Energy methods of single-position passive radar based on the wonderful points of the triangle.

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Translation.

The article discusses methods of single-position passive radar using the properties of a triangle and its remarkable points. Active radar provided the determination of the coordinates of objects by receiving reflected from these objects pulsed signals emitted by a radar station. At the same time, the station unmasked itself. In the technical literature, it is mistakenly stated that for the complete determination of the coordinates of an object, it is necessary to use several (≥2) radar stations spaced a certain (known) distance ”[2,3,4]. Passive radar supposedly does not allow you to find the range of the located object according to the data received at only one point. Such a statement is not only erroneous, but also harmful. Its harmfulness lies in the fact that it denies the fundamental possibility of creating a method of radiocoordinate, protected from detecting the location of his means by location by radio reconnaissance. In the article, five energy methods for single-position determination of the coordinates of the location of a source of radio emission (CMR IRI), using various remarkable points, are submitted for discussion. The advantage of the energy-based methods of the on-off determination of the ILC CMP over the goniometric or range-finding-goniometric described in [1] is the simplicity of the antenna system of the receiving device. Replacing a log-periodic or phased array antenna that is difficult to operate with a whip antenna allows you to perform a manual radar. At the same time, a scanning radio receiver (RPU) is used to measure the ILC parameters of the IRI, and for calculation: an arbitrary (virtual) point, forming a triangle with the location of the direction finder and IRI. The measured signal level of the desired IRI and the remarkable properties and points of this triangle make it possible to evaluate the ILC of the IRI. In this case, assumptions are made and the following algorithm is performed:

1. The environment is assumed to be isotropic.
2. The correlation dependences on the field strength (signal level) are established and used at the virtual point and the point of location of the RPU. The theory of the on-off determination of the ILC CMP is based on the established relationship, both by the distance between the points-vertices of the triangle,

and by the field strength (signal level). In this case, the field strength is taken inversely proportional to the corresponding distances. And the relationship of azimuths turn this method into a well-known on-off.

3. Based on the given coordinates of the reference RES accepted as true, the calibration characteristics (KX) of the method are established, which represent the dependences of the ILC IRI calculated in the Cartesian coordinate system on the true ones. The establishment of calibration characteristics is the main, fundamental and fundamental action, which allows, in addition to the measured azimuth to the desired IRI, to determine the distance to it.

4. According to the calibration characteristics of the method, the correction of the calculated ILC of the IRI is performed. The article shows that for some remarkable points the estimate differs from the actual coordinates of the IRI location. In this case, coordinate adjustment by (KX) method is introduced. Examples of obtaining KX by the latitude of the location of the desired IRI are given. Five remarkable points of the triangle are considered: the intersection point of the medians and bisectors and also the Lemoine points - the intersection points of the simedians.

A method for determining coordinates based on the theorem of cosines, sines, and jibs is considered. At the end of the article conclusions are made:

1. That among the 32000 remarkable points of the triangle, the number of which continues to increase, there must also be other wonderful points, similar to the point of Lemoine.

2. Based on the five remarkable points (ST) given as examples, for determining the ILC of the IRI, the following general stages can be distinguished:

1. Setting the coordinates of the location of the virtual point and the parameter meter of the desired IRI, for example, at the origin.

2. Measurement of the parameters of the desired IRI, performed by the direction finder on the RCP.

3. Obtaining formulas for linking the location of the ground with the coordinates of the vertex of the triangle, in which it is supposed to place the desired IRI.

4. Obtaining the calibration characteristics by the latitude or longitude of the location of the desired IRI using the communication formulas for each use case of the ST.

5. Obtaining the true values of the ILC of the IRI by calibration characteristics.

Keywords: location coordinates, calibration characteristics, single-positioning.

Main part

1. The method is based on medians.

To determine the ILC of the IRI based on medians, we use Fig. 1.1.

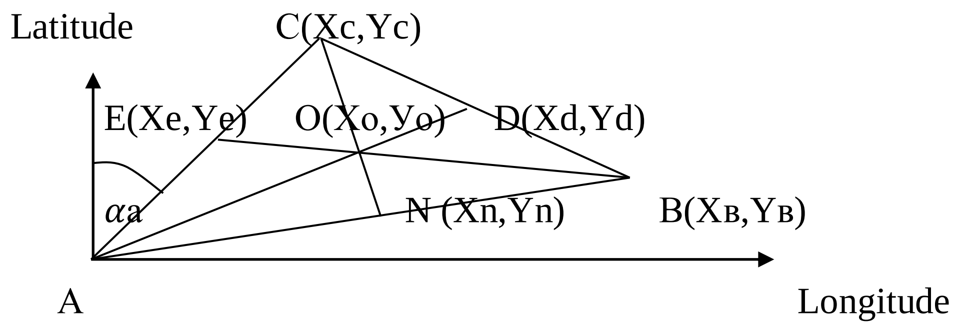


Fig.1.1. O (Xo,Уo)- intersection point of medians AD, BE, CN

The coordinates of the points of division by the medians of the opposite sides in half are written in the form:

$Xd = 0.5\,(Xc + Xb)$, $Yd = 0.5\,(Yc + Yb)$, $Xe = 0.5\,(Xc + Xa)$, $Ye = 0.5\,(Yc + Ya)$, $Xn = 0.5\,(Xb + Xa)$, $Yn = 0.5\,(Yb + Ya)$ (1.1).

We write the equation of the median AD:

$Yo = [Xo\,(Yd-Ya) + (XdYa - XaYd)] / (Xd-Xa)$.

Or for: $Xa = 0$, $Ya = 0$ $Yo = XoYd / Xd$ (2.1)

and BE medians:

$Yo = [Xo\,(Ye-Yb)\ XeYb-XbYe)] / (Xe-Xb)$ (3.1).

The coordinates of the point O (Xo, Yo) of the intersection of the medians are found from the joint solution of equations (2.1) and (3.1) under the condition

$Xa = 0$ and $Ya = 0$.

$Xo = [Xd\,(Xe\,Yb - Xb\,Ye] / [Yd\,((Xe-Xb) - Xd\,(Ye-Yb)]$ (4.1).

The y0 coordinate is obtained by substituting (4.1) into expression (2.1) or (3.1).

To obtain the ILC of IRI, we use the property of medians to divide at their O (Ho, Yo) intersection in a 2: 1 ratio. We write this property with the formula as applied to the median CN: CO: ON = 2: 1. We rewrite this relation through the coordinates of the points C, O, N.

$$(Xc - Xo)^2 + (Yc - Yo)^2 - 4[(Xo - Xn)^2 + (Yo - Yn)^2] = 0$$

From here we get the quadratic equation for determining the latitude of the MP IRI:

$$Ax_c^2 - B\,x_c + C = 0 \qquad (5.1),$$

where: $A = 1/cos_\alpha^2$, $B = x_o + y_o tg\alpha$, $C = y_o^2 + 4[(x_o - x_n)^2 + (y_o - y_n)^2]$

Equation (5.1) represents the calibration characteristic of the energy one-position method for determining the ILC of the IRI based on medians. For its numerical solution, the coordinates of the reference IRI are set (Xc, Yc), taking them as true, the distance to the reference RES is graded at points, and then (5.1) calculate (more precisely, recalculate) the coordinates (Xc, Yc) of each graded point. Figure 2.1 shows this characteristic.

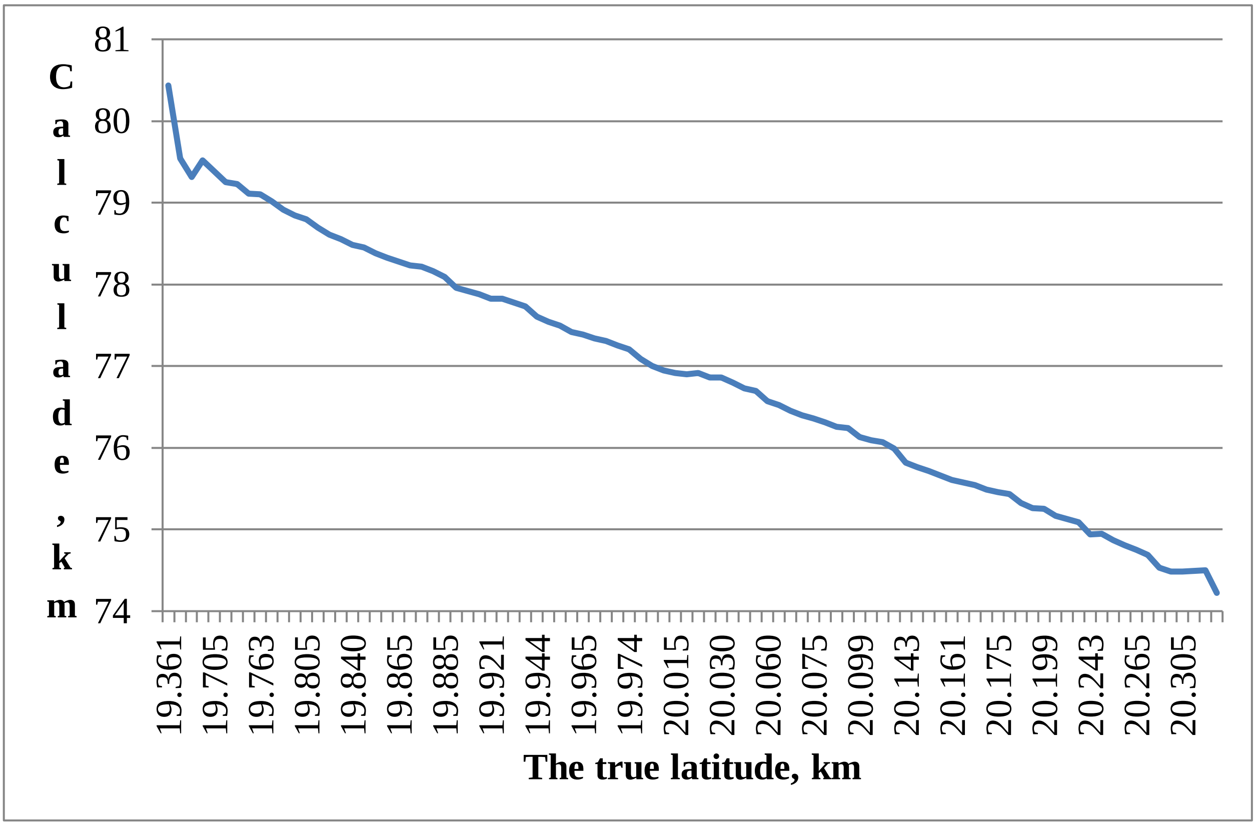


Fig. 2.1. Calibration characteristic of the energy one-position method based on medians.

2. Spiker's Center

The triangle jib is a segment, one vertex of which is in the middle of one of the sides of the triangle, the second vertex is on one of the two remaining sides, while the jib splits the perimeter of the triangle in half. In addition, the jib is parallel to one of the bisectors of the angle. Each of the jibs passes through the center of mass of the perimeter of the triangle ABC, so that all three jibs intersect in the center of Speaker.

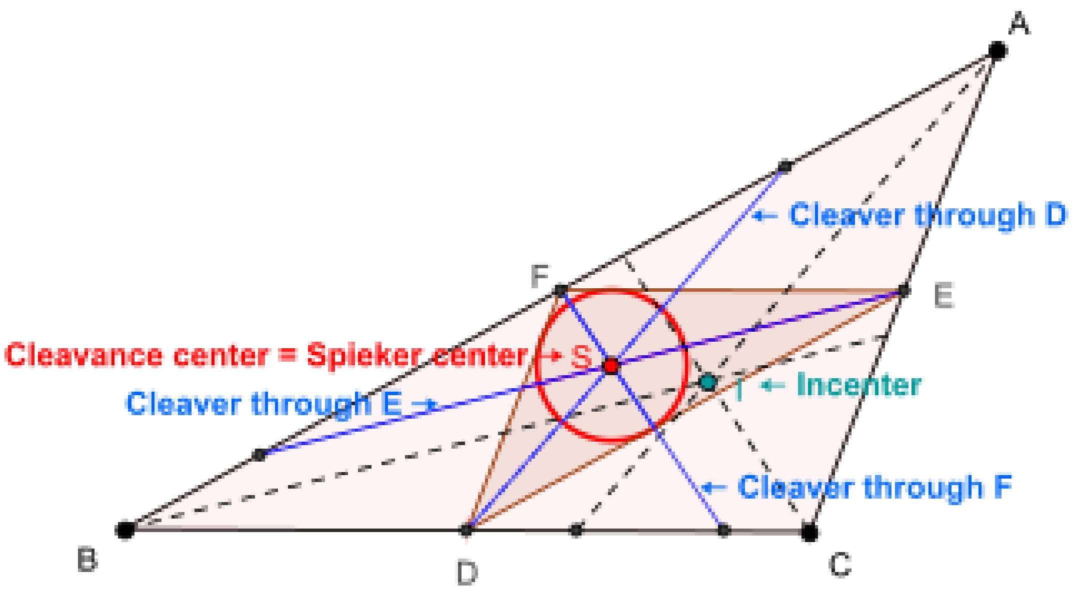


Fig. 1. 2. Shpiker's Center S - jib intersection center.

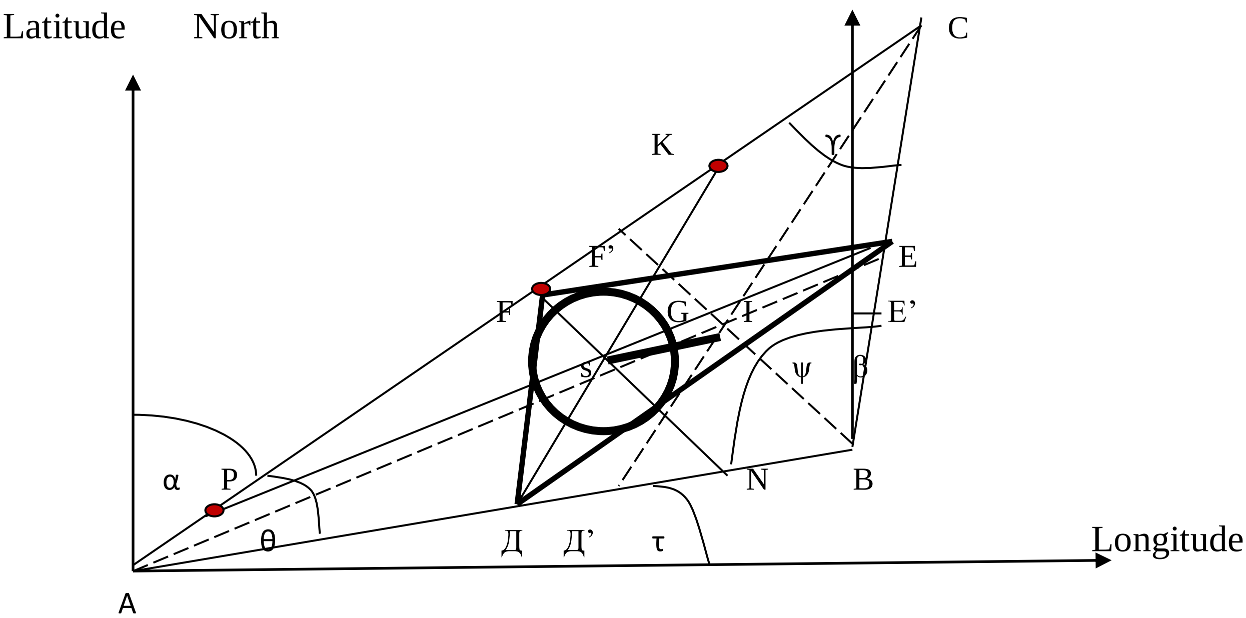


Fig. 2.2.Speaker Center S with three jibs: DK, FN, EP and bisectors:

And E ’, B F’ and C D ’.

The center of the Speaker of the triangle is the center of intersection of the jibs.

S is the radical center of three extracircles [6].

S is the center of the jibs of triangle ABC [1]

Each of the jibs allows you to determine the coordinates of the location of the radio emission source (ILC), located in the third vertex C of an arbitrary triangle ABC under the following assumptions:

1. The propagation medium is assumed to be isotropic.
2. In the range of the azimuth measured by the direction finder, there is only one IRI with constant parameters in terms of power, antenna suspension height, azimuth and other radiation parameters. In this case, the coordinates of only two vertices A and B of the ABC triangle formed together with the IRI and the measured azimuth α from the vertex A to the IRI are used.

The first, second and third versions of the on-off method for one jib from point E, which is the middle of the side of the aircraft, are based on determining the coordinates of the vertex C as the coordinates of the intersection points of the aircraft azimuth line with each of the three azimuth lines drawn through two points from three: C, P, F and K. The equation of a line drawn through points, C, P and F has the form:

$$y_c \; = x_c \, [y_F - y_p) + x_F y_P - x_P y_F] \big/ (x_P - x_F) \qquad (1.2).$$

We write the equations of lines drawn through points P and K, as well as F and K:

$$y_c \; = x_c [y_k - y_p) + x_k y_P - x_P y_k] \big/ (x_P - x_k) \qquad (2.2),$$

$$y_c \; = x_c [y_k - y_F) + x_k y_F - x_F y_k] \big/ (x_F - x_k) \qquad (3.2).$$

Let us consider in more detail the transformations (1.2) of the first variant. Equate (1.2) to the equation of the azimuthal line from point B in the IRI.

$$[x_c y_F - y_p) + x_F y_P - x_P y_F] \big/ (x_P - x_F) \; = \; [y_b + \quad (x_c - x_b)\, tg\beta]$$

Express from the last xc:

$x_c = \quad [x_p - x_F)[y_b - x_b tg\beta]/[\, y_F - y_P - (x_p - x_F)tg\beta]$

Since the jib AE divides the perimeter of the triangle into two halves, that is, EC + CP = PA + AB + BE, then CP = PA + AB. And since CP = AC-AR, then

(AP = (CA-AB)/2. Therefore, $x_p = {(x_c - AB\cos\alpha)}/{2}$ .After substituting $x_{p\_}$ we obtain the quadratic equation:

$$Ax_c^2 + Bx_c + C = 0, \qquad (4.2),$$

where: A = $tg_\beta^2 + 0.5 tg\alpha tg\beta$

B= $(y_b - x_b tg\beta)[1 - 0.5(1 - tg\alpha)]$

C=$(x_b - y_b)\, tg\beta - AB(y_b - x_b tg\beta)(1 + \, tg\alpha)$

Similarly, a solution is found to both equations (2.2) and (3.2) for determining x_c according to the second and third options.

Using equation (4.2), a calibration characteristic is constructed, shown in Fig. 3.2.

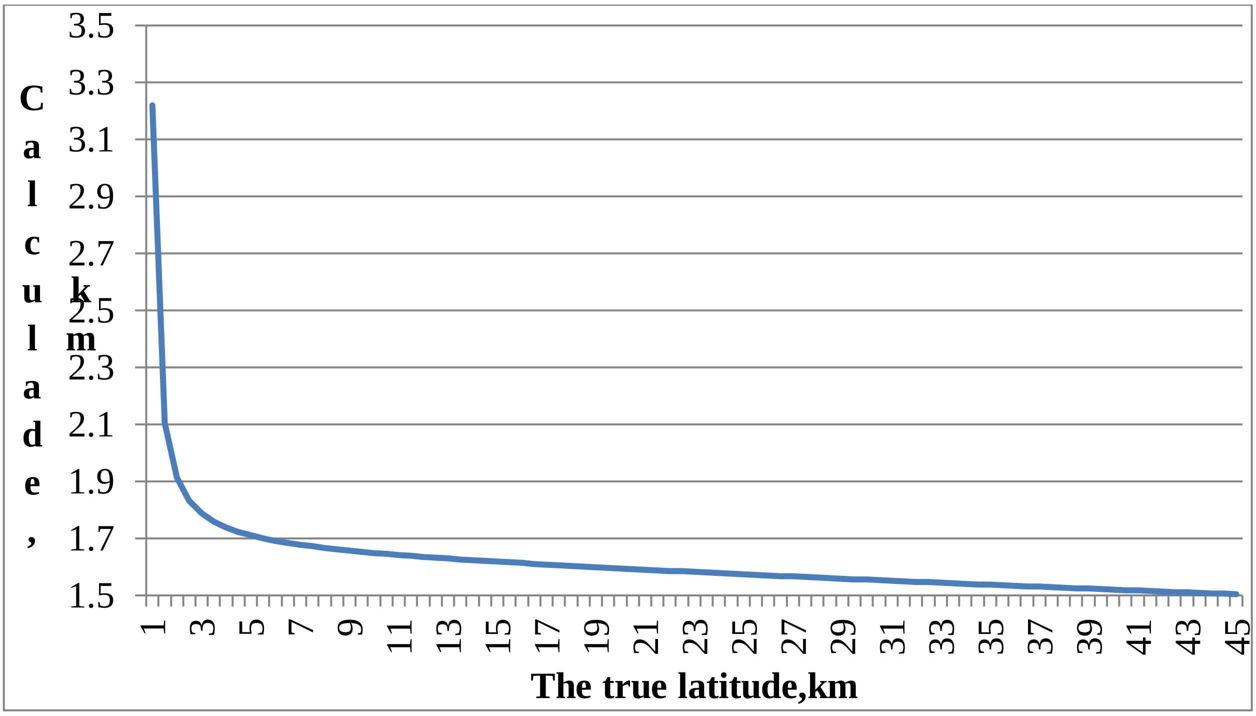
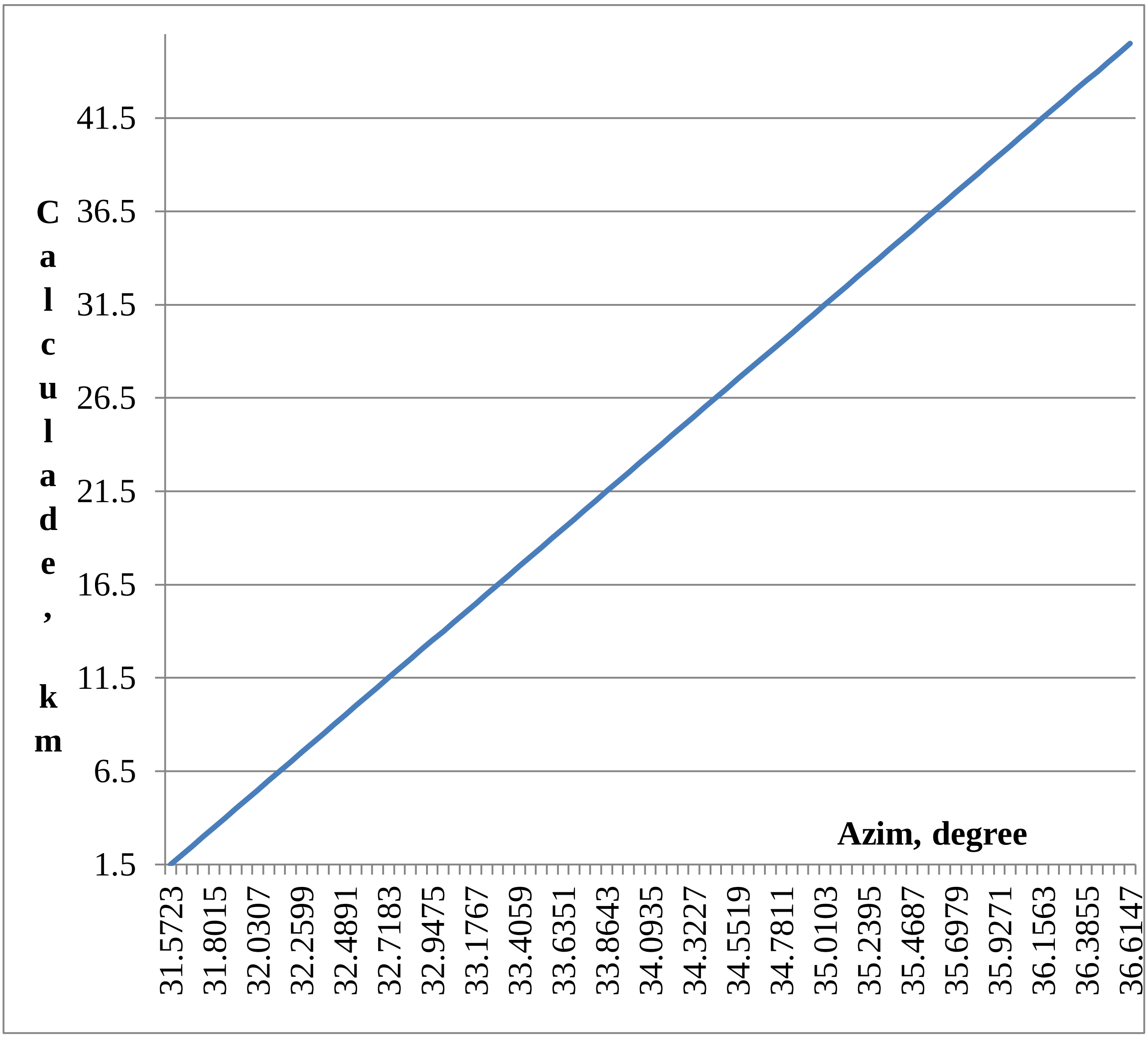


Figure 3.2. Latitude calibration characteristic.

The calibration characteristic allows us to obtain the true latitude of the IRI from the calculated latitude. To avoid hiding the nonlinearity of the KX, the desired function, the latitude, is located on the abscissa axis, and the argument, on the ordinate axis.

There is another way to display the results of determining the ILC of the IRI, for example, in the form of the dependence of the distance in km from the RCP to the desired IRI, determined (by measurement or calculation) on the measured (or calculated) azimuth or measured on the RCP field strength (GD-calibration ch



aracteristic). This display method is shown in Figure 4.2.

Figure 4.2. Latitude calibration feature.

A calibration characteristic was obtained for the range of measured azimuths of 31.5–36.4 degrees and allows us to obtain the true distance to the desired IRI from the measured azimuth. For example, with a measured azimuth of 34.0935 degrees, the distance to the IRI on the GD will be 23.5 km

Variants of on-off methods from the fourth to sixth for jib from point D, which is the middle of the side AB, and variants of the on-off methods from seventh to ninth for jib from point F, which is the middle of side AC, are based on determining the coordinates of the vertex C, as the coordinates of the points of intersection the azimuthal line of the aircraft with each of the three azimuthal lines drawn through two points from three: P, F and K. Determination of the ILC of the IRI is carried out similarly to the options for the jib from E. After determining the coordinates of the Shpiker point S, as the intersection point of the three jibs, we can also obtain three options for determining the IRF of the IRI, using the perpendicularity of the radius of the Spiker circle to each of the jibs: FD, FE, and DE.

Findings:

1.Using the direction finder to measure the azimuth to the desired IRI and the coordinates of the intersection points of the aircraft azimuth line with each of the three azimuth lines drawn through two points from three: F, P, and K, which are the start or end points of the three jibs, we got a total of 12 (taking into account the perpendicularity of the radius of the Shpiker circle and each of the jibs) variants of the method for the unambiguous one-position determination of the ILC of the IRI.

2. The Developed theory of an unambiguous one-position definition of the IRI CMP can probably not be applied to any remarkable point of the triangle. However, the identification of such remarkable points, the number of which already exceeds 32000 and continues to grow, is a serious difficulty in obtaining methods for single-position determination of the IRI CMP and requires the development of a special method for sorting these points.

3. The developed method is applicable not only to determining the coordinates of the location of radio sources, but also in other areas, in particular:

1. - to determine the coordinates of forest fire sites when using smoke detectors,

2. - to determine the coordinates of the location of submarines and schools of fish when using sound vibration sensors,

3. - to determine the coordinates of the location of areas of radioactive contamination, using appropriate radio sensors and drones, etc.

3. Definition of KMP IRI by the cosine and sine theorem

$$R_{ab}{}^2 = R_{bc}{}^2 + R_{ac}{}^2 - 2R_{bc}\, R_{ac} \cos(\theta + \beta)\,. \quad (1.3)$$

Since , $R_{ac} = AC = \frac{x_c - x_a}{\cos\alpha}$, a $R_{bc} = BC = \frac{x_c - x_b}{\cos\beta}$, the expression (1) appears in the form:

$$R_{ab}{}^{2} = \frac{(x_c - x_b)^2}{\cos\beta^2} + \frac{(x_c - x_a)^2}{\cos\alpha^2} - 2\frac{x_c - x_b}{\cos\beta}\frac{x_c - x_a}{\cos\alpha}\cos(\theta+\beta). \quad (2.3)$$

Expression (2) is a functional with respect to the desired function

$x_c = F[x_a, x_b, AB, \cos\alpha, \cos\theta, \cos\beta(x_c)]$ since $\cos\beta(x_c)$ is a function

the desired latitude x_s. After conversion and simplification

we get a linear equation with one unknown x_s to determine the latitude:

$$x_c = \frac{B}{A} \quad (3.3)$$

where: $A = {}^{1}/_{\cos^2_\alpha} + 2\cos(\theta+\beta) \,/\, \cos\alpha\cos\beta$

$B = x_b\,[\mathrm{tg}\alpha - 2\cos(\theta+\beta) \,/\, \cos\alpha\cos\beta]$.

$R_{ab} = \sqrt{x_b{}^{2} + y_b{}^{2}}$.

Using equation (3.3), the calibration characteristic of the cosine method in latitude was obtained and is shown below in Fig. 1.3.

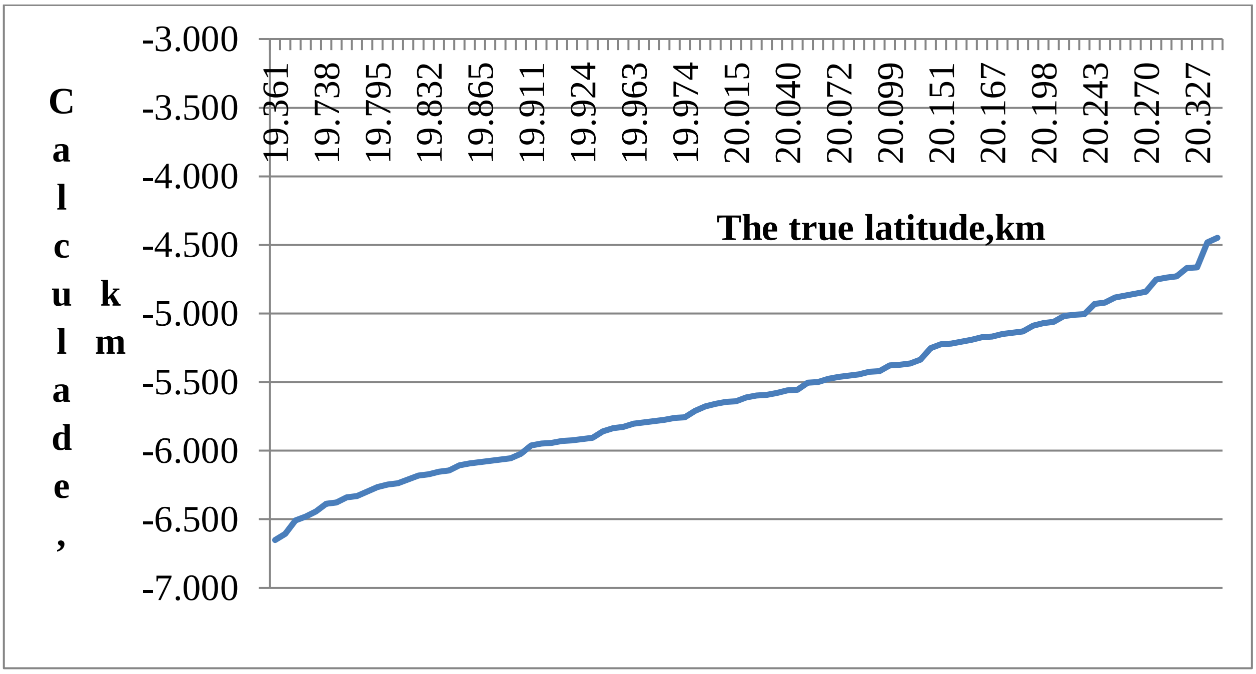


Fig. 1.3. Calibration characteristic of the method in latitude.

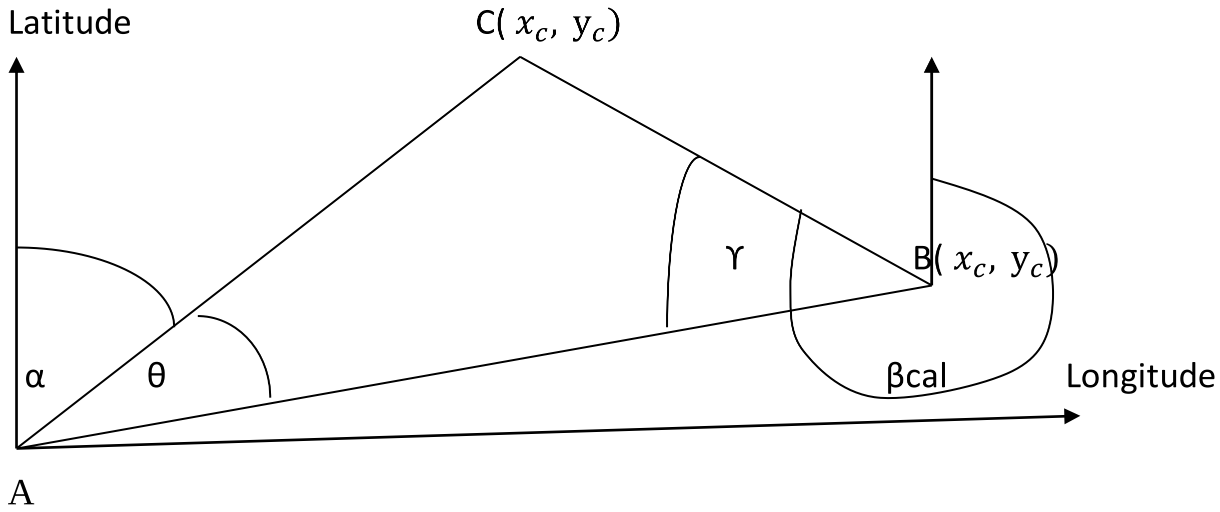


Fig. 2.3. ABC triangle with the azimuth α measured at point A in the IRI

and calculated for point B in the azimuth of β.

The procedure for determining the ILC of Iran is as follows. At the maximum distance along the EM of the reach of the direction finding device of the RCP, the reference RES on the measured azimuth is selected. Then evenly calibrate this distance and recalculate the coordinates of each calibration point. A calibration dependence is obtained as a function of the coordinates (latitude) of the point x_c_c MP IRI from the azimuth α measured on it. Since each calibrated point corresponds to the latitude of the location and azimuth, then the latitude of the MP IR is uniquely determined from the measured azimuth α.

$$BC/\sin\theta = AC/\sin\Upsilon \qquad (1.3).$$

Since $BC = \sqrt{x_b^2 + x_c^2 - 2x_b\, x_c + y_b^2 + y_c^2 - 2y_b\, y_c}$, AC= $x_c/cos\alpha$ and

ϒ= βвыч $-\pi$-(α+θ), a tgβ= $[x_c tg\alpha - y_b]/(x_c - x_b)$ then after substituting these expressions in (1) we obtain the quadratic equation for x_c in form:

$$Ax_c^2 - Bx_c + C = 0 \qquad (2.3),$$

where: $A = (sin_{\Upsilon}^2 - sin_{\theta}^2)/sin_{\Upsilon}^2 cos_{\alpha}^2$,

$B = 2(x_b - y_b tg\alpha)$, $C = x_b^2 + y_b^2$.

Using equation (2.3), a calibration characteristic of the method of sines in latitude was obtained, shown in Fig. 3.3 below.

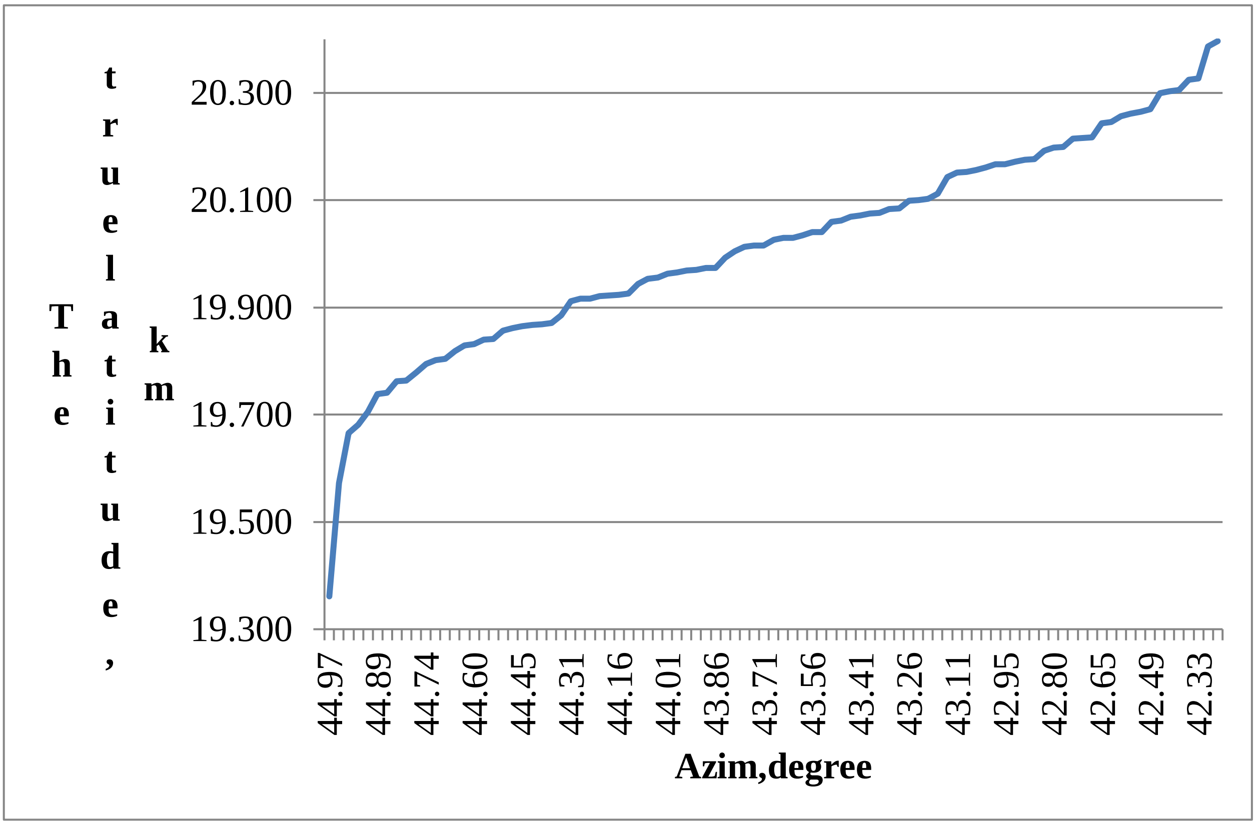


Fig.3.3. The calibration characteristic of the method of sines in latitude

With a measured azimuth of, for example, 44.16 degrees, the latitude of the Iranian MP will be 19.922 km according to the calibration characteristic.

4. The method based on bisectors.

Consider the definition of ILC IRI passive energy

one-way method based on bisectors. To illustrate the method, we present Fig. 1.4.

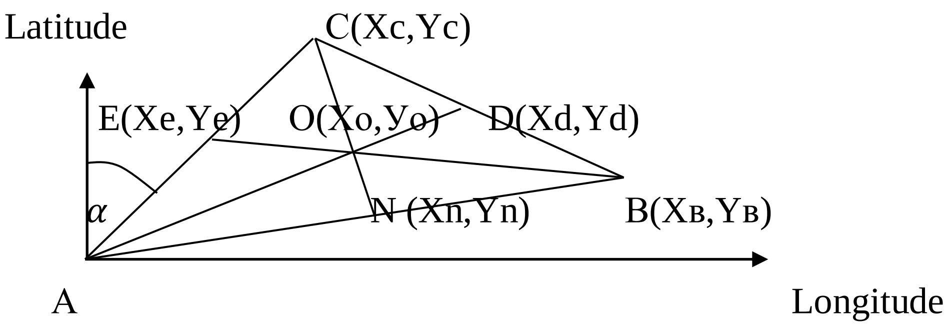


Fig. 1.4. Triangle ABC with bisectors CN and BE.

As the main feature of the bisector, we use its property to divide the opposite side into parts proportional to the sides of the triangle adjacent to it. We write this property for the bisector CN, using Fig. 1.4, in the form of the formula:

AN: BN = AC: BC. (1.4)

We denote the ratio of the sides of the AS: BC by M. Since BN = AB-AN, then

AN: (AB-AN) = M and write this formula (1.4) in the form

AN = AB * M: (1 + M) (2.4)

in which the value of M is determined through the distances AC = x_c/ cosα

and BC=$\sqrt{(x_c \,/\, \cos\alpha)^2 \quad - 2x_c(x_b+y_b) + \mathrm{x}_\mathrm{b}^2 \ + \mathrm{y}_\mathrm{b}^2}$

AN : (AB-AN)= $x_n/(x_b - x_n)$ =M $\quad x_n = x_b\mathrm{M}/(1 + M)$

Since AC: BC = $\frac{x_c\cos\beta}{(x_c-x_b)\cos\alpha}$ =$x_n/(x_b - x_n)$,hence:

x_n=$\frac{x_c\cos\beta}{(x_c-x_b)\cos\alpha} = \frac{x_c x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}$ (3.4)

Since the coordinate x_nточки N depends on the unknown x_c, it is necessary to compose another equation. We will write it for the ACN triangle

AN^2=$AC^2 + CN^2$-2 AN CN cos ϒ/2 (4.4), where:

ϒ=α-β, a AN=$\sqrt{\mathrm{x}_\mathrm{n}^2 + \mathrm{y}_\mathrm{n}^2}$=$x_n(1 + \mathrm{c}tg\tau)$

CN=$\sqrt{(x_c - \ x_n)^2 \quad - (y_c - \ y_n)^2}$ =$\sqrt{\mathrm{x}_\mathrm{c}^2 - 2x_c x_n + \mathrm{x}_\mathrm{n}^2 + \mathrm{y}_\mathrm{c}^2 - 2y_c y_n + \mathrm{y}_\mathrm{n}^2}$=

$\sqrt{\mathrm{x}_\mathrm{c}^2 + \mathrm{x}_\mathrm{c}^2 tg_\alpha^2 - 2x_c(x_n + y_n) + \mathrm{x}_\mathrm{n}^2 + \mathrm{y}_\mathrm{n}^2}$=$\sqrt{\frac{\mathrm{x}_\mathrm{c}^2}{cos_\alpha^2} - 2x_c\left(x_n + \frac{x_n}{tg\tau}\right) + AN^2}$

Substituting in (3.4) expressions for CN^2, AC^2 and AN, we will receive:

AN^2=$\mathrm{x}_\mathrm{c}^2/cos_\alpha^2 + \mathrm{x}_\mathrm{c}^2/cos_\alpha^2 - 2x_c x_n(1 + \mathrm{c}tg\tau) + AN^2$-2 $x_n(1 + \mathrm{c}tg\tau)$ $\sqrt{\mathrm{x}_\mathrm{c}^2/cos_\alpha^2 - 2x_c x_n(1 + \mathrm{c}tg\tau) + \mathrm{x}_\mathrm{n}^2 + \mathrm{y}_\mathrm{n}^2}$ cos ϒ/2. Or, after reduction of AN^2we will receive:

$$2x_c^2/cos_\alpha^2 - 2x_c x_n(1+ctg\tau) = 2\,x_n(1+ctg\tau)\sqrt{\frac{x_c^2}{cos_\alpha^2} - 2x_c x_n(1+ctg\tau) + x_n^2\,[\,1+\ (1+ctg\tau)^2]}\ \cos\Upsilon/2$$

Let's put it here (2.4). $2x_c^2/cos_\alpha^2 - \frac{2x_c^2 x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}(1+ctg\tau) = 2\frac{x_c x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}(1+ctg\tau)$
$\sqrt{\frac{x_c^2}{cos_\alpha^2} - 2x_c\frac{x_c x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}(1+ctg\tau) + [\frac{x_c x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}]^2\,[\,1+\ (1+ctg\tau)^2]}$
$\cos\Upsilon/2$. Reduce by$2x_c^2$. Then we will receive:

$$1/cos_\alpha^2 - \frac{x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}(1+ctg\tau) =$$

$$\sqrt{\frac{1}{cos_\alpha^2} - \frac{2x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}(1+ctg\tau) + [\frac{x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}]^2\,[\,1+\ (1+ctg\tau)^2]}$$

$\cos\Upsilon/2$. Let's square both parts of this equation. Then:

$$1/cos_\alpha^4 - \frac{2x_b\cos\beta(1+ctg\tau)}{[x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha]cos_\alpha^2} + [\frac{x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}(1+ctg\tau)]^2 =$$

$\{\frac{1}{cos_\alpha^2} - \frac{2x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}(1+ctg\tau) + [\frac{x_b\cos\beta}{x_c(\cos\alpha+\cos\beta)-x_b\cos\alpha}]^2\,[\,1+$
$(1+ctg\tau)^2]\}(\,\cos\Upsilon/2\,)^2$. Free from denominators containing unknown.

$$[x_c(\cos\alpha+\cos\beta) - x_b\cos\alpha]^2 cos_\alpha^2\ [\frac{1}{(\,\cos\Upsilon/2\,)^2 cos_\alpha^4} - \frac{1}{cos_\alpha^2}] - [x_c(\cos\alpha+\cos\beta) - x_b\cos\alpha]/(\,\cos\Upsilon/2\,)^2[2x_b\cos\beta(1+ctg\tau) - x_b cos_\alpha^2\ \cos\beta(1+ctg\tau)^2] - [(\cos\alpha+\cos\beta) - x_b\cos\alpha]cos_\alpha^2\ [2x_b\cos\beta(1+ctg\tau)] + [x_b\cos\alpha\cos\beta(1+ctg\tau)]^2 = 0$$

After squaring and distributing by degrees of x_c, we get the square equation:

$$Ax_c^2 + Bx_c + C = 0 \qquad (5.4)\text{, where:}$$

$$A = [\frac{1}{(\,\cos\Upsilon/2\,)^2 cos_\alpha^4} - \frac{1}{cos_\alpha^2}]\,(\cos\alpha+\cos\beta)^2$$

$$B = x_b(\cos\alpha+\cos\beta)\,\cos\beta(1+ctg\tau)[\,\frac{2-(1+ctg\tau)cos_\alpha^2}{\cos\Upsilon/2\,)^2} + 2cos_\alpha^2\ ]$$

$$C = [x_b^2 cos_\alpha^2 - \ \cos\beta(1+ctg\tau)][2\,\cos\alpha + (1+ctg\tau)\cos\beta]$$

As per equation (5.4) calibration and calibration characteristics of single-position method of bisector are obtained, given below.

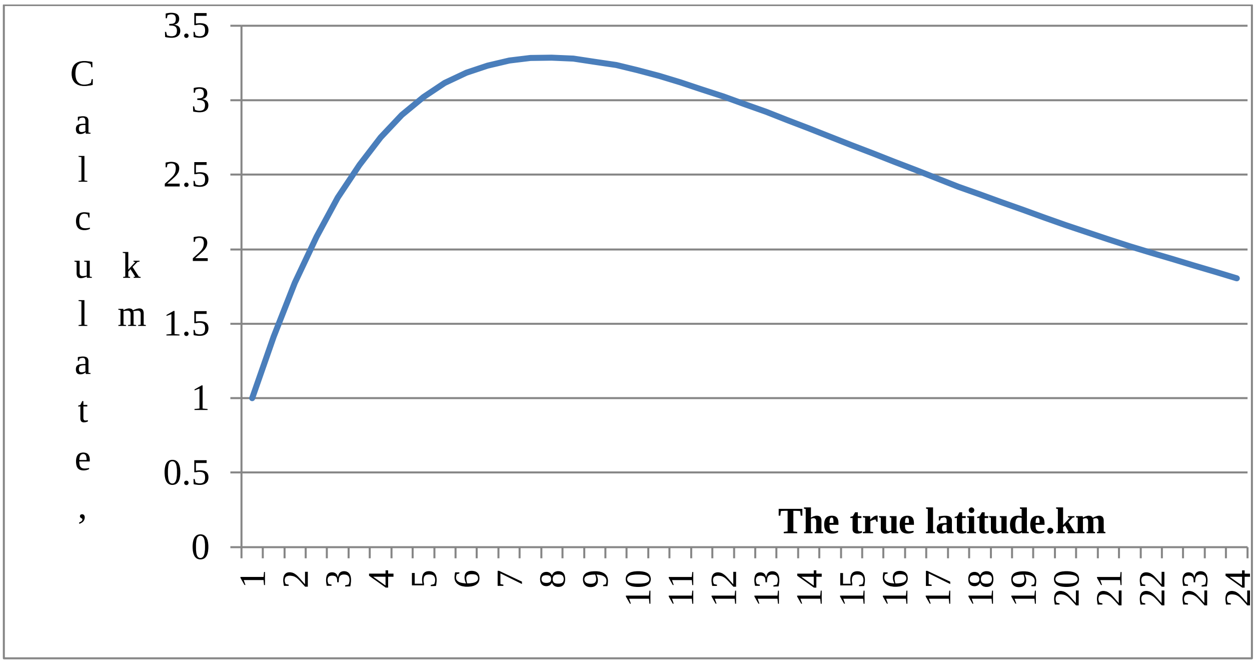


Fig. 2.4. Calibration characteristic of the bisector method in latitude.

The same characteristic of the method can be converted into a calibration one, as the dependence of the true latitude Xc on the measured azimuth to the desired IRI and is presented in Fig. 3.4

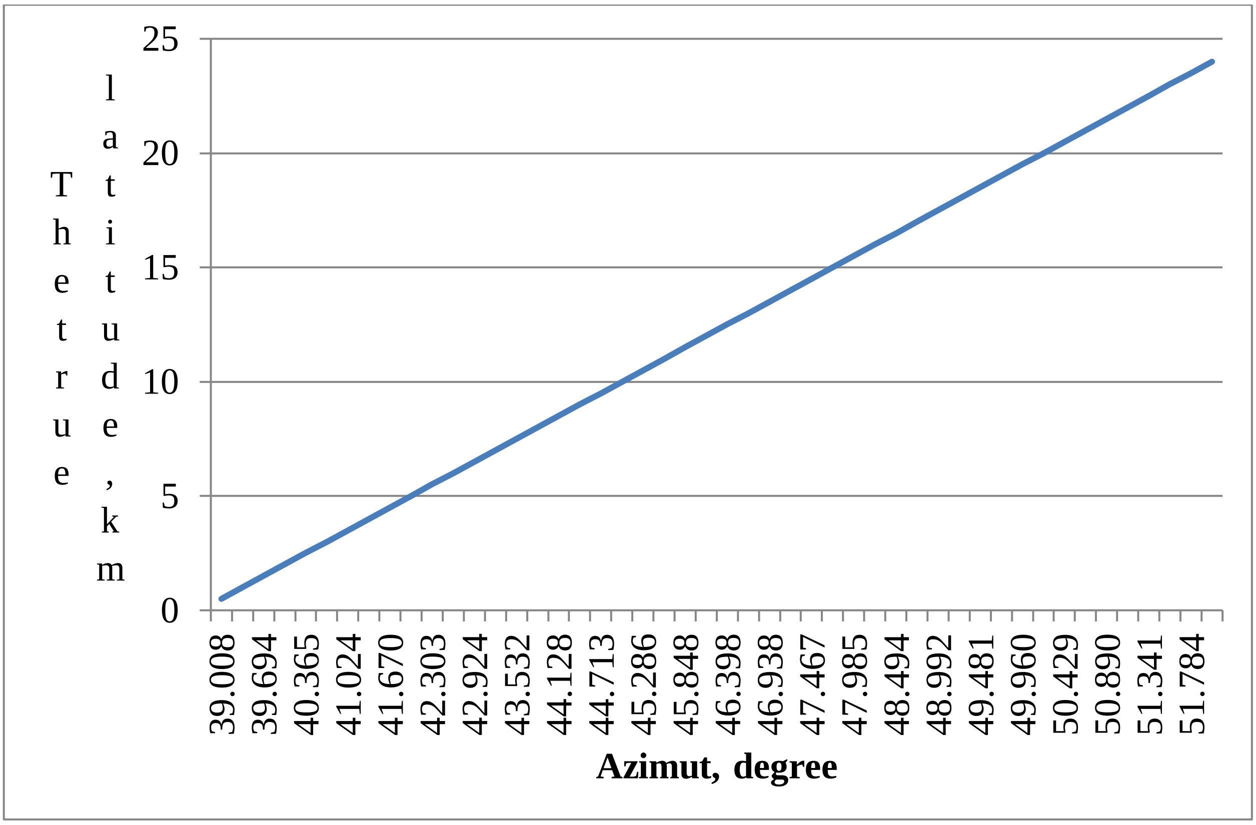


Fig. 3.4.The calibration characteristic of bisector method by latitude.

Conclusions:

1. Calculation of a way of bisectors by results of measurement of an azimuth α can be executed by three options with use of corners at each top of a triangle: $\theta=\pi/2-\alpha-\tau$, $\Upsilon=\alpha-\beta$ and $\psi = \pi/2+ \tau + \beta$.

2. The most obvious representation of the results of the ILC IRI calculation and convenient for use is the calibration characteristic of the method.

5. The method for determining ILC of Iran based on Simedian

In the encyclopedia of triangle centers [5,6], supported by professor of mathematics at the University of Evansville (Indiana) Clark Kimberling, in 2017 there were more than 6,000 remarkable points of the triangle, in 2018 there were more than 17000 such points. In 2019, there were already more than 32,000 and continues to increase. Known: points of Brokar, Gergon, Apollonius, Van Abel, Lemoine, Nagel, Poncelet, Schifler, and many others. Their peculiarity is that they coordinate the coordinates of the vertices of the triangle with their coordinates. Since two of the three vertices can be set, knowing their coordinates, it is probably possible to determine the coordinates of the third vertex, which, by assumption, is the desired IRI, from the results of measuring the azimuth or field strength.

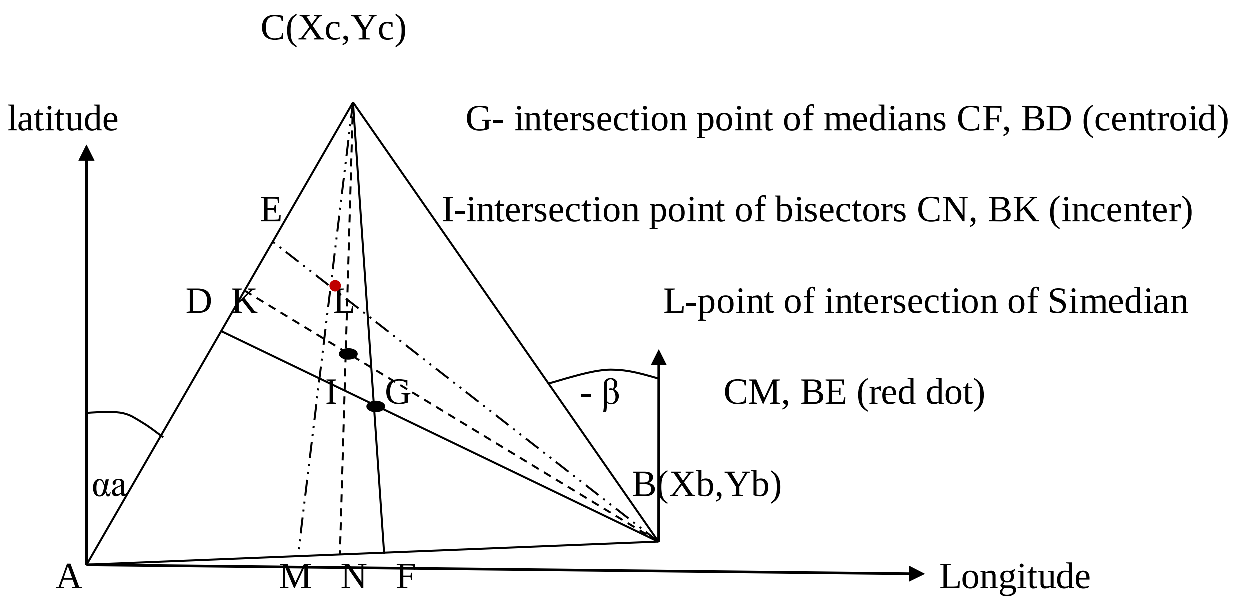


Figure 1.5: ABC Triangle with Three Great Points

Lemoine point has three equivalent definitions:

1. The intersection point of the lines connecting each vertex of the triangle with the intersection points of the tangents to the circumscribed circle drawn from two other vertices.
2. The intersection point of the Simedians.
3. The point of intersection of the lines connecting the midpoints of the sides of the triangle with the midpoints of their corresponding heights.

The following properties of the Lemoine point are of interest:

1. The distances from the Lemoine point to the sides of the triangle are proportional the lengths of the sides.
2. The Lemoine point is the intersection point of the medians of the triangle formed by the projections of the Lemoine point on the sides. Moreover, such a point is unique.
3. The Lemoine point is the Gergonn point of a triangle formed by tangents to the circumscribed circle at the vertices of the triangle.
4. Simediana divides the opposite side into parts proportional to the squares of the lengths of the adjacent sides.

The G-centroid, also called the Grebe point, had already been considered before for determining the IIRC. The intersection points of the bisectors I with the sides AB and AC were considered above as intermediate in the way of determining the intersection point of the BE and SM median media that are symmetric with respect to the bisectors and determine the coordinates of the Lemoine point L, recognized as one of the gems in the crown of modern geometry [6]. We use the fourth property of the Smedian - to divide the opposite side into parts proportional to the squares of the lengths of the adjacent sides.

AM:MB =$AC^2 : BC^2 = M^2$.

Since AM:MB=AM⁄(AB-AM), thenAM=$ABM^2 / (1 + M^2)$. Since

$AM : MB = AM / AB - AM = x_M / x_B - x_M$, then $x_M = x_B M^2 / (1 + M^2)$, then

$M^2 = AC^2 : BC^2 = x_c{}^2 cos_\beta^2 / (x_c - x_b)^2 cos_\alpha^2$. (1.5)

Since the coordinates of the M-point of division of the AB side depend on an unknown value of x _ s, it is necessary to compose another equation. We compose it for the ACM triangle:

$$CM^2 = AC^2 + AM^2 - 2AC\,AM\cos\theta \qquad (2.5)$$

$$CM^2 = (x_c - x_m)^2 + (y_c - y_m)^2 = x_c^2 - 2x_c x_m + x_m^2 + y_c^2 - 2y_c y_m + y_m^2 =$$

$$x_c^2/\cos^2_\alpha - 2x_c(x_m + y_m) + [x_в M^2/(1 + M^2)]^2 + [x_в M^2/(1 + M^2)ctg\tau]^2$$

$$x_c^2/\cos^2_\alpha - 2x_c(x_m + y_m) + [M^2/(1 + M^2)]^2[x_b^2(1 + 1/ctg^2_\tau)] = x_c^2/\cos^2_\alpha +$$

$$+AB^2M^4/(1 + M^2)^2 - 2x_c AB\cos\theta M^2/(1 + M^2)\cos\alpha$$

$$-2x_c(x_m + y_m) + [M^2/(1 + M^2)]^2[x_b^2(1 + 1/ctg^2_\tau) - AB^2] =$$

$$-2x_c AB\cos\theta M^2/(1 + M^2)\cos\alpha$$

$$[M^2/(1 + M^2)]^2[x_b^2(1 + tg^2_\tau) - AB^2] = 2x_c x_m[(1 + tg\tau) -$$
$$AB\cos\theta M^2/(1 + M^2)\cos\alpha]$$

$$[M^2/(1 + M^2)]^2\,[x_b^2(1 + tg^2_\tau) - AB^2] =$$
$$2x_c\,M^2/(1 + M^2)\,[(1 + tg\tau)\,AB\cos\theta/\cos\alpha]$$

$$x_c = M^2/(1 + M^2)\,[x_b^2(1 + tg^2_\tau) - AB^2]\cos\alpha/\,2[(1 + tg\tau)AB\cos\theta]$$

$$x_c = M^2[x_b^2/\cos^2_\tau - AB^2]\cos\alpha/\,2[(1 + tg\tau)AB(1 + M^2)\cos\theta]$$

Similar to the method, the bisector will obtain the calibration and calibration characteristics given in Fig.2.5 and Fig.3.5Similarly to the bisector method, we

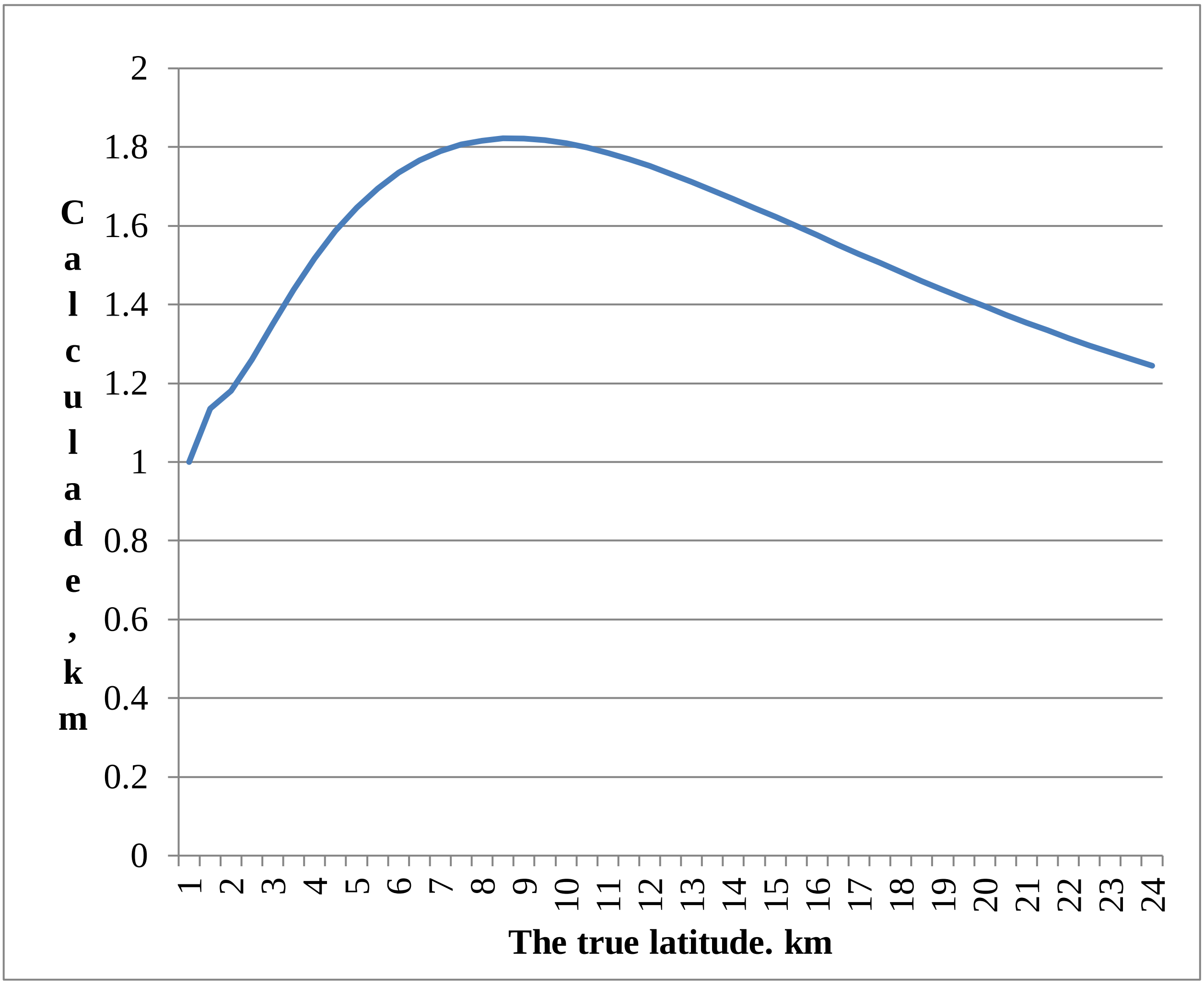


Fig.2.5. Calibration characteristic of a single-position passive energy method for determining the ILC of the IRI based on Simedian.

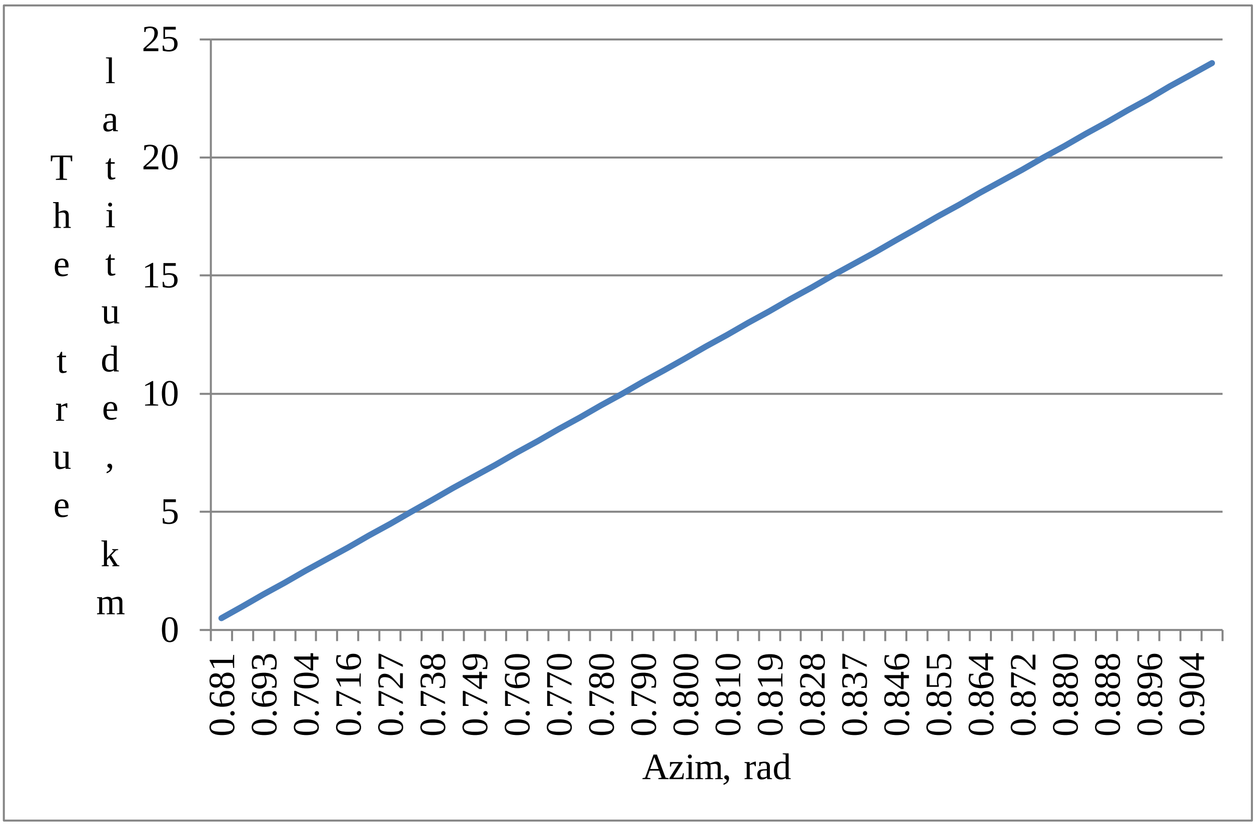


Fig.3.5. Calibration characteristic of a single-position passive energy method for determining the ILC of the IRI based on Simedian.

Findings:

1. Determination of the ILC of the IRI in a single-position passive way is possible both using the remarkable properties of triangles and its wonderful points.
2. Since the number of properties of a triangle and its remarkable points is significantly greater than the functional dependences in the triangle, and is constantly increasing, the use of these points for the purpose of radio coordinate measurement should be considered promising.
3. The properties of the bisectors and simedian are well combined with the difference-relative method for determining the ILC of the IRI.
4. The most visible representation of the results of the ILC IRI calculation and convenient for use is the calibration characteristics of the methods.

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