National Human Exposure Assessment Survey (NHEXAS)

Arizona Study

Quality Systems and Implementation Plan for Human Exposure Assessment

The University of Arizona
Tucson, Arizona 85721

Cooperative Agreement CR 821560

Standard Operating Procedure **SOP-UA-F-22.1**

Title: Operation and Initialization of the Magellan GPS Satellite Navigator

Source: The University of Arizona

U.S. Environmental Protection Agency
Office of Research and Development
Human Exposure & Atmospheric Sciences Division
Human Exposure Research Branch

Operation and Initialization of the Magellan GPS Satellite Navigator

1.0 PURPOSE AND APPLICABILITY

This SOP describes the general procedures for the operation and initialization of the Magellan Trailblazer and the Magellan Trailblazer XL GPS Satellite Navigator.

2.0 DEFINITIONS

2.1 COORDINATES = The numerical values that describe a position. Degree is the most common unit of the coordinates. The latitude is 0° at the equator and reaches to 90°N at the north pole or 90°S at the south pole. The longitude is 0° at the prime meridian (the prime meridian passes through Greenwich, England) and spans 360° around the globe. Parts of a degree are minutes; there are 60 minutes (written as 60') to a degree. Fractions of a minute can be expressed as decimals or seconds; there are 60 seconds (written as 60") to a minute.

2.2 COORDINATE SYSTEM = The format that is used to describe a position.

2.3 FIELD COORDINATOR = The employee of the research project who supervises field data collection and operations. The Field Coordinator collates individual data into HH packets and upon completion of all visits, sampling and QA checks, forwards the packet to the Data Coordinator.

2.4 GPS = Global Positioning System

2.5 HOUSEHOLD(HH) = The residence occupied by a study respondent.

2.6 HOUSEHOLD IDENTIFICATION NUMBER(HHID) = A unique number and character combination which is assigned to each respondent household for identification purposes. This number must be recorded on all data(forms, samples, questionnaires,correspondence) generated by the household.

2.7 LATITUDE/LONGITUDE = The most common coordinate system is Latitude/Longitude (Lat/Lon). It projects lines of longitude (parallels) and lines of longitude (meridians). A position can be described as the intersection of a line of latitude and a line of longitude. Lines of latitude are horizontal lines parallel to the equator. Lines of longitude are the vertical lines perpendicular to the equator and pass through the poles (Fig.5).

2.8 MAGELLAN GPS TRAILBLAZER (Fig.7) / TRAILBLAZER XL (Fig.8) = The satellite receiver that enables us to locate our position in Latitude/Longtide and UTM coordinates. It can also determine our elevation if it locates at least four satellites.

2.9 MEMORY LOSS = It occurs when batteries are removed for greater than 10 minutes. When memory loss occurs the unit must be reinitialized.

2.10 N/A = Not Applicable.

2.11 NAVIGATION = Moving from one place to another and knowing where you are in relation to the path between those locations.

2.12 POSITION = A location that can be described in a unique, numerical way.

2.13 POSITION FIX = The coordinates of a location as determined by the GPS receiver or any other orientation technique.

2.14 TEAM LEADER = The member of the field team who is primarily responsible for respondent conduct, data collection, field form and questionnaire completion and site QC (Quality Qontrol) checks of all data.

2.15 TRIANGULATION = Obtaining the coordinates of a position by calculating its distance from other positions with known coordinates.

2.16 UTM Coordinates = Universal Tranverse Mercator. A coordinate system which is used on land-based maps and quad sheets that are produced by government map providers. UTM projects sections of the globe onto a flat surface. Each section is called a zone. There are 60 zones to cover the entire earth between 84°N and 80°S (polar areas are not included). Each zone is 6° wide as projected from the earth's center. A UTM position is described by three elements; the zone it is in, the easting and the northing. Eastings (east/west) and Northings (north/south) measure in meters the location of a position within a zone (Fig.6).

2.17 UT TIME - UNIVERSAL TIME = The standard time at the prime meridian, which passes through Greenwich, England and is a basis for calculating time in other parts of the world. For example when the UT time is 12:00, this means that in Tucson the local time is 05:00.

2.18 WAYPOINT - A saved (either by writing down or by storing in the receiver's memory) position fix.

3.0 REFERENCES

3.1 Magellan Trailblazer GPS Satellite Navigator Reference Guide, 1994, by Magellan Systems Corporation.

3.2 Magellan Trailblazer. XL GPS Satellite Navigator Reference Guide, 1996, by Magellan

Systems Corporation.

4.0 DISCUSSION

GPS is a constellation of 20 or more navigation satellites that orbit the earth. The precise time and position information transmitted by these satellites is used by the GPS receiver (Magellan Trailblazer for this SOP) to triangulate a position fix. The receiver can compute elevation in addition to position if the number of visible satellites is sufficient (3 satellites are needed for position and 4 for position and elevation). The accuracy of a commercial GPS receiver is within 33.8 meters for the Easting, within 41.5 meters for the Northing, and within 193 feet for the elevation based on a statistical analysis of GPS readings (Appendix A).

Two types of GPS receivers are used. The Magellan Trailblazer and the Magellan Trailblazer XL.

5.0 RESPONSIBILITIES

5.1 The Field Coordinator is responsible for:

(a) 10% QA of receiver's accuracy, by cross-referencing with geocoded street address information, using the ArcInfo mapping package and the U.S Bureau of the Census TIGER files.

5.2 The team leader is responsible for:

(a) Standardizing the GPS at the field office before field use.
(b) Checking that position coordinates have been taken and recorded for each household.

5.3 Team members are responsible for:

(a) obtaining the position coordinates Lat/Lon and UTM;
(b) the elevation of the household if possible;
(c) recording them on the descriptive questionnaire;
(d) initializing the receiver when is moved 300 miles or more from its last position fix.
(e) verify that the coordinates collected at each household are within one degree (latitude, longitude) of expected value.

6.0 MATERIALS AND REAGENTS

6.1 Materials

(a) The Magellan GPS Trailblazer and Trailblazer. XL receivers (Fig.7, 8).
WEIGHT: 14 ounces

SIZE : 15.6 in ′ 3.5 in ′ 1.25 in, not including antenna

TEMPERATURE:
Operating: 14°F - 140°F
Storage: -40°F - 167°F

(b) Antenna. Detachable quadrifilar attached on the receiver.

(c) Case. Waterproof (non-submersible).

(d) Three AA Batteries.

6.2 Reagents - N/A.

7.0 PROCEDURE

7.1 Preparation

7.1.1 Field site selection criteria

GPS measurements will be taken at a non-obstructed location as close as possible to the HH.

7.1.2 Reagents - N/A.

7.1.3 Standards/Blanks

Before taking the GPS into the field, the Team Leader will collect UTM coordinate and elevation readings for the back yard of the field office. The readings must be within 100 meters (UTM) and 35 meters(elevation) of the known facility coordinates for use in the field (see 7.1.4 INITIALIZATION C4, C3, C5 below). If the GPS fails do not take it into the field and follow procedures outlined in the UA-G-2.X. Latitude at Field Office = 32°14'32" N; Longitude = 110°57'24" W and elevation = 2512. Address is 1435 North Fremont Avenue #128, Tucson, Arizona 85719.

7.1.4 Samplers

POWER

(a) Insert three AA alkaline batteries in the battery tray at the back of the receiver. Alkaline batteries will power the receiver for 5 hours or more of continuous operation.

(b) If the battery power level drops, a warning message will appear on all displays (LOW BATT). The receiver has sufficient power to operate for up to 30 minutes after the message is displayed. Spare batteries must be carried by the operator.

INITIALIZATION

(a) When it is required Initialize the receiver after a memory loss or when the receiver is moved 300 miles or more from its last position fix. During the initialization an estimation, within 300 miles, of the initial position (coordinates and elevation), time and date are entered in the receiver.

(b) Place.

In order to obtain best results, the initialization procedure must take place in an open area where the antenna has a clear, unobstructed view of the sky. However, GPS signals will pass through glass and canvas.

(c) Enter the initial Position/Time/Date

1. Press **AUX/SETUP** and the **LEFT ARROW**. "INITIALIZE" is highlighted. Press **ENTER**.
2. The initial position is displayed as zero for both Latitude and Longitude in degrees/minutes/seconds.
3. Press the **UP/DOWN ARROWS** to enter the first digit of your latitude. Press the **RIGHT ARROW** to move the cursor to the next digit and repeat. Press **ENTER** to save the entry. The latitude of the back yard of the Respiratory Sciences building is 32°14'32"N.
4. Enter your longitude in the same manner as the latitude. Press **ENTER** to save the entry. The longitude of the back yard of the Respiratory Sciences building is 110°57'24"W.
5. Key in the elevation in feet. Press **ENTER** to save the entry. Use the **UP/DOWN ARROWS** to change the digits and **RIGHT/LEFT ARROW** move through them. The elevation of the back yard of the Respiratory Sciences building is +2512 ft. Press **ENTER**.
6. Enter the UT approximate time (time at the Prime Meridian). It is not necessary to enter the time if it is not known, but it would accelerate the receiver's response. Tucson's time is 7 hours behind UT time.

Note: The Magellan GPS does not need UT time to initialize. A standard factor of 7 hours will help speed the process, but daylight savings, etc. Need not be considered. Press **ENTER.**

7. Key in the current date at Prime Meridian (keep in mind the time difference). Press **ENTER.**
8. The receiver has returned to the SETUP menu. Press POS/WPT.
9. The initial latitude, longitude and elevation will appear on the screen under the POSITION function. As the receiver is searching for satellites, "SEARCHING" will also appear on the screen. When satellites are located and acquired, asterisks (in the Trailblazer) or bars (in the Trailblazer XL) will be displayed. Wait until the receiver displays the current position fix and elevation (if applicable).
10. The initialization is finished. Record the position coordinates, if necessary, and turn the power off. Initialization is documented in the GPS equipment notebook/folder.

THE FIELD KIT AND BUCKET MUST BE STOCKED WITH:

(a) The Receiver;
(b) Extra AA batteries;
(c) The Descriptive Questionnaire
(d) A photocopy of the receiver's field guide.

7.2 Field Procedures

7.2.1 Blanks Deployed - N/A

7.2.2 Procedure

(a) Pick a spot on the household's yard where the antenna will have a clear, unobstructed view of the sky.
(b) Rotate the antenna vertical to the hypothetical level ground.
(c) Press **POWER**.
{For Trailblazer only: On screen appears a specific key sequence (AUX, RIGHT, CLEAR). The receiver will not turn on unless this key sequence is pressed. (This is a softlock option activated so as to prevent the receiver from being turned on accidentally).}
(d) The coordinates and elevation from the last position fix will appear on the screen under the POSITION function. As the receiver is searching for satellites, "SEARCHING" will also appear on the screen. When satellites are located and required, asterisks (Trailblazer) or bars (Trailblazer XL) are displayed. Wait a few minutes until the receiver displays the current position fix, elevation (if applicable)

and local time.

(e) If SEARCHING appears at the bottom of the screen continuously for more than 10 - 15 minutes, the satellites have been blocked from view. Change your position on the yard or try again later (if possible).

(f) If elevation cannot be computed a 2_D message will appear at the bottom of the screen. In that case try to change your position in the household yard until the message disappears. If, the receiver cannot obtain the elevation a second time then a fourth satellite is not available; try again later during the same visit, if possible, or at the next visit.

(g) If the displayed coordinates are in the UTM system (Fig.3), record the Zone, Easting, Northing and Elevation in the GPS section(Fig.1) on the descriptive questionnaire. If the displayed coordinates are in theLat/Lon system(Fig.2), record the Latitude, Longitude and Elevation (same as in UTM).

(h) After recording the displayed coordinates,

For Trailblazer:
(1) Press **AUX/SETUP** and the **LEFT ARROW** to go to the SETUP menu.
(2) Highlight the COORD. SYSTEM menu by pressing the down arrow. Press **ENTER**.
(3) Highlight the coordinate system (UTM or Lat/Lon) that has not been recorded. Press **ENTER**.
(4) Press **POS/WPT**. The new coordinates are now displayed on the screen.

For Trailblazer XL: Press the **UPPER ARROW**. The new coordinates are displayed on the screen.

(i) Record the new coordinates.

(j) Press **POWER** to turn the receiver off.

7.3 Calculations

None

7.4 Quality Control

7.4.1 Tolerance Limits

TEMPERATURE:
Operating: 14°F - 140°F
Storage: -40°F - 167°F

7.4.2 Detection Limits

(a) Greatest Accuracy - 25 meters (coordinates in Lat/Long.)

(b) Best results are obtained when the the antenna has an unobstructed view of the sky. Signals will not go through metal and you are unlikely to obtain signals in a permanent structure. Do not stand under thick foliage.
(c) In order to provide the best signal reception, the antenna must be vertical.

7.4.3 Corrective Actions

(a) Figure 4 contains message icons that appear at the bottom of the screen to provide visual indications of the receiver status.

8.0 RECORDS

(a) Coordinates in both UTM and LAT/LON systems must be recorded on the descriptive questionnaire.
(b) Elevation must be recorded, if possible.
(c) Missing information or affected accuracy (consult Fig.4) must be acknowledged.

8.1 The Magellan GPS Trailblazer and Trailblazer XL have a folder and equipment maintenance sheet upon which maintenance, initialization are recorded.

Figure 1. GPS Data Table in the Descriptive Questionnaire

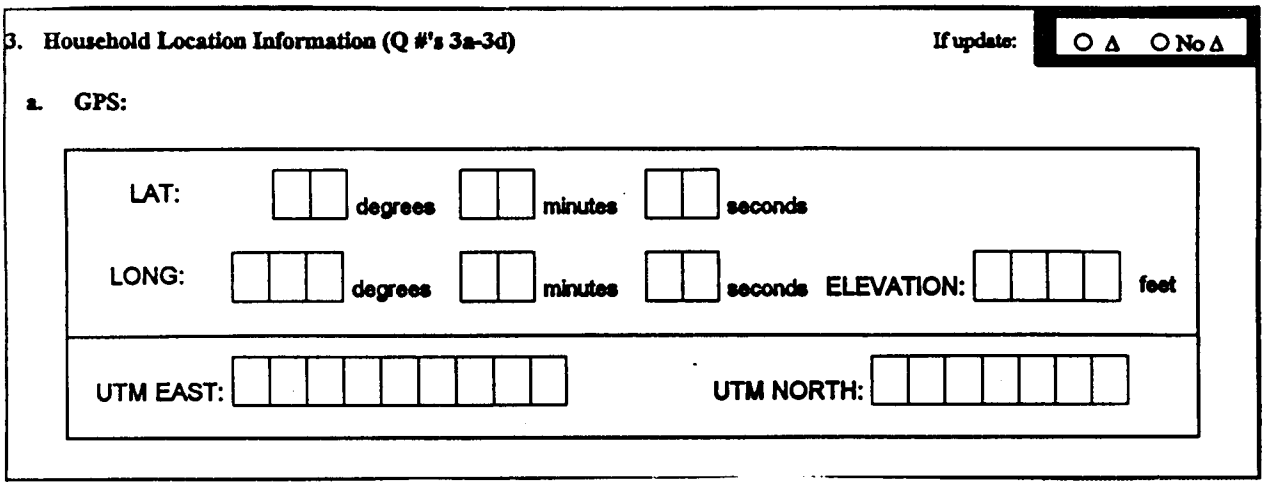


Figure 2.
Latitude/Longitude Coord. Display

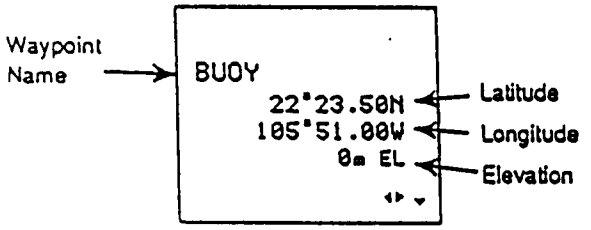


Figure 3.
UTM Coord. Display

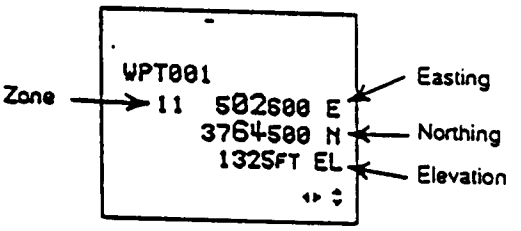


Figure 4. GPS Message Icons

Message Icons

Message icons provide visual indications of the receiver status.

The Old Data symbol. Appears when the receiver has just been turned on or when satellites have been blocked from view for more then 10 seconds.

The GQ (Geometric Quality) symbol. Appears when the satellites used for the fix are not optimally located, relative to each other. This affects the accuracy of the position fix, which may not be accurate enough for navigation.

The SQ (Signal Quality) symbol. The signals received from one or more of the satellites being used for the position fix is weak; the receiver may lose it. This has minimal effect on accuracy.

Appears when the receiver is in 2D (i.e., when elevation is not computed).

Arrow symbols. The arrow symbols appear in the lower right-hand corner of the display when additional options are available and can be accessed by pressing one of the indicated arrows.

Figure 5. Longitude / Latitude / Prime Meridian

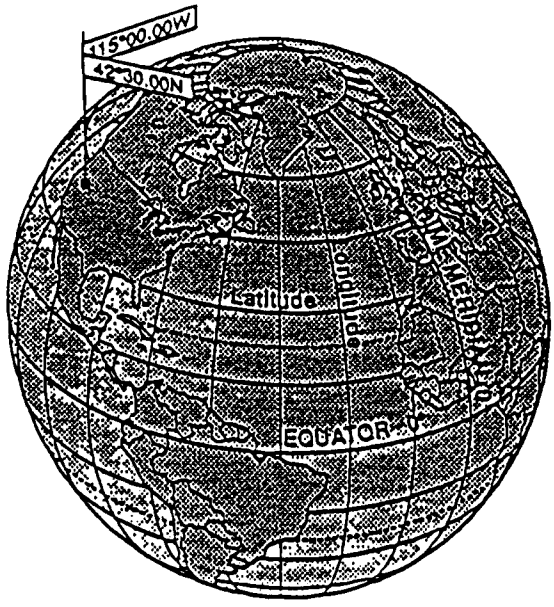


Figure 6. UTM Coordinate System

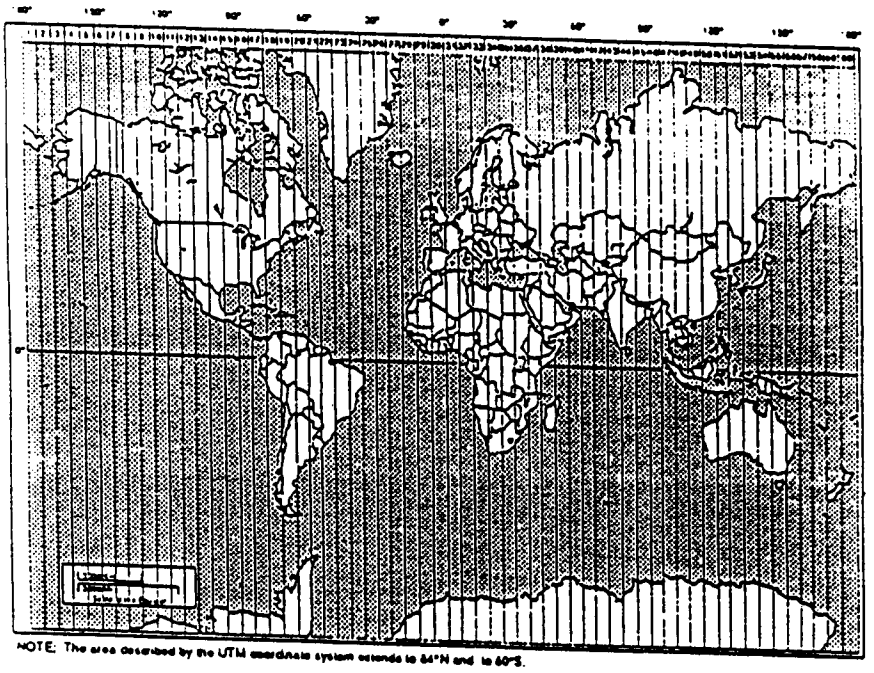


Figure 7. Magellan GPS Trailblazer

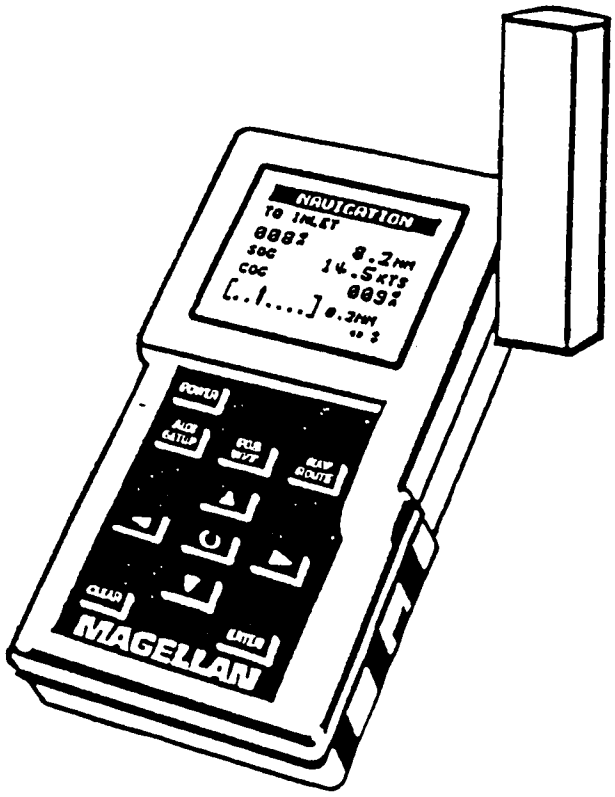
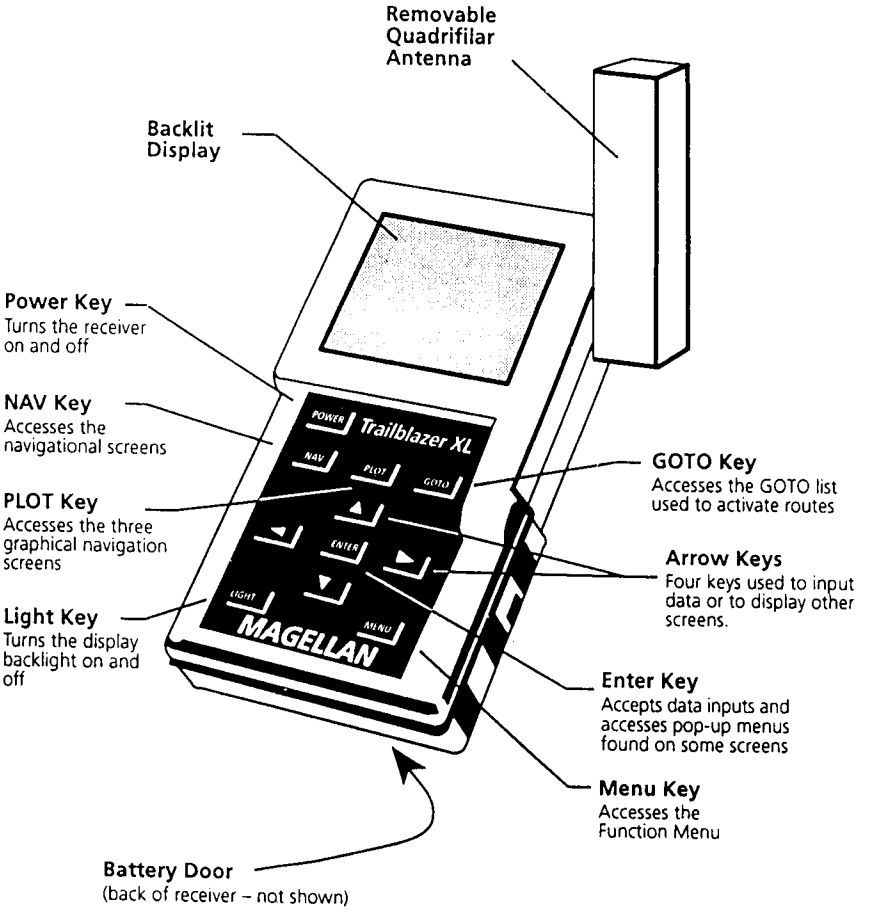


Figure 8. Magellan GPS Trailblazer XL



Appendix A. Statistical Report (page 1 of 2)

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-------------------------------------------------------------
|                    Statistics Report                      |
-------------------------------------------------------------

  Column Name : Easting
 Number of column points: 22
  Number of valid values: 22
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 22
          Number of zero: 0
              Maximum:       504171.0000
              Minimum:       504032.0000
     Sum of raw value:     11090346.0000
Sum of absolute value:     11090346.0000
      Arithmetic mean:       504106.6364
       Geometric mean:       504106.6353
       Quadratic mean:       504106.6374
        Harmonic mean:       504106.6342
        Absolute mean:       504106.6364
               Median:       504116.0000
       Sum of squares:    5.59071704E+12
             Variance:         1140.14719
   Standard deviation:         33.7660656
   Absolute deviation:         25.4628099
       Standard error:         7.19894937
95 % confidence interval:
      [504091.6653 , 504121.6074]
99 % confidence interval:
      [504086.2536 , 504127.0192]
    Coeff. of variance:      0.00669819899
              Skewness:       -0.716368643
    Coeff. of skewness:       -0.358184321
              Kurtosis:      -0.0647001071
    Coeff. of kurtosis:         2.93529989

  Percentiles:
        10 percentile:       504055.0000
        25 percentile:       504096.0000
        50 percentile:       504116.0000
        75 percentile:       504125.0000
        90 percentile:       504131.0000

  Quartiles:
       First quartile:       504096.0000
      Second quartile:       504116.0000
       Third quartile:       504125.0000


  Column Name : Northing
 Number of column points: 22
  Number of valid values: 22
 Number of missing value: 0
Number of negative value: 0
Number of positive value: 22
          Number of zero: 0
              Maximum:      3567205.0000
              Minimum:      3567014.0000
     Sum of raw value:     78475771.0000
Sum of absolute value:     78475771.0000
      Arithmetic mean:      3567080.5000
       Geometric mean:      3567080.4998
       Quadratic mean:      3567080.5002
        Harmonic mean:      3567080.4995
        Absolute mean:      3567080.5000
```

Appendix A. Statistical Report (page 2 of 2)

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                Median:          3567077.0000
        Sum of squares:       2.79929392E+14
              Variance:             1725.88095
    Standard deviation:               41.5437234
    Absolute deviation:               26.8181818
         Standard error:               8.85715158
95 % confidence interval:
     [3567062.0805 , 3567098.9195]
99 % confidence interval:
     [3567055.4222 , 3567105.5778]
    Coeff. of variance:          0.00116464216
              Skewness:               1.21856843
    Coeff. of skewness:            0.609284216
              Kurtosis:               1.86585839
    Coeff. of kurtosis:               4.86585839

  Percentiles:
        10 percentile:          3567035.0000
        25 percentile:          3567063.0000
        50 percentile:          3567077.0000
        75 percentile:          3567082.0000
        90 percentile:          3567108.0000

  Quartiles:
       First quartile:          3567063.0000
      Second quartile:          3567077.0000
       Third quartile:          3567082.0000


   Column Name : Elevation
 Number of column points: 22
  Number of valid values: 20
 Number of missing value: 2
Number of negative value: 0
Number of positive value: 20
          Number of zero: 0
                 Maximum:             2779.00000
                 Minimum:             1998.00000
     Sum of raw value:                47404.0000
Sum of absolute value:                47404.0000
       Arithmetic mean:               2370.20000
        Geometric mean:               2362.69079
        Quadratic mean:               2377.65986
         Harmonic mean:               2355.13658
         Absolute mean:               2370.20000
                Median:               2390.50000
         Sum of squares:          113065328.0000
              Variance:                37282.4842
    Standard deviation:                193.086727
    Absolute deviation:                140.240000
         Standard error:               43.1755048
95 % confidence interval:
     [2279.83263 , 2460.56737]
99 % confidence interval:
     [2246.67769 , 2493.72231]
    Coeff. of variance:                8.14643183
              Skewness:             0.0410393136
    Coeff. of skewness:             0.0205196568
              Kurtosis:              -0.426624360
    Coeff. of kurtosis:               2.57337564

  Percentiles:
        10 percentile:               2067.00000
        25 percentile:               2228.00000
        50 percentile:               2378.00000
        75 percentile:               2426.00000
        90 percentile:               2638.00000

  Quartiles:
       First quartile:               2228.00000
      Second quartile:               2378.00000
       Third quartile:               2426.00000
```