U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

COMPSYS 21

Geodetic Computations
User Documentation

March 9, 2010

Federal Aviation Administration
AeroNav Services

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COMPSYS 21
Geodetic Computations
Version 3.0

1.0 INTRODUCTION

COMPSYS 21 is a graphics user interface created by the Information Technology Office's Technical Services Group for the National Aeronautical Navigation Services. This user-friendly interface is one part of the development designed to support the compilation of aeronautical charts and products. It provides the ability to perform geodetic computations.

1.1. Computations

The COMPSYS 21 interface includes eight geodetic computations. These include Forward, Inverse, Segment/Segment, Bearing/Bearing, Segment Distance, Circle Bearing, Circle/Circle and Segment Bearing. Results can be sent to a user specified printer or saved to a file. The COMPSYS 21 pull down also contains the Airport Reference Point calculation.

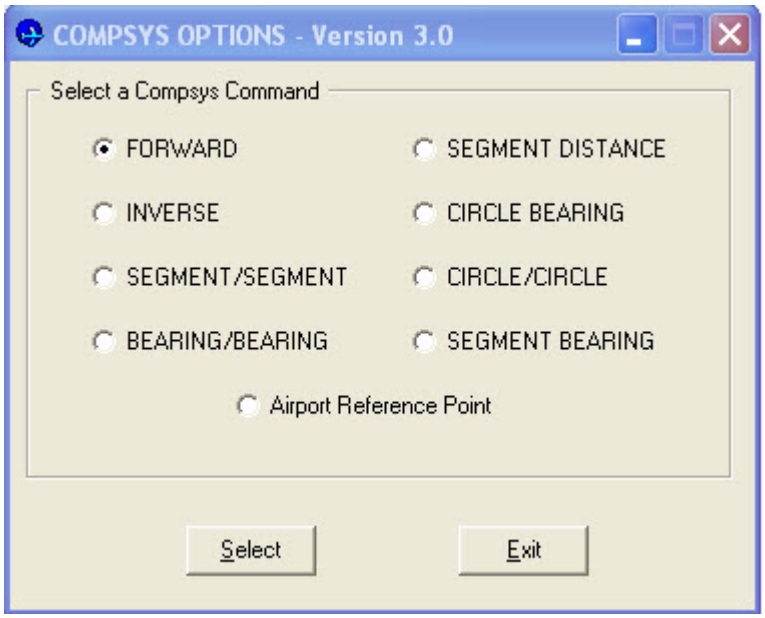
All computations are based on solutions of the geodetic forward and inverse after T. Vincenty, modified Rainford's method, with Helmert's elliptical terms. Intersection computation is also based on equations from SP-138 (NAVOCEANO, Spheroidal Geodesics Reference Systems, and local geometry by P.D. Thomas. Forward and Inverse routines are fully certified by the Department of Commerce/National Oceanic and Atmospheric Administration (NOAA)/National Geodetic Survey (NGS), the agency responsible for geodesy. The forward and inverse computations are the basis of all COMPSYS 21 calculations. NGS also has three-dimensional versions that take into consideration the height component. The COMPSYS 21 toolkit is based upon the two dimensional version. Forward and Inverse computations are effective at any distance short of ANTIPODAL.

The user may create a shortcut on their desktop if desired. Just click on the COMPSYS 21 executable **(COMPSYS21.EXE)** and select COMPSYS 21. The initial setup will add COMPSYS21 as a selection under programs from the start menu.

Shortcut

<Click on Executable

COMPSYS 21



Click on the desired COMPSYS 21 calculation and then click on **Select** or double click on the desired routine. A blank form will appear for user inputs.

1.2. Ellipsoids:

The earth is not a sphere but an ellipsoid. Due to centrifugal force generated by the rotation of the earth on its axis, the earth is flattened slightly at the poles and bulging somewhat at the equator. This shape is further influenced by the pull of gravity on different parts of the earth's surface. This shape is called a geoid. These variations in the geoid mean that a certain ellipsoid may fit different areas of the world more closely. Thus, other ellipsoids can be selected in COMPSYS 21. In 1983, the GRS80 ellipsoid was adopted for worldwide usage. AeroNav Services computations are derived from this standard ellipsoid.

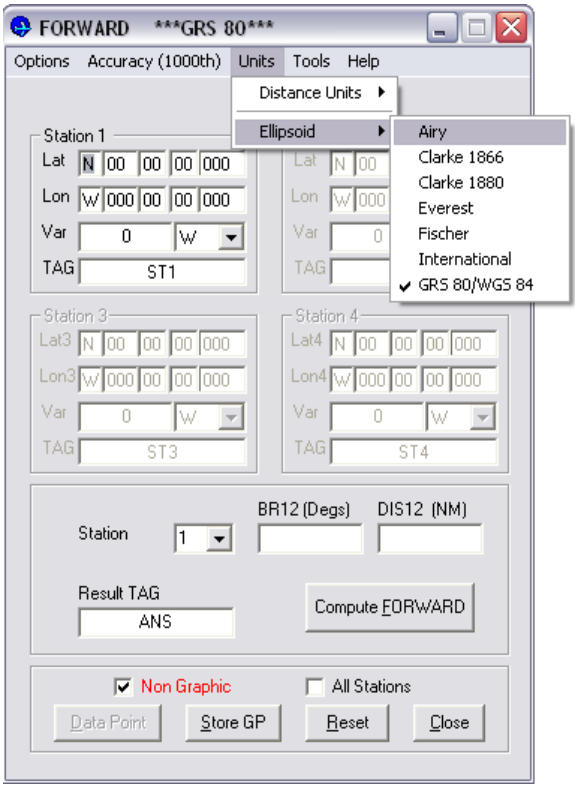
The default ellipsoid for all calculations within COMPSYS 21 is the Geodetic Reference System of 1980 (GRS80). This ellipsoid is identical to the World Geodetic System of 1984 (WGS84). An

ellipsoid's size is defined by the semi major axis (a) and it's flattening (f). In the case of these two ellipsoids, the difference in one of the constants is only a tenth of a millimeter.

GRS80/WGS84 Constants

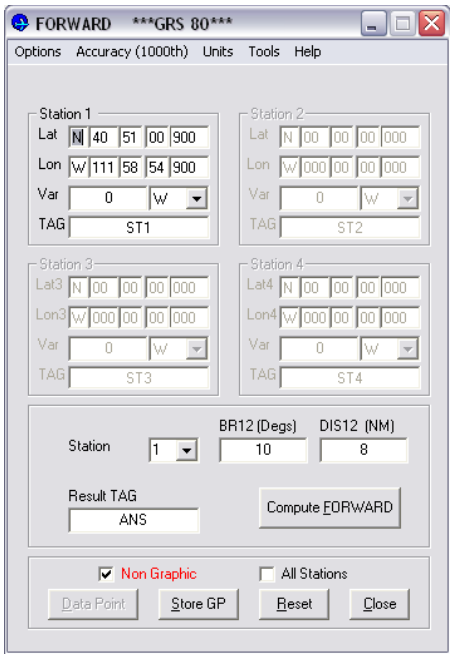
Parameter	Notation	Units	GRS80	WGS84
Semimajor Axis	a	m	6378137	6378137
Semiminor axis	b	m	6356752.3141	6356752.3142
Flattening	f		0.00335281068118	0.00335281066474

Ellipsoids



<GRS80/WGS84

The ellipsoid selected will always appear on the top of the computation chosen and in any result that is saved to a file. The ellipsoid will remain active until another is picked or COMPSYS 21 is exited.



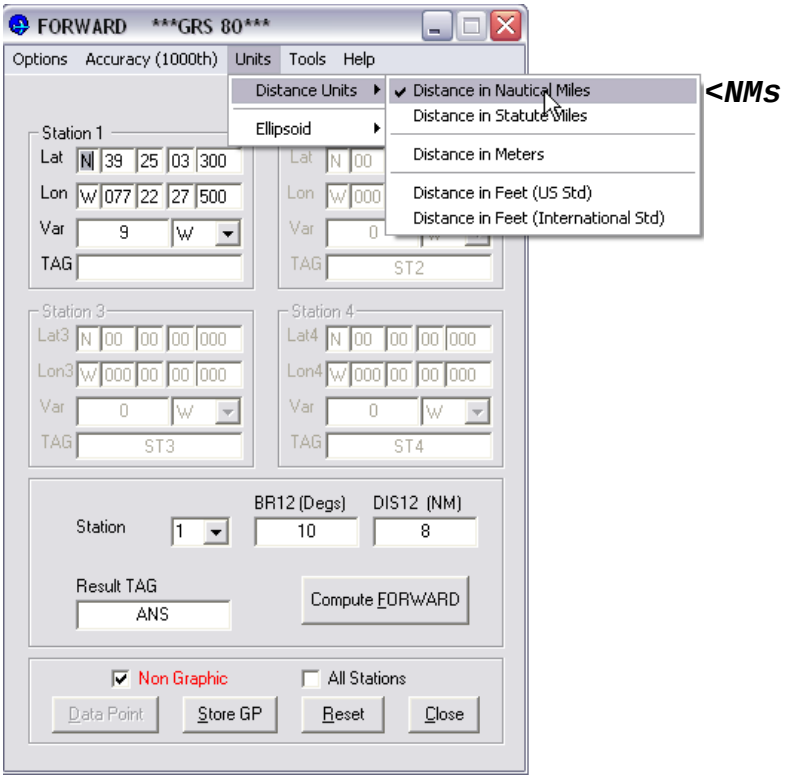
<Ellipsoid

1.3. Units:

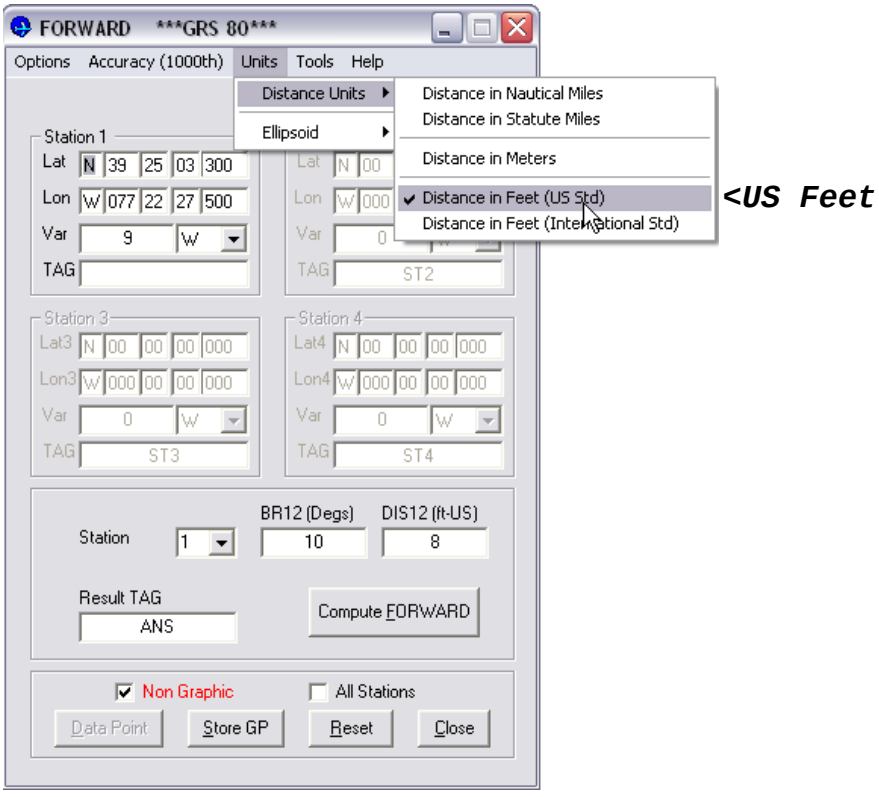
COMPSYS 21 by default uses nautical miles as the input and output distance units. COMPSYS 21 uses the international standard for a nautical mile. This standard defines one nautical mile as exactly 1852 meters. The actual distance of a nautical mile varies somewhat depending on where you are on a meridian. All computations within COMPSYS 21 are calculated in meters.

COMPSYS 21 provides the user the ability to input a distance in Statue Miles, Meters, U.S. Feet or International Feet. In 1866, the U.S. Congress defined one meter as exactly 39.37 inches. The International foot was defined in 1959 when a number of countries agreed that one-inch was equal to 2.54 centimeters.

FORWARD NAUTICAL MILES



FORWARD COMPUTATION in US Standard Feet

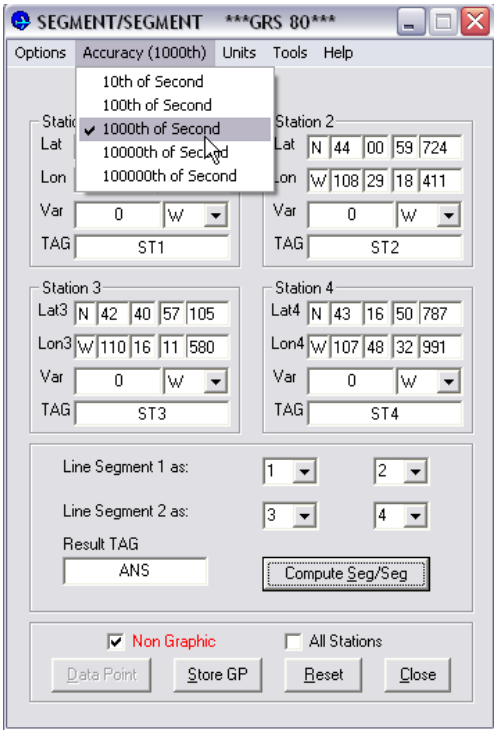


1.4. Accuracy

By default, the resolution accuracy for all COMPSYS 21 calculations is 1000th of a second. The user can easily select a different resolution if desired.

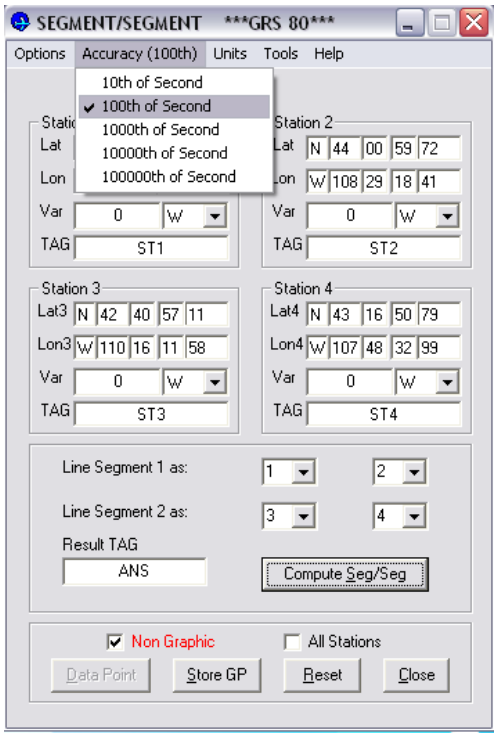
Accuracy Resolution

1000th >

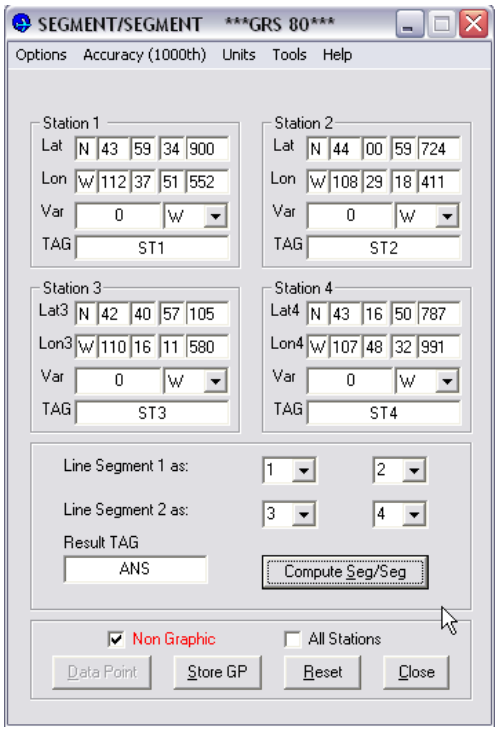


Once a station is entered, the entire value that was entered is stored within the COMPSYS session. If the user selects a different accuracy the stations' values are rounded.

100th >

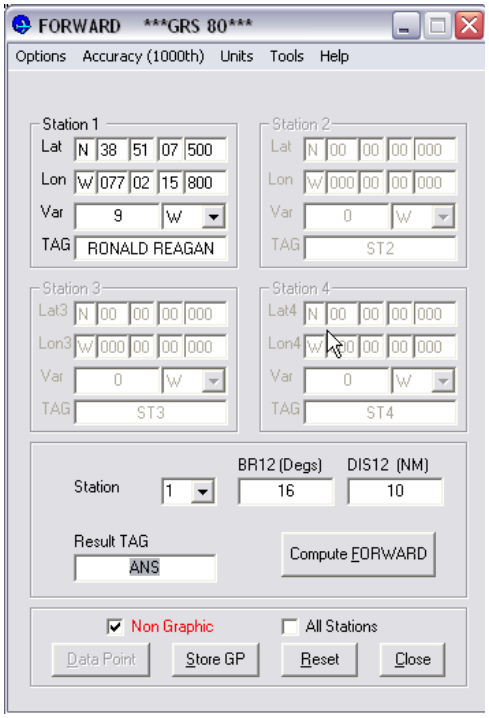


If the user selects the original accuracy, it will revert to the resolution of that accuracy. As mentioned, the resolution of the station is stored at the resolution **that** was entered. The answer is stored at the resolution of 100,000th of a second. The Store GP button will only store the station at the resolution of the accuracy that is selected.



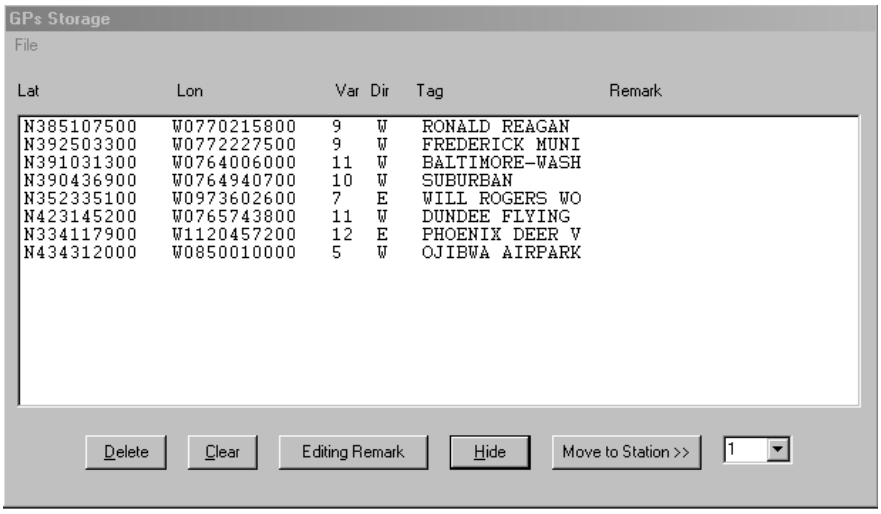
1.5. Store GP:

Geographic Positions can be stored at the active accuracy resolution for additional or future computations. Select the **Store GP** button to open the GPs Storage form. Any of the four stations and the results can be dragged over into this form. Once stored, a position can be selected for any computation.

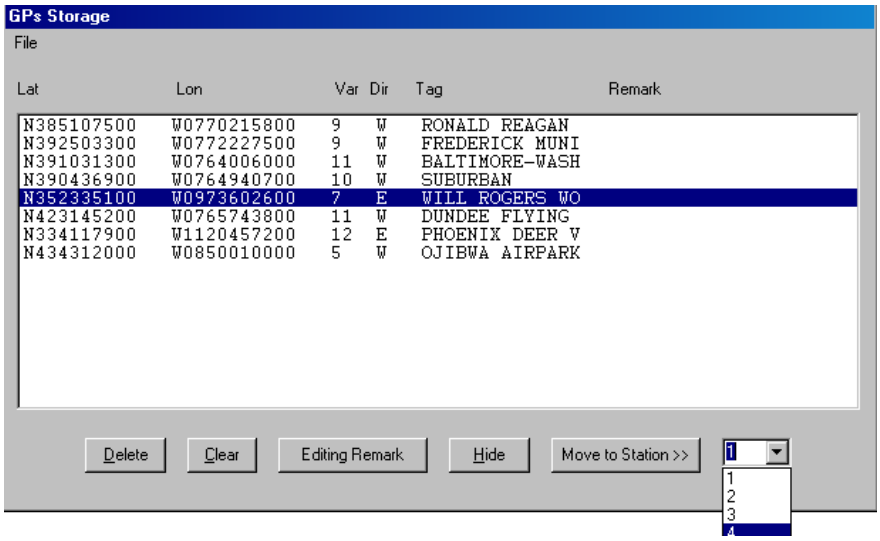


Store GP>

Storage Form

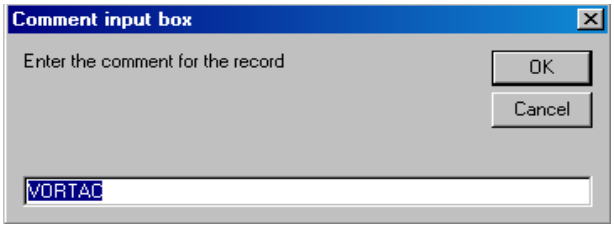


A stored station can be selected by clicking to highlight the record. Once selected, choose the station number and then the **Move to Station** button. In this example, the row highlighted will be copied into station four for a geodetic calculation.

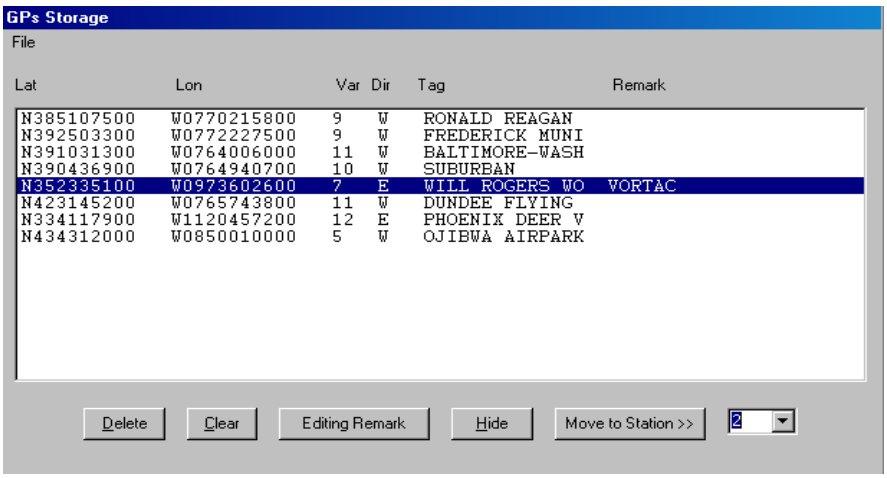


A remark can be added to aid the user. The **Editing Remark** button is used to add or edit a remark.

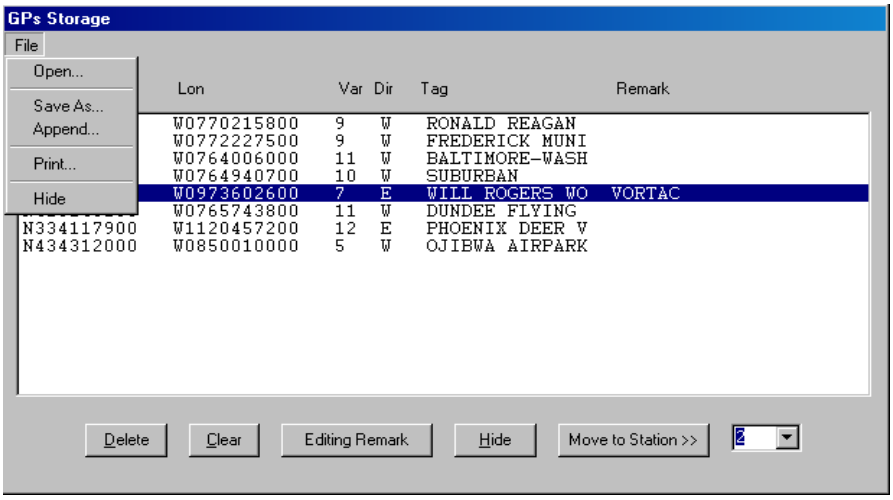
Remark Box



GPs Storage with added Remark



The GPs Storage list can be printed, saved or appended to a file. A list of geographic positions can be saved to a file and opened for future use. These options are available under the file pull down. The command button **Hide** will move the GPs Storage form to the background.



1.6. Tools

The tools utilities provide the ability to view a log file of COMPSYS calculations. It is not intended to be used for general usage and was created for internal quality assurance of the geodetic calculator.

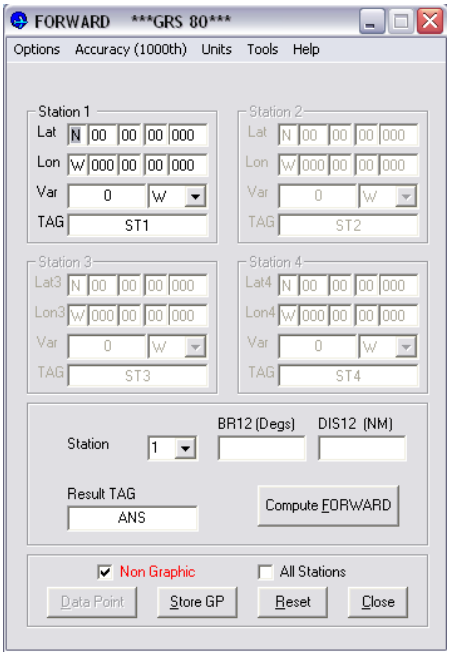
2.0 COMPSYS 21 CALCULATIONS:

2.1. Forward

Given station one, plus a bearing and distance, the forward geodetic computation will return the geographic position of station two. The stations that are required will be black and others will be greyed out. All stations can be activated with the check box **All Stations**.

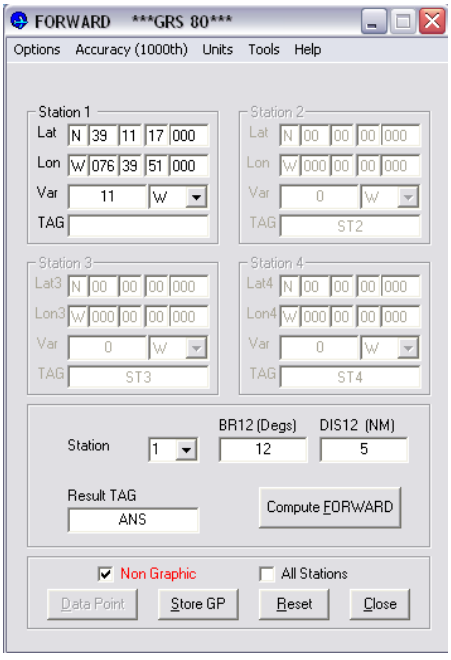
FORWARD

Station 1>



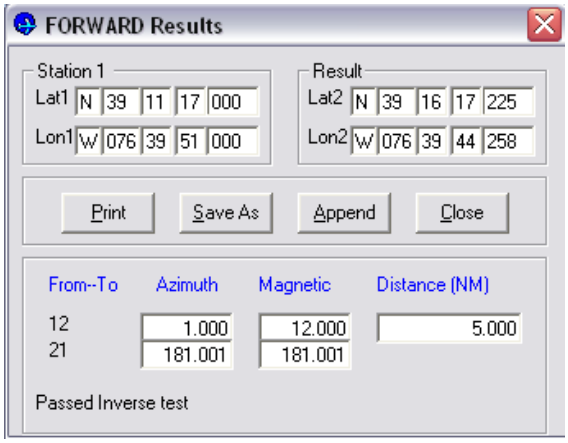
<All Stations

After the latitude and longitude for station one has been entered, key in the bearing, distance and magnetic variation. The user can key in a tag for the result if desired. The default tag is **ANS** for answer. Once complete, select the **Compute FORWARD** button.



<Bearing, Distance

A forward calculation is verified with the inverse calculation for accuracy. A warning message will appear if a calculation does not pass the accuracy test.

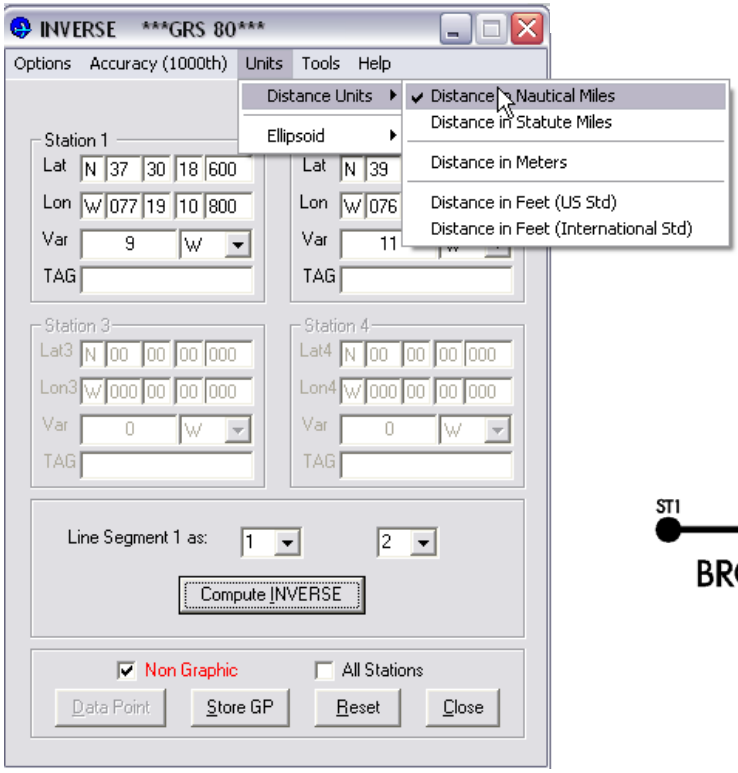


Passed>

2.2. Inverse

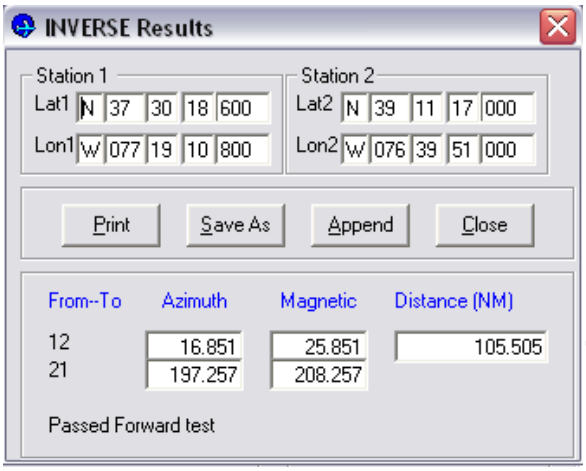
Given station 1 and station 2, this geodetic computation will calculate the bearings and distance between the two points. The user will find this very useful when validating or calculating the mileages between fixes or navaids. The units can be defined as nautical miles, feet, or statute miles. An inverse calculation is verified with the forward calculation.

INVERSE



<Output Units

INVERSE RESULTS

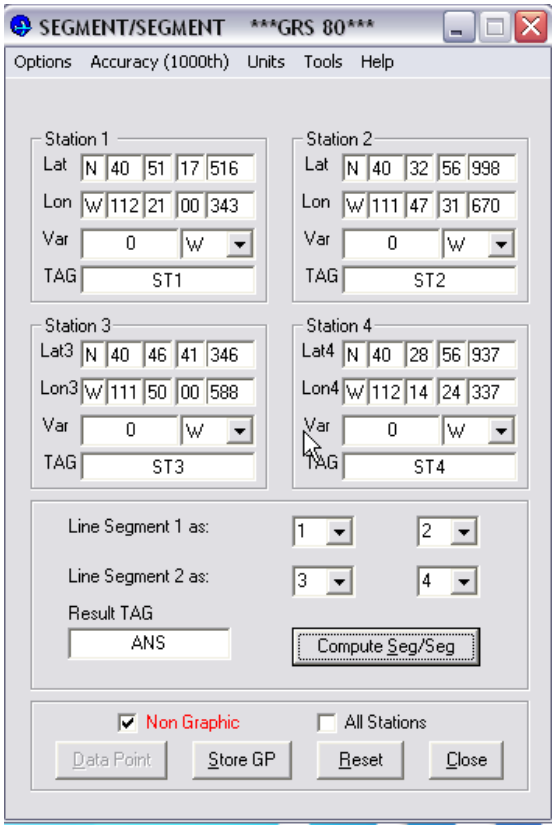


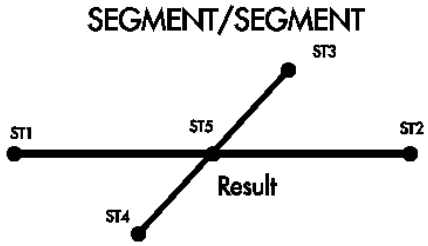
< *Distance*

2.3. Segment/Segment

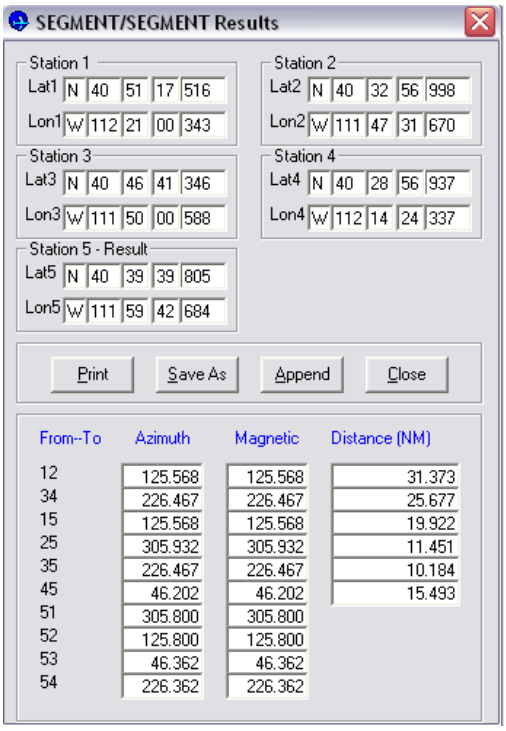
This computation is used when there is a line segment between station 1 and 2 and another between stations 3 and 4. It will calculate position 5 where the line segments intersect.

SEGMENT/SEGMENT



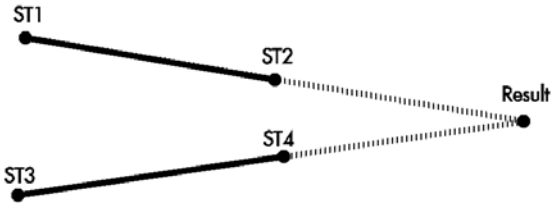


SEGMENT/SEGMENT
RESULTS



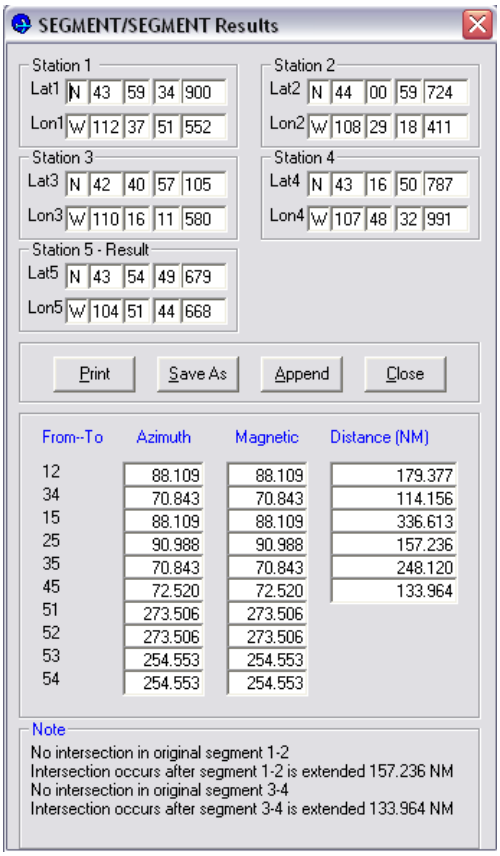
If the line segments do not intersect, COMPSYS 21 will extend the segments to find an intersection. It will extend the segments up to 2000 nautical miles to find an intersection. A note will appear on the results window indicating how far the segments were extended.

No Intersection in Original Segment
SEGMENT/SEGMENT



SEGMENT/SEGMENT
RESULTS

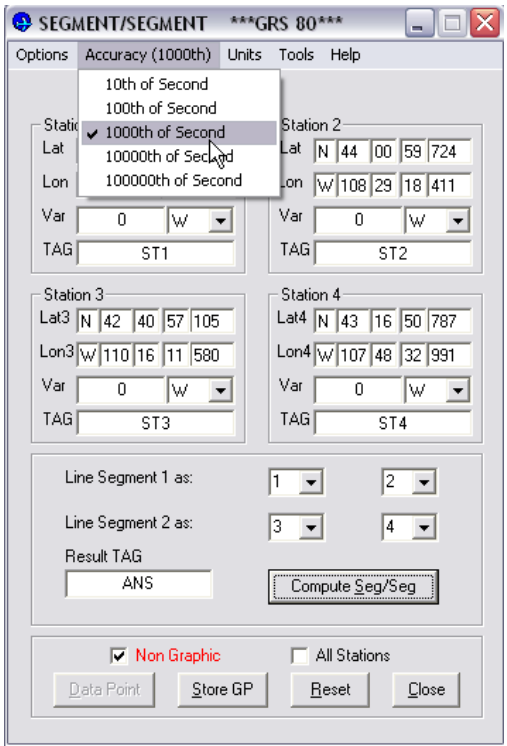
Note>



By default, the accuracy for all COMPSYS 21 calculations is 1000th of a second. The user can pick a different accuracy if desired.

SEGMENT/SEGMENT
Accuracy

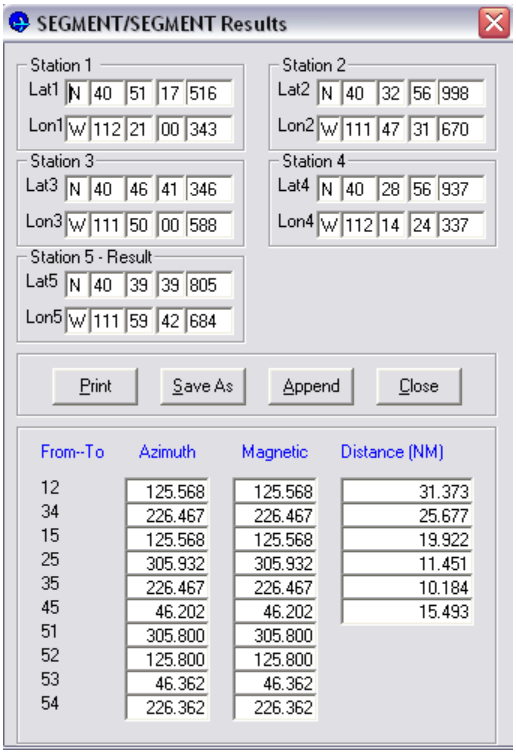
1000th >



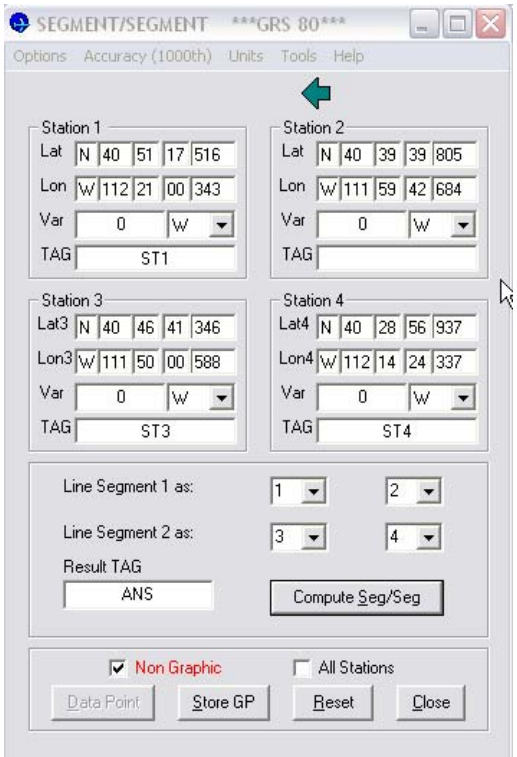
The results of a COMPSYS 21 calculation can be dragged back into the form to do another calculation. For example, the segment/segment result or station five can be used for another calculation such as Inverse. An arrow will appear in the original window when a station has been dropped.

Drag Result

Drag Result>

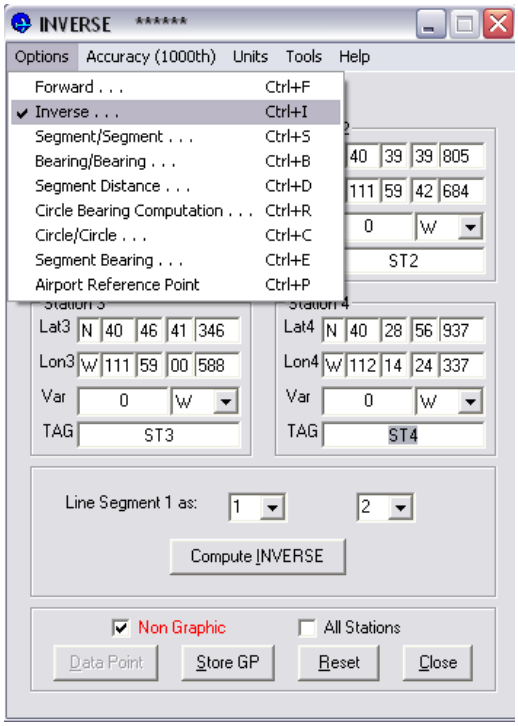


Drop Result

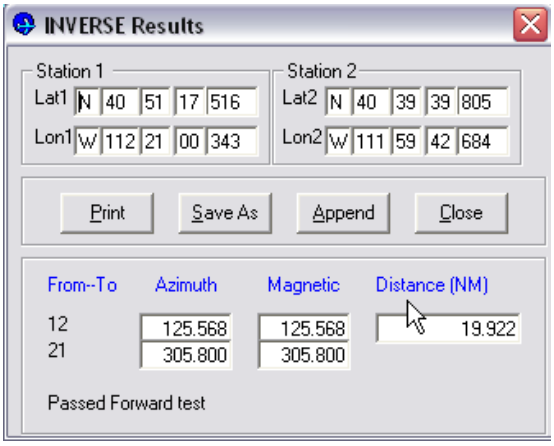


< Arrow

Select Another Computation

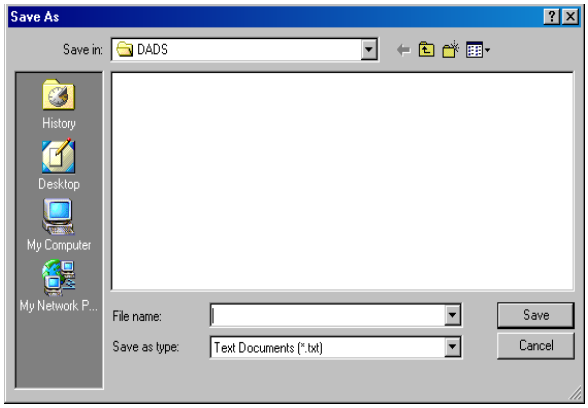


Compute Results



The results of any COMPSYS 21 calculation can be printed or saved in to a user specified file. Just select **Save As** or **Append** for an existing file. Choose a valid directory and specify a file name. The result is a simple text file that can be viewed in a simple editor such as WordPad or NotePad. These files can be saved as a record or emailed to others.

SAVE AS



SAVED FILE

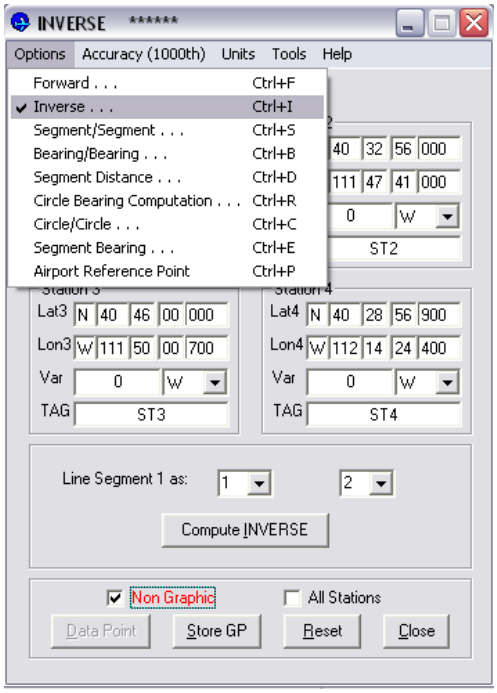
comps.txt - Notepad

File Edit Format View Help

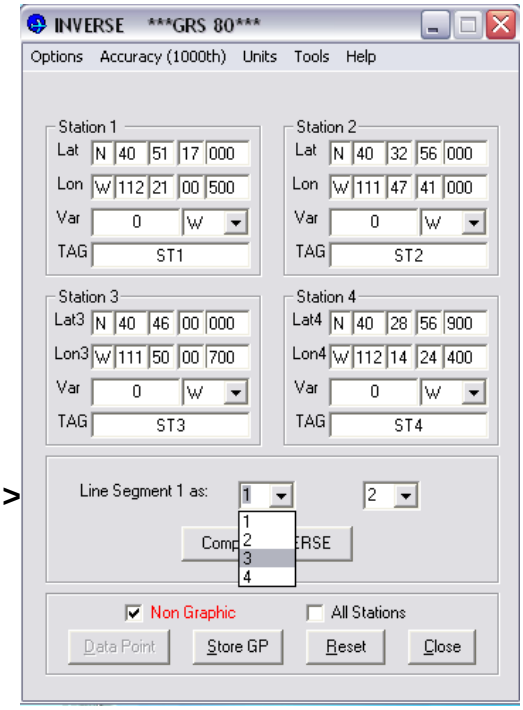
```
                                COMPSYS21
                                Version 3.0
          * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

                    US DOT/Federal Aviation Administration
                              AeroNav Services
                          Information Technology Staff
                             1305 East-West Highway
                          Silver Spring, Maryland 20910
                              Tel: (800) 626-3677
                          Email: 9-AMC-Aerochart@faa.gov


***    SEGMENT/SEGMENT (GRS 80)    ***    3/9/2010 (2010068), 8:24:52 AM
***
***    Distance conversion factor:
***    1 Nautical mile = 1852.00 Meters


Station          Latitude          Longitude         Variation         Tag
1 (I)            41 51 17.516N     112 21 00.343W    000.000W          ST1
2 (I)            40 39 39.805N     111 59 42.684W    000.000W          ST2
3 (I)            40 46 41.346N     111 50 00.588W    000.000W          ST3
4 (I)            40 28 56.937N     112 14 24.337W    000.000W          ST4
5 (A)            40 39 39.805N     111 59 42.684W    --                ANS


From--To         Azimuth           Magnetic          Distance
12               167.238           167.238           073.368 NM
34               226.467           226.467           025.677 NM
15               167.238           167.238           073.368 NM
25               347.243           347.243           000.000 NM
35               226.467           226.467           010.184 NM
45               046.202           046.202           015.493 NM
51               347.473           347.473
52               167.243           167.243
53               046.362           046.362
54               226.362           226.362
```

Additional COMPSYS 21 calculations can be executed with the current stations. Under options, just select the COMPSYS 21 routine desired.

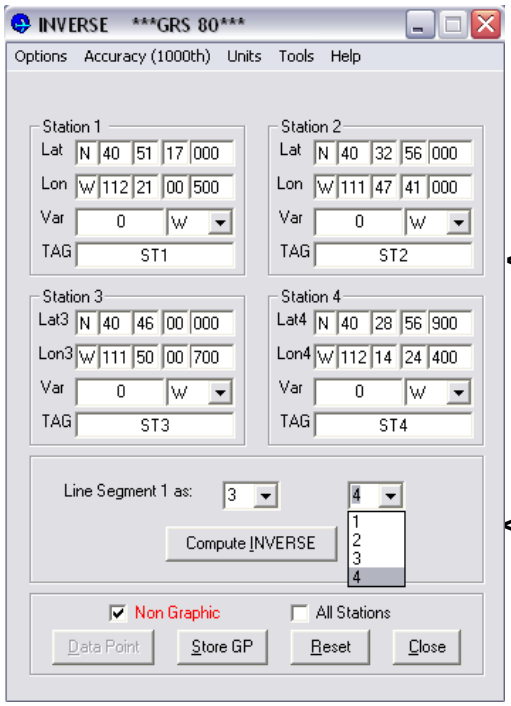
OPTIONS PULL DOWN



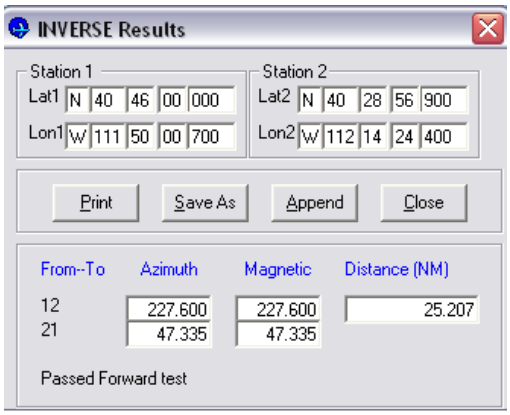
For instance, the user might want to do an inverse calculation on two of the stations that were previously used for a Segment/Segment calculation. Just select the station desired for **ST1** and the other for **ST2.**



ST1>

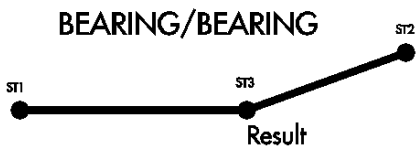


Notice that the Inverse Results window will show only the two stations you have selected.



2.4. Bearing/Bearing

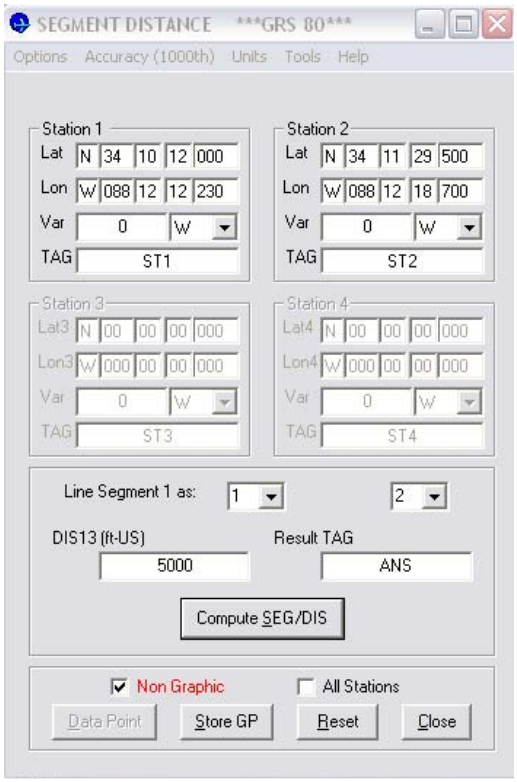
Given station 1 and station 2, with bearings, this program will calculate the geographic position of station three.



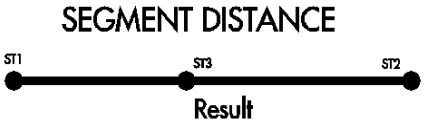
2.5. Segment Distance

Given a line segment between station 1 and station 2, and a distance from station 1 to station 3, this program will calculate the geographic position of station three on the line segment. If the distance is greater than the distance between ST1 and ST2, the line segment will be extended.

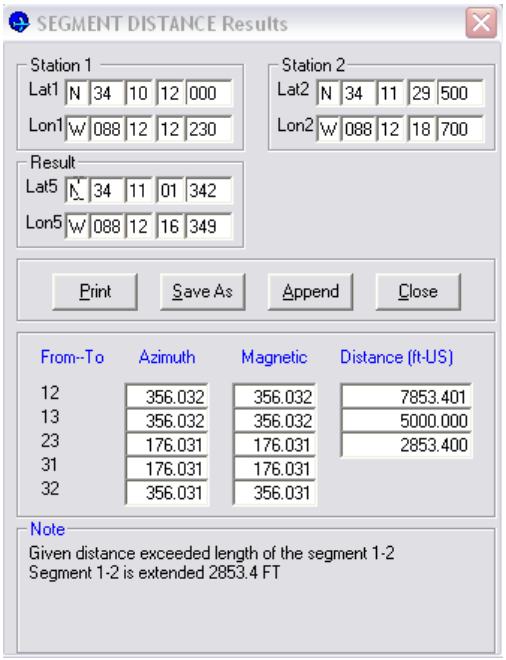
Segment Distance



Distance >



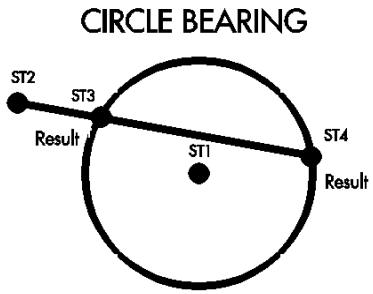
Segment Distance Result



Segment Extended >

2.6. Circle Bearing

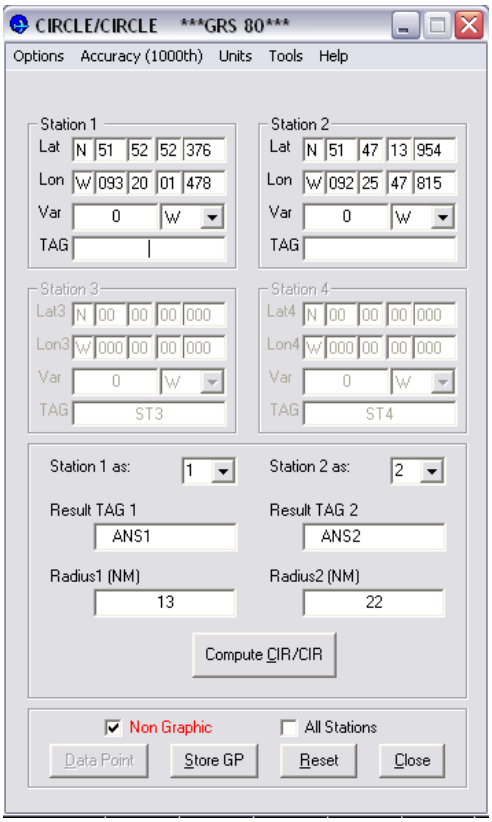
Given a position and radius for station 1, and position and bearing for station 2, this program will calculate the geographic position of stations 3 and 4 where the bearing from station 2 intersects the circle. If station two is within the circle there will be only one result.

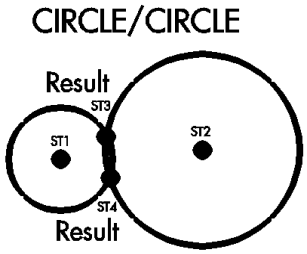


2.7. Circle/Circle

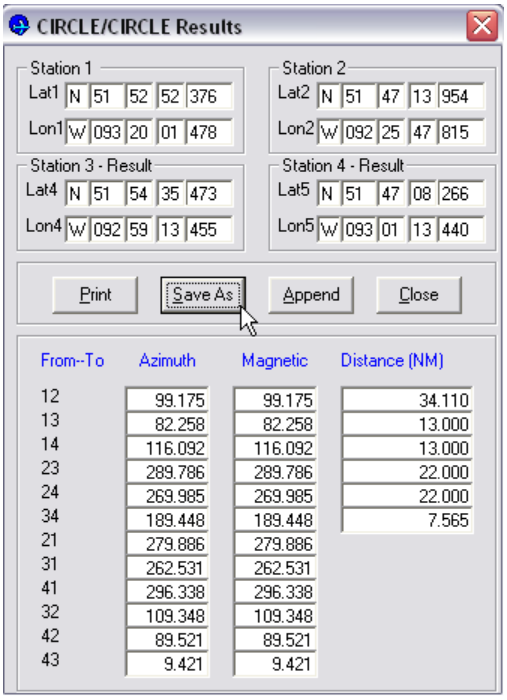
Given both stations 1 and 2, and the radius for both, this program will calculate the geographic positions of stations 3 and 4 where the circles intersect. Only one result will occur when the circles are tangent.

Circle/Circle



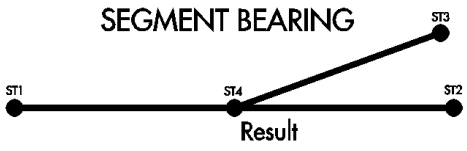


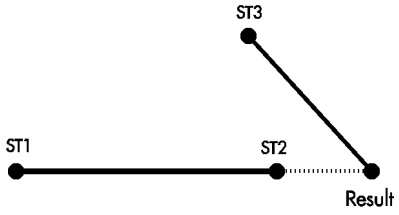
Circle/Circle Results



2.8. Segment Bearing

Given a line segment between stations 1 and 2, and a bearing from station 3, this program will calculate the geographic position of station 4 where the radial intersects. If the radial does not intersect, the original line segment defined by ST1 and ST2, COMPSYS 21 will extend the line to find an intersection.

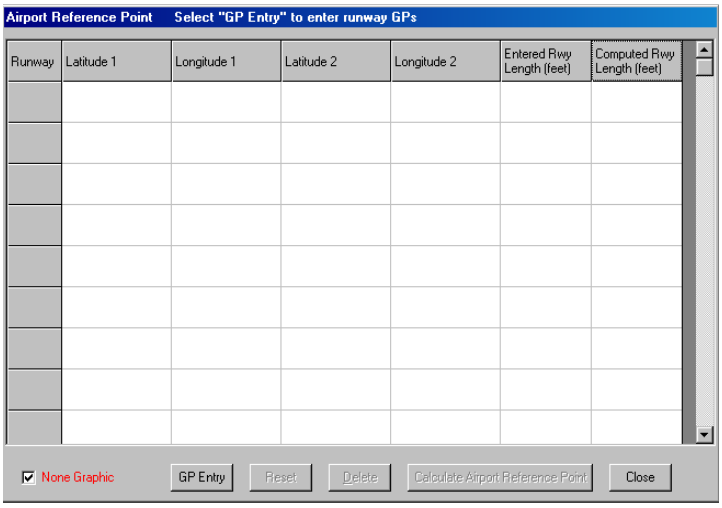




2.9. Airport Reference Point

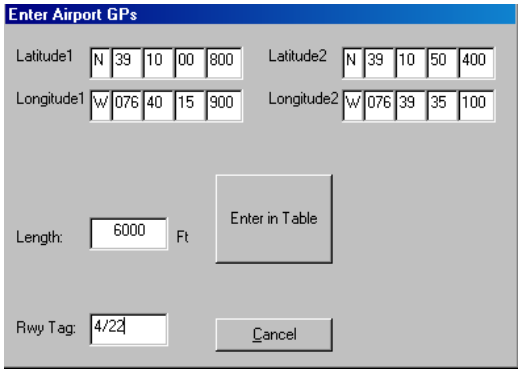
This option calculates the airport reference point based upon the runway ends and the length of the runways. Just select the **GP Entry** button and a **Data Entry** window will appear to enter in the coordinates. When the data has been entered in correctly, select **Enter in Table** button to insert onto the form.

Airport Reference Point Form



GP Entry>

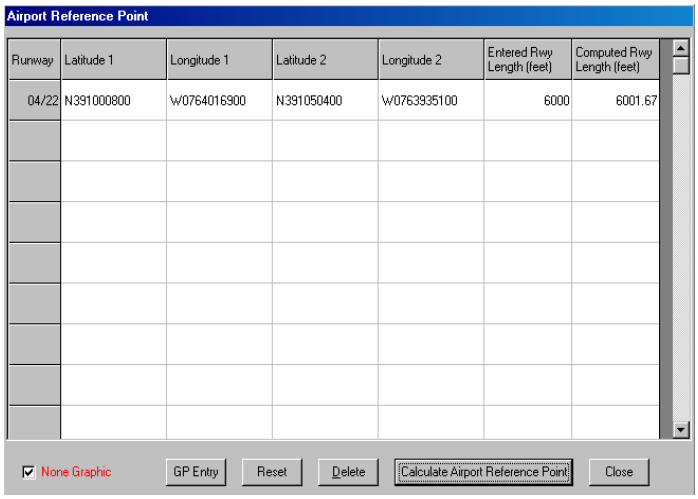
Data Entry



<Enter in Table

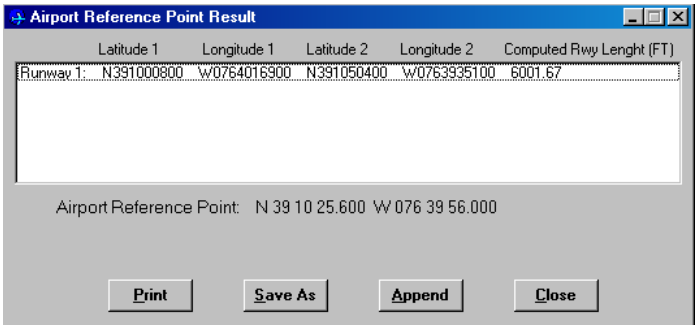
Every time the user selects the Enter in Table button, another row will appear on the Airport Reference Point form. When all runways have been entered, select **Calculate Airport Reference Point**. A window will appear with the results along with the options to either print or save the results to a file.

Sample Completed Form



<Calculate Airport Reference Point

Airport Reference Point Result



3.0 REFERENCE DOCUMENTS:

Direct and Inverse Solution of Geodesics on the Ellipsoid with Application of Nested Equations, T. Vincenty, *Survey Review*, April 1975.

Spheroidal Geodesics, Reference Systems, & Local Geometry, Naval Oceanographic Office, January 1993.

4.0 QUESTIONS:

Questions regarding COMPSYS can be directed to AeroNav Services at (800) 626-3677 or by email at 9-AMC-Aerochart@faa.gov.