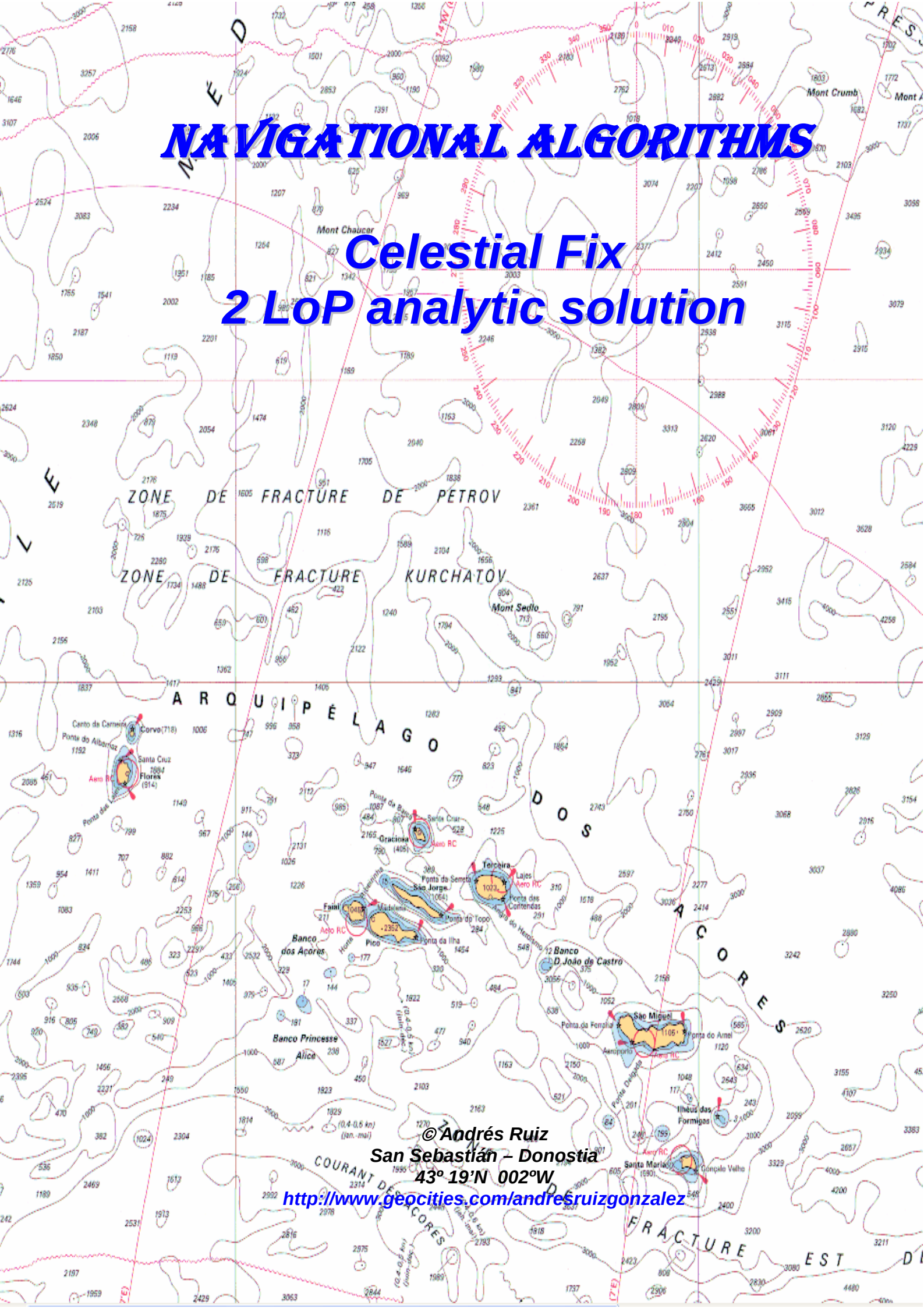
NAVIGATIONAL ALGORITHMS
Celestial Fix
2 LoP analytic solution
ZONE DE FRACTURE DE PETROV
ZONE DE FRACTURE KURCHATOV
ARQUIPÉLAGO DOS AÇORES
Mont Chaucer
Mont Crumb
Mont Sedlo
Banco dos Açores
Banco Princesse Alice
Banco D.João de Castro
COURANT DES AÇORES
FRACTURE EST
Corvo(718)
Santa Cruz
Flores (914)
Graciosa (405)
Terceira
São Jorge (1064)
Pico
Faial
Madalena
São Miguel
Santa Maria (690)
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Index

Abstract

This paper describes the numerical solution of the problem in classical celestial navigation: calculate the position by two lines of position.
Two cases are treated: the *Fix*, where the two observations may be considered as simultaneous, and the *Running Fix,* where in general due to the time elapsed between the two measurements with the sextant, you must move the first line to the instant of the second one.

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Variables

P Intercept of a sight

p = Ho – Hc

Towards = + / Away = –

Z Azimuth (true)

Measured clockwise around the horizon from 0° to 360°, is the arc of the horizon between the meridian of a place and the vertical circle passing through a celestial body.

B Latitude

N (+) / S (–)

L Longitude

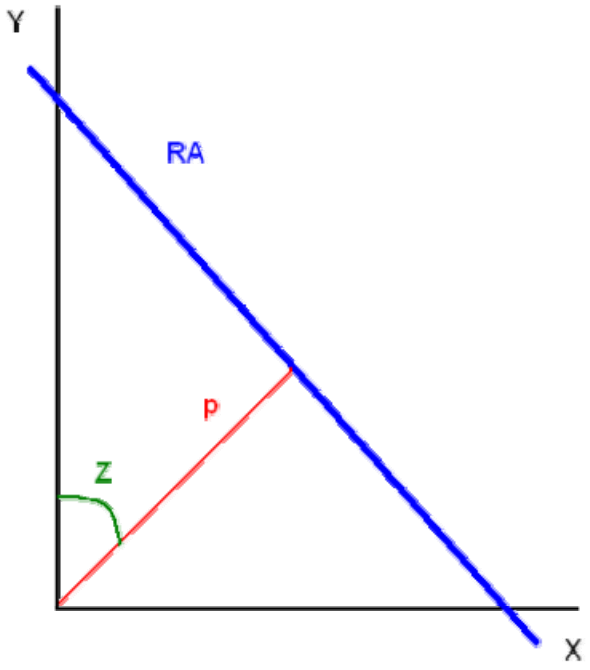
E (+) / W (–)

Equation of the Line of Position

The equation of a line in the Cartesian plane is given by:

$$y = f(x) = m\,x + b$$

Where m is the slope and b is the ordinate at the origin.



LoP in the Cartesian plane

From the figure it follows the relationship of m y b, with the parameters characterizing the line of position, LoP: p and Z

$$m = \tan(180º\text{-}Z) = -\tan Z$$
$$b = p/\cos Z$$

Substituting these values into the equation and rearranging terms, leads to the equation of the LoP:

$$\mathbf{p = x \sin Z + y \cos Z}$$

Fix by two LoP

Position (B, L) can be calculated analytically as the intersection of two LoP, taking the estimated position as the origin of Cartesian coordinates. The process merely mathematically formulate the graphic method used in the nautical chart.

If both are obtained simultaneously:

$$p1 = x \sin Z1 + y \cos Z1$$
$$p2 = x \sin Z2 + y \cos Z2$$

Solving this system of two equations the point (x, y) is obtained; the cut between the two LoP. The latitude and longitude will be obtained from the estimated position (Be, Le).

If p is in nautical miles:

$$B = Be + y/60$$
$$L = Le + x/60/COS(B)$$

The calculation process is detailed in the appendix. The required data is:

- Estimated Posicion: Be, Le
- LoP1: p1, Z1
- LoP2: p2, Z2

Running Fix

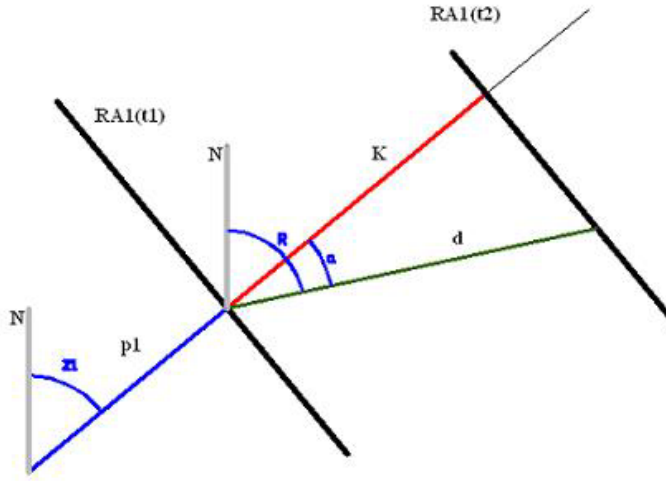
In the more general case the two LoPs will be obtained for different moments in time: t1 and t2.

Let R and d be the course and distance sailed between t1 and t2. The first LoP, RA1(t1), must be moved to the instant of the second observation; RA1(t2). In this way the intersection of RA1(t2) and RA2(t2) give us the position.

The distance sailed can be calculated as a function of time elapsed between the

observations and the speed sailed at constant course:

$$d = V\,(t2-t1)$$



Move of a LoP.

In the figure, K is the distance to be moving the first LoP.

$$\cos \alpha = K/d$$
$$Z1 + \alpha = R$$
$$K = d \cos(R-Z1)$$

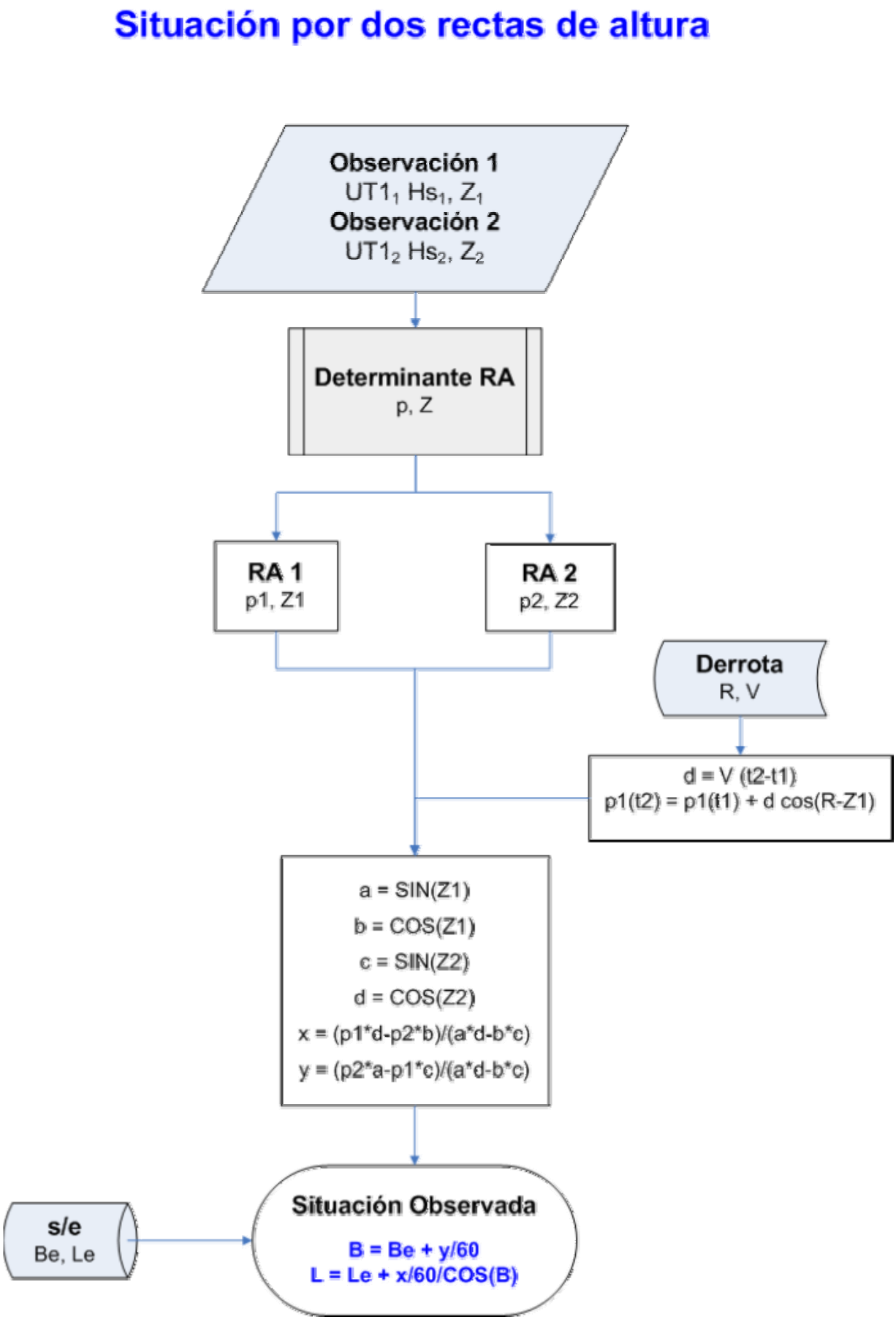
So the intercept was corrected by:

$$p1(t2) = p1(t1) + K$$

$$\mathbf{p1}(t2) = \mathbf{p1}(t1) + \mathbf{d\ cos(R-Z1)}$$

Of course, if both observations are simultaneous, t1 = t2, the distance is d = 0, and the intercept does not change.

A1. Algorithm



A2. Example

Be = 12.00

Le = -17.75

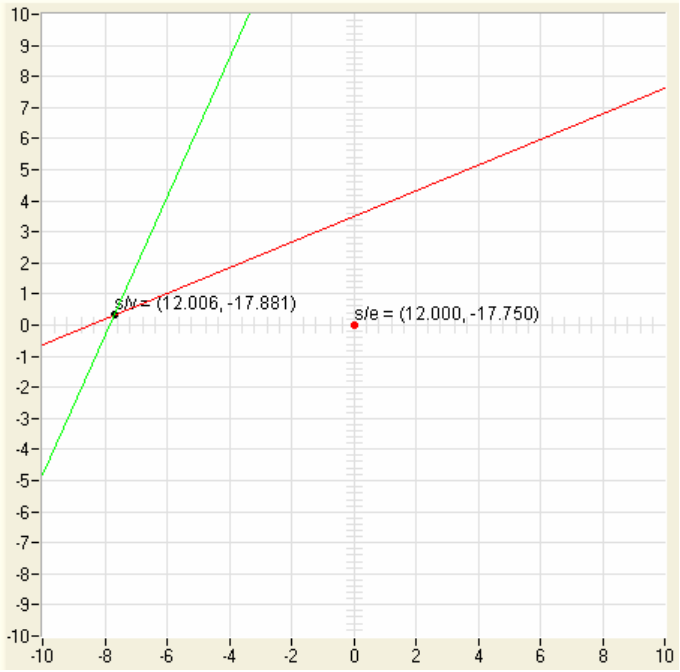
R = 343º

V = 0

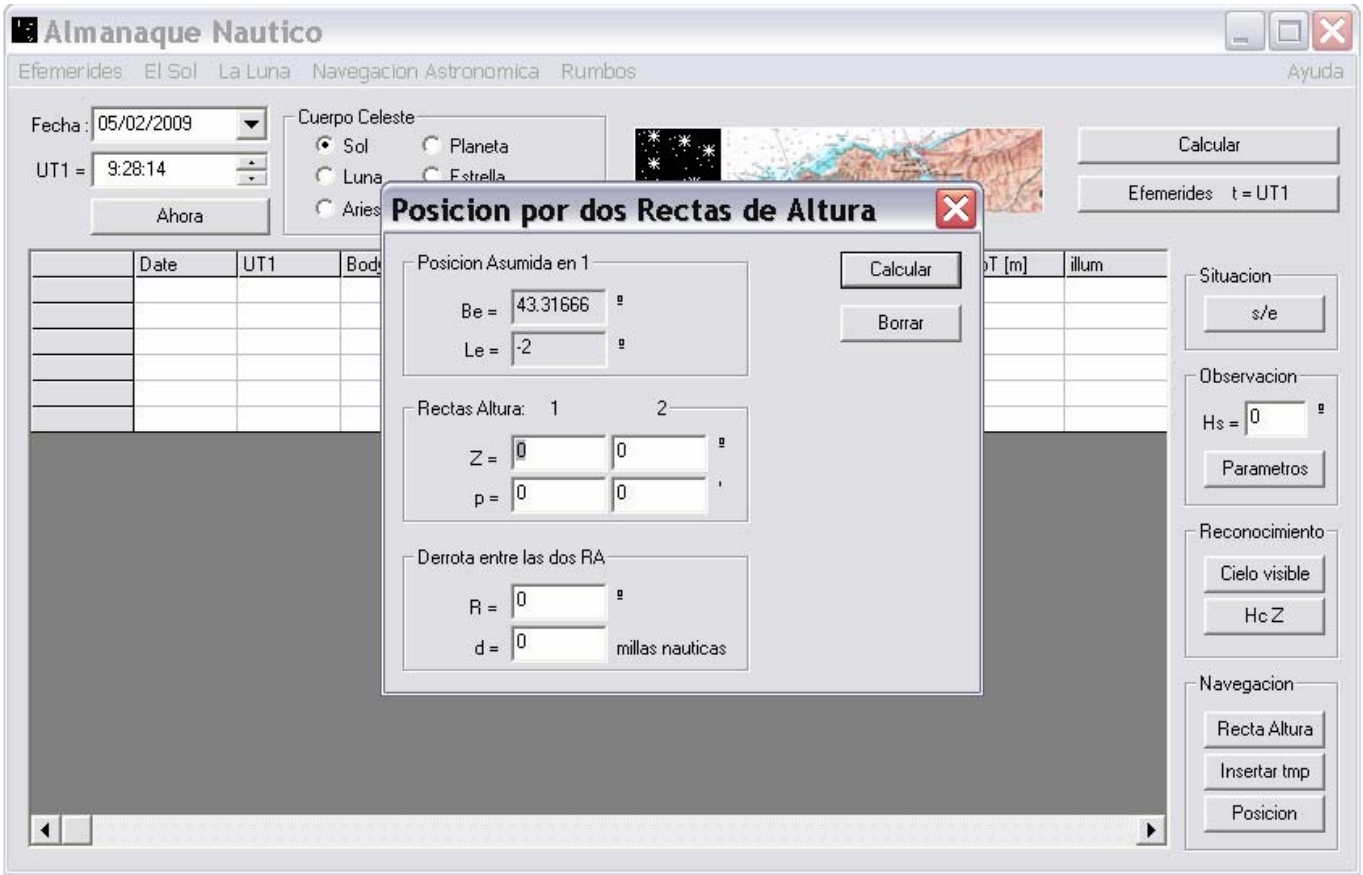
Z (º)	p (mn)
337.5854	3.24
294.1474	7.152

B = 12.0056º

L = -17.8810º



A3. Software



Available at the Navigational Algorithms web page.

A4. Source code

```
/*
FILE: 2RA.c

Posición por 2 Rectas de Altura

This file contains proprietary information of Andrés Ruiz Gonzalez
Andrés Ruiz. San Sebastian - Donostia. Gipuzkoa
Copyright (c) 1998
*/

#include <math.h>
#include "../Nav/angulos.hpp"


void Posicion2LOPSimultaneas( double Lat, double Lon, double p1, double Z1, double p2, double Z2,
                              double *B, double *L )
{
   double x, y; // [nm]

   *B = *L = 0;

   double a = SIN(Z1);
   double b = COS(Z1);
   double c = SIN(Z2);
   double d = COS(Z2);

   x = (p1*d-p2*b)/(a*d-b*c);
   y = (p2*a-p1*c)/(a*d-b*c);

   *B = Lat + y/60.0;
   *L = Lon + x/60.0/COS(*B);

   if ( *L > +180.0 ) *L -= 360.0;
   if ( *L < -180.0 ) *L += 360.0;
}

void Posicion2LOPNoSimultaneas ( double Lat, double Lon, double p1, double Z1, double p2, double Z2,
                                 double R, double D,
                                 double *B, double *L )
{
   Posicion2LOP( Lat, Lon, p1+D*COS(R-Z1), Z1, p2, Z2, B, L );
}
```

A5. References

- http://es.wikipedia.org/wiki/Recta