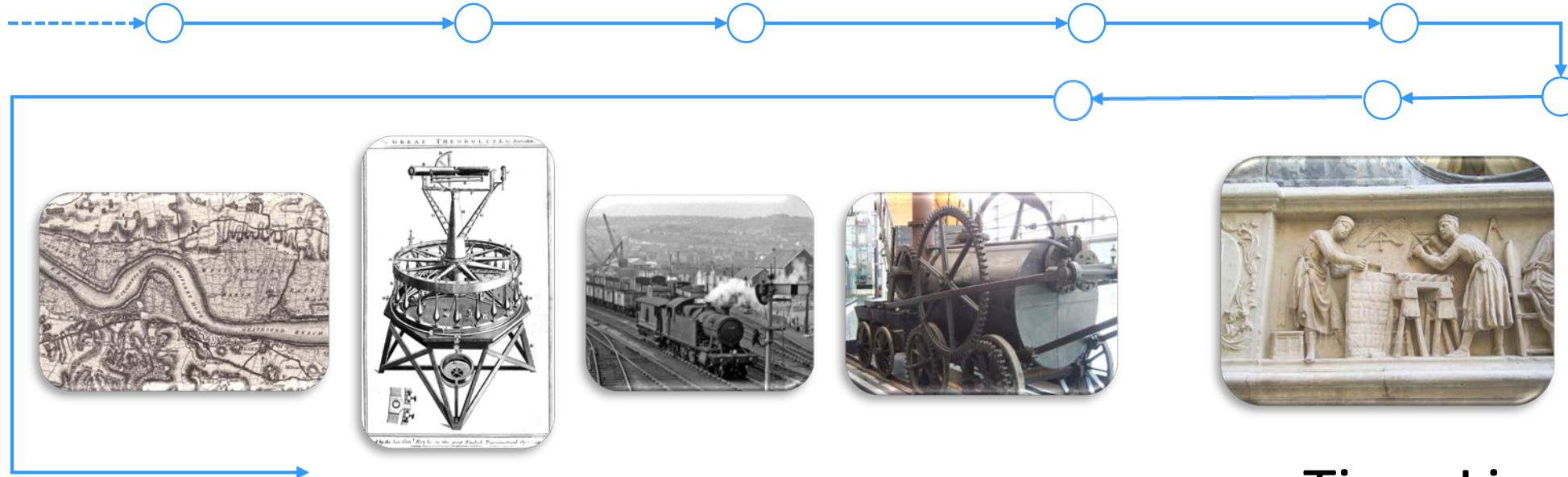
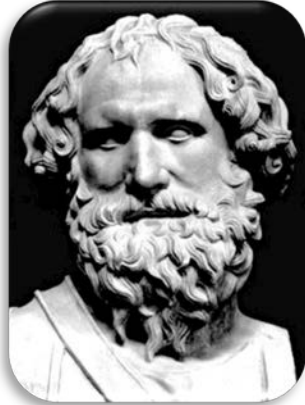
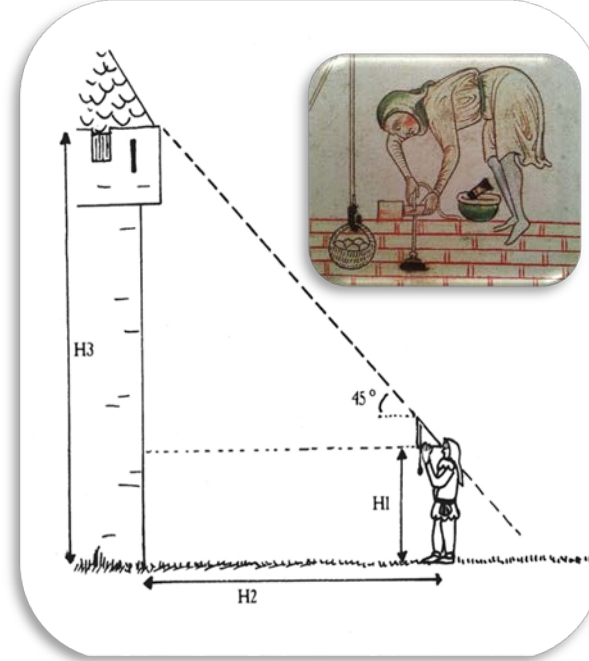
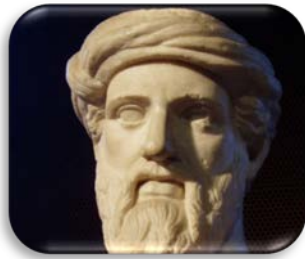
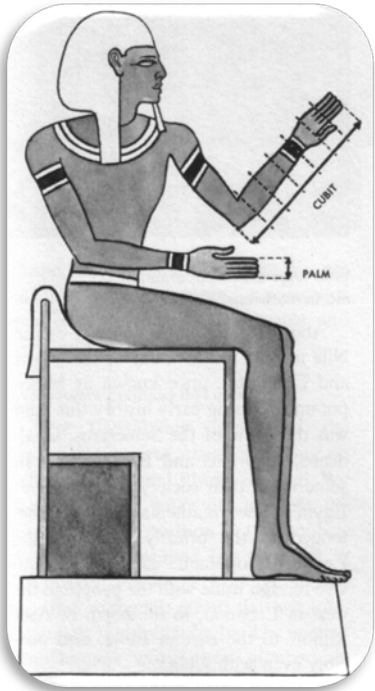
Collins English Dictionary. Copyright © HarperCollins Publishers



Measurement and Recording



Mathematics and Writing

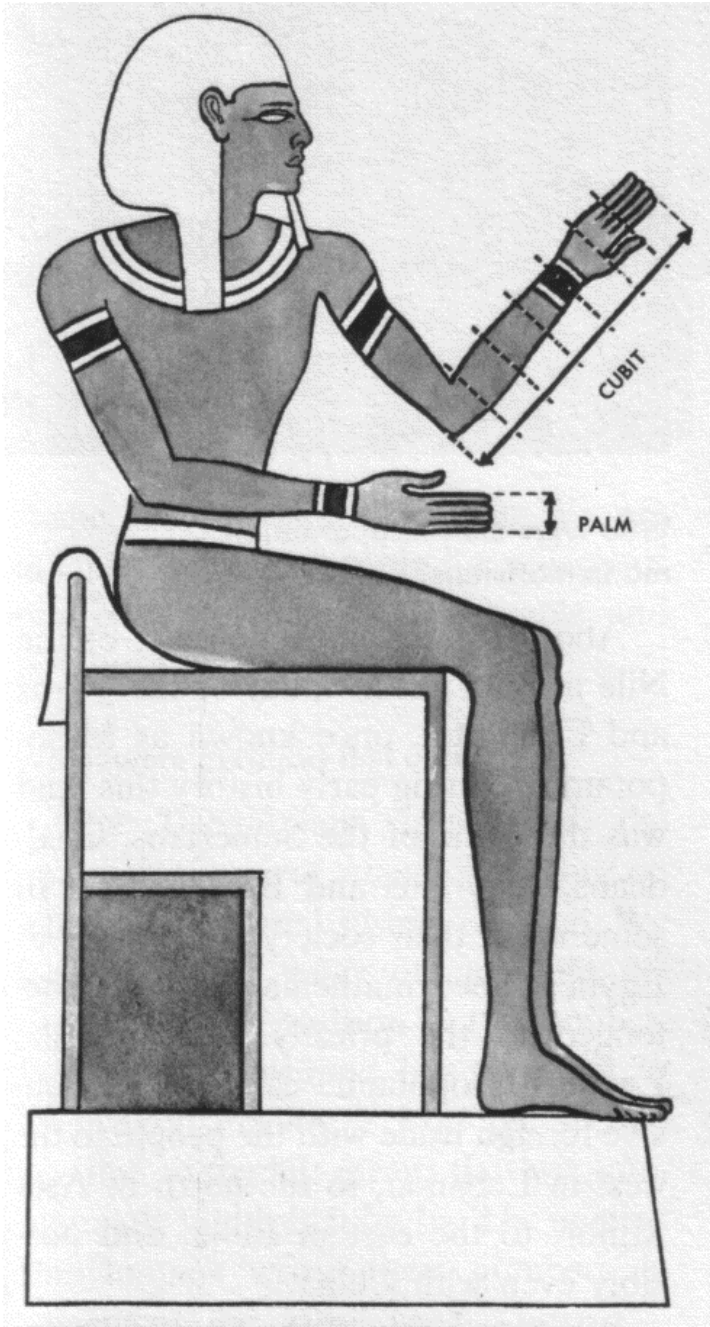


Time Line

Ancient History or Antiquity



Pyramids of Giza, Egypt
Great Pyramid
Constructed 2560BC
By Pharaoh Khufu
440 cubits side base
280 cubits high



<http://2.bp.blogspot.com/-T2TknoeVZRE/T-IgAMIQ-vI/AAAAAAAAAlo/OMk9SuTZmNA/s1600/cubit.gif>



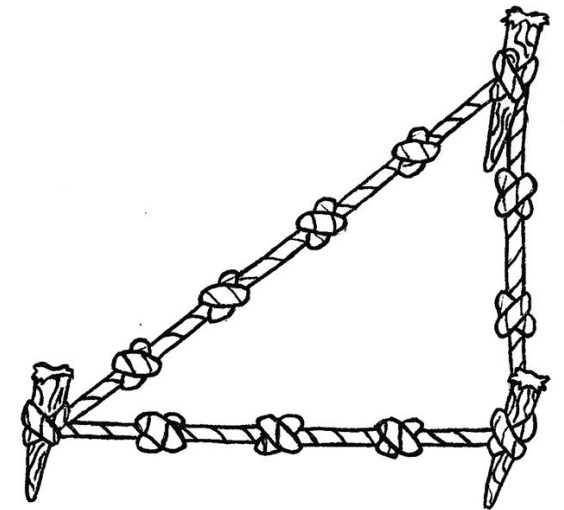
http://www.yallatours.com/blog/deir_el_medina/louvre-cubit.jpg



<https://4815162342execute.wordpress.com/lost-themes/hieroglyphs/>



<http://www.taneter.org/Menna%20Surveying.jpg>



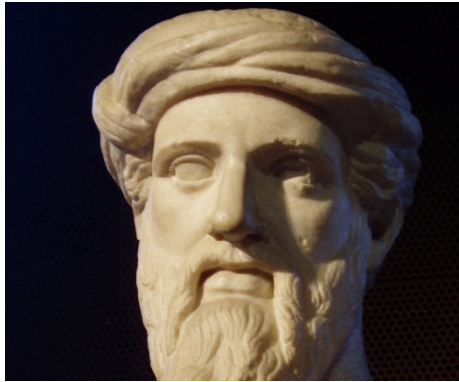
Ancient Egypt



Acropolis, Greece
The Parthenon
Constructed C5th BC
By Phidias
Ratio 4:9

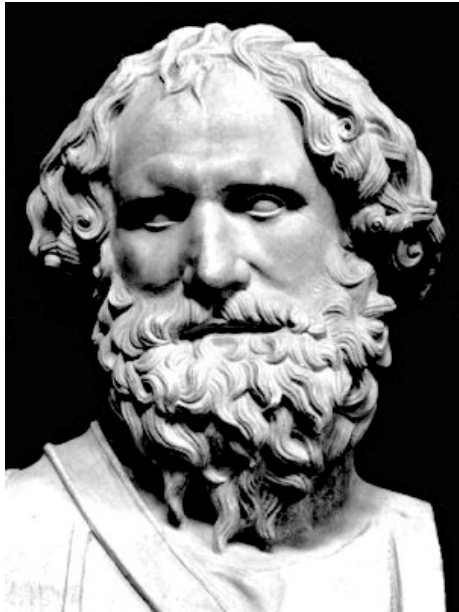
<http://www.hexapolis.com/2014/06/27/8-fascinating-facts-about-the-parthenon-the-cultural-icon-from-ancient-greece/>

Pythagoras born 570 BCE



<https://youtu.be/YompsDIEdtc>

Archimedes born 287BCE



<https://youtu.be/sw66gzBD9fe>



<http://edgarlowen.com/map-ancient-greece.jpg>

Ancient Greece / Hellenistic

Units of Measurement during the Greek Period

1 digit or *daktylos* - plural : *daktyloi* (19.3 mm)
2 digits = 1 *condylos*
4 digits = 1 *palaiste*
8 digits = 1 *dichas*
12 digits = 1 *spithame*
16 digits = 1 *pous* or foot - plural *podes* (309 mm)
20 digits = 1 *pygon* (called “Remen” by the Egyptians)
24 digits = 1 *pechya* or *pechys* (πεχυα) (**small cubit**)
40 digits = 1 *bema*
72 digits = 4.5 feet = 1 *xylon*

1 foot *pous* – plural *podes* (309 mm)
6 feet = 1 *orgyia* (1.854 m)
10 feet = 1 *akaina*
100 feet = 1 *plethron*
600 feet or 6 *plethra* = 1 *stadion* (185.4 m)

1 *stadion* (185.4 m) (Different variants of the stadion exist with around + - 30 m differences)
2 *stadia* = 1 *diaulos*
6 *diauloi* = 1 *dolichos*

Lengths were measured by:

Schoinion, a cord of some standard length, *Schoinourgos*, the land surveyor. Heron of Alexandria knew that for example the length of the *schoinion* could change by humidity and he gave some recipes how to keep the distance as constant as possible, by hanging weights or smearing the *schoinion* with wax. The *schoinion* was 100 *cubits* divided in 8 *hammata* (knots)

halysis (metallic chain). This did not have the problems of the cord but it was probably expensive and too heavy to be used often as the *schoinion*.

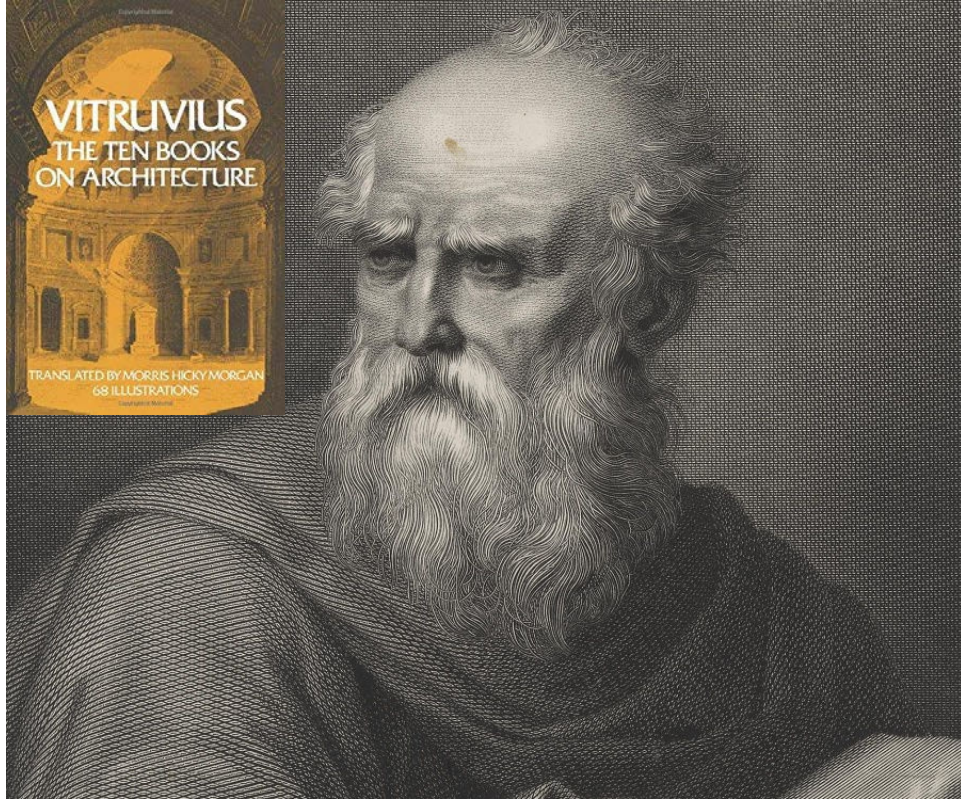
kalamos measuring rod from reed or wood.



Rome, Italy
The Colloseum
Constructed 70-80AD
Reign of Vespasian &
Titus.
Elliptical plan 640 R ft
long x 528 R ft wide

<http://colosseumromeitaly.blogspot.com/>

Vitruvius born 80-70 BCE



<https://www.thefamouspeople.com/profiles/vitruvius-34320.php>

Vitruvius asserts in his book *De architectura* (the ten books of architecture) that a structure must exhibit the three qualities of *firmitatis*, *utilitatis*, *venustatis* – that is, stability, utility, beauty.

Odometer:

<http://www.hellenicaworld.com/Greece/Technology/en/Measurements.html>



The odometer of Vitruvius was based on chariot wheels of 4 feet (1.2 m) diameter turning 400 times in one Roman **mile** (about 1400 m). For each revolution a pin on the axle engaged a 400 tooth cogwheel thus turning it one complete revolution per mile. This engaged another gear with holes along the circumference, where pebbles (*calculus*) were located, that were to drop one by one into a box. The distance travelled would thus be given simply by counting the number of pebbles.

Sleeswyk, André Wegener "Vitruvius' Odometer", *Scientific American* 245.4 (October, 1981), pp. 188–200

Early Roman Period

The Groma



<https://www.satpalda.com/blogs/evolution-in-surveying-techniques>

<https://youtu.be/-pIUTs2XD50>



<https://www.worldatlas.com/articles/5-important-cities-of-the-roman-empire.html>

Other surveying equipment used by the Roman included:
Dioptra, Libella and Chorobates.

Roman Empire



<https://daydreamtourist.files.wordpress.com/2014/05/harold-shot-2.jpg>

- Romans leave Britain around 400 AD
- Subsequent invasions, Anglo-Saxon (410 – 1066)
- Viking Expansion (800 – 1150) raids and settlement.
- Norman invasion 1066
- William the Conqueror – commissions the Domesday Book 1086.



<https://thelincolnite.co.uk/2017/03/931-year-old-domesday-book-coming-to-lincoln-for-special-exhibition/>

The Domesday Book is a great land survey from 1086, commissioned by William the Conqueror to assess the extent of the land and resources being owned in England (parts of Wales and Scotland) at the time, and the extent of the taxes he could raise. The information collected was recorded by hand in two huge books, in the space of around a year. William died before it was fully completed.

Britain Post Roman Period

Barleycorn: $\frac{1}{3}$ of an inch, the notional base unit under the Composition of Yards and Perches.

Digit: $\frac{3}{4}$ inch **Finger:** $\frac{7}{8}$ inch

Inch: 3 barleycorns (the historical legal definition)

Palm: 3 inches **Hand:** 4 inches

Shaftment: Width of the hand and outstretched thumb, 6 $\frac{1}{2}$ inches before 1066, 6 thereafter

Span: Width of the outstretched hand, from the tip of the thumb to the tip of the little finger, 3 palms = 9 inches.

Foot: Prior to the Anglo-Saxon invasions, the Roman foot of 11.65 inches (296 mm) was used. The Anglo-Saxons introduced a North-German foot of 13.2 inches (335 mm), divided into 4 palms or 12 thumbs, while the Roman foot continued to be used in the construction crafts. In the late 13th century, the modern foot of 304.8 mm was introduced, equal to exactly $\frac{10}{11}$ Anglo-Saxon foot.

Cubit: From fingertips to elbow, 18 inches.

Yard: (= Ulna) 3 feet = 36 inches, the practical base unit as the length of the prototype bar held by the Crown or Exchequer.

Fathom: Distance between arms outstretched, from fingertip to fingertip, equalling 6 feet.

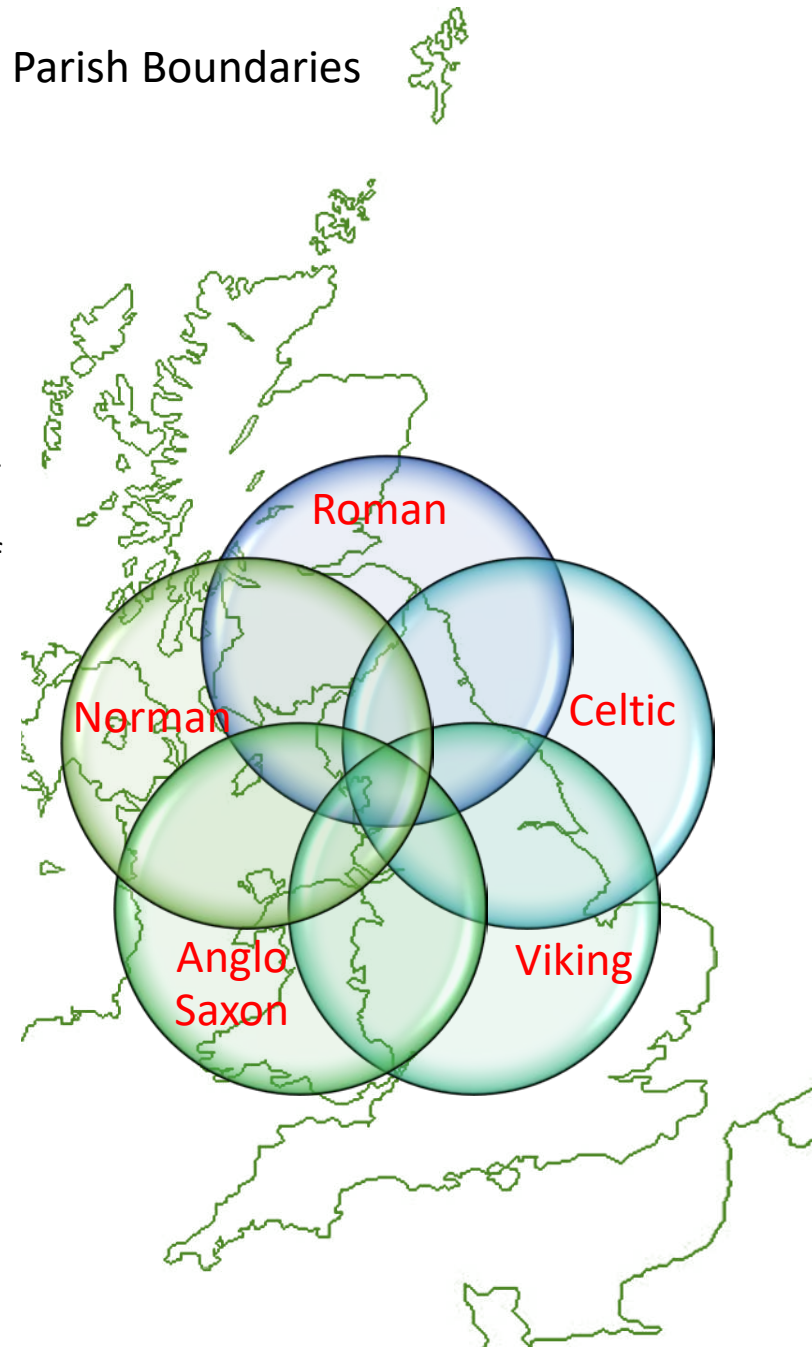
Rod: (= perch) (= pole) Used for surveying land and in architecture. The rod is the same length today as in Anglo-Saxon times, although its composition in terms of feet were changed by the Composition of Yards and Perches from 15 feet to 16 $\frac{1}{2}$. The pole is commonly used as a measurement for Allotment Gardens. (See also perch as an area and a volume unit.)

Furlong (= stade) Notionally the distance a plough team could furrow without rest, but actually a measure of 40 rods or 600 feet prior to the Composition of Yards and Perches and 40 rods or 660 feet afterwards.

Mile : Originally the Roman mile alternatively reckoned as 5000 feet, 1000 paces, or 8 stades but adjusted to 5280 feet in 1593 to account for the differences introduced to these methods of reckoning by the Composition of Yards and Perches.

League: Notionally an hour's travel, but usually reckoned as three miles. Approximate length of the traditional "mile" in German and Scandinavian countries.

- Parish Boundaries





https://en.wikipedia.org/wiki/Salisbury_Cathedral

Salisbury Cathedral (1220-1258)
 Stone Mason: Elias of Dereham
 Patron: Richard Poore



<https://thomasguild.blogspot.com/2013/09/the-medieval-toolchest-level-and-plumb.html>

The medieval mason was not a monk but a highly skilled lay craftsman who combined the roles of architect, builder, craftsman, designer and engineer. Using only a set of compasses, a set square and a staff or rope marked off in halves, thirds and fifths, the mason was able to construct some of the most amazing structures ever built: http://www.bbc.co.uk/history/british/middle_ages/architecture_medmason_01.shtml

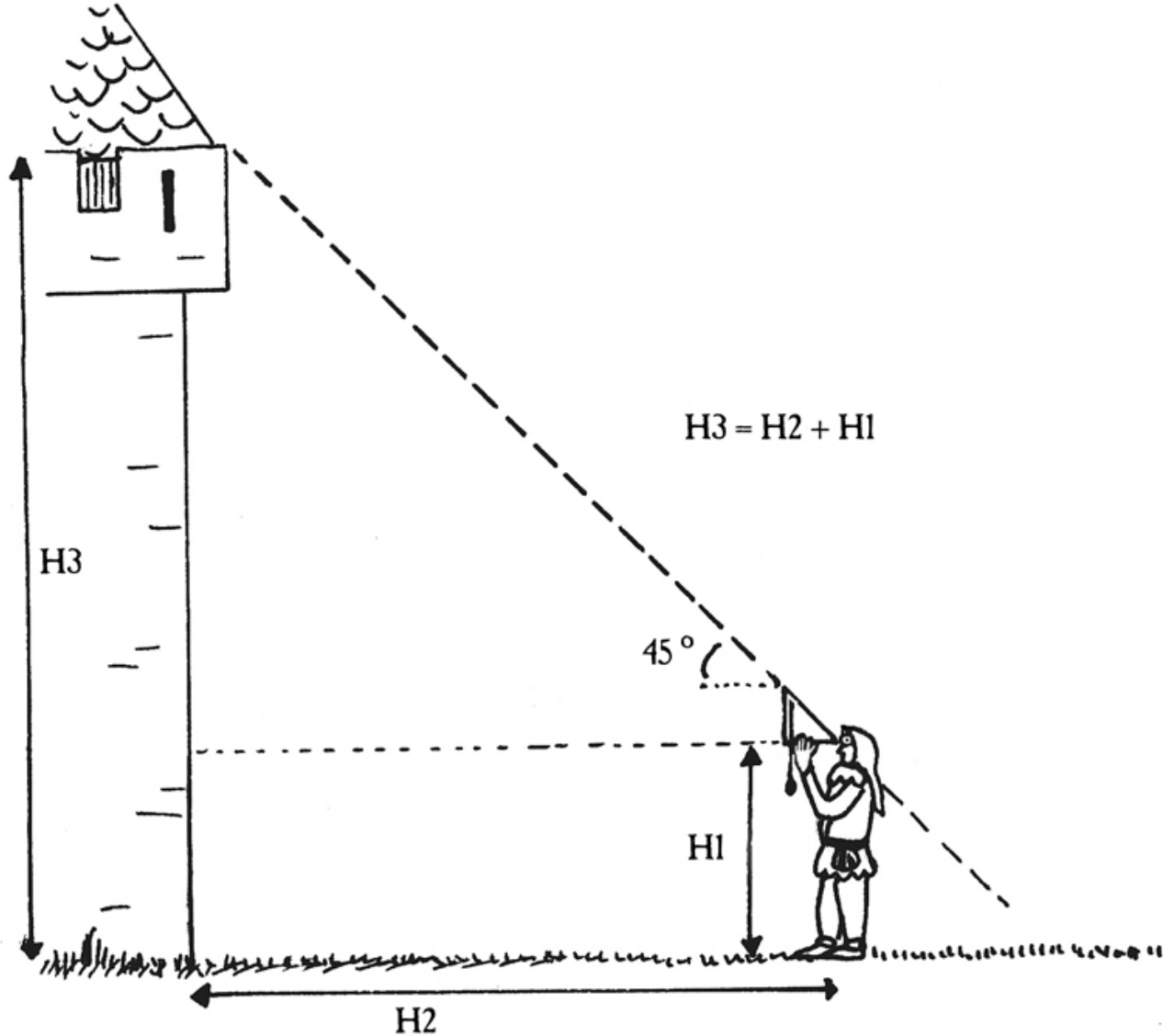


Gothic Period c1180 - 1520



https://en.wikipedia.org/wiki/Hampton_Court_Palace#/media/File:Great_Gate,_Hampton_Court_Palace.jpg

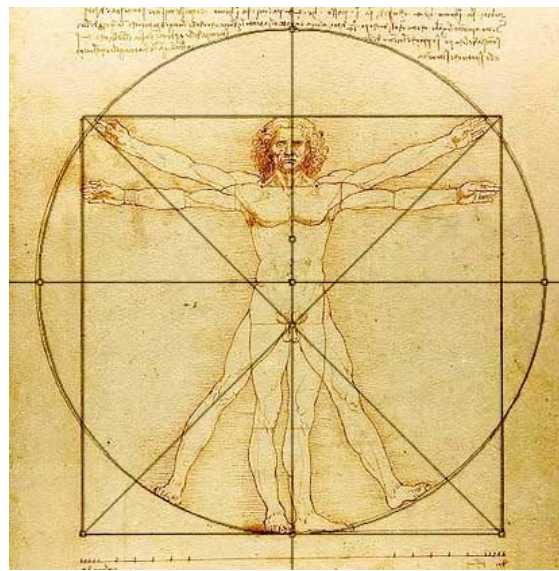
Hampton Court Palace
Completed 1525



Tudor Period c1485 - 1603



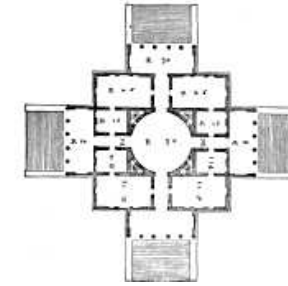
Filippo Brunelleschi 1377-1446 (Florence Cathedral)



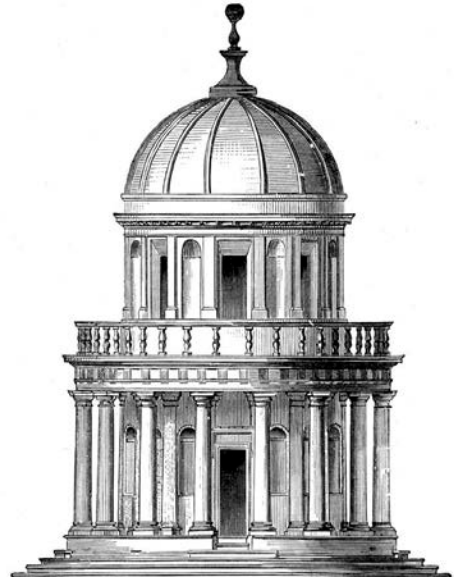
Leonardo Da Vinci 1452 -1519
'Vitruvian Man'



Villa Rotunda. Andrea Palladio 1508-1580
I Quattro Libri dell'Architettura, 1570

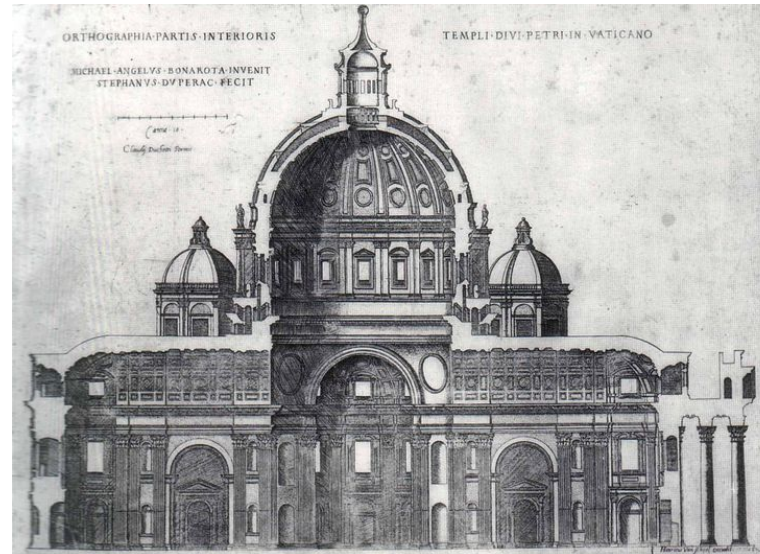


https://en.wikipedia.org/wiki/Andrea_Palladio#/media/File:PalladioRotondaPlan.jpg



<https://www.pinterest.co.uk/pin/70720656625314854/>

Donato Bramante 1444 – 1514
Tempietto Rome



<https://www.pinterest.co.uk/pin/283304632782621349/>

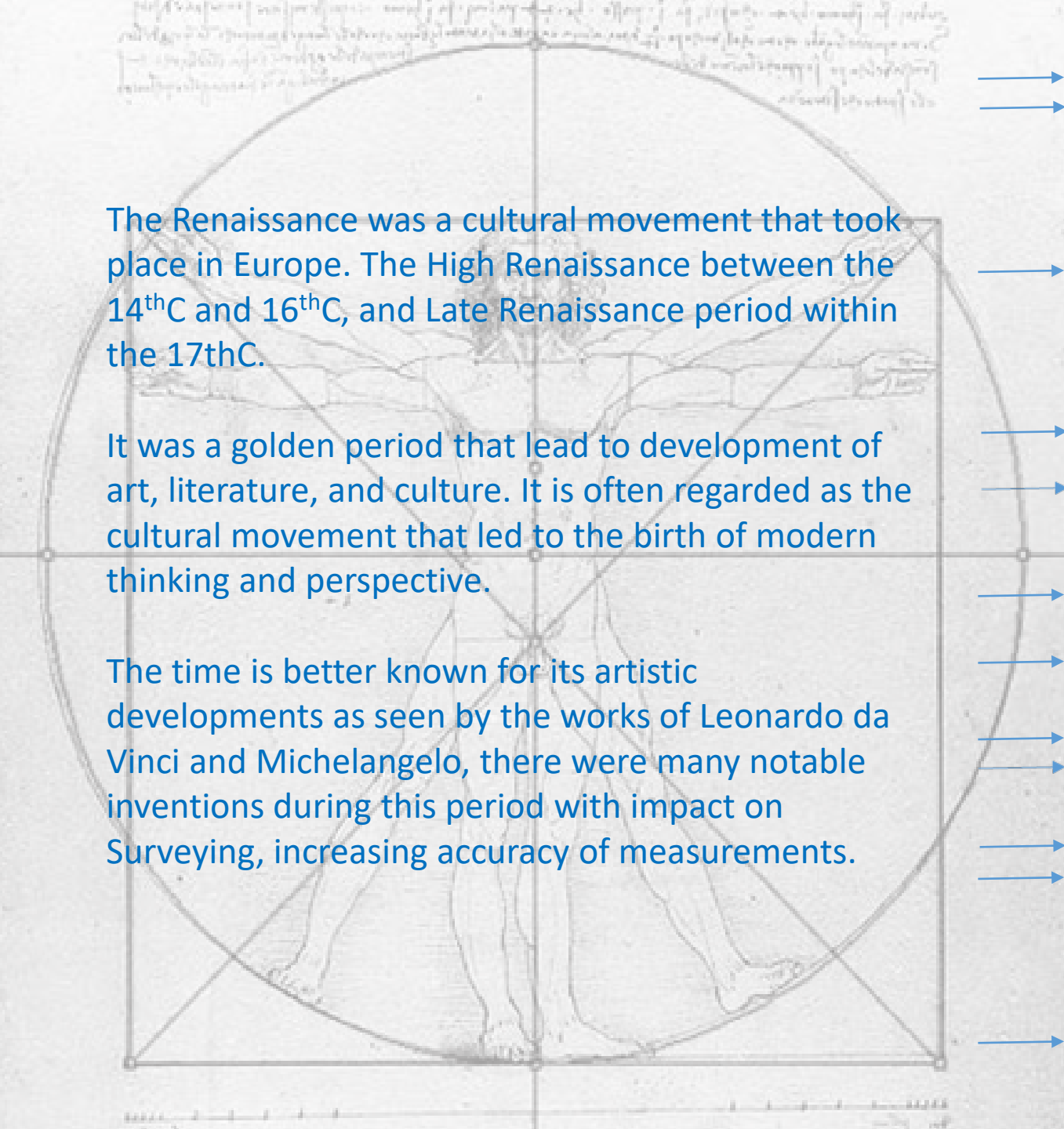
Michelangelo 1475-1564 St Peters Dome, Rome

Renaissance: Cultural melting pot for Art, Architecture, Science, Philosophy, Engineering, Mathematics. Emerging from Italy and spreading throughout Europe.

Proportion – Geometry - Mathematics

Renaissance Europe 14thC - 16thC



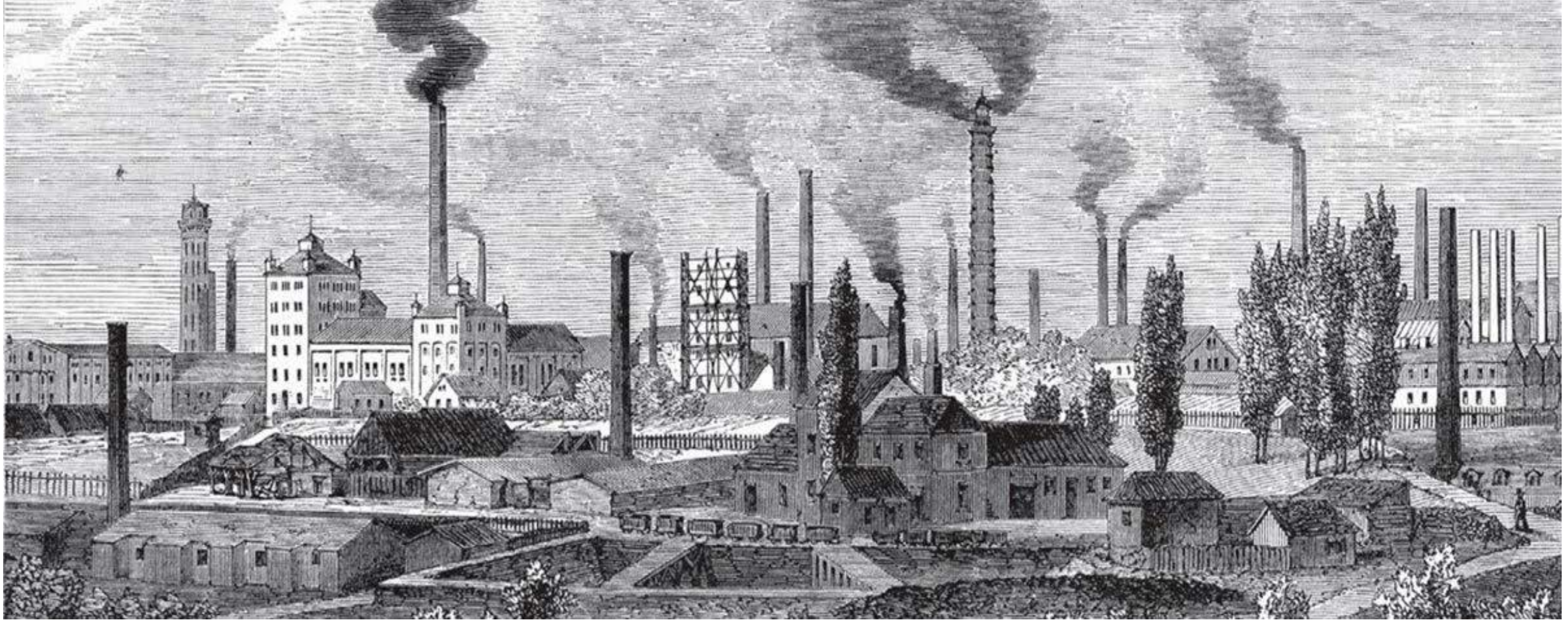


The Renaissance was a cultural movement that took place in Europe. The High Renaissance between the 14thC and 16thC, and Late Renaissance period within the 17thC.

It was a golden period that led to development of art, literature, and culture. It is often regarded as the cultural movement that led to the birth of modern thinking and perspective.

The time is better known for its artistic developments as seen by the works of Leonardo da Vinci and Michelangelo, there were many notable inventions during this period with impact on Surveying, increasing accuracy of measurements.

- 1300 - The first mechanical clock.
- 1366 - Scales for weighing.
- 1400 - First golf ball was invented
- 1411 - The trigger for the gun. The first piano called the Spinet invented.
- 1420 - Oil painting was invented.
- 1421 - Hoisting gear invented in Florence.
- 1450 - Lenses for near-sighted people invented by Nicholas of Cusa.
- 1456 - Printing press by Gutenberg.
- 1465 - Drypoint engravings invented.
- 1475 - Muzzle loaded rifles invented in Italy.
- 1485 - Leonardo da Vinci designed the first parachute.
- 1487 - Bell chimes.
- 1500 - The first flush toilets were invented.
- 1510 - Pocket watch invented by Peter Henlein.
- 1514 - Nicolaus Copernicus established the fact that the centre of the universe is not the Earth.
- 1579 - Azimuth Instrument 'Theodolite'
- 1589 - Knitting machine invented by William Lee.
- 1590 - Compound microscope invented by Zacharias Janssen.
- 1593 - Galileo Galilei invented the water thermometer.
- 1608 - First refracting telescope was invented by Hans Lippershey.
- 1620 - The first submarine was invented by Cornelis Drebbel.
- 1624 - Slide Rule was invented by William Oughtred.
- 1625 - Method of blood transfusion was invented by Jean Baptiste Denys.
- 1636 - W. Gascoigne invents the micrometer.
- 1642 - Adding Machine invented by Blaise Pascal.
- 1643 - Barometer invented by Torricelli.
- 1650 - The first air pump.
- 1656 - The pendulum clock was invented by Christian Huygens.
- 1661 - Thevenot invented the Bubble Spirit Level .
- 1663 - The first reflecting telescope was constructed by James Gregory.
- 1670 - Champagne was invented by Dom Perignon.
- 1671 - The first calculating machine invented by Gottfried Wilhelm Leibniz.
- 1671 - Sir Isaac Newton publishes his major work, Principia, which contains the three laws of motion and the law of universal gravitation.
- 1679 - Pressure cooker invented by Denis Papin.
- 1698 - Steam pump invented by Thomas Savery.



<https://www.learnodo-newtonic.com/wp-content/uploads/2018/03/Industrial-Revolution-Facts-Featured.jpg>

Industrial Revolution 18thC/ 19thC



https://d3d00swyhr67nd.cloudfront.net/w944h944/SW/SW_MTLIB_PCF3.jpg

Industrial Revolution 18thC/ 19thC



<https://i.pinimg.com/736x/48/74/ca/4874cabde94482adfe48d830608b6ad0--coal-mining-south-wales.jpg>

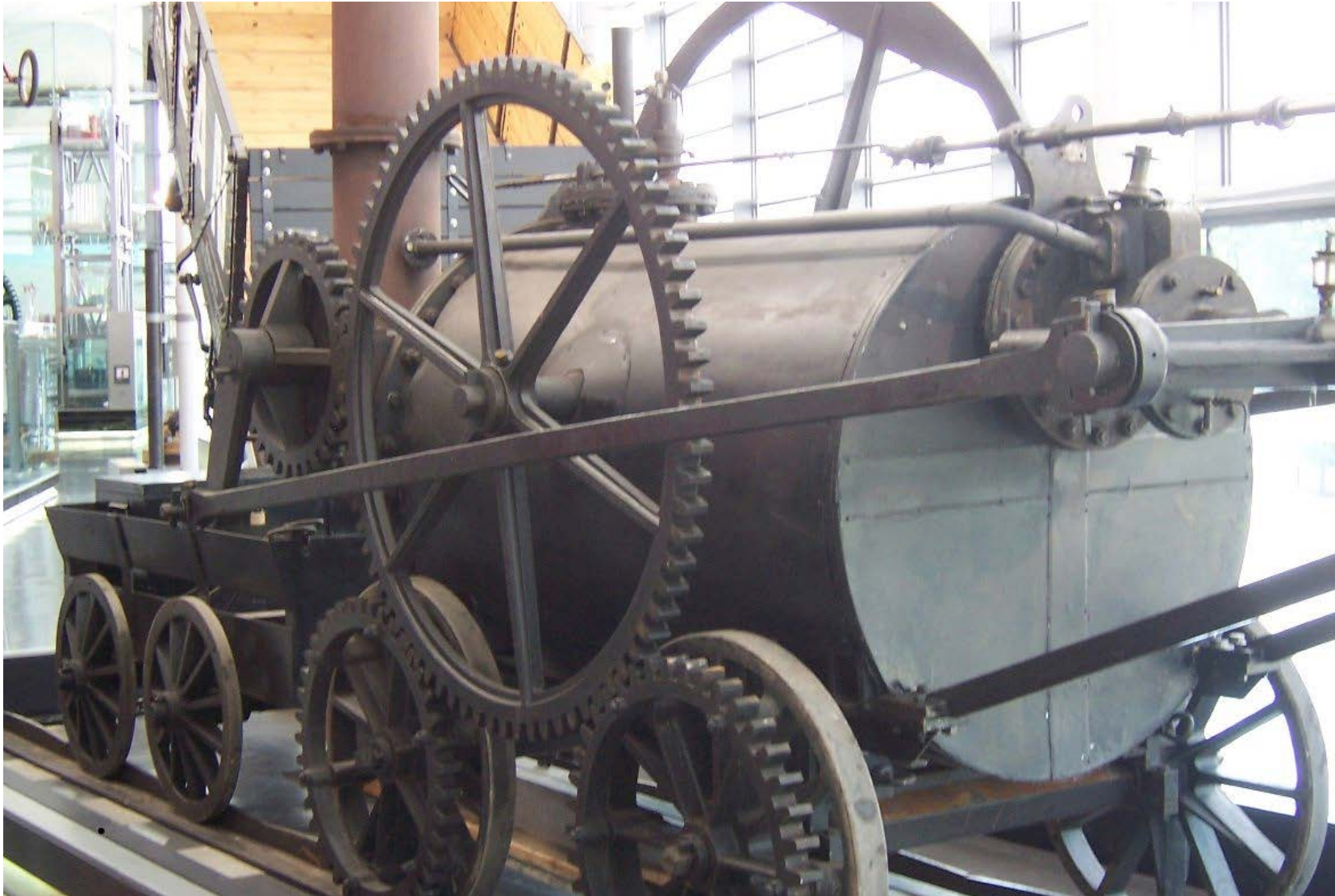
Industrial Revolution 18thC/ 19thC



http://lightmoor.co.uk/BDLbooksample_pics/B9129_samp2.jpg

Industrial Revolution 18thC/ 19thC

ABCA 4002
DIGITAL SURVEYING: LEVEL 4



The world's first locomotive-hauled railway journey took place on 21 February 1804, when Richard Trevithick's unnamed steam locomotive hauled a train along the tramway of the Penydarren Ironworks, in Merthyr Tydfil.

https://en.wikipedia.org/wiki/Richard_Trevithick#/media/File:TrevithicksEngine.jpg

Industrial Revolution 18thC/ 19thC



[http://www.swansea docks.co.uk/images/E%20-%20H/geograph-2542410-by-Ben-Brooksbank%20\(5\).jpg](http://www.swansea docks.co.uk/images/E%20-%20H/geograph-2542410-by-Ben-Brooksbank%20(5).jpg)

Industrial Revolution 18thC/ 19thC

CYCLOPÆDIA:

OR, AN

UNIVERSAL DICTIONARY

OF

ARTS and SCIENCES;

CONTAINING

The DEFINITIONS of the TERMS;

And ACCOUNTS of

The THINGS signify'd thereby,

In the several ARTS,

Both LIBERAL and MECHANICAL,

And the several SCIENCES,

HUMAN and DIVINE:

The Figures, Kinds, Properties, Productions, Preparations, and Uses,
of Things NATURAL and ARTIFICIAL;

The Rise, Progress, and State of Things ECCLESIASTICAL,
CIVIL, MILITARY, and COMMERCIAL:

With the several Systems, Sects, Opinions, &c. among Philosophers, Divines,
Mathematicians, Physicians, Antiquaries, Critics, &c.

The Whole intended as a Course of Ancient and Modern LEARNING.

Compiled from the best Authors, Dictionaries, Journals, Memoirs,
Transactions, Ephemerides, &c. in several Languages.

In TWO VOLUMES.

By E. CHAMBERS Gent.

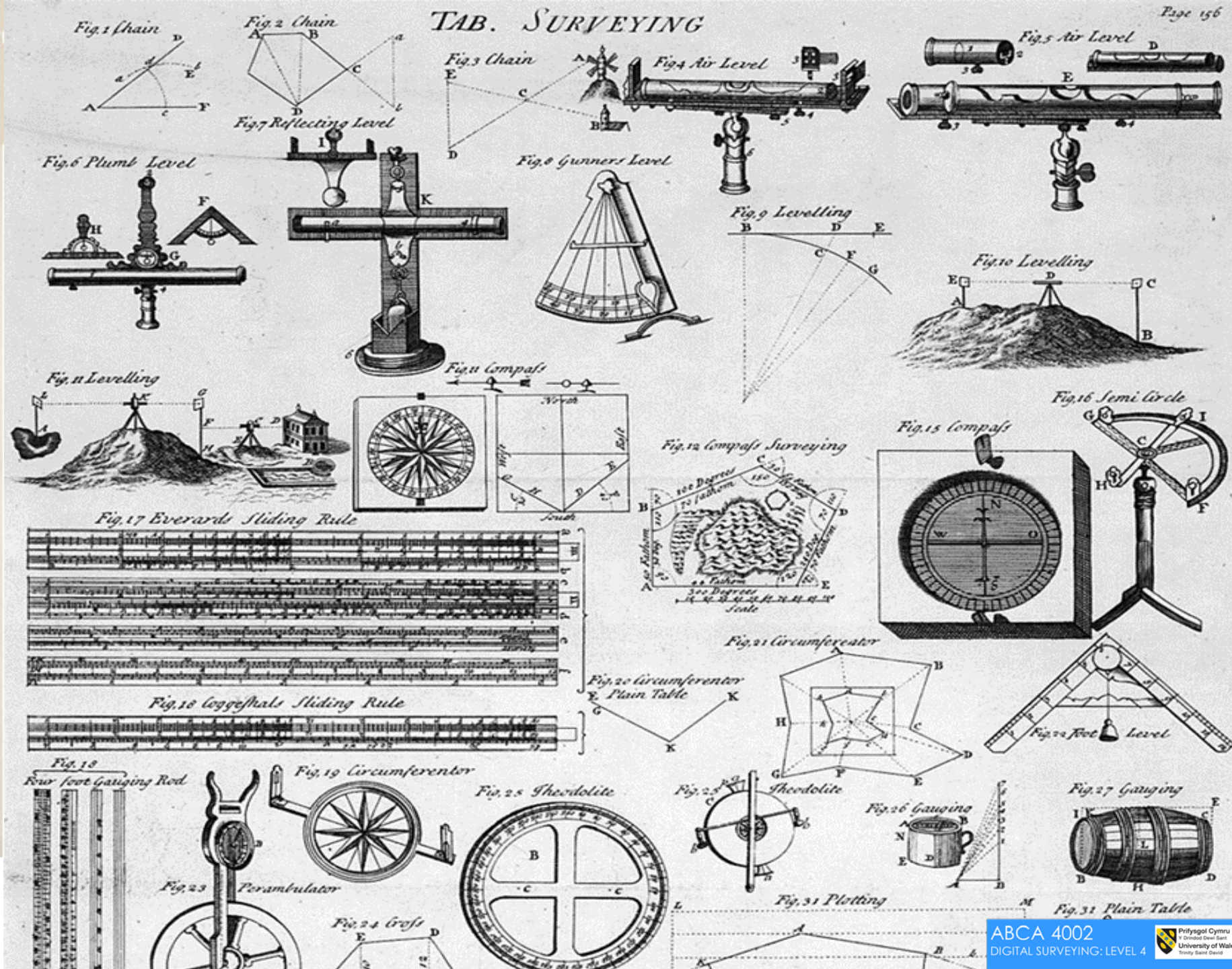
*Floris ut apes in salubris omnia libat,
Omnis nos* ———— LUCRET.

VOLUME the FIRST.

LONDON:

Printed for James and John Knapton, John Darby, David Midwinter, Arthur Bettsworth,
John Sears, Robert Giffing, John Pendergast, William and John Lewis, John Osborn and The
Longman; Charles Rivington, John Hulse, Renssela Robinson, Francis Clay, Aaron Ward,
Edward Symon, Daniel Browne, Andrew Johnson, and Thomas Osborn. MDCCLXXXVIII.

Chambers Cyclopedia 1728
More accurate instruments were
developed



A

Consider the horizontal distances between A – A and B – B
Are they the same ?

A

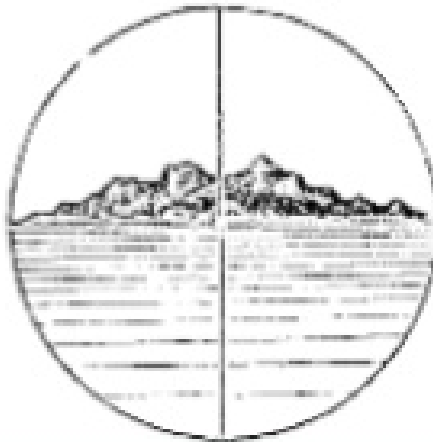
B

B

The science of Geodetic and Plane surveying were developed.

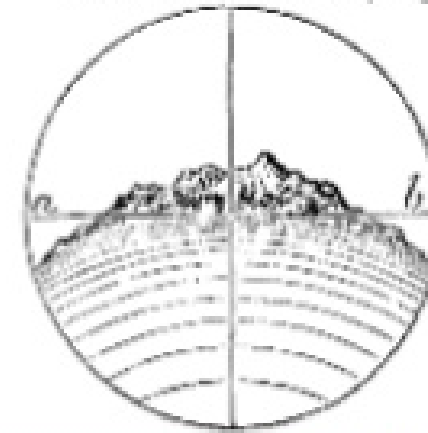
DIFFERENCE BETWEEN GEODETIC AND PLANE SURVEYING

Plane Surveying



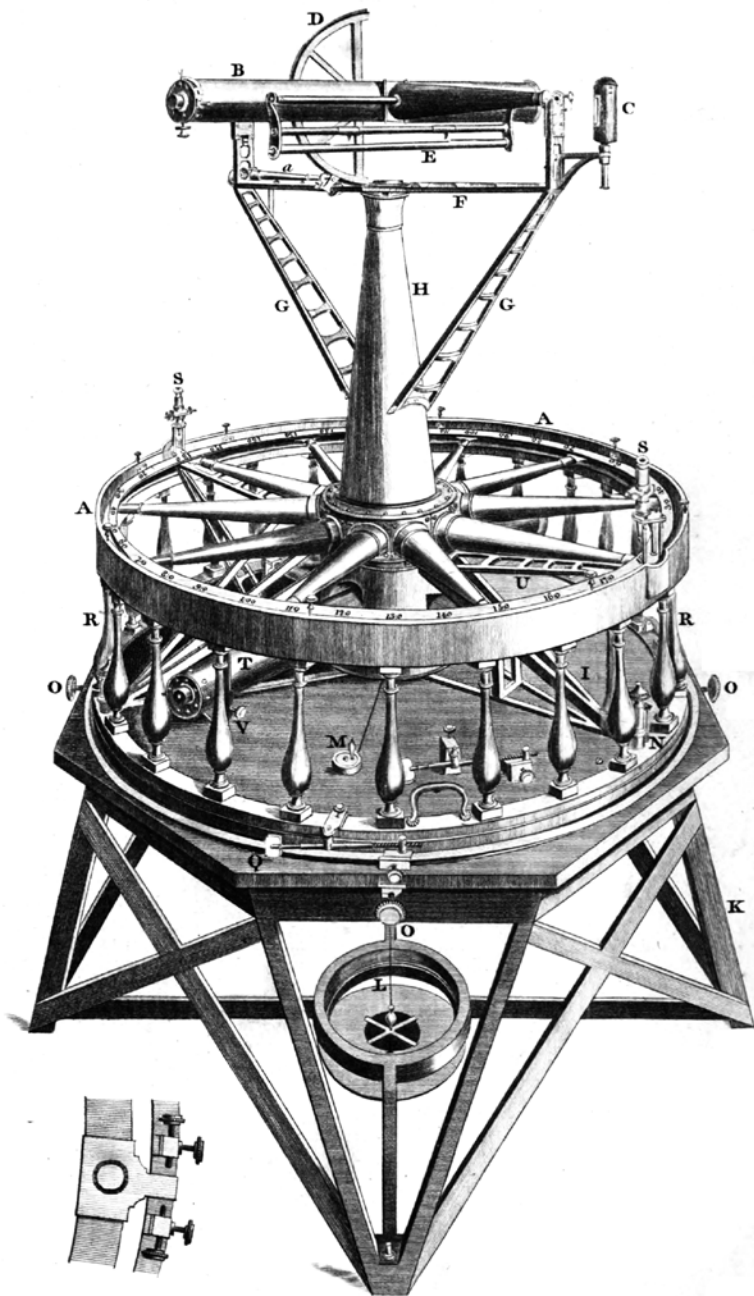
- ☐ Earth surface is considered as a **plane** surface.
- ☐ The curvature of the earth is **ignored**.
- ☐ The line joining any two stations is considered as a **straight line**.
- ☐ The **triangle** formed by any three points is considered as a **plane**.
- ☐ The angles of the triangle are considered to be **plane angles**.
- ☐ Carried out for a **small area < 250km²**.

Geodetic Surveying



- ☐ Earth surface is considered as a **curved** surface.
- ☐ The curvature of the earth is **taken into account**.
- ☐ The line joining any two stations is considered as a **curved line**.
- ☐ The **triangle** formed by any three points is considered as **spherical**.
- ☐ The **angles** of the triangle are considered to be **spherical**.
- ☐ Carried out for a **large area > 250km²**.

Industrial Revolution 18thC/ 19thC



Used by the late Gen.^l Roy &c. in the great English Trigonometrical Operations.
London. Printed and Published by W and S. Jones, Stationers, 42, Strand, 1787.

William Roy's lifelong mission was to build a superior map of Britain, unparalleled in its accuracy. The day the Board of Ordnance set his suggested plan into action, Ordnance Survey was born.

In 1784 William Roy, founder of Ordnance Survey, was commissioned by The Royal Society to geodetically connect the Royal Observatories of Greenwich and Paris to resolve a dispute over their relative positions.

Jesse Ramsden, the leading instrument maker of the day took three years in the make the instrument that measured three feet across – The Great Theodolite.

Under the authority of the Master General of the Board of Ordnance, Roy began the London/Paris triangulation in 1785. By using angle measurements and at least a single measured baseline length, a whole country can be measured using the triangulation method. A dense framework of triangles with accurate coordinates at the nodes allows for accurate surveying of map features. Utilising the theodolite and trigonometry, Roy created a network of accurately measured triangles that extended to France and then back to a verification baseline in Kent.

SOH CAH TOA

$$\sin \alpha = \frac{a}{c}$$

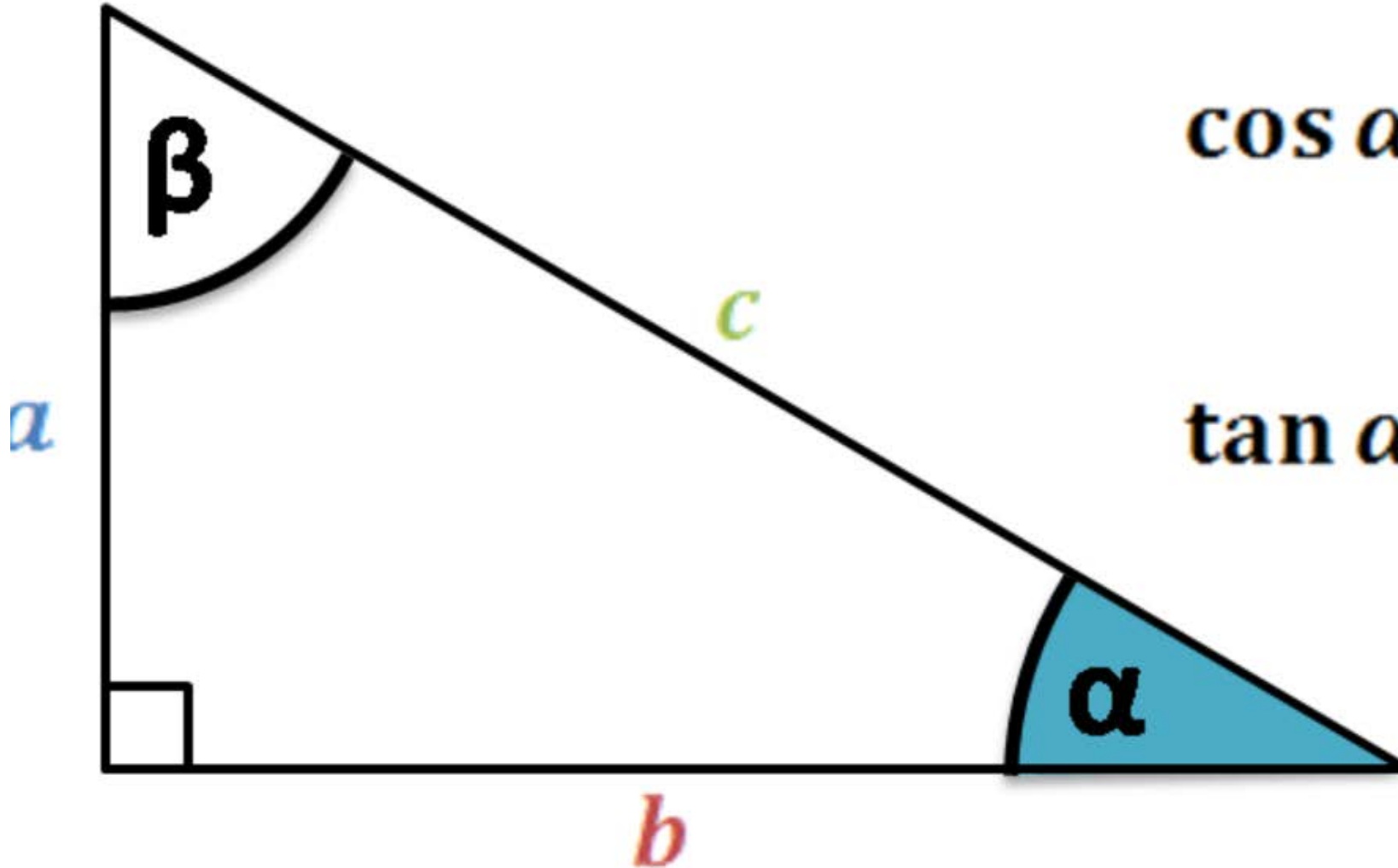
Opposite
Hypotenuse

$$\cos \alpha = \frac{b}{c}$$

Adjacent
Hypotenuse

$$\tan \alpha = \frac{a}{b}$$

Opposite
Adjacent





The first Ordnance Survey map was published in 1801. England's most south-easterly county, Kent, was one area most vulnerable to French invasion.

These early maps, with their elaborate hill shading and attention to communication routes, highlight the emphasis given to military use. In time, this military face would soften and the map design was developed to appeal to a much wider audience.



Modern Era – Surveying Today

Surveying Today - What do we use surveying for?

- Mapping the earth above and below the sea.
- Prepare navigational maps (land, air, sea).
- Establish boundaries of public and private lands.
- Develop data bases for natural resource management.
- Development of engineering data for:
 - Bridge construction.
 - Roads.
 - Buildings.
 - Land development.

Surveying Today - What are the Five Main Areas on Surveyors Work?

- Research, analysis, and decision making.
- Field work {Data acquisition}.
- Computing {Data processing}.
- Mapping {Data representation}.
- Stake-out / Setting out

Surveying Today - What are the two Major Methods of Surveying?

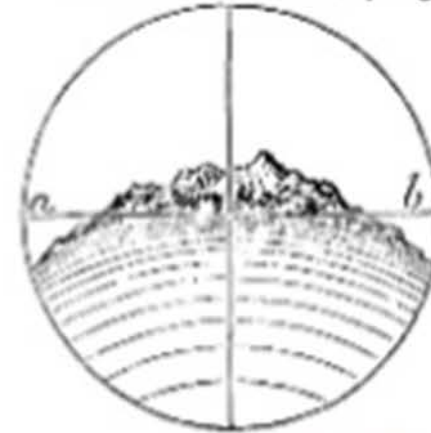
DIFFERENCE BETWEEN GEODETIC AND PLANE SURVEYING

Plane Surveying



- ☐ Earth surface is considered as a **plane** surface.
- ☐ The curvature of the earth is **ignored**.
- ☐ The line joining any two stations is considered as a **straight line**.
- ☐ The **triangle** formed by any three points is considered as a **plane**.
- ☐ The angles of the triangle are considered to be **plane angles**.
- ☐ Carried out for a **small area < 250km²**.

Geodetic Surveying



- ☐ Earth surface is considered as a **curved** surface.
- ☐ The curvature of the earth is **taken into account**.
- ☐ The line joining any two stations is considered as a **curved line**.
- ☐ The **triangle** formed by any three points is considered as **spherical**.
- ☐ The **angles** of the triangle are considered to be **spherical**.
- ☐ Carried out for a **large area > 250km²**.

CADASTRAL SURVEYS are usually closed surveys which are undertaken in urban and rural locations for the purpose of determining and defining property lines and boundaries, corners, and areas. These surveys are also made to fix the boundaries of municipalities, towns, and provincial jurisdictions.



CITY SURVEYS are surveys of the areas in and near a city for the purpose of planning expansions or improvements, locating property lines, fixing reference monuments, determining the physical features and configuration of the land, and preparing maps.



CONSTRUCTION SURVEYS these are surveys which are undertaken at a construction site to provide data regarding grades, reference lines, dimensions, ground configuration, and the location and elevation of structures which are of concern to engineers, architects, and builders.



FORESTRY SURVEYS a type of survey executed in connection with forest management and mensuration, and the production and conservation of forest lands.



HYDROGRAPHIC SURVEYS refer to surveying streams, lakes, reservoirs, harbour's, oceans, and other bodies of water. These surveys are made to map shore lines, chart the shape of areas underlying water surfaces, and measure the flows of the stream. They are of general importance in connection with navigation, development of water supply and resources, flood control, irrigation, production of hydro-electric power, sub aqueous constructions, and recreation



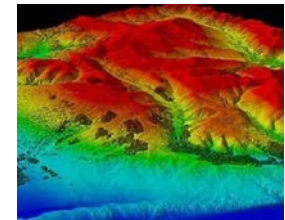
INDUSTRIAL SURVEY sometimes known as optical tooling. It refers to the use of surveying techniques in ship building, construction and assembly of aircraft, layout and installation of heavy and complex machinery, and in other industries where very accurate dimensional layouts are required.



MINE SURVEYS are surveys which are performed to determine the position of all underground excavations and surface mine structures, to fix surfaces boundaries of mining claims, determine geological formations, to calculate excavated volumes, and establish lines and grades for other related mining work.



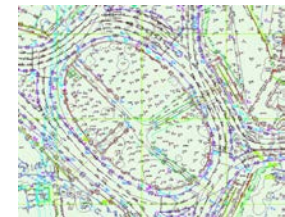
PHOTOGRAMMETRIC SURVEYS a type of survey which makes use of photographs taken with specially designed cameras either from airplanes or ground stations. Measurements are obtained from the photographs which are used in conjunction with limited ground surveys.



ROUTE SURVEYS involves the determination of alignment, grades, earthwork quantities, location of natural and artificial objects in connection with the planning, design, and construction of highways, railroads, pipelines, canals, transmission lines, and other linear projects.



TOPOGRAPHIC SURVEYS are those surveys made for determining the shape of the ground, and the location and elevation of natural and artificial features upon it. The features shown include such natural objects as hills, mountains, rivers, lakes, relief of the ground surface, etc.; and works , such as roads, building, ports, towns, municipalities, and bridges.



Equipment and Tools for Surveying

CYCLOPÆDIA:

OR, AN
UNIVERSAL DICTIONARY

OF ARTS and SCIENCES;

CONTAINING
The DEFINITIONS of the TERMS,
And ACCOUNTS of
The THINGS signify'd thereby,

In the several ARTS,
Both LIBERAL and MECHANICAL,

And the several SCIENCES,
HUMAN and DIVINE:

The Figures, Kinds, Properties, Productions, Preparations, and Uses,
of Things NATURAL and ARTIFICIAL;

The Rise, Progress, and State of Things ECCLESIASTICAL,
CIVIL, MILITARY, and COMMERCIAL:

With the several Systems, Sects, Opinions, &c. among Philosophers, Divines,
Mathematicians, Physicians, Antiquaries, Critics, &c.

The Whole intended as a Course of Ancient and Modern LEARNING.

Compiled from the best Authors, Dictionaries, Journals, Memoirs,
Transactions, Ephemerides, &c. in several Languages.

In TWO VOLUMES.

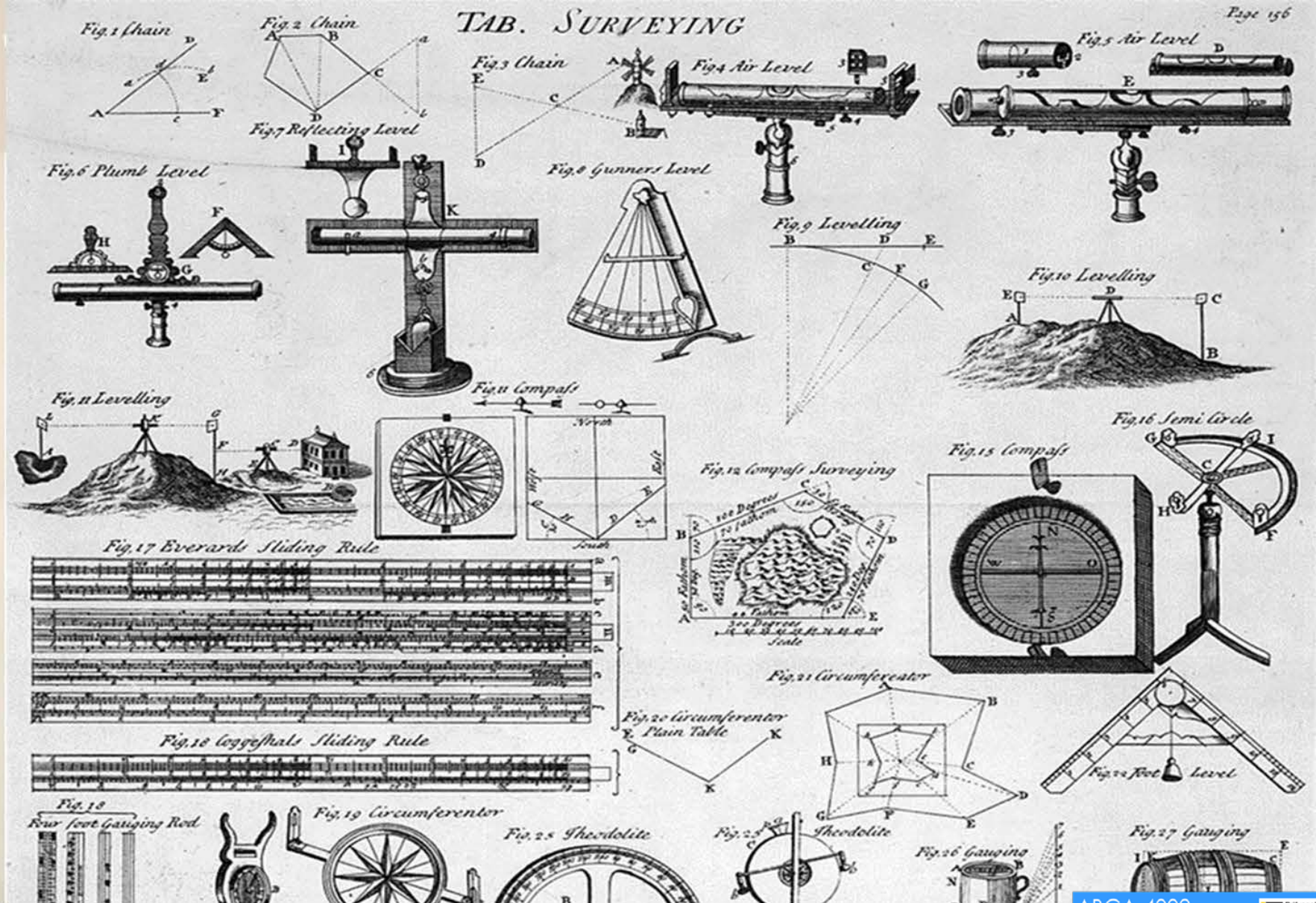
By E. CHAMBERS Gent.

*Floris ut apes in salubris omnia libas,
Omnia nos* — LUCRET.

VOLUME the FIRST.

LONDON:

Printed for James and John Knapp, John Darby, Daniel Midwinter, Arthur Butcherell,
John Seaton, Robert Giffing, John Pendergast, William and John Lewis, John Osborn and The
Langman, Charles Riccington, John Hodge, Rowland Robinson, Francis Clay, Aaron Ward,
Edward Symon, Daniel Browne, Andrew Johnson, and Thomas Osborn. MDCCXXXVIII.



General: The Basics

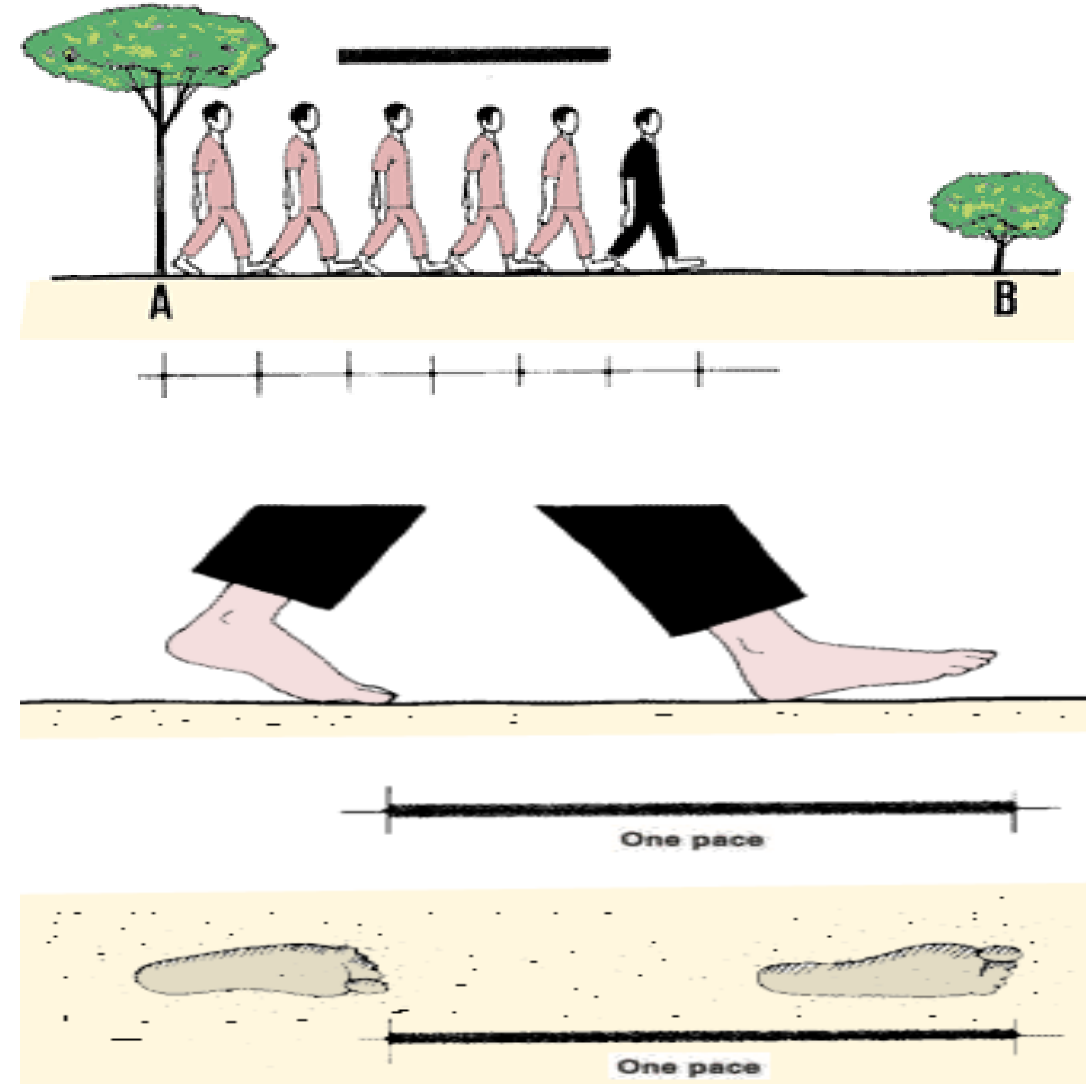


General: Pacing

Pacing: The ability to pace distance is very useful

A person can determine their pace by counting the number of paces necessary to walk a distance that has been previously measured. The natural pace of each individual normally varies from 700 – 950mm.

- A pace is defined as one step
- A stride is consider two steps



Finding your Own Pace Factor.

To measure the average length of your **normal pace** (the pace factor, or **PF**):

- take 100 normal steps on horizontal ground, starting with the toes of your back foot from a well-marked point, A, and walking along a straight line.
- Mark the end of your last step with peg B, at the toes of your front foot.

Measure the distance AB (in metres) with, for example, a tape and calculate your pace factor PF (in metres) as follows:

Pacing Factor (PF) = Measured distance / Number of pace

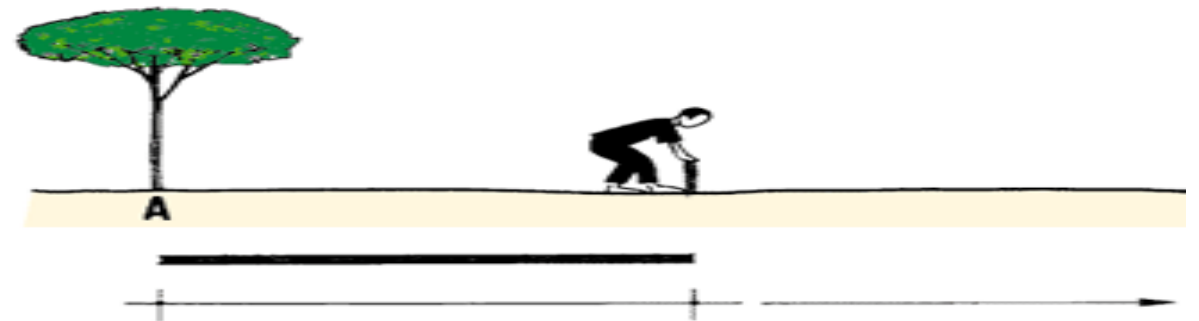
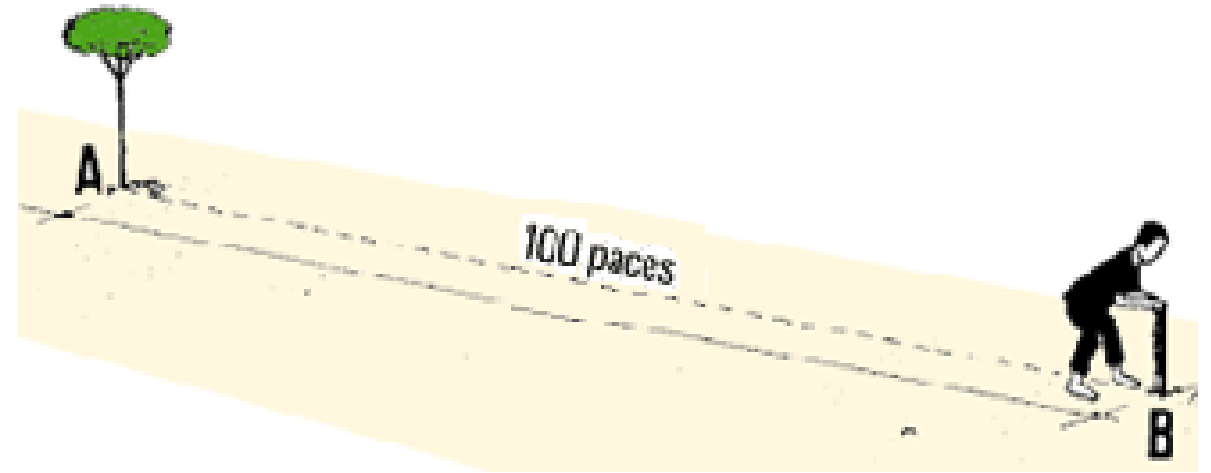
Distance measured with a tape = 76m

Number of pace = 100 paces

Example

If for 100 paces, you measure a distance of 76 m, then your pace factor is calculated like this:

$PF = 76 \text{ m} \div 100 = 0.76 \text{ m}$

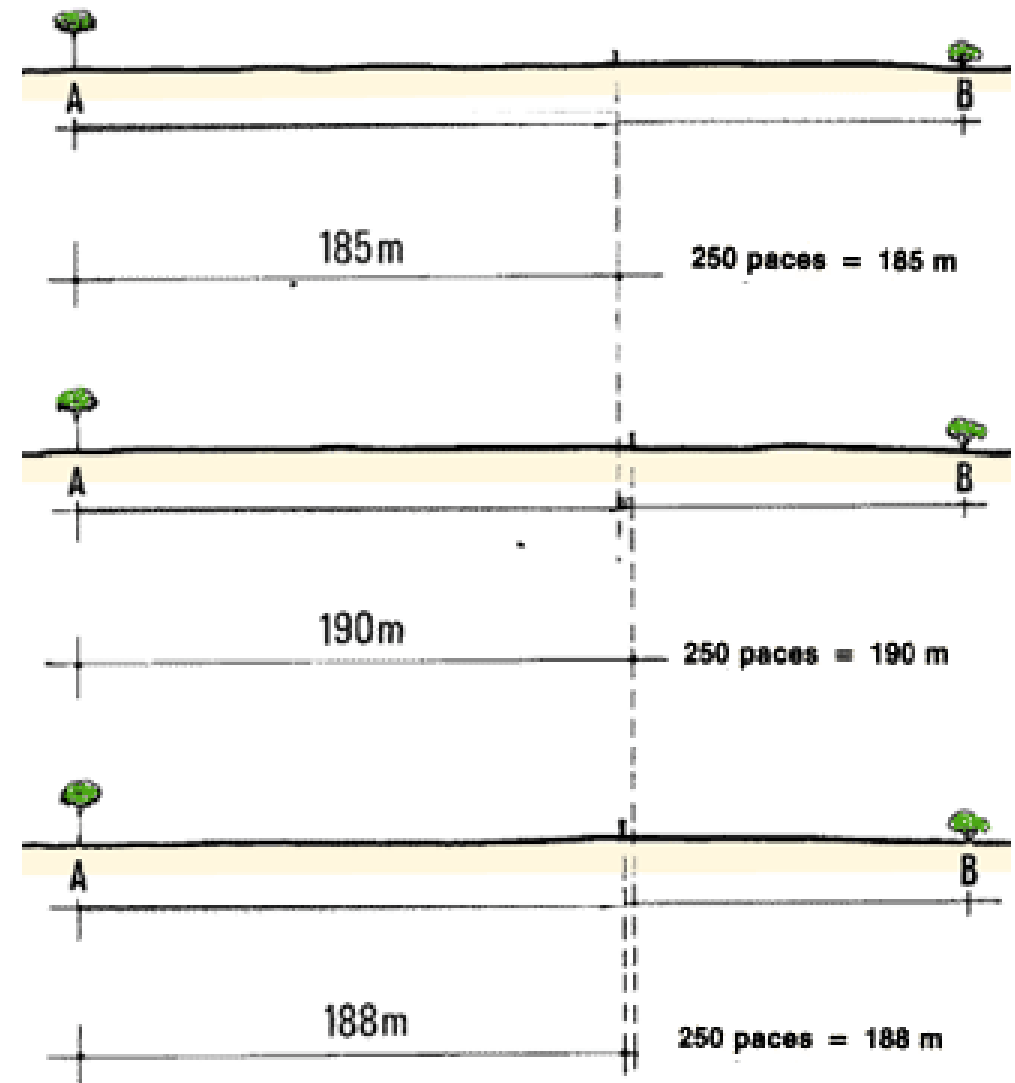


- walk over a **longer distance** (at least 250 paces)
- **repeat** the measurements at least three times and calculate **the average PF**.

Example:

For 250 paces, you measure successively
185 m, 190 m and 188 m;
in total, for $3 \times 250 = 750$ paces, you have walked $185 + 190 + 188 \text{ m} = 563 \text{ m}$;

Therefore your average pace factor, $\text{PF} = 563 \text{ m} \div 750 = 0.75 \text{ m}$.



Distance (m) = N x PF,

N = Number of Steps,

PF = Pace Factor

Example

To measure ABCD,
pace distances

AB = 127 steps;

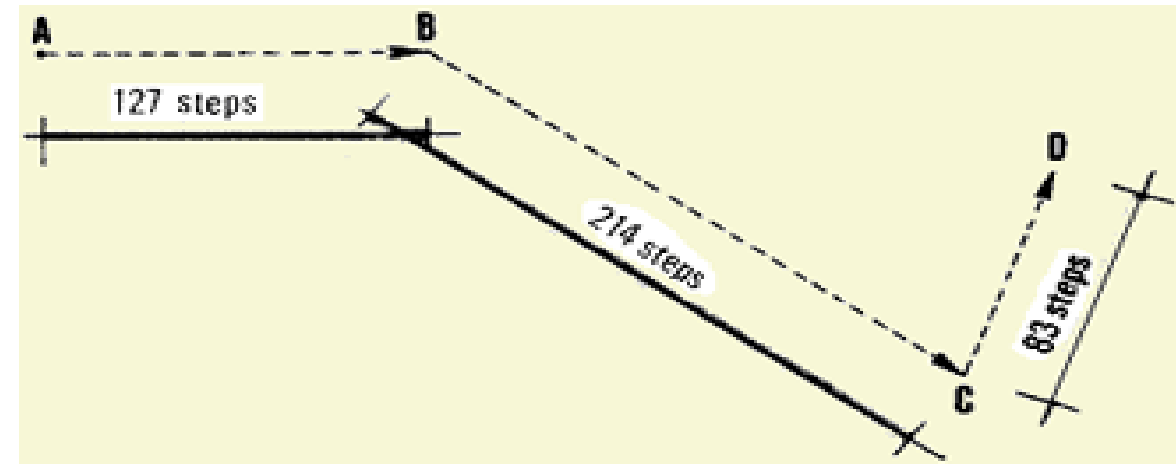
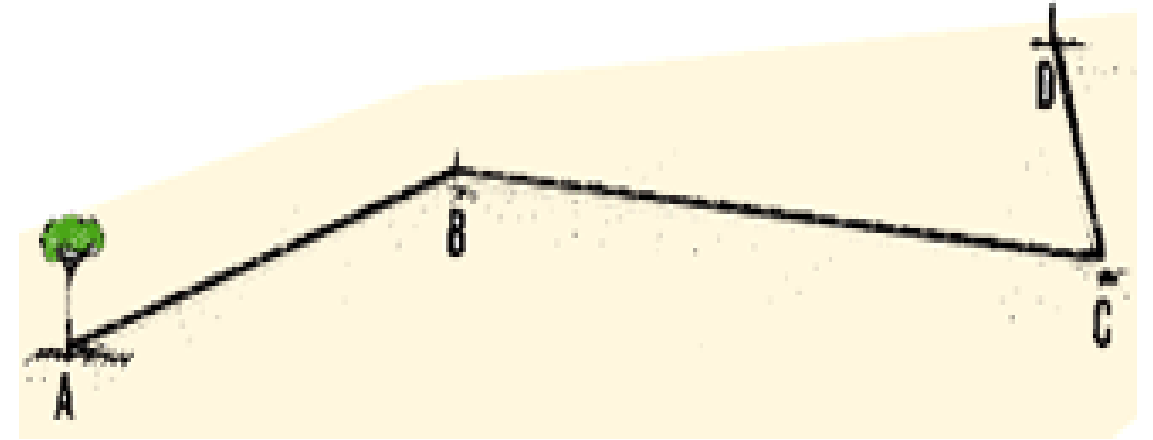
BC = 214 steps; and

CD = 83 steps.

ABCD = 127 + 214 + 83 = **424** steps.

If PF = **0.75** m,

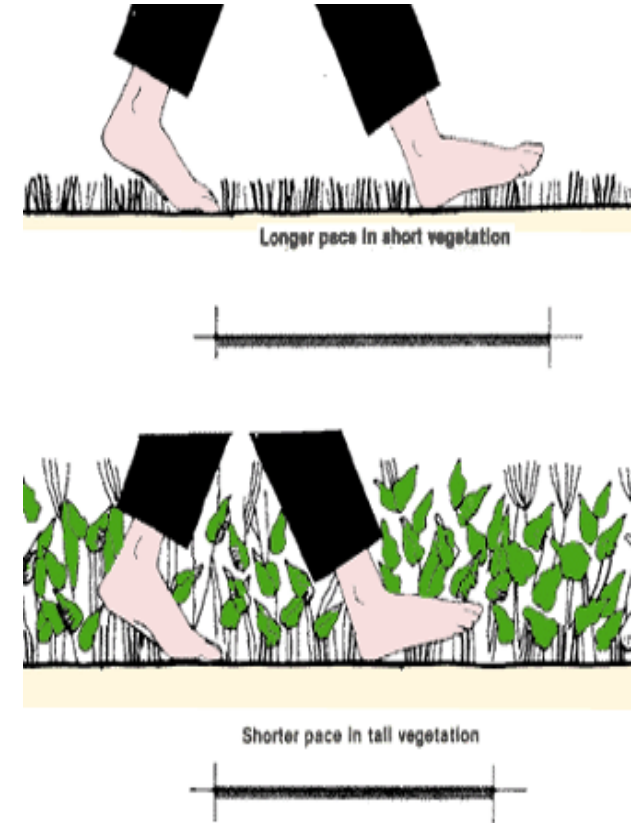
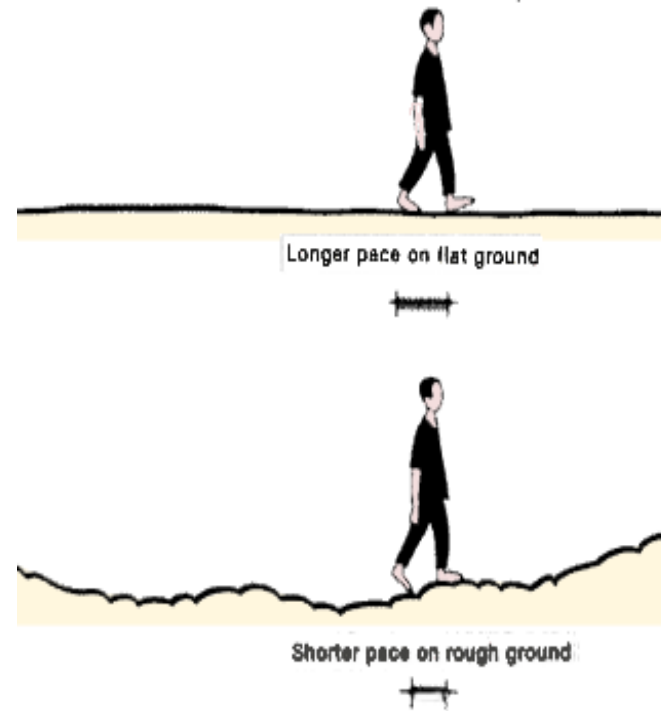
ABCD = **424** x **0.75** m = 318 m



Your pace factor will vary, depending on **the type of terrain** you are measuring.

Remember:

- Pace will be shorter in tall vegetation than in short vegetation;
- Pace will be shorter walking uphill than walking downhill;
- Pace will be shorter walking on sloping ground than on flat ground;
- Pace will be shorter walking on soft ground than on hard ground.
- To get the best results, you should first make your paces as nearly the same length as possible. To do this, walk over known distances, both on level ground and on uneven or sloping ground. Adjust your pace so that it is as regular as possible.



Building Surveying: Linear Measurement

Surveying tapes are available in lengths up to 100m, but a 30m tape is the most common length in use. Two types of tapes are commonly used:

Steel Tapes

- All steel tapes are manufactured so that they measure their normal length at a specific temperature and under a certain pull, which is generally 20°C and 50N.
- With care it is possible to take measurements using a steel tape with an accuracy of 1 in 10,000 (or 3mm for a 30m distance)

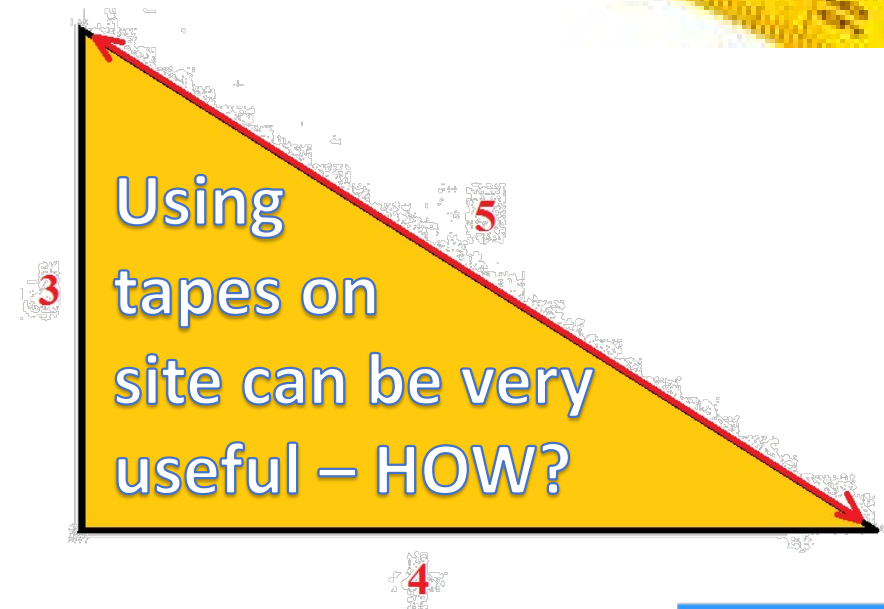
Fibreglass Tapes

- Fibreglass tapes are manufactured from fibreglass strands embedded in PVC.
- Compared to steel tapes they are lighter, more flexible and less likely to break.
- They are also rust free.
- They stretch more when pulled
- The accuracy of a fibreglass tape is lower at 1 in 1000 (i.e. a precision of 30mm in a 30m length).



Building Surveying: Linear Measurement

- The tape is not the standard length
- Poor alignment of the tape
- Tape not horizontal
- Tape twisted or not straight.
- Human error of observations
- Variations in temperature
- Variations in tension
- Tape Sag.



Building Surveying: Other Linear Measurement



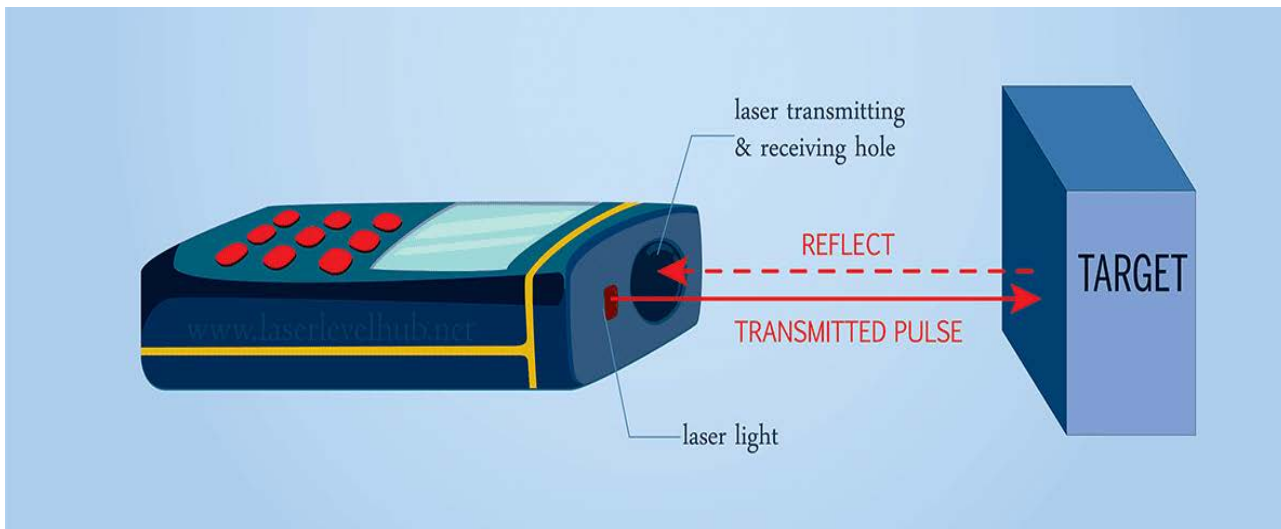
Measuring Wheels and Rods can be used to supplement other equipment.

Building Surveying: Linear Measurement

Disto / Laser measuring

Typically used in building surveys. Hand held disto equipment use laser beam. Modern versions can calculate room areas, volumes and angled slopes.

- Accuracy = $\pm 3\text{mm}$; Range = 200m; Single Operator; useful when
- not possible to use inaccessible heights/points etc
- Errors: requires baseline calibration; errors due to weather
- Safety: Lasers must NOT be pointed in the eye



Building Surveying: Other Measurement

In Building Surveying you will also be looking at other factors especially when assessing existing buildings.

Thermal Camera

Thermal bridging / heat loss detecting areas of poor detailing, damage or construction defects.

Moisture Meter / Protimeter

Areas of damp / water ingress detecting both moisture (damp) and humidity levels.



Land Surveying: Measurement

Automatic Levelling

Building Level/Dumpy Level

Requires Tripod, Levelling staff, changing plate and Level.

Two methods of levelling 'Rise and Fall' and 'Height of Collimation' Methods.



Land Surveying: Measurement

Digital Laser Levels

Requires: Tripod, levelling staff with integrated sensor or bar coded staff, change plate and laser level.

Laser levels can be limited when there are lots of obstructions, such as scaffolding and railing.

Where precise levelling or monitoring work is required laser level can use an INVAR bar coded staff.



Land Surveying: Measurement

Theodolites

Requires: Tripod, plumb bob / ranging rod tape and theodolite.

Theodolites are used for measuring horizontal and vertical angles. Measurements required on both faces of the theodolites to determine instrument errors.

Theodolites can be used underground and are used in mining operations.



iStockphoto.com/pryzmat

Land Surveying: Measurement

Total Stations

Requires: Tripod, detail pole, prism and Total Station.
Total stations can be used to measure distances and angles with the use of the prism and details pole.

Offers two modes of measurement, with infra red and Red laser mode. Total stations enable measurements to be taken where access is restricted such as, railways, motorway white lines. Can also be used for measurement of elevations.

Total stations have built in recording ability where measurements and angles can be downloaded and digitally transferred through industry software.



Land Surveying: Measurement

Laser Scanners

Requires: Tripod, detail pole, prism, reflected target and scanner.

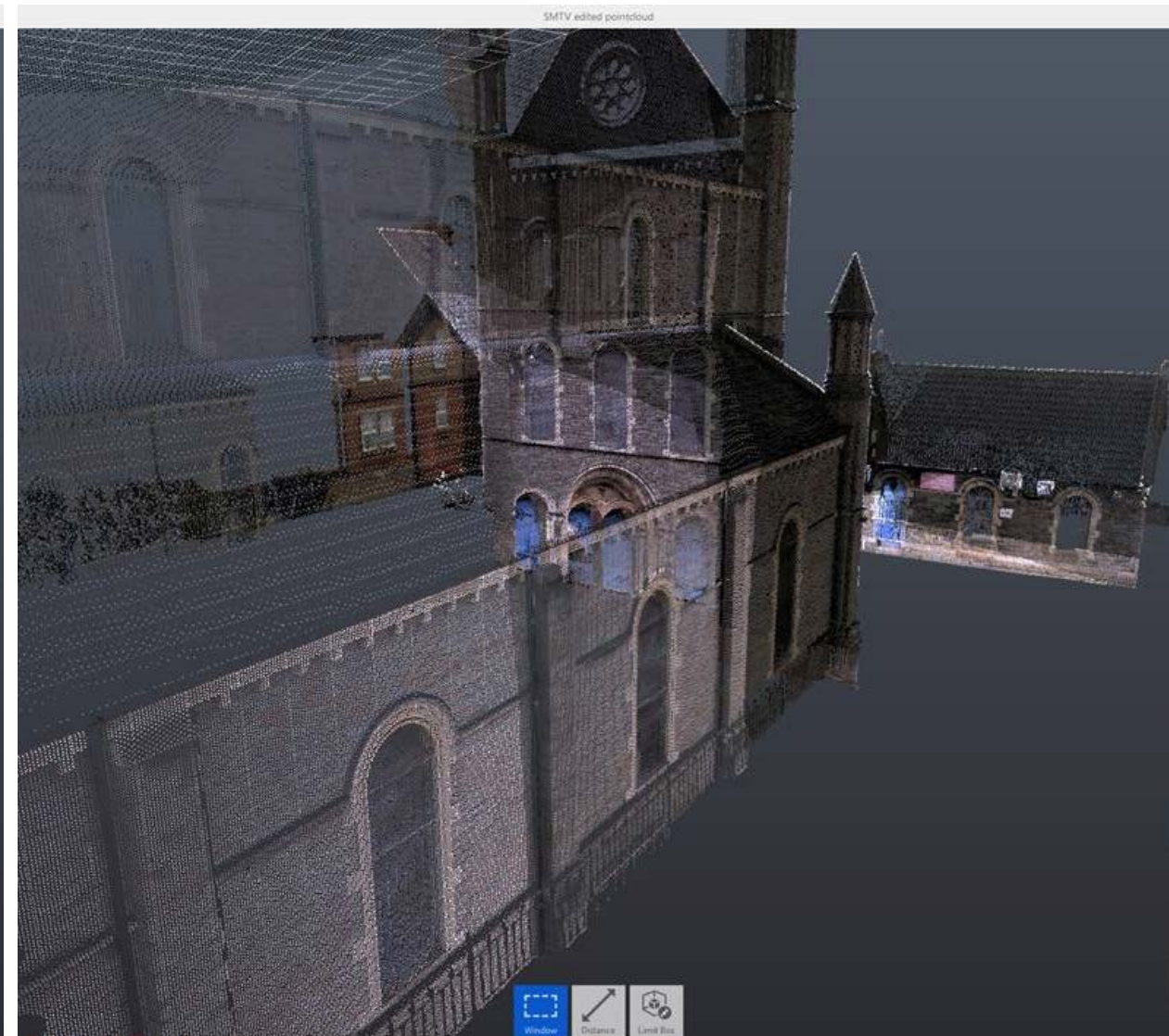
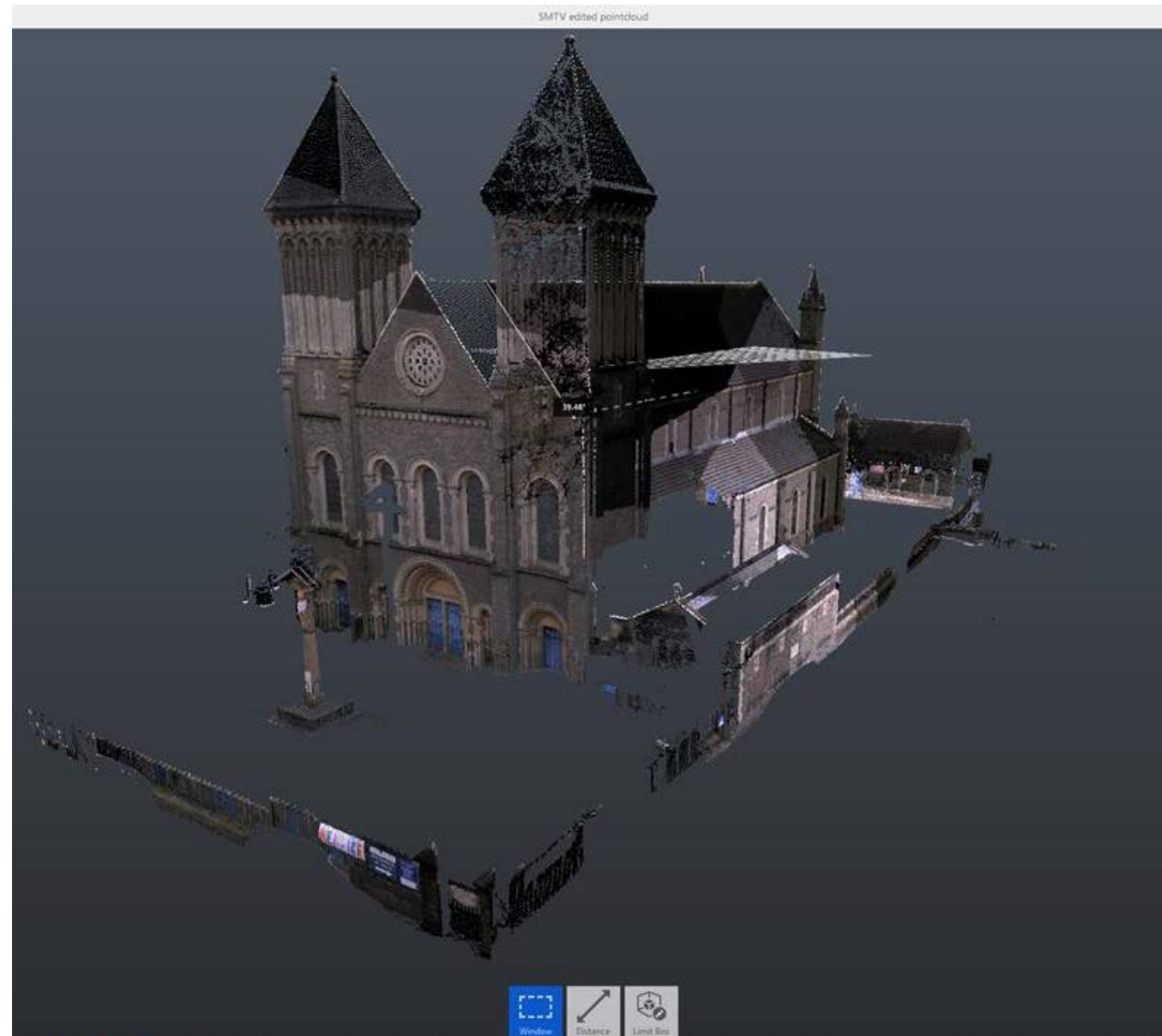
Laser scanners undertake highly accurate detailed surveys, through to production of basic point cloud and rendered photographic imagery.

Typically used for historic buildings and in areas where access is restricted, for example complex pipework installations.

Data can be downloaded and digitally transferred for use in industry software.



St Mary's Church – Grade II listed.



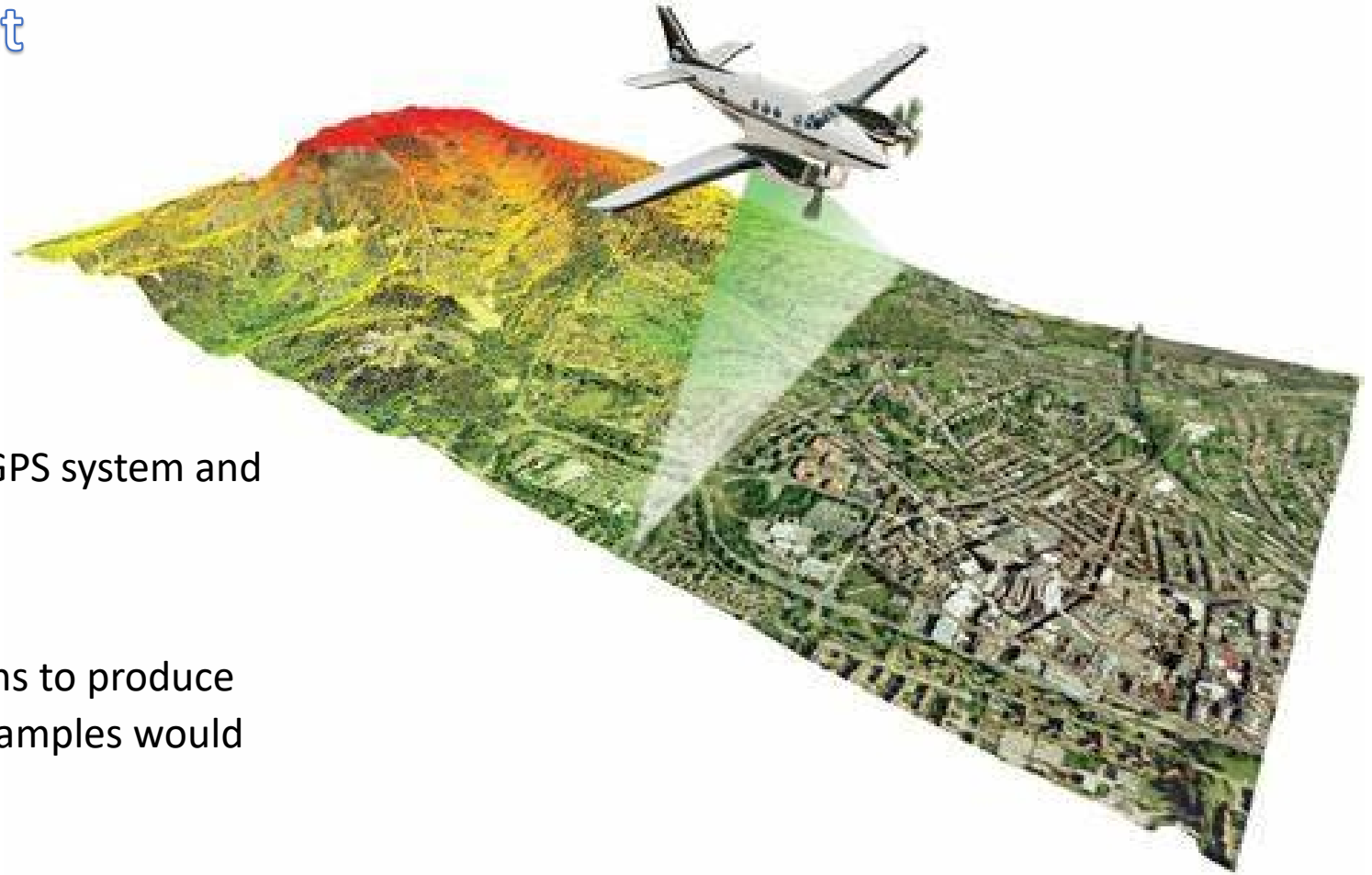
Land Surveying: Measurement

Airborne Laser Scanner

LIDAR (Light Detection and Ranging)

Laser scanners mounted on aircraft utilising a GPS system and inertial navigations system.

LIDAR process scans the ground with laser beams to produce and level survey of large open areas. Typical examples would be NWR.



Land Surveying: Measurement

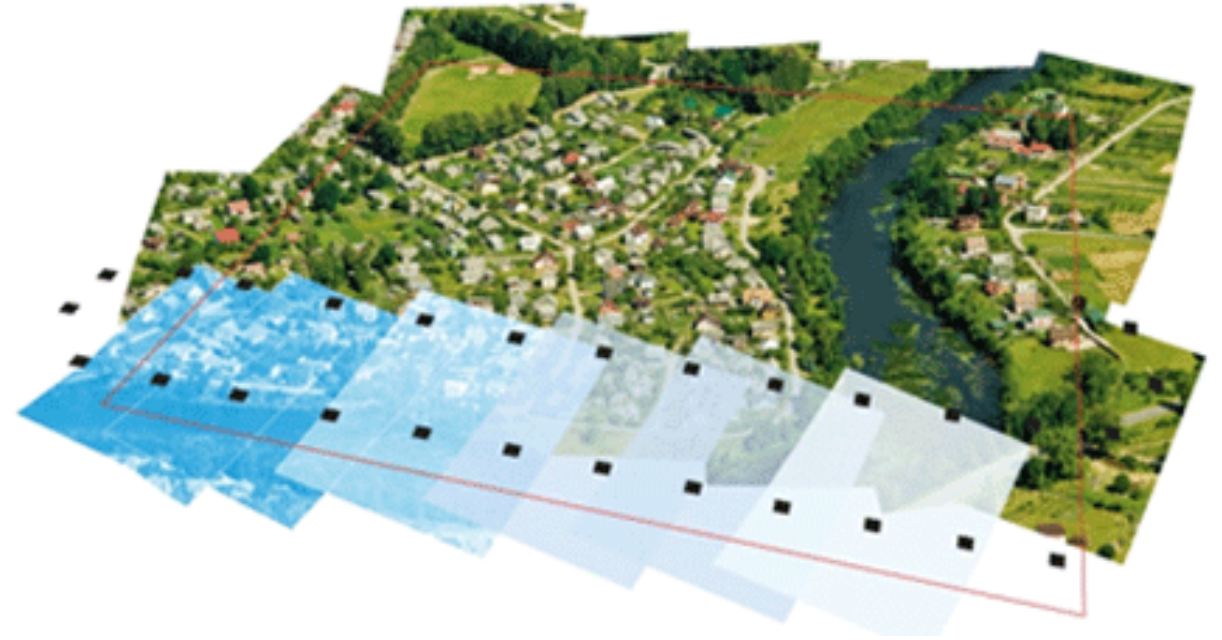
Photogrammetry

Aircraft mounted photographic system, with GPS and inertial navigation system.

Photogrammetry requires ground control and ground markers produced by a conventional surveying. Fixed patterns of flight are used to produce overlapping photographs.

Stereoscopic images are produced from the photography to produce a 3D image of the site.

LIDAR has been preferred in recent time to photogrammetry, however with the rise of the use of Drone technology photogrammetry is now becoming a more favourable and affordable option.



Land Surveying: Measurement

GNSS System

Commonly referred to as GPS.

Comprises of: GPS Base station, GPS Rover, Data logger / pad, Tripod and detail pole.

The principle of system is the utilisation of measurement taken from GNSS (global navigation Satellite System) to measure the distance to the satellites to triangulate and calculate your position.

GPS - US satellite system

GLONASS – Russian Satellite system

Gallileo – European Satellite system

BeiDou – Chinese Satellite system.

To create accurate data, the Base Station will need to be left in position for at least 4 hours.

