# Determining the Actual Positions of the Lost State Border Points

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**Abstract -** *In this article the determining of actual positions of the lost state border points (pillars) is investigated. For this investigation, the author used geodetic measurements which was settled by A.H. McMahon while defining the border between Afghanistan and Iran during 1902-1905. To determine actual positions of boundary demarcation points (pillars) on the terrain, and as a result of the research one-time inverse intersection method was suggested which is more precise and easier compared to other methods.*

**Key Words:  Afghanistan, Iran, state border points, A.H. McMahon delegation, inverse intersection, reverse swing, WGS84, Trimble GNSS.**

## 1. INTRODUCTION

Afghanistan is an ancient country, its borders with all the neighbouring countries, except Pakistan, is 3305 km [1]. These borders were established and designated by the pillars of different delegations between 1870-1905 years. As we know, these pillars were built with high resolution and durability requirements. These pillars exist for more than a century, but they can be lost in the consequence of natural disasters (flooding) or artificially (intended and random). The border between Afghanistan and Iran from the top of "Malik Siya" mount to the top of "Siya Koh" mount is 475 km length, which were designed by 90 pillars by A.H. McMahon delegation between 1902-1905 [4]. From these pillars only 6 of them are on both sides of coast of the Helmand River. There is an opinion that during the flood in the Helmand River, about 60 years ago, these pillars were destroyed and today we don't know their exact location. The definition of the true locations of these points (pillars) on the consent of the two sides is the most important task for both Afghanistan and Iran.

## 2. INVESTIGATION

By using the technology of that time, the A.H. McMahon delegation determined astronomical coordinates for each point separately and from 3 to 6 magnetic azimuths towards to the specific points of land or durable artificial constructions in the terrain. According to these data, it is necessary to find established positions of lost pillars so that both sides are satisfied, but how?

Applying A.H. McMahon data, two methods were reviewed to find the solution: Updating coordinates of the points in the WGS84 system and inverse intersection (reverse swing) method.

### 2.1 Updating coordinates of the points in the WGS84 system:

Department of Geodesy under the Ministry of Urban Development and Land in Afghanistan during the updates of the state-border pillars that were built by A.H. McMahon in WGS84 coordinate system to determine actual positions lost pillars, acted according to the following scheme:

The coordinates of 5 boundary demarcation pillars and 6 after lost pillars in the WGS84 system measured by Trimble GNSS Receiver. Further, these coordinates were compared with astronomical coordinates measured by A.H. McMahon to the corresponding points as a result was obtained average difference as follow: latitude 4.28823 second with positive (+) sign and longitude 2 minutes, 21.38666 second with negative (-) sign.

These values were accepted as a difference between WGS84 coordinate system and A.H. McMahon astronomic coordinate system. The values were added to the astronomic coordinates of lost points, as a result of which we obtained the coordinates of lost boundary demarcation points (pillars) in the WGS84 system. A group of specialists by using the data from Trimble GNSS Receiver, found the location of lost pillars with 50 to 100 meters error by the A.H. McMahon definition on the territory of Afghanistan or Iran. Such accuracy (error) is not acceptable for both sides.

### 2.2 An inverse intersection (reverse swing) method:

As was mentioned above that, A.H. McMahon determined for the each pillar astronomical coordinates, and then magnetic azimuths were measured towards to specific points of the land and to artificial durable objects. Graphic documentation

(drawings) of the McMahon delegation were built in two small scales (1 inch = 4 miles and 1 inch = 1 mile), therefore, to determine the position of lost pillars, these drawings are not recommended because of the gross error.

To conduct research based on the data of the 53th lost pillar, the model was made at the territory of the Kabul Polytechnic University. In the model three directions of magnetic azimuth were accepted. At each direction, the specific points 1, 2 and 3 were selected, and the rectangular coordinates were given by Trimble GNSS Receiver as follow Table -1.

**Table -1**: rectangular coordinates and magnetic azimuth

| Points | $E(Y)$ $m$ | $N(X)$ $m$ | Directions | Magnetic azimuth |
|---|---|---|---|---|
| 1 | 0511069.329 | 3821441.603 | 53 - 1 | 4° 20′ |
| 2 | 0511081.580 | 3821425.323 | 53 - 2 | 47° 00′ |
| 3 | 0511072.792 | 3821398.770 | 53 - 1 | 184° 40′ |

Also, the first and second angle clockwise were calculated. To obtain first angle, the first magnetic azimuth were extracted from second magnetic azimuth ($\beta_1 = 42° 40′$), and for obtaining the second angle, the first magnetic azimuth extracted from third magnetic azimuth ($\beta_2 = 180° 20′$) Table -1.

Applying these data by using the D'Alembert's formula, we calculate the initial directional angle ($\alpha_1$) [2].

$$tan\,\alpha_1 = \frac{(y_2 - y_1)\cot\beta_1 + (y_1 - y_3)\cot\beta_2 + (x_3 - x_2)}{(x_2 - x_1)\cot\beta_1 + (x_1 - x_3)\cot\beta_2 - (y_3 - y_2)}$$

$$\alpha_1 = 94°45′41.32''$$

Using this data, we calculate the coordinates of the lost points of the subject model with the following formula [2].

$$\left.\begin{array}{l} y_1 - y = (x_1 - x)\tan\alpha_1 \\ y_2 - y = (x_2 - x)\tan(\alpha_1 + \beta_1) \\ y_3 - y = (x_3 - x)\tan(\alpha_1 + \beta_2) \end{array}\right\}$$

As a result, the coordinates of lost points (pillars) was calculated:

$$x = 0511066.845 \cdot y = 3821322.013$$

And in the model the coordinates of this point were measured with the Trimble GNSS Receiver:

$$x = 0511067.371 \cdot y = 3821322.543$$

Their difference was also calculated:

$$f_y = 0.530m;\ f_x = 0.526m \text{ and } f_l = 0.748m$$

As you can see these concepts determined the location of the point with an error of 0.748 meters. To determine the position of the pillar in the model, the following actions were taken:

The calculated coordinates of the points were displayed in the Find program and Trimble GNSS Receiver, then searching for location and found it, which is located at a distance of 0.75 meters from the point of the selected model. It is worth to say that if we were able to use accurate GNSS receivers, the results would be much more accurate than it is.

It is worth mentioning that we can find the location of the lost pillars using an electronic tachometer as well as linear and angular intersection. But a more accurate and simple method is inverse intersection (reverse swing).

## 3. CONCLUSIONS

As a result of these investigations, it can be said that inverse intersection (reverse swing) method is the only scientific solution for such problems. Therefore, we recommend the inverse intersection (reverse swing) method to find the actual (true) positions of the lost points (pillars) on the state border between Afghanistan and Iran. To obtain reliable and acceptable results for both parties during the practical implementation of tasks, i.e. while measuring and finding the actual positions of the lost state border points (pillars), use a dual-frequency or high-precision GNSS receiver, as well as carry out extra measurement at the points. It should be noted that in such cases, the method of finding lost state boundary demarcation points (pillars) is chosen only with the consent of both parties.

It is worth to mentioning that any of above-mentioned methods for determining actual positions of lost boundary demarcation points (pillars) can be used only as agreement between parties.

## ACKNOWLEDGEMENT

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## BIOGRAPHIES

I was born in 1956 in Nangarhar province, Afghanistan. I defend my doctoral dissertation in 1994 in "Moscow State Mining University" I'm working as Dean and Professor of Geomatics and Cadastre Faculty in Kabul Polytechnic University.