



A Computerized Integrated System for Geodetic Networks Design

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ABSTRACT:

This research presents a model for surveying networks configuration which is designed and called a Computerized Integrated System for Triangulation Network Modeling (**CISTNM**). It focuses on the strength of figure as a concept then on estimating the relative error (*RE*) for the computed side (base line) triangulation element. The **CISTNM** can compute the maximum elevations of the highest obstacles of the line of sight, the observational signal tower height, the contribution of each triangulation station with their intervisibility test and analysis. The model is characterized by the flexibility to select either a single figure or a combined figures network option. Each option includes three other implicit options such as: triangles, quadrilaterals, and central-point figures (which is to be subdivided into: triangle; quadrilateral, and pentagon). The model also has the property of the diverse modes of display for the output results; i.e. the results can be displayed in the shape of Two-Dimensional (2-D) and Three- Dimensional (3-D) representations. Visual Basic is the software depended as a main core in designing **CISTNM** to draw the suggested network in 2-D to display the network point positions and formations, and it can be linked with the available software such as ArcMap (GIS). The input data which is used as an application of the targeted geodetic surveying techniques (triangulation) is Chamchamal region as a case study in this research. The area lies in the north of Iraq. The results obtained after this application and verification, have proved that the **CISTNM** can perform the required task easily and accurately.

KEYWORDS: Geodetic Surveying, Network Formation, GIS Modeling, VB Model

نظام برمجي متكامل لتصميم الشبكات الجيوديسية

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الخلاصة:

يقدم هذا البحث نظام مبرمج في الحاسوب لنمذجة متكاملة لتصميم الشبكات وسمي بـ (**CISTNM**). والنموذج يركز على مفهوم متانة الشكل كمعادلة رياضية مستخدمة لتخمين قيمة الخطأ النسبي للضلع المقيس والذي يسمى بـ (خط القاعدة). بالإضافة لمكانيته في حساب منسوب أعلى عائق يعترض خط النظر وأرتفاع برج الرصد بأستخدامه معادلات فحص وتحليل تبادل الرؤية بين أي محطتين من محطات شبكة التثليث. البرنامج ذو قابلية لأختيار واحدة من حالتين لتشكيل شبكة التثليث بشكل مفرد من نفس العنصر أو مركب من

عناصر مختلفة. بالإضافة الى تضمّن كل اختيار ثلاثة أختيارات ضمنية مثل المثلثات، الأشكال الرباعية والأشكال ذوات النقطة المركزية (التي تقسم الى مثلث بنقطة مركزية، رباعي بنقطة مركزية وشكل متعدد الأضلاع بنقطة مركزية) وكما لديه أساليب متعددة

الأشكال لعرض نتائج ثنائية أو ثلاثية الأبعاد. النموذج تم بناؤه باستخدام برنامج (Visual Basic (version 6.0 كلغة برمجية أساسية للنظام لأظهار مواقع نقاط التثليث وكيفية تشكيلها ورسم شبكة التثليث المقترحة بشكل ثنائي الأبعاد، إضافة الى ربطه ببرامج مساعدة مثل برنامج ArcMap (GIS). البيانات المدخلة في البرنامج المصمم كانت تستهدف منطقة ججمال الواقعة في شمال العراق كموضوع لدراسة إحدى تقنيات المسح الجيوديسي. أما النتائج التي أستحصلت بعد التطبيق والتحقق من كفاءة أداء البرنامج قد أثبتت بأن CISTNM يؤدي المهمة المطلوبة بسهولة ودقة.

الكلمات الرئيسية: المساحة الجيوديسية، تشكيل الشبكات، النمذجة باستخدام نظم المعلومات الجغرافية، نماذج البرمجة المرئية.

1. INTRODUCTION:

In a given topographical situation, some alternative solutions usually suggested to obtain a horizontal control network. The task of a network designer is determined from the available alternatives, the most economical and practical solution that will produce the required network of control points according to the desired standards of accuracy [Kilyana, 1996]. The aim behind designing, computation, measuring and adjustment procedures is establishing the horizontal point's positions, these positions being expressed as easting and northing on a plane coordinate system. Horizontal control surveys are usually performed to establish a basic control network (framework of known point locations) from which supplemental surveying and mapping work is performed. They are distinguished by the use of redundant, interconnected, permanently ground control points.

There are various techniques to establish horizontal control networks on the map to achieve the best network design Triangulation and trilateration. Triangulation and trilateration consists of a series of joined or overlapping triangles in which all the angles and lengths of these triangles are measured; whereas, combined control survey consists of a network of triangles in which all the required angles and distances are measured. The triangulation network has gained its importance as it appoints the shape of the earth, the formation and projection an accurate basis for the plane and photogrammetric surveying; therefore, it is so significant procedure to implement the huge building like dams and bridges [Kilyana, 1996] and [AL-Shapheay, 2004], the main disadvantages of these techniques are need to tedious calculations.

Integrated models are those models that link different software's in a proper way to allow the transfer of data between this software's to achieve certain tasks. Integrated models are rather rare or expensive, while each of the software contributing in the developed model is available and free. For example, Visual Basic, GIS, Ms-Excel...etc., are available software nowadays, whereas a specialized integrated model for triangulation modeling is not freely available. Hence, the design of such model is essential. In this research integrated software called CISTNM is designed in order to produce the best geometric design of horizontal control network. CISTNM have the property that allows the user to make the decision about the form, nature and details of the design and make sure of its results accuracy and workability. The main challenge in building an integrated model for a special purpose is the proper linkage between the available software's in order to achieve the research objectives, the following methodology is adopted:

1. Designing an integrated system phase: to design the integrated triangulation network system by using Visual Basic and Active X technology (Active variable sharing in all software's), to share information between (ArcMap, Ms-Excel, Ms-Access and Ms-Word).
2. Implementing an integrated system phase: to apply different types of the triangulation network figures such as single figure or combined figures to estimate and study the accuracy of R and RE in computed side length; in addition to, estimate the distances, azimuths and positions (easting, northing) and elevations (h) values to obtain the best results design.
3. Verification and application phase: to perform and valid of the output results by



applying comparison between the results of the CISTNM with the hand calculation, then applying it on the real work to check its validity.

2. NETWORK FORMATION:

The simplest form (or figure) of horizontal control survey (triangulation) system is to divide the study area into a chain of geometric figures whose corners are the ground control points (GCPs) that linked each other by angular measurements; and in order to achieve the best accuracy for the final results and adjustment procedures are done later. In a triangulation system, a chain of figures is employed like triangles, quadrilaterals, central-point figures or a combination or an overlapping of these figures [Phahsa, 1999]. The computations for such a system can be arranged to provide checks on the computed values of most of the sides. Triangulation networks formation consists of a number of steps of design and application as follows [Davis, 1981]:

(1) **Strength of figure** to evaluate the relative error value for the proposed network lengths;(2) **Reconnaissance** to select the location of stations;(3) **Visibility** to find the obstacles elevation between any two stations that have effect on the intervisibility;(4) **Astronomic Observation** of one or more stations in order to determine the starting station of the measured base line;(5) **Measurements of the Base Lines and Angles** to accurate selection and measurement and determination computations and adjustments; and(6) **Triangulation Network Computations** including determining the distances, coordinates(easting, northing), azimuths for all triangulation points and then adjustments process of the triangulation network to provide the best estimates of coordinates for all points.

3. GIS AND SURVEYING MODELING:

Geographical Information System (GIS) can be defined as an organized collection of software and geographic data that allow efficient storage, analysis, and presentation of spatially explicit and geographically referenced information. GIS is a tool that allows users to create queries (user created searches), edit data, analysis the spatial information and present and display the results of all these operations [AL-Shapheay, 2004]. By doing

network modeling in a GIS environment, the output of the triangulation network records can be obtained as spatial records in the form of map layers, which can visualize real objects by vector and raster data formats together with graphs and multimedia presentations [Matejicek, et al., 2002].

4. COMPUTERIZED INTEGRATED SYSTEM FOR TRIANGULATION NETWORK MODELING (CISTNM):

The first step is to prepare the topographical maps to determine the strength of figures [Phahsa, 1999], as well as intervisibility between triangulation stations. This determination includes selection of stations, determining of the resulting triangles size and type, the number of occupied stations and the observed angles, azimuths or distances; as well as what concerns the necessary signals towers. These steps lead to the reconnaissance which includes specified stations located on high positions to avoid the cost of building towers and achieve the required intervisibility [Habeb and AL-Saifi, 2008].

The basic equations depending on the designed model are the strength of figure and the relative error equations. Determining the strength of figure is a vital factor in the preliminary stages of triangulation networks formation in order to ensure complete uniform accuracy throughout the network [Davis, 1981].The strength of figure can be defined as the comparative precision of computed sides lengths in a triangulation network as determined by the angles measurement, the number of conditions to be satisfied, and the distribution of the base lines. In other words, the strength of figure is a function of three major factors; they are the geometric strength of the triangles making up the network; the number of triangles between base lines; the number of angle and side conditions and observed directions in the network as shown in eq. (1) below [AL-Shapheay, 2004]:

$$R = (D - C / D) \sum (\delta_{A_i}^2 + \delta_{A_i} \delta_{B_i} + \delta_{B_i}^2) \quad (1)$$

Where: R is the strength of figure, D is the number of observed directions except the base line in the network, C is the number of angle and side conditions, δ_{A_i} and δ_{B_i} are the respective

logarithmic difference of the sine and A_i and B_i = angles in each triangles opposite to the known and unknown sides respectively.

The accuracy of the strength of figure can be tested by calculating the relative error (RE) in the calculated side's length using the eqs. (2) and (3) [Kilyana, 1996] and [AL-Shapheay, 2004]:

$$\delta_s^2 = \frac{4}{3} \delta_\alpha^2 * \Sigma R \quad (2)$$

$$RE_{office} = \delta_s / \mu * 10^6 \quad (3)$$

Where: δ_s is the standard error in the computed side, δ_α is the standard error in the observed direction, RE_{office} is the relative error in the computed side in the office work and μ is the transformation factor ($\mu = 0.43429 * 10^6$). Therefore, strength of figure (R) plays an important role in the designs and accuracy of horizontal control networks [Agor, 1995].

After the stations have been selected, a good visibility can be achieved through certain processes like the *two dimensional (2-D) interpolation and test of intervisibility*. Visibility (also termed as intervisibility) depends on the line of sight as it is the graphic line between two stations on a surface showing the parts of the surface along the line whether they are visible or not from an observer as shown in Fig.(1).

The *interpolation* process estimates the elevation (z) values of a certain point from a limited number of stations as shown in Fig. (2), and describe in eq. (4) below:

Where: $a1 = X - X1$, $a2 = X2 - X$,
 $b1 = Y - Y2$, $b2 = Y4 - Y$

$$Z_{12} = \frac{Z1 * a2 + Z2 * a1}{a1 + a2}, Z_{34} = \frac{Z3 * a2 + Z4 * a1}{a1 + a2}$$

$$Z = \frac{Z_{12} * b2 + Z_{34} * b1}{b1 + b2} \quad (4)$$

The *test of intervisibility*, on the other hand, is the analysis of visibility if the earth surface features that affects on the line of sight as they

affected the shape contour lines; therefore, the surface shape dramatically affects the position and visibility for the observer. In other words, if two stations are selected and linked by a line of sight, then the profile is drawn between them, so, according to the interpolation method and be found the point of the highest elevation which will later determine the signal tower height [Shukri et al., 1983, Phahsa, 1999 and Habeeb and AL-Saifi, 2008]. Accordingly, the test of intervisibility can be applied by the following equation [Bomford, 1962]:

$$H_{C1} = H_A + \left[(H_B - H_A) * \left[\frac{S_1}{S_1 + S_2} \right] \right] - 0.0675(S_1 * S_2) \quad (5)$$

Where: H_{C1} is the elevation of obstacle point, H_A is the elevation of station (A), H_B is the elevation of station (B), S_1 is the distance from station (A) to the obstacle point along the line of sight and S_2 is the distance from station (B) to the obstacle station along the line of sight.

In order to determine the minimum height of towers and thickness of its signal towers use the following equations below:

$$H_C = h + H_{C1} \quad (6)$$

$$r = \left[\frac{(S_1 + S_2) * \delta_\alpha}{\rho} \right] \quad (7)$$

Where: H_C is the height of tower, h is the safety distance, r is the thickness of signal towers, δ_α is the standard error in the observed direction and ρ is the number of degrees per radian ($\rho^\circ = 1/\sin(1^\circ)$).

The whole process figuring of the triangulation networks formation depends on determining the base line after locating the initial point. In other words, the accurate selection and measurement and determination of the base line are the basis of the design and calculations of the whole targeted triangulation network. Hence, the base line will be connected to the main network to calculate the other side's lengths in the network by knowing the measured base line length and its two angles



using the sine law until getting into the next base line [Davis, 1981]. Therefore, there are certain considerations to be taken into account when selecting the base line location, they are:

1. The area should be allowed for a good linking or connecting of the base line to the triangulation network.
2. It should be an exposed area to allow measuring the base line directly.
3. Base line should be linked by Laplace station at any two end points and the line of sight placed higher than the earth surface to avoid being influenced by the obstacles that can later influence the precision of base line connection with the network then influenced on the design accuracy.

4.1 Software Used In the CISTNM Model

The CISTNM program is formulated and written using Visual Basic (version 6.0) as the basic programming languages and as a control tool for integrating the model with available software. This available software is: Ms-Access and Ms-Excel for storing and displaying the input and output data, Arc Map (GIS) (version 8.1) for georeferencing of the base map and drawing TINs and/or contour line layers to show the variation in the elevations over the area under study, and Ms-Word for educational and demonstration purposes of the model.

4.2 Advantages and Capabilities of the Designed Model

1. The model uses to allow different selection of the figures type and size for triangulation network and decides which design is applicable or not.
2. The model can be used to allow different selection of the input required data for triangulation points formation by using import required data file (*.txt or *.xls), click or keyboard.
3. The model offers flexibility for forming triangulation network by using either any one from five options such as triangles, quadelatrials, and central-points figures like (triangle, pentagon, and quadelatrial) that forming of triangulation network in a chain of single figure or combined figures.

4. The model has Message box appearing if a user forgets to fill any data requirement of property.
5. The model offers verification of the strength of figure (R) and relative error (RE) values to achieve optimum R and RE values by using updating or/and changing all the type and size figure in the previous selection then comparison between the output results with the specifications for horizontal control and preparing table for printing the output results.
6. The model can be calculated distances, azimuths and locations (easting, northing) for the any triangulation points selected.
7. The model offers flexibility for drawing 2-D triangulation network to show influence of different positions of the triangulation network point's and show the effect of these positions on the intervisibility analysis.
8. The model can perform the intervisibility analysis for each triangulation points through estimate the point's elevations then determine the maximum elevation and tower height values in the suggested network using display profile by a chart that linking between the elevations and distances.
9. The model offers flexibility for drawing as 3-D TIN and/or as contour line layers to show influence of different elevations extended over a base map of the case study.

5. APPLICATION OF THE DESIGNED MODEL (CASE STUDY):

After presenting the suggested model and giving the description of its design, here comes the practical aspect in this research. The suggested case study suggested is the Chamchamal area which is used as the designed network in the model. The topological data of this area Coordinates (x , y) and Elevation (z), are available by (MOWR), the area description extend between Latitude and Longitude Coordinates range from 35°30'00" to 36°00'00" North, and from 43°15'00" to 44°45'00" East, respectively; as an overall featuring of the area, it has valleys and mountains representing the active features of the region land coverage; with an area (2966.08 Km²) with a dense grid in the area of

(100m); this area surrounds the designed triangulation network points; and the Small Zap and Golak Rivers passing through it as in **Fig.(3)**. In this study, four points were selected as GCPs, three points are pointed on the topographic map using GIS software to make the georeferencing process and the fourth point is used for checking process as shown in **Fig.(4)**.

For this application, the following procedures steps are used:

1. Data modeling using GIS.
2. Selection the type of the input data and network formation.
3. Input the base line coordinates for the suggestion design.

5.1 Selection the Best Figure

The objective of this experiment is to select the best strongly network design on the Chamchamal area which data are used as input in CISTNM. **Figs. (5), (13) and (16)** illustrate layouts forming of the figures done to be selected in addition to, the characteristics previously mentioned with respect to the compliance distances, angles, and intervisibility, as well as the required strength of figure and precision. Tables give the results obtained from the computations done and figures shows the analysis of intervisibility between all the points or stations constituting the suggested design of the triangulation network, as through observing the profile graphs indicated and then the best as it complies with the required triangulation network standards.

Figure (5) illustrates the first suggestion design includes the minimum distances values equal to (5.8~6 Km); **Fig. (6)** represents the output results for the angles and distances; the output results for the strength of figure (R) as shown in **Table (1)** that indicated the desirable limit (R1 and R2) in the single figure equal to (4.9 and 7.1), and the maximum value equal to (14.7~15) in the last triangle leading to lack the accuracy and then reject this design, and profile graphs for this suggestion design illustrated from **Fig. (7) to Fig. (12)** that indicated the stations 5 with 3, and 3 with 4 have no intervisibility between them because the line of sight includes the obstacles with height equal to (482.5 and 900 m) according to apply eq. (6).

The second suggestion design for the triangulation network is the best layout obtained as shown in **Fig. (13)**; the output results for the strength of figure as shown in **Table (2)** and the intervisibility analysis for designing this layout are shown in **Figs (14) and (15)**. From the results of **Table (2)** that indicated to the above design represented stronger layouts (maximum strength of figure values equal to (10.7~11)) and the distances values in this triangulation network are equal to the required standards (First Order) and the profile graphs display the intervisibility analysis successfully between any two stations.

The output results for the third layout suggestion as shown in **Table (3)** indicated that the largest strength of figure value in the second triangle equal to (16.5~17) also, this design includes two distances less than the required standard equal to (3.3 and 4.3 Km); the stations 3 and 4 with 5 have no intervisibility between them and the height of obstacles equal to (1280 and 1000 m) as shown from **Figs. (17) and (18)**; therefore, this suggested design is rejected.

Selection has been proved that the best design is to be selected for measuring and verifying the network total strength is the triangle (layout two). This hypothesis is built on the bases of hand calculations computerized procedures, field information, results and data analysis.

5.2 Comparisons of Remaining Figures with Optimum Layout Results

The results obtained from the model implementation on the layout two have been compared with the different figures in order to select the optimum design of the network with saving cost and time through the selections, applications and verifications. The final output results for the networks suggestion design from remaining figures represented by **Table (4)** that summaries the strength of figures results obtained from comparing the hypothesis applications to a variety of geometric figures with the layout two and **Figs. (19), (20) and (21)** that display draw of different networks design.

After fulfilling all the process data collections, input, calculations, applications, verifications, the final results given by the developed model for the best network design are represented in **Tables (5) and (6) and Fig. (22)**.



6. CONCLUSIONS:

1. This research provides means of planning and implementing geodetic network with special respect to triangulation.
2. There are certain significant considerations taken in the networks design are (strength of figure, triangulation point positions and length of sides).
3. The integrated computerized system CISTNM investigated and devised in this research has manipulated options and utilized the Visual Basic (VB) computer language successfully in this field of engineering knowledge. Furthermore, this

language simplifies the task of programming the user interfaces system and the result in computer programs which considered as user friendly.

4. The use of visualization in the presentation of the input and output data assist the user and economizes the time, cost, and effort needed to fulfill the work of the network design.
5. The verification and application of the developed model in the case study shows the affectivity of CISTNM used successfully in real applications.

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LIST OF ABBREVIATIONS:

CISTNM: Computerized Integrated System for Triangulation Network Modeling

GCPs: Ground Control Points

GIS: Geographical Information System

R: Strength of Figure

RE: Relative Error

TINs: Triangulated Irregular Networks

2-D: Two-Dimensional

3-D: Three- Dimensional

VB: Visual Basic

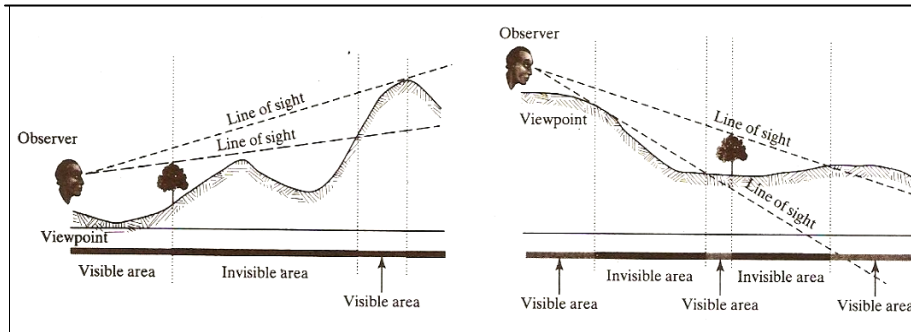


Fig. (1) Viewshed Analysis [Yeung, 2008]

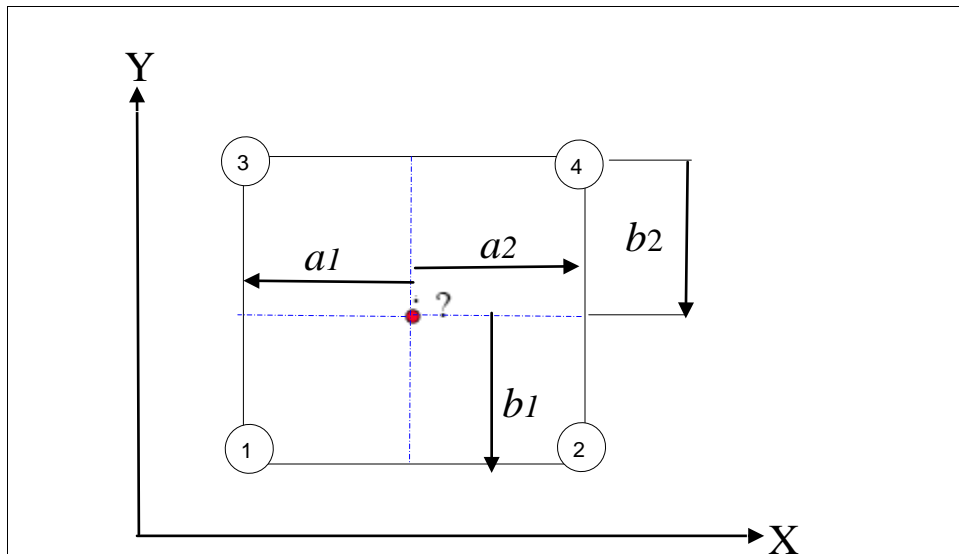


Fig. (2) Unknown Point Elevation

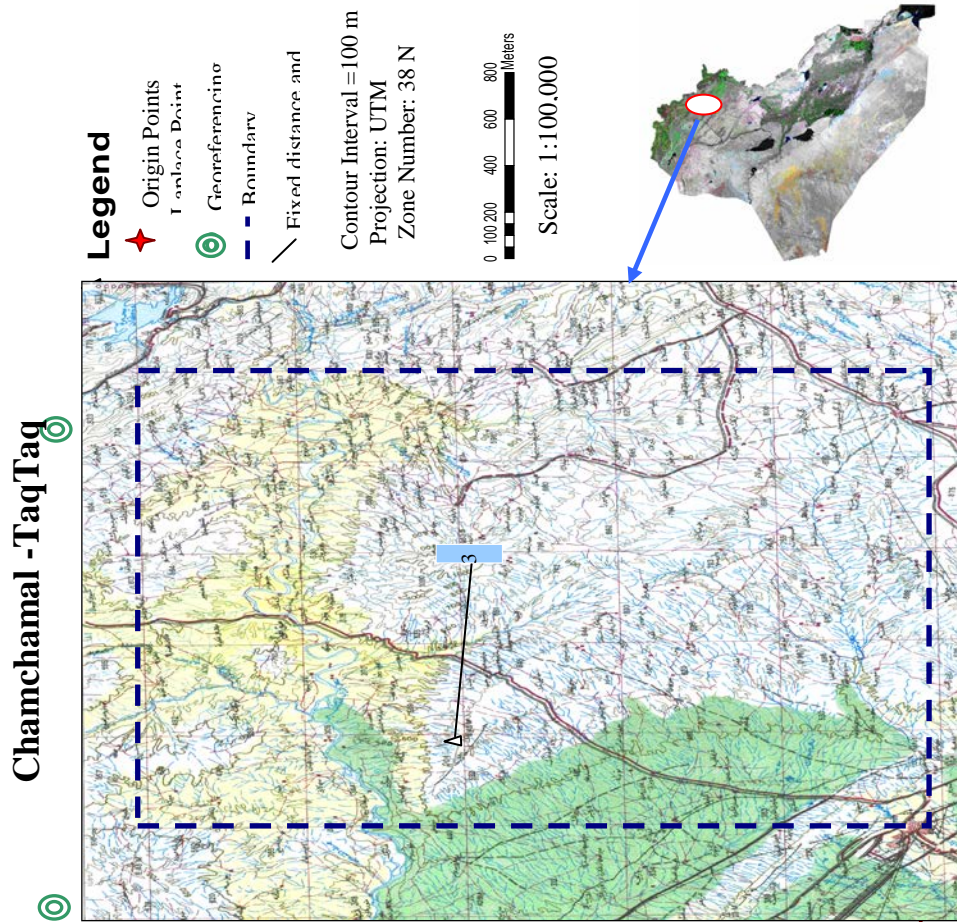


Fig. (3) Study Area Map

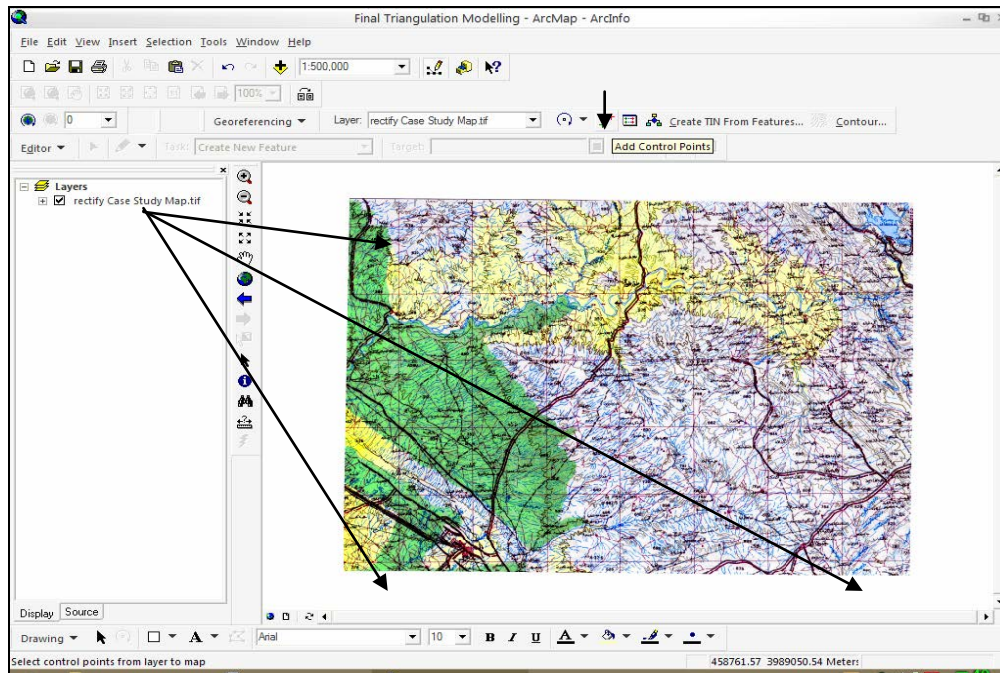


Fig. (4) Georeferencing Process

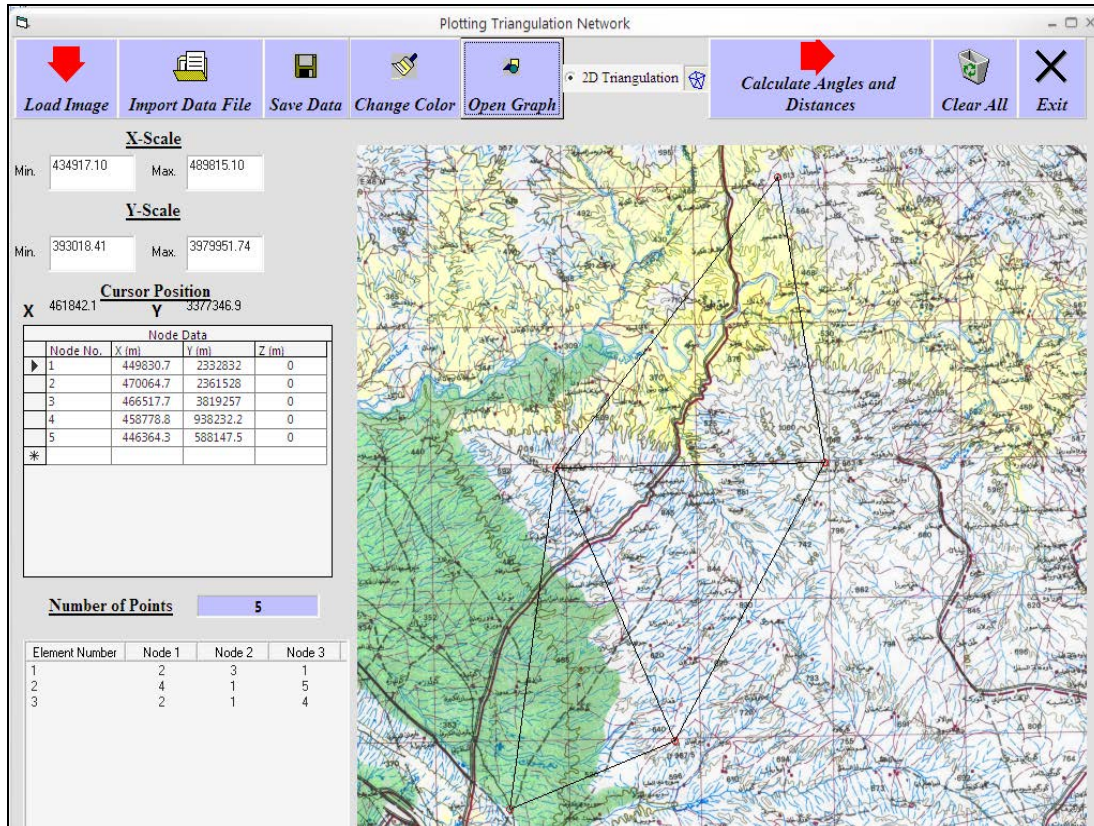


Fig. (5) Designing of the First Layout

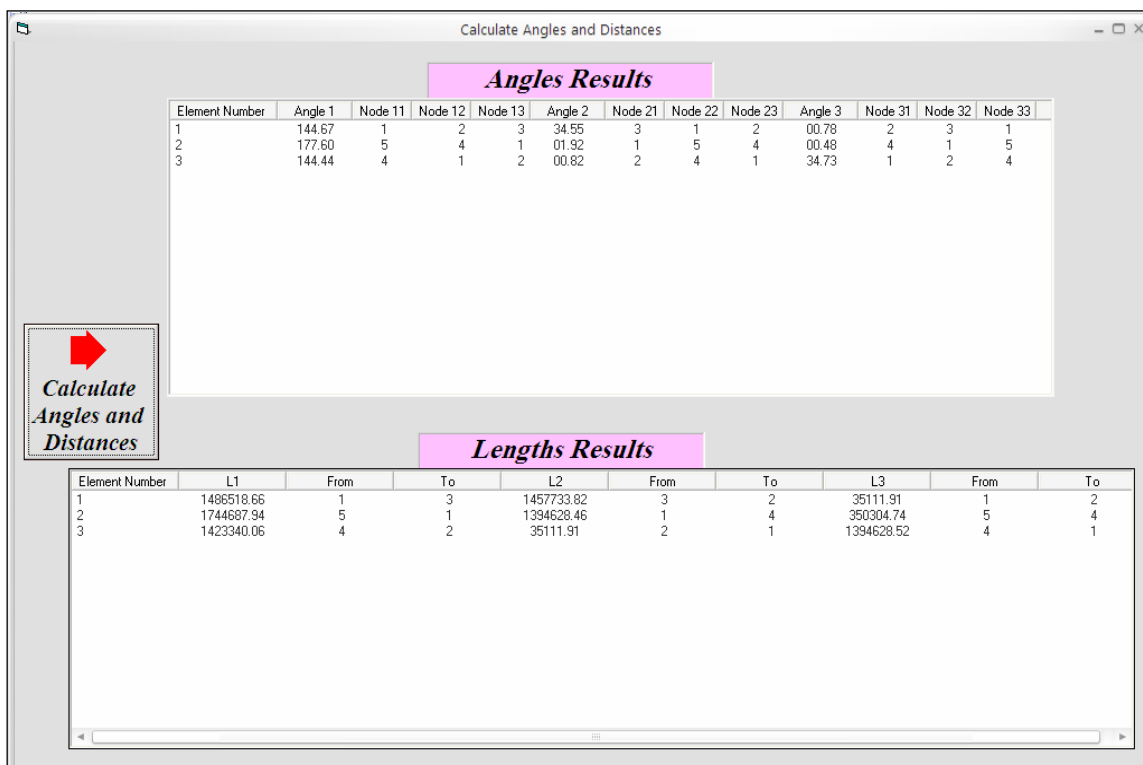


Fig. (6) Angles and Distances Result for the First Layout

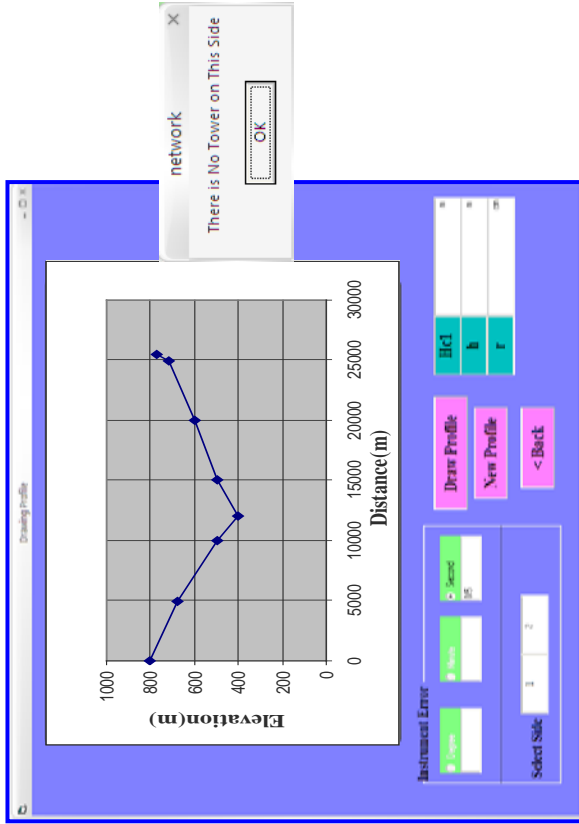


Fig. (7) Intervisibility between Line (1-2)

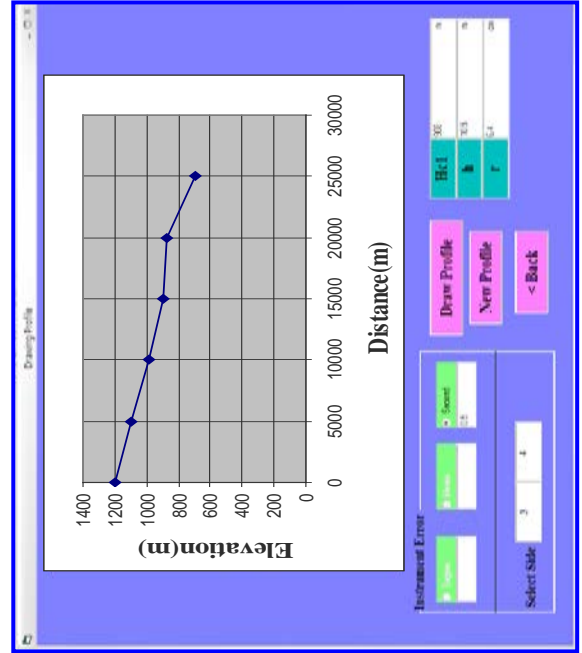


Fig. (8) Intervisibility between Line (3-4)

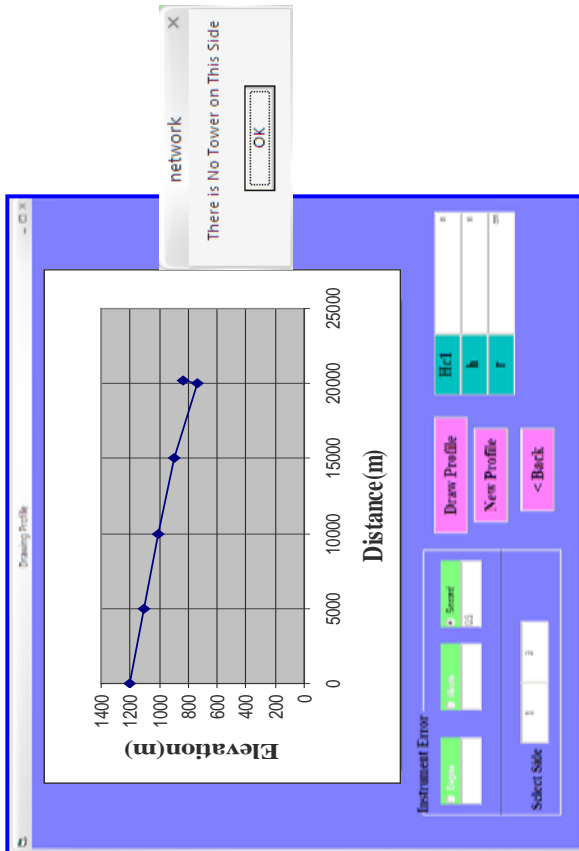


Fig. (9) Intervisibility between Line (1-3)

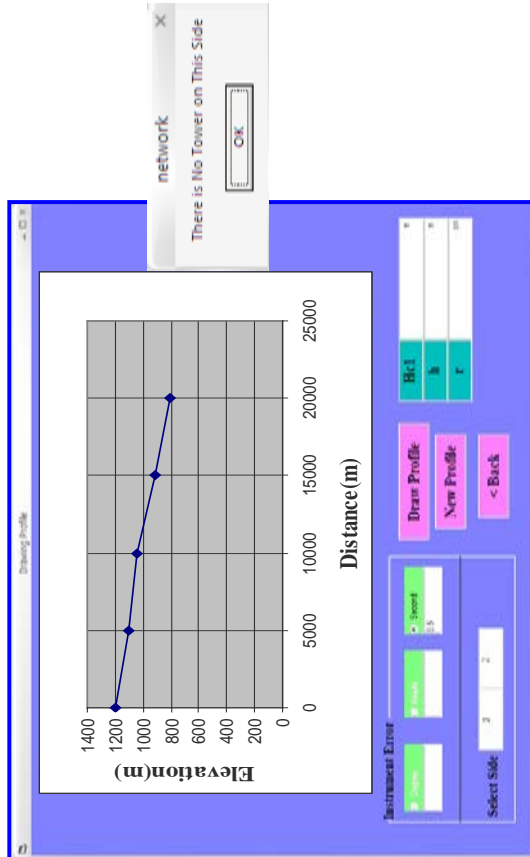


Fig. (10) Intervisibility between Line (3-2)

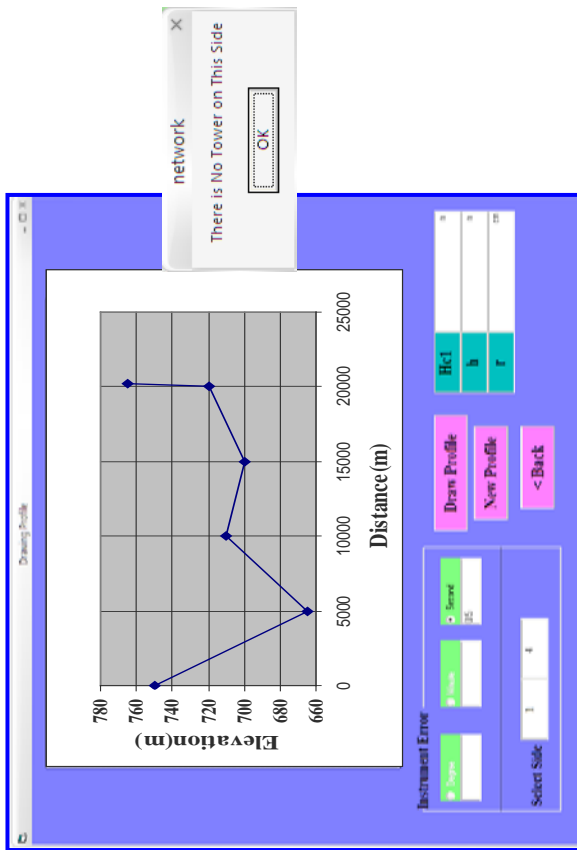


Fig. (11) Intervisibility between Line (1-4)

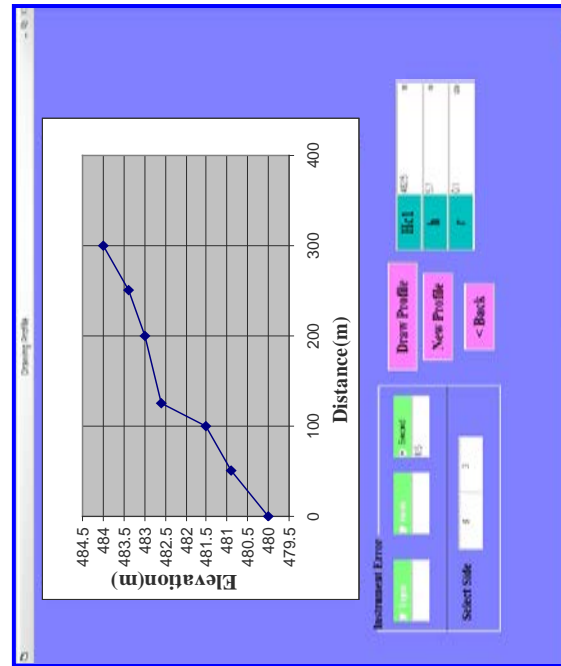


Fig. (12) Intervisibility between Line (5-3)

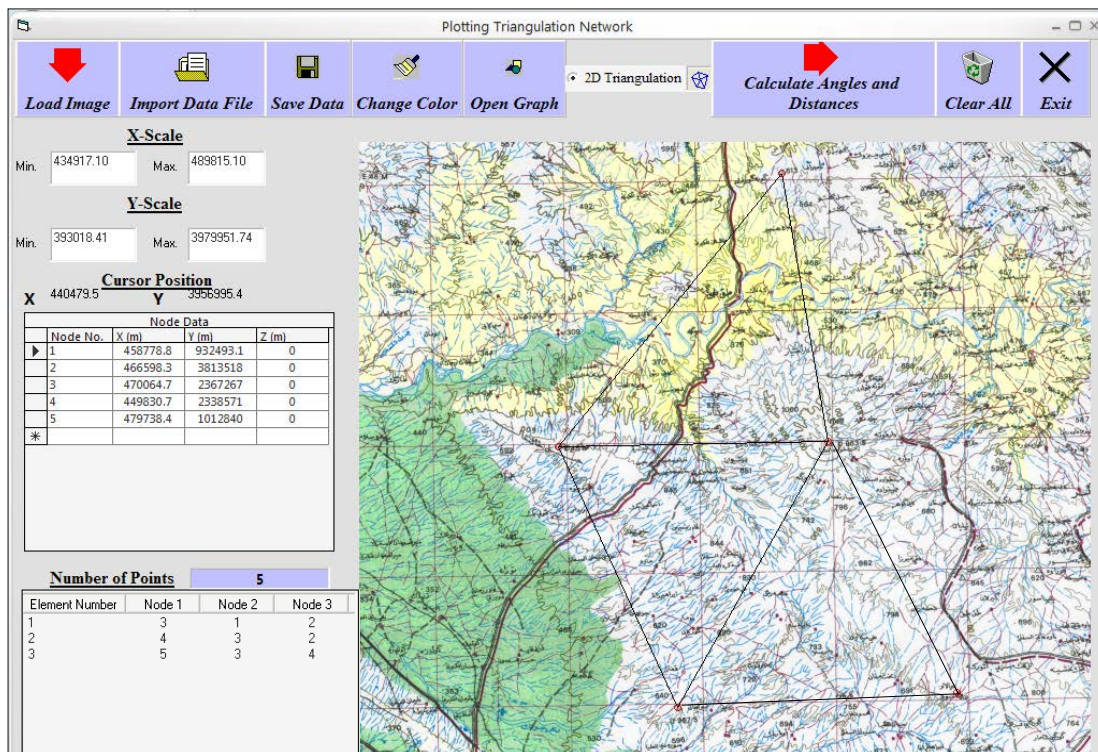


Fig. (13) Designing of the Second Layout

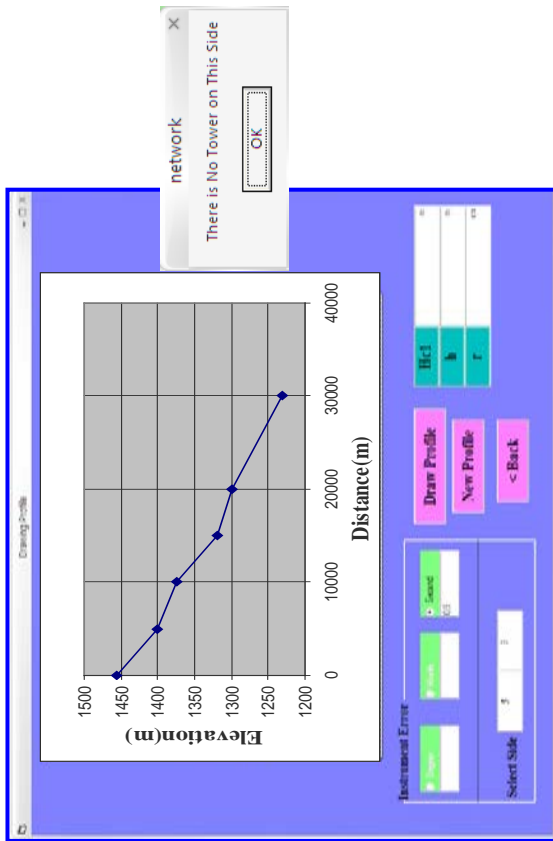


Fig. (14) Intervisibility between Line (5-3)

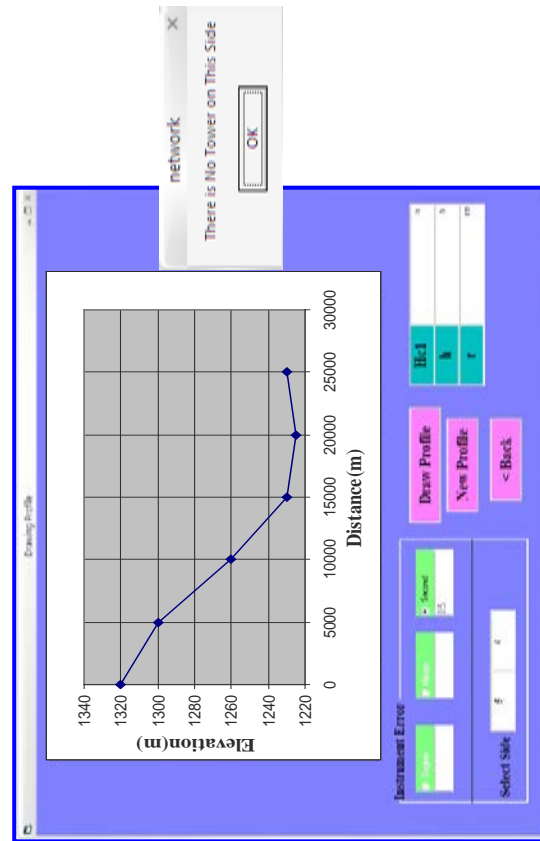


Fig. (15) Intervisibility between Line (5-4)

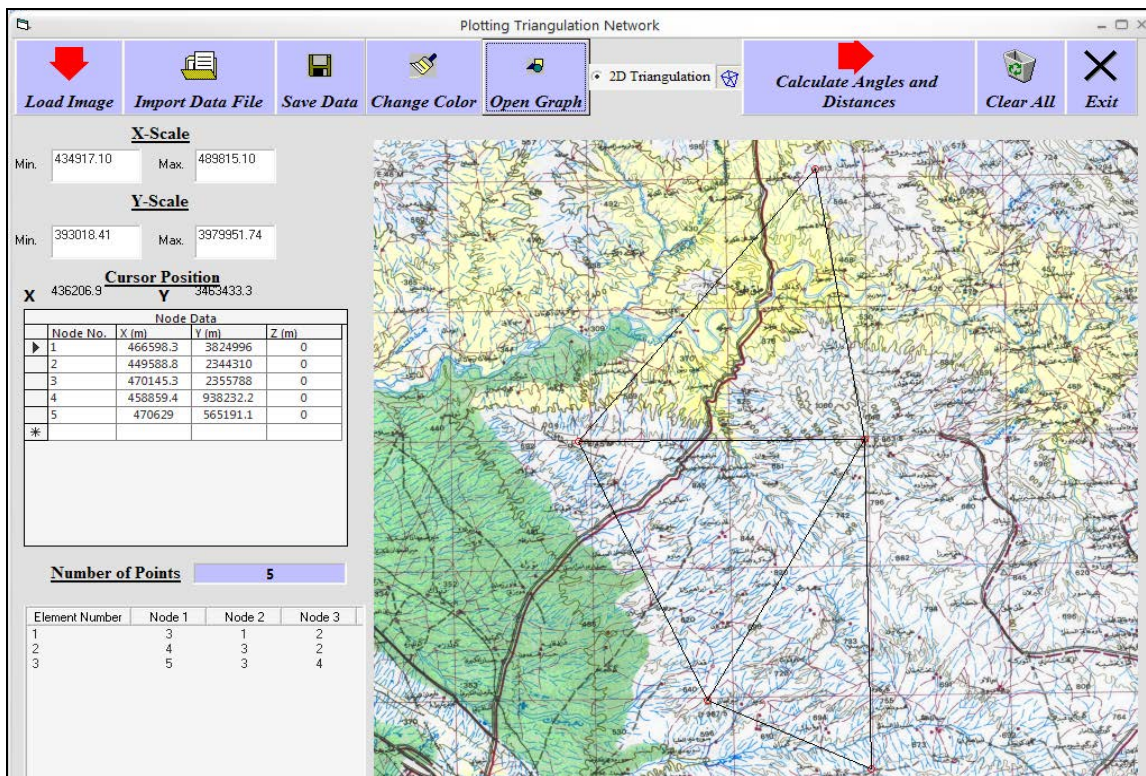


Fig. (16) Designing of the Third Layout

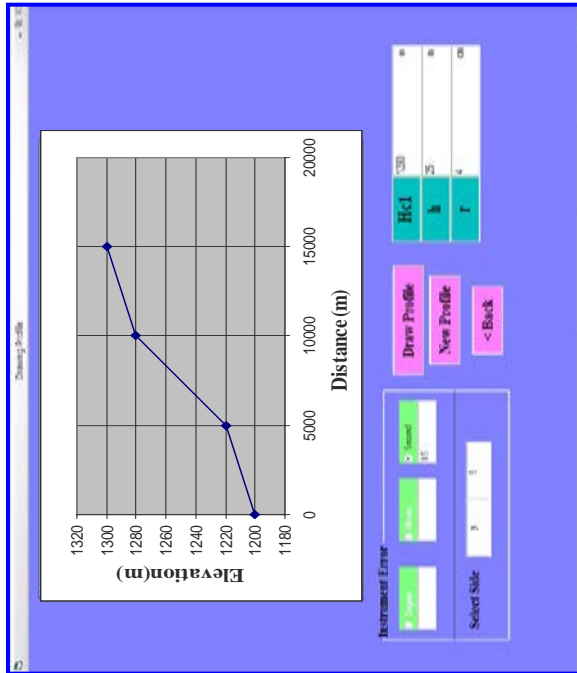


Fig. (17) Intervisibility between Line (3-5)

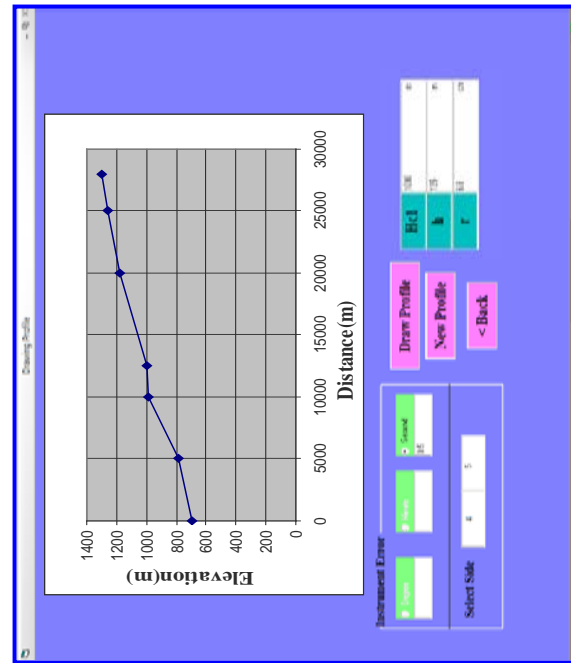


Fig. (18) Intervisibility between Line (4-5)

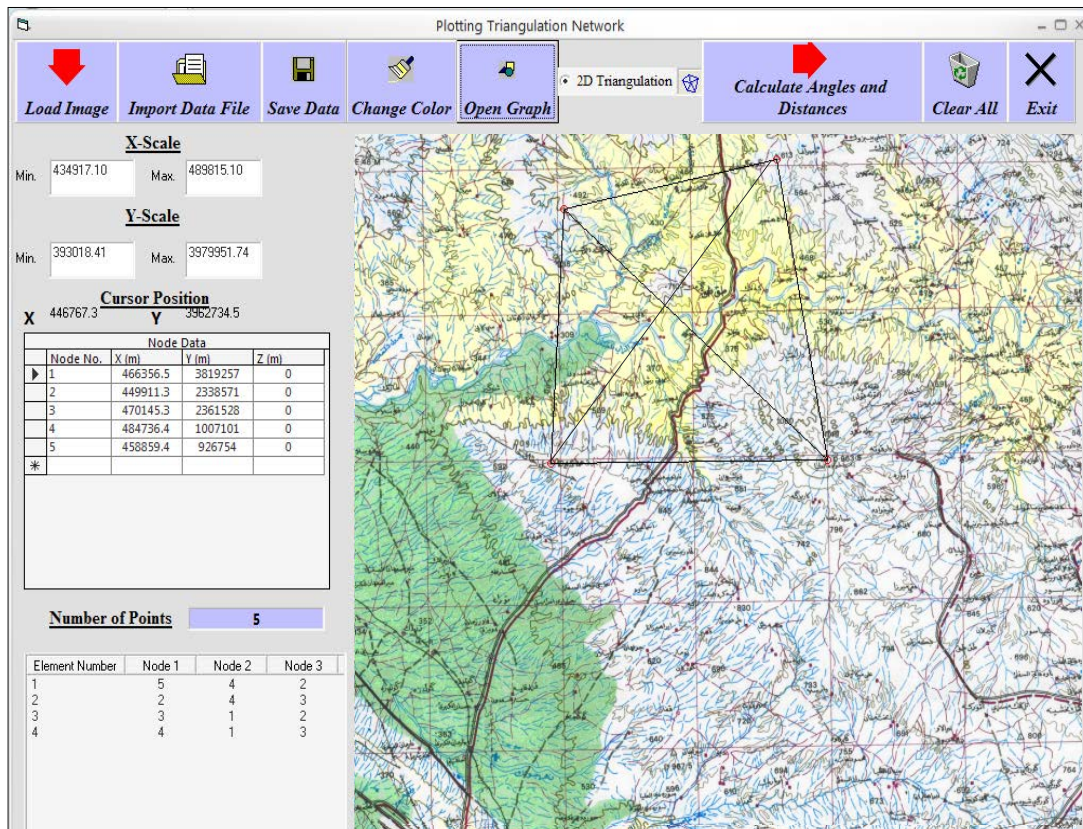


Fig. (19) Designing the Chain of Quadrilaterals Layout

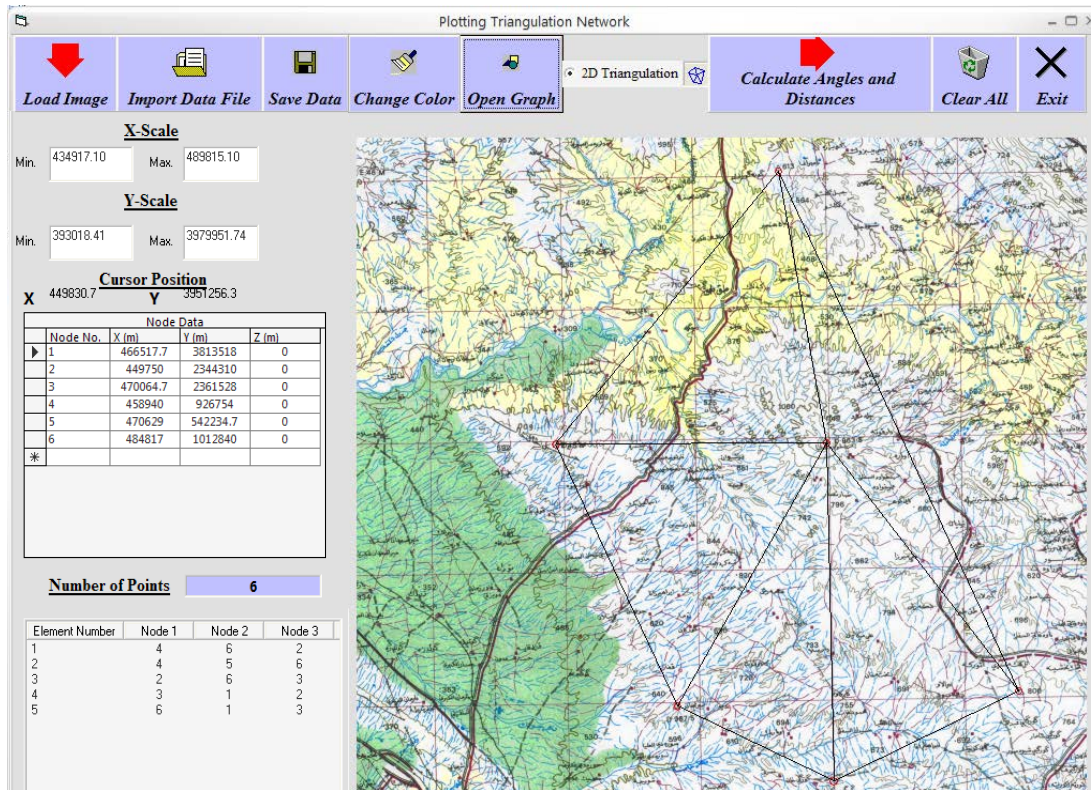


Fig. (20) Designing the Chain of Central-Point Pentagon Layout

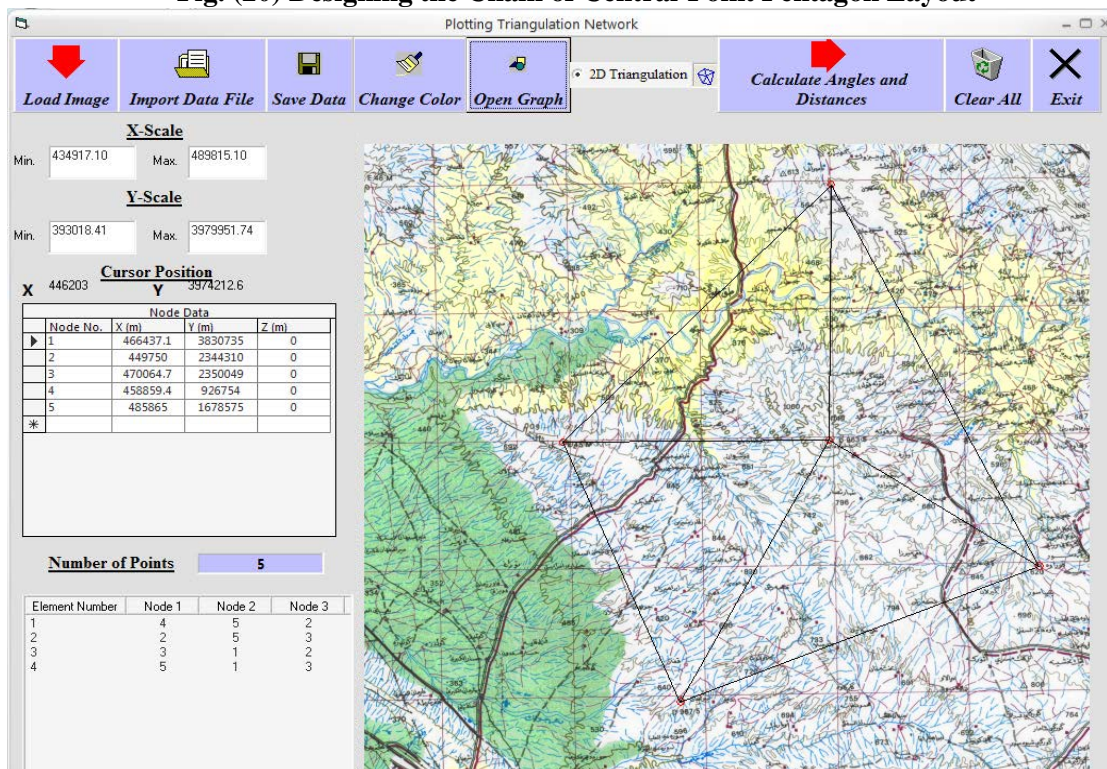


Fig. (21) Designing the Chain of Central-Point Quadilatral Layout

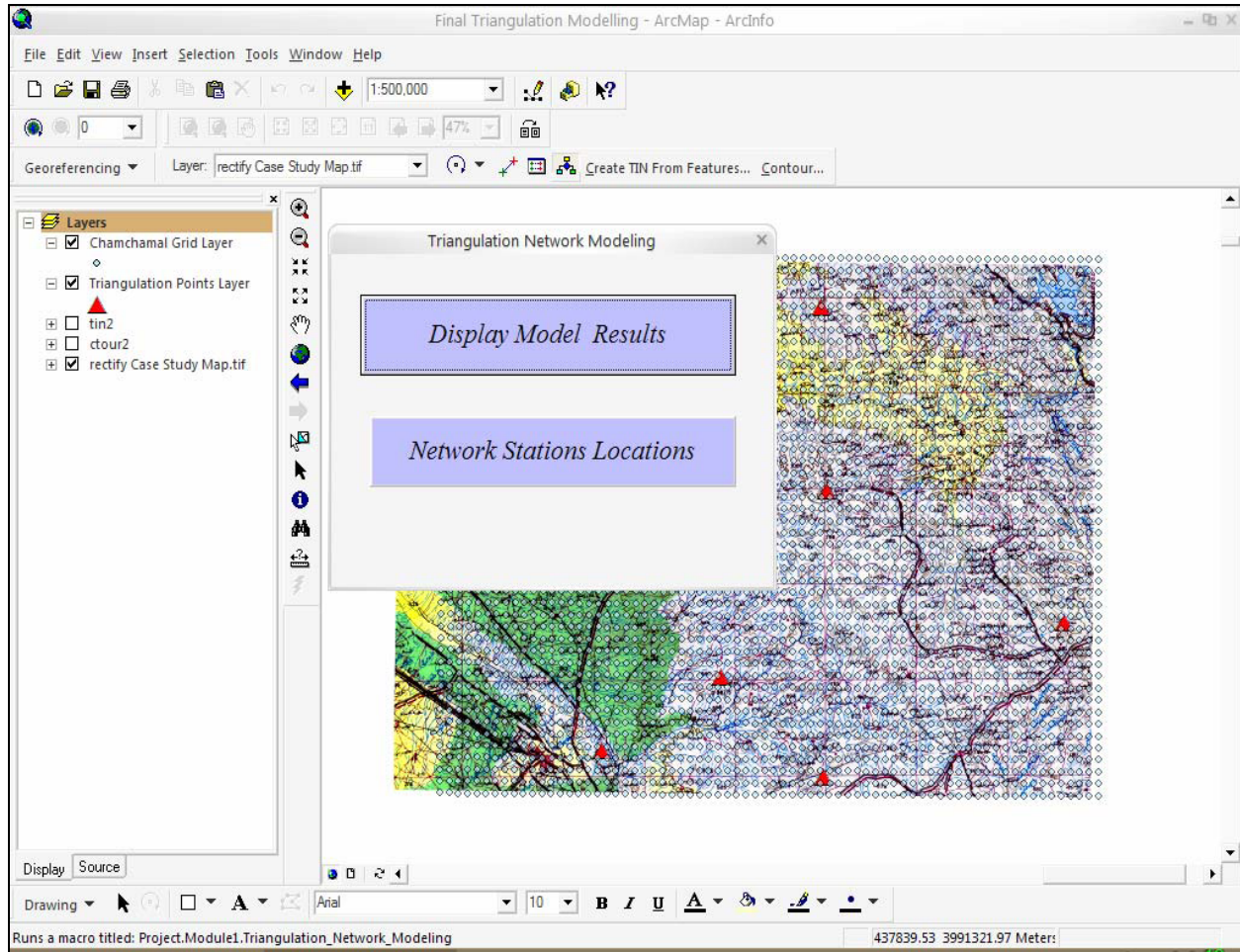


Fig. (22) Final Modeling Layout for the Case Study

Table (1) Comparison between the Results Obtained by the Developed Model and Hand Calculations (for the First Network Design)

| Triangle Nodes | CISTNM Calculations | | Hand Calculations | |
|----------------|---------------------|---------------|-------------------|---------------|
| | R | $Q = 4/3 * R$ | R | $Q = 4/3 * R$ |
| 2-3-1 | 7.1 | 9.4 | 7 | 9.3 |
| 4-1-5 | 4.9 | 6.6 | 5 | 6.6 |
| 2-1-4 | 14.7 | 19.6 | 14.6 | 19.5 |

Table (2) Comparison between the Results Obtained by the Developed Model and Hand Calculations (for the Second Network Design)

| Triangle Nodes | CISTNM Calculations | | Hand Calculations | |
|----------------|---------------------|---------------|-------------------|---------------|
| | R | $Q = 4/3 * R$ | R | $Q = 4/3 * R$ |
| 3-1-2 | 10.7 | 14.2 | 10.7 | 14.2 |
| 4-3-2 | 3.4 | 4.5 | 3.4 | 4.5 |
| 5-3-4 | 3.2 | 4.2 | 3.1 | 4.1 |



Table (3) Comparison between the Results Obtained by the Developed Model and Hand Calculations (for the Third Network Design)

| Triangle Nodes | CISTNM Calculations | | Hand Calculations | |
|----------------|---------------------|---------------|-------------------|---------------|
| | <i>R</i> | $Q = 4/3 * R$ | <i>R</i> | $Q = 4/3 * R$ |
| 3-1-2 | 3.4 | 4.5 | 3.4 | 4.5 |
| 4-3-2 | 16.5 | 22.1 | 16.4 | 21.9 |
| 5-3-4 | 9.3 | 12.4 | 9.3 | 12.4 |

Table (4) Results for the Developed Model





| Type of Figure | No. of Elements | <i>R</i> | | $Q = 4/3 * R$ |
|---|-----------------|----------|------|---------------|
| | | Min. | Max. | |
|  | 3 | 3.2 | 10.7 | 4.2 |
|  | 1 | 3.6 | 20.1 | 4.8 |
|  | 1 | 14.4 | 21.8 | 19.2 |
|  | 1 | 8.9 | 18.6 | 11.9 |

Table (5) Azimuths and Distances Results for the Best Obtain Layout

| Line | Azimuth (in Degree) | Distance (m) |
|---------|---------------------|--------------|
| 3---- 1 | 179.1036 | 20151.5 |
| 1---- 3 | 93.2749 | |
| 2---- 3 | 40.4922 | 19172.9 |
| 3---- 4 | 58.5332 | 22739.2 |
| 4---- 3 | 238.5332 | |
| 5---- 3 | 152.0603 | 29452.7 |
| 3---- 5 | 27.5357 | |
| 5---- 4 | 38.3342 | 38203.6 |
| 4---- 5 | 188.3347 | |
| 5---- 6 | 31.0912 | 30785.7 |
| 6---- 5 | 211.0904 | |
| 6---- 4 | 138.0907 | 15346.0 |
| 4---- 6 | 41.5052 | |
| 1---- 4 | 66.5754 | 21470.6 |
| 4---- 1 | 113.0205 | |
| 1---- 2 | 44.1146 | 27067.1 |
| 2---- 1 | 44.1148 | |
| 3---- 2 | 92.1320 | 19172.9 |

Table (6) Coordinates and Elevations Results for the Best Obtain Layout

| Point | Easting (m) | Northing (m) | Elevation (m) |
|-------|-------------|--------------|---------------|
| 1 | 488568.4 | 3940780.2 | 775.4 |
| 2 | 469573.0 | 3978866.0 | 813.0 |
| 3 | 470316.6 | 3959707.5 | 1202.7 |
| 4 | 458568.4 | 3940238.2 | 675.2 |
| 5 | 496346.1 | 394526.0 | 1440.6 |
| 6 | 470000.0 | 3930000.0 | 755.4 |