# SELECTION OPTIMUM MEASURED METHOD FOR HORIZONTAL DISTANCE [+]

**Abdull-Kadir Abdull-Hadi Ibrahim** [*]

**Abstract:**

**The research presents the results of actual measurement on which calibrated horizontal distance measure previously were evaluated as to their applicability to real value clustering. When using various techniques to which implemented two techniques, *first* is traditional technique such as pacing ,tapping, tachometric survey, total station , global positioning system.(GPS) and *the second* is graphical technique such as aerial photograph and satellite image, software Google earth programmer image, global mapper and GIS (geographic information system) programming , (ARCMAP, ARCINFO), and this evaluation study was done to determine the accuracy in measuring for each techniques several times forward & backward and compute standard divisions by using (MATLAB) programming . The researcher select the method of measuring horizontal distance with steel tape and do all the correction is the optimal method.**

## اختيارطريقة مثلئ لدقة قياس المسافة الافقية

عبد القادر عبد الهادي ابراهيم

المستخلص :

هذا البحث يعرض نتائج القياسات الفعلية التي أجريت على مسافة افقية تم معايرتها مسبقا والعمل على تقيمها بمدى قربها تطبيقيا الى القيمة الحقيقية لها. من خلال استخدام تقنيات مختلفة حيث تم تنفيذ تقنيتين: الاولى التقنيات التقليدية مثل الخطوات والقياس بالأشرطة المختلفة والمسح التاكيومتري وجهاز المحطة الشاملة وجهاز تحديد التموضع العالمي . والاسلوب الثاني هي التقنيات الترسيمية مثل التصوير الجوي وبرنامج (GOOGEL EARTH) وبرنامج (GLOBER MAPPER) بالإضافة الى برنامج نظام المعلومات الجغرافي ,ARCMAP ) .ARCINFO) GIS

أجريت الدراسة لتقييم ولتحديد دقة القياس لكل تقنية مستخدمة في البحث وقيست المسافة لعدة مرات ذهابا وايابا وتم حساب الانحراف المعياري باستخدام البرنامج الاحصائي (MATLAB) وكانت طريقة القياس بالشريط الفولاذي مع اجراء كافة التصحيحات المشار اليها في متن البحث هي الطريقة المثلى في قياس المسافة الافقية على الارض المستوية والحصول على دقة عالية.

[+]Received on 22/5/2011 , Accepted on 3/6/2013
[*]Assist professor / Institute of Technology- Baghdad

## Introduction:

We all agree that there is no true value. However, whenever, wherever you measured a certain distance, For example: If you measured a distance by pacing, the result will be different than using Odometer, Electronic tape (Disto- light), Chain and Tape.

So on when using optical instrument such as; level instrument, you will find various result than using Substance bar, Tachometers, Optical Rangefinder, Theodolite, Total station and Global positioning system (DGPS).

Each technique has its own accuracy and depends upon the type of work and the precision needed

For these considerations 'the research try to study available techniques to calculate the standard division and accuracy, and for the future the research will be helpful to surveyor to select the exact technique for his fieldwork.

## Measurement Technology:

There are various techniques for measuring distances. They can be mainly divided into two categories.

A- Traditional techniques.

B- Graphical or Image techniques.

***Field*** technique or traditional techniques involve taking measurements on site and include pacing, odometer wheel, taping, optical rangefinder, disto-light D5, level, substance bar, theodolite by stadia and tangential method, electronic distance measurement instruments (EDM) & "total station ".

***Image*** technique or **Graphica**l technique use some form of photography for the analysis. Aerial photographs may be available from municipal or county agencies. Recently, one meter per pixel orthophotographs have become available on the Internet at no cost. Distance can be determined directly by a technician by rule. If the images are in digital format on the computer, software can be used to make distance calculations. Image based techniques vary in the equipment and the technical expertise required.

**Photograph and Computer Image Techniques-**

- Ariel photograph & (stereo- meter), *length*.
- Google earth, *length*.
- Computer Software, global mapper, Geographic information system (GIS), ARCMAP programming, *length*.

### A. Field Techniques:-

The following field techniques measure distances between two points. They are listed in order of least to most accurate.

- Pacing, *length*.
- Odometer Wheel, *length*.
- Level instrument*, (reading upper &lower hair).*
- Substance bar, *horizontal angle*.
- Tangential, *middle reading, vertical angle*.
- Stadia, *reading upper &lower hair, vertical angle.*
- Taping, (chain & tape), *length*.
- Disto-light, *length*.
- Optical Rangefinder, *length*.
- Electronic Distance Measurement (EDM), *length.*

- Total Station, *length*.
- Global Positioning System (GPS) *coordinates*.

**1. Pacing:**

Where approximate result is required, distance may be determined pacing. This method is used for reconnaissance survey, for preparation of military plans. Also used for approximate checking distance made by other methods. The length of an individual's pace (76cm) is determined by walking a known length such as the length of tape (50 – 100 m) and dividing the distance by the number of steps taken. It requires no equipment and little training. The accuracy of the method is between 30 cm in 30 m (1/50 - 1/100) of measurement, measuring distance by counting steps (paces).or use *passometer* to count the number of paces. Distance is calculated by multiplying the number of paces by the individuals pace factor. (Figure1).The required distance may be obtained by multiplying the number of paces by the average length of pace. The length of pace varies with the **[1]**:

1. Individual, age, height, physical condition and person's skill
2. The nature of the ground (uphill and downhill)
3. The slope of the country
4. The speed of pacing.

**Field measurement:-**

In the field the searcher's measurement the distance (NH2-NH3) by his steps forward and backward, the result as follow:-

Mean for forward steps = 146 paces * **0.76m per pace =110.960m**

Mean for backward steps =147 paces * **0.76m per pace =111.720m**

Average=110.960+111.720=222.680 /2 =**111.340m**


**Figuer1. The individual pace for searcher is 76cm (individual step )**

**Table 1 Advantage and Disadvantages in Pacing**

| Advantages in Pacing | Disadvantages in Pacing |
|---|---|
| 1- A quick, easy method of determine distances.<br>2-use for estimation.<br>3-No specialized equipment used. | 1-Topography affects accuracy<br>2-Requires practice to take a consistent pace.<br>3-Must able to traverse the distance. |
| Accuracy of distance paced1/50 to 1/100 | |

❖ **Number of paces may be counted by passometer**

➢ Passometer:

Passometer is pocket an instrument shaped like watch and is carried in pocket or attached to one leg. The mechanism of the instrument is operated by motion of the body and it automatically register the number of paces, thus avoiding the monotony and strain of

counting the paces, by the surveyor, the number of paces registered by the passometer can then be multiplied by the average length of the pace to get the distance as shown in Figure 2.


**Figure 2-passometer**

- **Pedometer:**

It is similar to passometer. But it registers the distance walked by the persons carrying it. The distance is read by means of an indicator. It is fitted with a stud or Knob, which when pressed release indicator to zero; it may be carried in the same way as the passometer.

### 3.1.1 2. Odometer

An odometer is a wheel rolled between two points. The distance is calculated by multiplying the number of revolutions by the wheel's circumference. The smoother the path the wheel travels, the more accurate the measurement. This method is particularly useful for curved lines. Odometer wheels can also be used to verify other measurements. The accuracy of the method is approximately 1/200. The gear ratio of the odometer is usually designed to provide a measurement of the distance in standard units--feet, decimal feet, feet and inches and/or meters (See figure 3).

**Field measurement:-**

Mean for forward = the counter reading= **109.780 m**
Mean for backward= the counter reading= **110.050 m**
**Average** =109.780+110.050=219.830/2 =**109.915 m**


**Figure 3- the Odometer instrument to measure length of a distance.**

**Table2 Advantages and Disadvantages in odometer**

| Advantages in Odometer | Disadvantages in Odometer |
|---|---|
| ➢ Easy to use<br>➢ Don't need exercise or experience.<br>➢ Fast to give you idea about distance | ➢ Accuracy is influenced by surface conditions.<br>➢ Must be able to traverse distance.<br>➢ Only measures slope distance. |
| ➢ accuracy 1/100 -1/200 | |

**3-Level instrument:-**

**A-Regular Level**

An optical instrument use to measure the differential height of the surface on the ground also can determine the horizontal distance by using the different between upper reading hair & lower reading hair on the staff then multiply by 100) (See figuer4).

**Figuer 4.- Regular level in used**

**B-Digital Level insturment:-**

Digital levels come with a wide range of software functions. Single height measurements are easy to make and also just as easy is measuring all the elements in a line leveling job. With the program "Line Adjustment", measured heights can be compared directly with the height of fixed points and adjusted to them if desired. Staking out absolute heights or height differences or point-to-point measurements is all easily possible. Distance measurement (See figure 5).

**Field measurement:-**

Mean for **forward:**

Reading upper hair or distance line above: 2.675 m

Reading lower hair or distance line below: 1.565 m

**Difference L: 1.110 m**

Result: Distance d = 100 x L =**111.000m**

Mean for **backward**

Reading upper hair or Distance line above: 2.575 m

Reading lower hair or Distance line below: 1.466 m

**Difference L: 1.109m**

Result: Distance d = 100 x L =**110.900m**

Average distance =**111.000m+110.900=221.90m/2 110.95m**

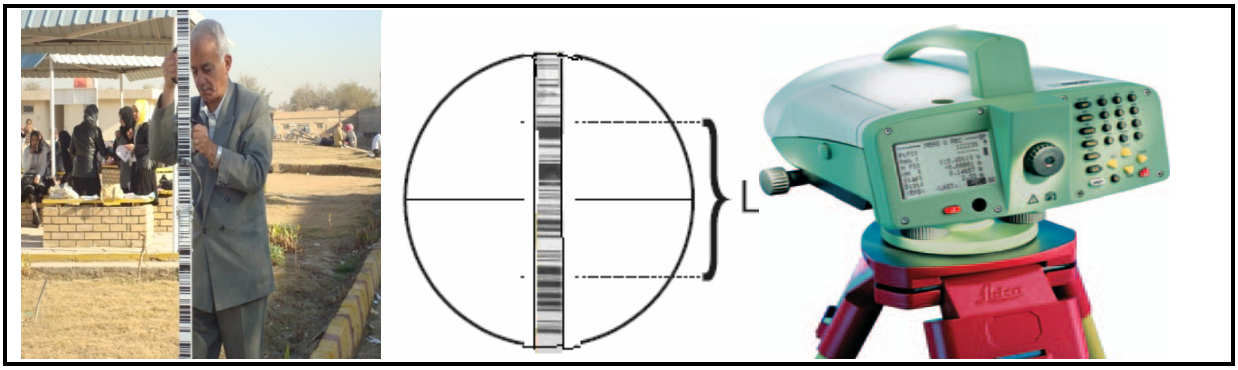


**Figure 5 measuring a distance by digital level instrument**

**Table3 Advantages and Disadvantages in level**

| Advantages in level | Disadvantages in level |
|---|---|
| ➢ fast method<br>➢ Easy to use<br>➢ For approximation in case of regular level<br>➢ More **accuracy** for digital level. | ➢ Not accurate in case of regular level<br>➢ Staff held vertically<br>➢ Only measures flat ground.<br>➢ Need experience (digital level). |
| ➢ accuracy 1/250 -1/500 | |

### 3.1.2 -4.Optical Rangefinder

An optical rangefinder uses the focusing of lenses on a distant object to estimate the distance to the object. This technique is the same as single-reflex lens cameras. Rangefinders have a maximum range of 500 m (See figure 6). And there is another type a **laser rangefinder** is a device which uses a laser beam to determine the distance to an object. The most common form of laser rangefinder operates on the time of flight principle by sending a laser pulse in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target and returned to the sender. Due to the high speed of light, this technique is not appropriate for high precision sub-millimeter measurements, where triangulation and other techniques are often used.

The precision of the instrument is determined by the rise or fall time of the laser pulse and the speed of the receiver. One that uses very sharp laser pulses and has a very fast detector can range an object to within a few millimeters.

Despite the beam being narrow, it will eventually spread over long distances due to the divergence of the laser beam, as well as due to scintillation and beam wander effects, caused by the presence of air bubbles in the air acting as lenses ranging in size from microscopic to roughly half the height of the laser beam's path above the earth [2].

### 3.1.2.Calculation:

The distance between point A and B is given by

$$D = \frac{ct}{2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where $c$ is the speed of light in the atmosphere and $t$ is the amount of time for the round-trip between A and B.

$$t = \frac{\varphi}{\omega} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where $\varphi$ is the delay which made by the light traveling and ω is the angular frequency of optical modulation.

Then substitute the values in the equation D=ct/2, D=1/2 ct=1/2 c·φ/ω=c/(4πf) (Nπ+Δφ)=c/4f (N+ΔN)=U(N+)

In this equation, U stands for the unit length.

ΔΦ stands for the delay part which does not fulfill π.

ΔN stands the decimal value. ΔN=φ/ω

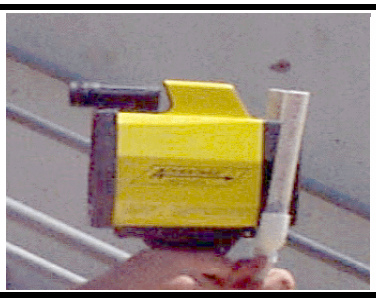

Figure 6 a. A hand held laser rangefinder.

Figure 6 b.Laser rangefinder

**Field measurement:-**

Mean for forward digital reading for distance =**110.300m**
Mean for backward digital reading for distance=**110.380m**
**Average = 110.300m +110.380m=220.680m/2 =110.340m**

**Table 4 Advantages and Disadvantages in Optical Rangefinder**

| Advantages in Optical Rangefinder | Disadvantages in Optical Rangefinder |
|---|---|
| ➢ Easy to use in the field<br>➢ high techniques<br>➢ fast result digital display | ➢ Accuracy depend on the long of distance<br>➢ Only measures on flat surface.<br>➢ Source of power battery always charging |
| ➢ For the laser Rangefinder accuracy 1/1000-1/2000 | |

**5 -Electronic tape:-**

**T**he Electronic Tape Measure sends out narrow beams of sound waves that bounce off solid objects back to the hand-held receiver. Custom electronics and a microprocessor then convert elapsed time into a distance measurement and display it on the LCD. When used with its electronic target, the Combo PRO model uses both sound waves and an infrared beam [3]. **T**he Electronic Tape Measure also has a built-in calculator to add linear measurements and compute areas and volumes. Intelligent software, accurate results and easy-to-understand instructions complete the attractive package. **T**his is a two- range measurement kit. You can use single unit for measuring distances less than 60 feet (18 meters), which is fine for indoor measurement. If you use the target unit you can measure up to 250 feet (75meters) with accuracy of 99.5% ± 1 cm, (See figure 7).

**Field measurement:-**

Mean for forward digital reading for distance =**110.275m**
Mean for backward digital reading for distance=**110.270m**
Average =**110.275m+110.270m=220.545m/2 =110.2725m**

Figure 7 measuring a distance by disto-light (D5)

**Table 5 Advantages and Disadvantages in disto-light**

| Advantages in disto-light | Disadvantages in disto-light |
|---|---|
| ➢ Easy to use<br>➢ Modern tech<br>➢ Fast and don't need exercise. | ➢ Accuracy depend on the long of distance<br>➢ Only measures in door or use special target. |
| ➢ Accuracy 1/5000 | |

## 6-Subtense Bar instrument:

Subtense Bar, Distances are determined using a theodolite with high accuracy (1″) to determine a horizontal angle subtended by two targets precisely spaced at a fixed distance of 2 meters apart on a subtense bar. Computed by H = cot (α/2). Can achieve an accuracy of 1/2500 to1/3000.

**Figurer 8 Measuring distance by subtense Bar**

**Field measurement:-**

Mean for Forward α1= reading for ends of subtended angle= 00˚00′00″and 01˚02′22″

Horizontal distance =cot (α/2). = cot (00 ˚ 31′ 11″) = **110.240m**

Mean for backward α2 reading for ends of subtended angle =15˚00′ 00″and 16˚02′ 20″

Horizontal distance =cot (α/2). = cot (00 ˚ 31′ 10″) =110.299m ≈**110.300m**

**110.240m+110.300m=220.540m/2** Average= **110.270m**

**Table 6 Advantages and Disadvantages in Subtense Bar**

| Advantages in Subtense Bar | Disadvantages in Subtense Bar |
|---|---|
| ➢ Middle accuracy<br>➢ Fast measurements<br>➢ Use when there is obstacles on survey line such lack , pound, river<br>➢ Use in forest when it difficult to use tape. | ➢ Accuracy depends on the long of distance and the precise of reading the subtended angle.<br>➢ Only measures use special target.<br>➢ Heavy tool<br>➢ Need two professional person one Setup theodolite and other setup and orients subtense bar |
| ➢ Accuracy1/2500- 1/3000 | |

## 7- Theodolite instrument:

There are two mainly method to measure distance with theodolite instrument.

### 3.1.2 A. Stadia method:-

Stadia measurements use a surveying theodolite telescope diagramed. There are three horizontal lines crossing the vertical line in the middle of the telescope. The distance measured is proportional to the difference between the top and bottom rod readings. Stadia accuracy can reach 1/500.

Distance by stadia requires an instrument with stadia cross hairs.
The distance between the stadia crosshairs is designed so that the divergence of the sights across the two stadia crosshairs is 10 cm when the instrument is 100 m from the rod. (Assuming an instrument stadia factor of 100.)
This results in the equation
$H.D= K*S*\cos^2 \Phi$
Where: K= stadia factor of 100
S= stadia interval, the distance between the upper hair and lower hair &Φ= vertical angle

**Field measurement:-**
Mean for forward. Reading for stadia hair and vertical angle= upper reading 3.470m
Lower reading 2.365m & Vertical angle 00˚ 02`20``
$H.D= K*S*\cos^2 \Phi$ =100* (3.470-2.365)*cos² 00˚ 02`20``=**110.499m**
Mean for backward. Reading for stadia hair and vertical angle = upper reading 3.568m
Lower reading 2.462m & Vertical angle 00˚ 02`30``
$H.D= K*S*\cos^2 \Phi$ =100* (3.568-2.462)*cos² 00˚ 02`30``=110.599m
Average=110.549m ≈ 110.550m

**Figure 9 Measuring distance by stadia method**

**Table 7 Advantages and Disadvantages in stadia method(moffitt)**

| Advantages in stadia | Disadvantages in stadia |
|---|---|
| ➢ Works by line of sight. Not necessary to walk distance.<br>➢ Distances can be measured with the same setup used to record elevations. | ➢ Must have instrument with stadia crosshairs.<br>➢ May require multiple instrument setups. |
| ➢ When the rod is read directly, the precision of the measurement is 30cm.<br>➢ When better precision is required, the target and venire scale should be used. Precision =2 cm. | |
| Stadia accuracy can reach 1/5000. | |

**B-tangential method:-**
The tangential method of tacheometry is being used when stadia hairs are not present in the diaphragm of the instrument or when the staff is too far to read.
In this method, the staff sighted is fitted with two big targets (or vanes) spaced at a fixed vertical distances. Vertical angles corresponding to the vanes, say $\alpha_1$ and $\alpha_2$ are measured. The horizontal distance, say H.D and vertical intercept, say S are computed from the values s (pre-defined / known) $m_1$ and $m_2$. This method is less accurate than the stadia method.

**Field measurement:-**

Mean for forward. Reading for tangential method middle hair and vertical angle=
Reading middle hair M1=2.765m v. angle /00˚47`19``
M2=1.300m v. angle /00˚ 01`52``
Mean for backward Reading for tangential method middle hair and vertical angle=
Reading middle hair M1=2.754m v.angle=/00˚47`20``
M2=1.286m v.angle /00˚01`55``
By using equations , (m2-m1)/ (Tanα1-Tanα2) =mean forward distance= **110.802m**
Mean backward distance= **111.071m**
**Average=110.863m**


**Figure 10 Measuring distance by tangential method**

**Table 8 Advantages and Disadvantages in tangential method (from experience of the author)**

| Advantages in tangential | Disadvantages in tangential |
|---|---|
| ➢ Works by line of sight. Not necessary to walk distance.<br>➢ Fast and easy | ➢ Must have instrument with stadia crosshairs.<br>➢ Held the staff vertically on point |
| ➢ Tangential accuracy can reach 1/5000. | |

## 8- Tacheometer instrument:

Tacheometer is a transit theodolite with an analytic telescope fitted with two horizontal hairs called stadia hairs in addition to the central hair in ordinary telescopes (See figure 11).

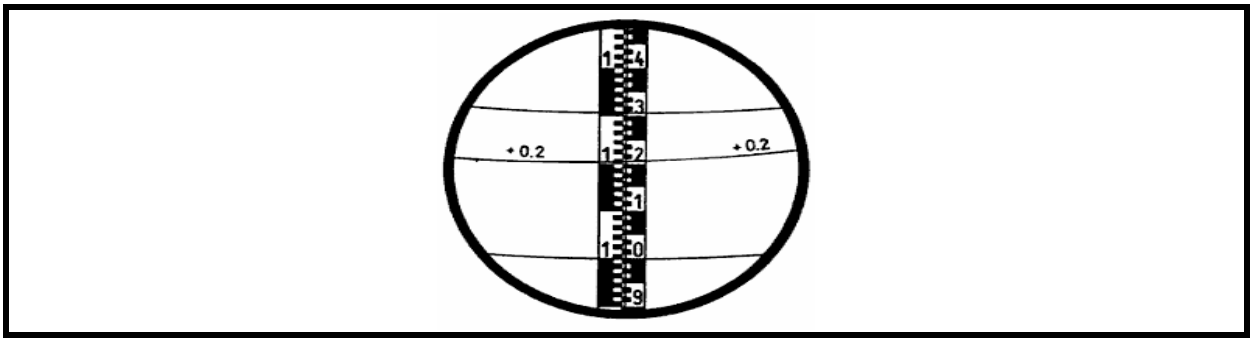


**Figure11 field view of the wild RDS**

**Field measurement:-**
Mean for forward. Distance hair reading 2.103 and zero hair at 1.000
Horizontal distance = **110.300m**
Mean for backward. Distance hair reading 3.102 and zero hair at 2.000
Horizontal distance = **110.200m**
**Average =110.250m**
The essential character of tacheometer are its multiplying constant for finding distance should be 100 and it should have good magnifying power to render clear staff reading even from long distance. By knowing distance and angle we can calculate the total distance (See figure12).

**Figure12 Tachometer** instrument in use

## 9. Chaining:

Measuring distance with chain or rope is the most accurate and common method, called as chaining. For work of ordinary precision a chain is used. Where great accuracy is required, a steel tape is used[3].

**a. By chain**
**3.1.3 b. Taping by cloth Tape**
Tape measures can be used for most small and medium distances (Figure 11). The most common tape length is 30 m, although longer tape lengths are also available. Plumb bobs are used to make horizontal measurements over rough and sloped terrain. Taping accuracy range from 1/1000 to1/5000. The accuracy attained will depend on the skill and attention to detail of personnel using the tape.

**c. Taping by steel tape**
Distances are determined using a steel tape. Corrections can be made to improve the accuracy of a set of linear measurements. Steel Chain Temperature Correction
Steel expands and contracts at fixed rate dependent upon the temperature.
The temperature correction for a steel tape is[4]:
Corrections for incorrect length, temperature, inconsistent pull, sag and improper alignment. Can achieve an accuracy of 1/5,000 to 1/10,000. Great care was taken when setting control points for other surveys.

**Field measurement: -** **Field measurement:-**
Mean for forward by chain **110.100m** & mean for forward by tape **110.175m**
Mean for backward by chain **110.200m** & mean for backward by tape **110.205m**
Average 110.115m Average **110.195m**


**Figuer13 measuring distance by tape**

### 3.1.4 10. Global Positioning System:-

Global Positioning System (GPS) represents a satellite-based surveying and navigation system. The system consists of a network of 24 satellites circling the earth with an altitude of 12,500 miles. The network was created and controlled by the US military. Civilian uses of the network are expanding, and it is becoming a significant resource for determining location. A GPS receiver uses the signal from four or more satellites to determine its position on or above the earth (Figure 14). Due to military interests, the signal being sent by the satellites is constantly being altered such that accuracy is limited to ± 100 m [5].

The measurement's accuracy using satellite systems may be increased in size:

1. Correcting the measurements taken with data from the military indicating the amount of error in the signal (post processing correction)
2. Correcting the measurement by placing a second receiver at a known location and computing the distance and direction from the known position to the new position (differential correction)

Differential correction can be done either in post processing or real time. Real time correction requires both receivers to have radio communication with each other. Depending on the receiver's design, measurements can be as accurate as ± 1 cm horizontally and ± 2 cm vertically. The output from the receiver is a point location—X, Y, Z coordinates—in either a known map coordinate system or in a local grid system (See figure 14).

**Field measurement:-**

Mean for forward digital reading =110.250m

Mean for backward digital reading =110. 26m Average distance =110.255m

**Figure 14 measuring by GPS navigation**

### 3.1.5 11. Electronic Distance Measurement (EDM):-

EDM is usually integrated into a *total station.* EDM emits a directed signal to a reflector located at the end point of a line. The signal is reflected back to the EDM, and the length of a line is determined (Figure ). Distance measurements of several miles are possible. Accuracy of 1/1,000,000 is obtainable by GPS SURVEY. The shorter the distance, the greater the error.

- EDM = Electronic Distance Measuring
- The term EDM is used to describe a category of instruments that measure distance using an electronic signal.

Therefore, if the speed of the signal is known (speed of light), and the time for the signal to travel to the target and back is known, the distance can be calculated.
Electric Distance Measurement (EDM) Distances are measured electronically by determining the number of full and partial waves of transmitted electromagnetic energy that are required in traveling the distance between the EDM and a prism. Can achieve an accuracy of +/- (1 mm + 1 ppm) to +/- (10 mm + 5 ppm). Total Station Instruments combine the electronic theodolite with an EDM.

### 3.1.6 12.Total Station:-

A "total station" has a theodolite, for horizontal and vertical angle measurement, and an EDM for electronic distance measurement (Figure 15). A manual total station uses manual reading of angles and is entered into a field book. An automatic total station reads and enters angles and distances into an electronic field book computer with the touch of a button. Most instruments used today read angles to 5 seconds of a degree or better.

**Field measurement:-**
Mean for forward digital reading = **10.260m**
Mean for backward digital reading= **110.270m** average reading= **110.265m**

**Figure.15 Electronic distance measurement (EDM) instrument.**

**Table 13 Advantages and Disadvantages in (EDM) instrument( from experience of the author)**

| Advantages of EDM's | Disadvantages of EDM's |
|---|---|
| ➢ Precise measurement of distance.<br>➢ Line of sight instrument<br>➢ Capable of measuring long distances<br>➢ Reflector less are single person operation | ➢ Electronic = batterers<br>➢ Accuracy affected by atmospheric conditions.<br>➢ Can be expensive. |
| ➢ Error ± (2 mm + 2 ppm x D) | |

### 3.1.7 B-Graphical technique:-

1. **Aerial photographs':-**

Aerial Photography Distances are determined from photographs taken by aerial cameras mounted in airplanes. **Errors up to 15% are possible,** Topographic maps developed from aerial photographs provide data which can be used for the design of engineering projects.
The horizontal distance (D), can also be measured, at least approximately **D= d x S**
Where: d is the distance in the photo between the **NH2** and **NH3** point of the line.
S is the **actual scale** factor at the mean level.

**Field measurement:-**
Mean for forward digital reading =**111.200m**
Mean for backward digital reading= **111.150m** Average reading= **111.175m**


**Figure.16 distance measurement on Aerial photographs'**

**2- Google earth:-**
Google Earth offers a number of tools that you can use to measure distances (See figuer17).
**Field measurement:-**
Mean for forward digital reading =**111.000m**
Mean for backward digital reading= **110.920m** Average reading= **110.960m.**


**Figure.17 measuring distance Google earth programmers**
**Using satellite image with resolution (60cm)**

C.Computer Software:-
**A- Global Mapper:-**
This programmed have many tools will descries the tool related with subject (distance measurement). Menu bar and toolbar, this section briefly reviews the menus and commands in order to understand the basic purpose of each. Figure 18 shows the program Menu Bar and Toolbar as they appear at startup [5].
Toolbar (See Figure18).


**Figure18. A distance measurement by Global Mapper programme Using satellite image with resolution (60cm)**

**Field measurement:-**
Mean for digital reading =**110.250m**

**B- Geographic Information Systems (GIS 9.2):-**
Software provides another option for measuring distance on. Orthophotographs For this project, ArcView® was used. However, there are other types of software that can be used for this same purpose. Orthophotographs can be opened in ArcView® as themes or layers (Figure 19).
Orthophotographs created by professional engineering/surveying companies should transfer directly into ArcView®.
The accuracy of this process depends on correctly identifying the distance and the resolution of the orthophotograph. Once again, personal knowledge of the site is critical in determining correct sits.

**To measure distance on screen with the measuring tool in ArcView:**
1. With at least one of the themes open, choose View-Properties from the View menu
2. Set "Map Units" to the units of the map source's projection (for City of Austin data, this is feet - for other themes you must know what projection that was used - the projection parameters will specify the unit)
3. Set "Distance Units" to whatever unit you would like to use as a measuring unit (e.g., feet or miles)
4. You can use the measuring tool and see the results in the "Distance Units" you specified.

**Field measurement:-**
Mean for forward digital reading =**110.950m**
Mean for backward digital reading= **111.040m** Average reading= **110.995m**

**Figure 19. Orthophotograph of study area inserted as a theme in ArcView**

**CHAPTER 4** The evaluation consisted of measuring distance of line in front of surveying department at institute of technology –Baghdad, between two Bench mark s (NH2-NH3) (See figure 20a ) and its coordinates determined by using GPS survey and the geodesics correction has been done (Leica GPS1200+ Surveying Systems) as shown in figure 20b .

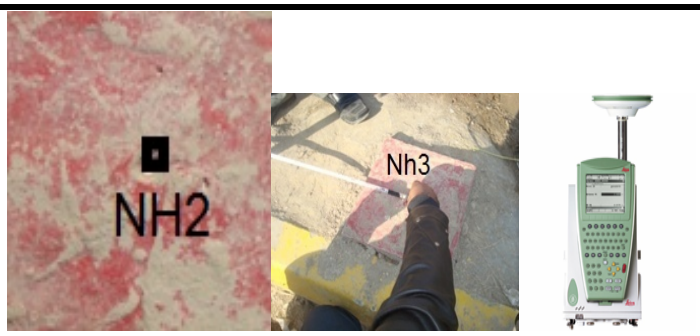


**Figure 20a- Bench marks NH2 &NH3** **Figure20b-Leica GPS1200+ Surveying Systems**

On flat ground and by using invar tape a distance NH2-Nh3 measuring precisely forward and Backward to eliminate the error and the data tabulated (See table 15.)

**Table 15 – initial measurements**

| From bench mark | To bench mark | Distance(M) | Mean(M) |
|---|---|---|---|
| NH2 | NH3 | 110.285 | 110.270m |
| NH3 | NH2 | 110.255 | |

To establishing base line should all the corrections be done (change in temperature, pressure, sag, alignment, tension) .So the distance (NH2-NH3) becomes **110.255m** (See table 16). This value counted as a base to compute the standard division and accuracy by using **matlab programmed**.

**Table 16. Base line measurements**

| Bench mark | NH2 | | NH3 | | Elevation |
|---|---|---|---|---|---|
| | E(m) | N(m) | E(m) | N(m) | |
| coordinates | 452475.013 | 3680227.710 | 452554.414 | 3680304.152 | NH2=29.9643m |
| Distance by using GPS | $\sqrt{a^2+b^2}$ | 110.2170m | | | NH3=29.9754m |
| Invar tape be4 correction | | 110.270m | | | |
| Invar tape after correction | | 110.255m | | | |

**Discussion:**

In appendix A - Description of measurement evaluation .Field based techniques were more consistent than image based techniques and provided results with errors less than 2.5%. Both the high-tech (GPS and total station) and low-tech (pacing and odometer wheel) methods yielded relatively accurate results, although the skill levels vary for the different methods. The extent of measurements necessary and the resources available will determine if

any of these methods are appropriate. In some cases, hiring a consultant to make the required measurements may be the preferred option.

Image based techniques require the least amount of surveying knowledge. Many agencies have access to orthophotographs or software needed for analyzing images. The Google Earth Programme method yielded the highest errors. However, the 10-15% error resulting from using this approach would be more than acceptable in many agencies. Other errors associated with image based techniques involve difficulties in site identification.

## Conclusions:

When selecting a technique for distance measurement, the agency must balance issues of accuracy. In addition, they must consider the nature of site, availability of images and equipment, technical expertise of staff, and time resources available.

## Suggestion:

The following are suggestions to eliminate the error and get the best results:
1-Allways measure the distance forward and backward.
2- Orientation is necessary for the distance longer than the tape used in field.
3- The best distance measuring technique/device to use is influenced by many factors.

a. Environment
b. Use of the data
c. Equipment available
d. Expertise of individuals
e. Personal preference
f. Topography
g. Client specifications
h. Regulations
i. Standard practice
j. The most important factor is the intended use of the data.

## References:

1. Brinker, R. C. and R. Minnick. 1989. The Surveying Handbook. 7th Edition. Van Nostrand Reinhold, New York,
2. Moffitt, F.H. and H. Bouchard. 1992. Surveying. 9th Edition. . HarperCollins. New York.
3. Raymond E, Davis, 2003, Surveying 4th Edition. McGraw-Hill. New York.
4. Wolf, P.R. and R.C. Brinker. 1998. Elementary Surveying. 9th Edition. HarperCollins. New York.
5. USGS. 1999. http://edcwww.cr.usgs.gov/Webglis/glisbin/guide.pl/glis/hyper/guide/usgs_doq.

**Result:**

***Note***: - **All measurement's repeated for several times to get the mean for forward and backward measurements.**

**Table 17- Description of measurement evaluation.**

| Technique | Measured Distance from point{ NH2-NH3} (M) | | Average (M) | ∑Standard division | Relative Accuracy |
|---|---|---|---|---|---|
| | Mean for Forward | Mean for Backward | | | |
| Pacing | 146*0.76m =110.96 | 147*0.76m =111.72 | 111.34 | #paces*m/pace ∑1.0850 | 1/50-1/100 |
| Odometer | 109.780 | 110.050 | 109.915 | ∑-0.3400 | 1/100-1/200 |
| Level | 111.000 | 110.900 | 110.950 | ∑0.6950 | 1/250-1/500 |
| chain | 110.100 | 110.200 | 110.115 | ∑-0.1400 | 1/1000-1/2500 |
| optical rangefinder | 110.300 | 110.380 | 110.340 | ∑0.0850 | 1/1000-1/3000 |
| Theodolite/stadia | 110.260 | 110.280 | 110.270 | ∑0.0150 | 1/1500-1/3000 |
| Subtense Bar | 110.240 | 110.300 | 110.270 | ∑0.0150 | 1/1000-1/5000 |
| Tacheometer | 110.275 | 110.260 | 110.270 | ∑0.0150 | 1/1000-1/5000 |
| Theodolite/tangential | 110.802 | 111.071 | 110.936 | ∑0.0682 | 1-1000-1/5000 |
| tape | 110.175 | 110.205 | 110.195 | ∑-0.0550 | 1/5000-1/10000 |
| steel | 110.300 | 110.280 | 110.290 | ∑0.0050 | 1/30000-1/100000 |
| Invar tape before corrections | 110.285 | 110.255 | 110.270 | ∑0.0015 | 1/100000-1/1000000 |
| Invar tape after corrections | | | 110.255 | ∑0.0000 | 1/100000-1/1000000 |
| Total station | 110.260 | 110.270 | 110.265 | ∑0.001 | 1100000 |
| GPS-navigation | 110.220 | 110.235 | 110.227 | ∑-0.0075 | 1:100000 |
| GPS survey | 110.2174 | 110.2176 | 110.217 | ∑-0.0075 | 1/100000 |
| orthophotograph | 111.200 | 111.150 | 111.175 | ∑0.9500 | 1/150-1/200 |
| Google Earth Programme | 110.920 | 111.000 | 110.960 | ∑1.5950 | 1/100-1/150 |
| Global Mapper | 110.250 | 110.620 | 110.435 | ∑0.6300 | 1/150-1/250 |
| GIS ,ArcView | 110.950 | 111.040 | 110.995 | ∑0.7500 | 1/150-1/250 |

Note:- NH1/في سطح الكلية Easing/**452528.744** Northing/ **3680229.498**

NH2/مجاور بناية عمادة الكلية الجديد Easing/**452475.013** Northing/**3680227.710**

NH3/بين النادي الصيفي وقسم الموارد Easing/**452554.414** Northing/**3680304.152**

By GPS navigation

NH2/ Easing=452475. Northing= 3680228 with 9 stars

NH3/ Easing=452555. Northing= 3680304 with 7 stars