Week 8

NREM 446/546
Week 8 2012

Reading assignment: GEOXT Offset Procedures--Instructor handout

Material presented this week contributes to the accomplishment of the following course goal:

<table>
<thead>
<tr>
<th>Goal</th>
<th>Description</th>
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<tr>
<td>3</td>
<td>Plan and conduct a GPS data acquisition session.</td>
</tr>
<tr>
<td>4</td>
<td>Post-process GPS data collected in the field to improve its accuracy</td>
</tr>
<tr>
<td>5</td>
<td>Transfer GPS data to a Geographic Information System (GIS) for use in spatial analysis.</td>
</tr>
<tr>
<td>6</td>
<td>Use GIS to perform basic spatial data analysis</td>
</tr>
</tbody>
</table>

Information obtained this week will help you understand some of the advanced use of GPS and will further refine your skills in post processing, export of data from GPS to GIS, and overlay of GPS data on aerial imagery.

After studying class notes and reading assignments, participating in class discussions, and conducting lab 8, you should be able to:

- Describe the various situations where offsets can be used to your advantage when collecting GPS data.
- Explain the different methods for collecting offset data using a GEOXT
- Explain the information necessary to collect a position, line or polygon using the various offset options available with a GEOXT
- Do the necessary setup on a GEOXT to allow for collecting data using the offset feature
- Collect GPS point, line, or area data using offsets where necessary
- Describe the ancillary data collected by Trimble GPS as a part of a data collection session
- Describe how ancillary data can be accessed from Pathfinder Office
NASA Pinning Down Where 'Here' is Better Than Ever

February 23, 2012

Before our Global Positioning System (GPS) navigation devices can tell us where we are, the satellites that make up the GPS need to know exactly where they are. For that, they rely on a network of sites that serve as "you are here" signs planted throughout the world. The catch is, the sites don’t sit still because they're on a planet that isn’t at rest, yet modern measurements require more and more accuracy in pinpointing where "here" is.

To meet this need, NASA is helping to lead an international effort to upgrade the four systems that supply this crucial location information. NASA's Jet Propulsion Laboratory, Pasadena, Calif., in partnership with NASA's Goddard Space Flight Center in Greenbelt, Md., is working to develop and build interferometry systems for the new Space Geodesy Project, which will serve as an example of what is required to measure Earth's properties to keep up with the ever-changing, yet subtle, movements in land as it raises and sinks along with shifts in the balances of the atmosphere and ocean. All of these movements tweak Earth’s shape, its orientation in space and its center of mass — the point deep inside the planet that everything rotates around. The changes show up in Earth's gravity field and literally slow down or speed up the planet's rotation.

"NASA and its sister agencies around the world are making major investments in new stations or upgrading existing stations to provide a network that will benefit the global community for years to come," says John Labrecque, Earth Surface and Interior Program Officer at NASA Headquarters.

GPS won't be the only beneficiary of the improvements. All observations of Earth from space — whether it's to measure how far earthquakes shift the land, map the world's ice sheets, watch the global mean sea level creep up or monitor the devastating reach of droughts and floods — depend on the International Terrestrial Reference Frame, which is determined by data from the network of designated sites.

For more information, visit: http://www.nasa.gov/topics/technology/features/heres-pin-down.html.
GPS Offset Measurements
Offset GPS Measurements

Sometimes it may be physically impossible or difficult to get to, stand by, or walk along a geographic feature that you may wish to collect GPS locations for.

- A tree across a river that can’t be crossed
- Centerline on an interstate highway
- A pond shoreline with a thick buffer of brush.
- Cave location half-way up a steep cliff
- A tiny rare plant under a dense tree canopy
For some point $pt$.

**Horizontal Offset (Top View)**

- Azimuth
- Inclination

**Feature offsets involve calculation of 2 quantities:**
- Azimuth offset
- Inclination offset

**Vertical Offset (Side View)**

We can measure/estimate slope distance & inclination using a tape measure & clinometer or a range finder.

These are used to calculate horizontal Easting & Northing offsets.
The Basic Idea

- Suppose I do an off GPS location for a point that is at an azimuth of 35° from the GPS unit.
- Also, suppose the off GPS location of the point is at an inclination of -10°.
- The slope distance (SD) to the point is 75 meters.
- What are the Easting and Northing coordinates of the point we are offset from?

Basic Trigonometry...

\[
\cos(10°) = \frac{HD}{SD} \\
\cos(10°) \times SD = HD \\
\sin(10°) = \frac{\text{rise}}{SD} \\
\sin(10°) \times SD = \text{rise}
\]
What is the Horizontal offset (HD) and the elevation difference (rise)?

Cosine (inclination) = \( \frac{a}{h} = \frac{HD}{SD} \)

\[ \cos(-10^\circ) \times SD = HD \]

Radians (-10°) = -0.17453

\[ \cos(-0.17453) = 0.9848 \]

\[ 0.9848 \times 75 = HD = 73.86 \text{ m} \]

Sine (inclination) = \( \frac{o}{h} = \frac{rise}{SD} \)

\[ \sin(-10^\circ) \times SD = rise \]

Radians (-10°) = -0.17453

\[ \sin(-0.17453) = -0.1736 \]

\[ -0.1736 \times 75 = rise = -13.02 \text{ m} \]

Radians = angle * \( \frac{\pi}{180} \)
Example

So now, what is the adjusted position for \( \text{pt} \)?

**GPS’s position is:**
- **N** 4650738 m
- **E** 466128 m
- **Elevation** = 280 m

Got these...
- **SD** = 75.00 m
- **HD** = 73.86 m
- \( \text{rise} \) = -13.02 m

\[
\text{Sine(azimuth)} = \frac{o}{h} = \frac{EA}{HD}
\]

\[
\sin(35^\circ) \times \text{HD} = \text{EA}
\]

\[
\text{Radians}(35^\circ) = 0.610865 \quad \left\{35 \times \frac{\pi}{180}\right\}
\]

\[
\sin(0.610865) = 0.573575
\]

\[
0.573575 \times 73.86 = 42.36425 \text{ m}
\]

\[
\text{pt}_E = 466128 + 42.36 = 466170.4 \text{ m}
\]

\[
\text{Cosine(azimuth)} = \frac{a}{h} = \frac{NA}{HD}
\]

\[
\cos(35^\circ) \times \text{HD} = \text{NA}
\]

\[
\text{Radians}(35^\circ) = 0.610865
\]

\[
\cos(0.610865) = 0.819152
\]

\[
0.819152 \times 73.86 = 60.50257 \text{ m}
\]

\[
\text{pt}_N = 4650738 + 60.50 = 4650799.5 \text{ m}
\]

\[
\text{pt}_{\text{elev}} = 280 - 13.02 = 266.98 \text{ m}
\]
• Set rover to feature = LINE
• Estimate the offset distance (we will pace or measure)
• Estimate inclination from your position to the actual line (+/- angle in degrees)
• Plug estimated distance & inclination into GeoXT
• Then tell GeoXT which side of your offset path the actual line is on (left or right)
• Then start walking as you collect fixes (GeoXT does the trig on the fly)
Polygon Features

- Set rover to feature = POLYGON
- Estimate the offset distance (we will pace or measure)
- Estimate inclination from your position to the actual line (+/- angle in degrees)
- Plug estimated distance & inclination into GeoXT
- Then tell GeoXT which side of your offset path the actual line is on (left or right)
- Then start walking as you collect fixes (GeoXT does the trig on the fly)
- Stop a couple meters short of closing the polygon. GeoXT extends last point to close poly
**Feature Offset**

*Note:*

- A feature (point, line, or polygon) can have only one offset associated with it.
- To collect a line feature or area feature using offsets, the same offset value must apply to the whole feature.
- May require a test run along/around the object to make sure you can remain a constant distance from it.
- However, you can measure a line in a series of multiple segments...all with different offsets.
In the Field

**Note:**

- Offsets are added to the GPS and digitized positions as they are recorded.
- Features are displayed in GPS map screen with their offsets.
- If a line or polygon feature that you’re offset from has acute angles they may appear distorted on the map.
- This is because exact offset values are not calculated for these positions until the feature is closed.
- When closed, the feature offsets are interpolated and the feature is redrawn more accurately.
Complex Offsets

• Here, you do not record any position information for the feature.

• Rather, 2 or 3 GPS reference positions are recorded around/near some feature.

• TerraSync uses Coordinate Geometry (COGO) to calculate the feature position...
  • Similar to the way the GPS receiver uses known SV positions to locate itself.

• Can use 2 or 3 reference points and specify either distance or bearing to feature.

• Types of Complex Offsets:
  • Distance-distance
  • Triple distance
  • Bearing-bearing
  • Triple bearing
Complex Offsets

**Distance-distance offsets**

- Uses the distance between the feature and 2 reference positions (A & B) to specify the position of the feature.

- The feature’s location is at the intersection of circles centered at A & B

- Like trilateration, there is 2 answers, so you need to specify the direction the feature is in relative to the path from A to B.
**Complex Offsets**

**Triple distance offset**
- Uses the distance between the feature and 3 reference positions (A, B, & C) to specify the position of the feature.
- The feature’s location is at the intersection of the 3 circles.
- There is only one possible intersection point, so no directions are needed.
Complex Offsets

**Bearing-bearing offset**

- Uses the bearing from north from each of 2 reference points (A & B) to the feature to specify the position to the feature.

- Feature’s location is where the 2 bearing lines intersect.
**Complex Offsets**

**Triple bearing offset**
- Uses the bearing from north from each of 3 reference points (A, B, & C) to the feature to specify the position to the feature.

- Feature’s location is where the 3 bearing lines intersect.

- Much like the bearing-bearing offset, the 3rd measurement provides mathematical redundancy that can improve accuracy.
• Off GPS location for a point (pt) is at an azimuth of 83° from the unit.
• The off GPS location of the point (pt) is at an inclination of 20°.
• The slope distance (SD) to the point is 243 meters.
• What is pt’s UTM position?

\[
\begin{align*}
\cos(\theta) &= \frac{o}{h} = \frac{HD}{SD} \\
\cos(\theta) \times SD &= HD \\
\sin(\theta) &= \frac{o}{h} = \frac{rise}{SD} \\
\sin(\theta) \times SD &= rise \\
\sin(\theta) \times HD &= EA \\
\cos(\theta) &= \frac{o}{h} = \frac{NA}{HD} \\
\cos(\theta) \times HD &= NA
\end{align*}
\]

GPS’s position:
- N 4650738 m
- E 466128 m
- Elevation = 3310 m
START HERE
Ancillary Info in PFO: Feature & Position
Ancillary Info in PFO: SSF
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALM</td>
<td>Almanac Data</td>
</tr>
<tr>
<td>ATT</td>
<td>Attributes (predefined in Data Dictionary)</td>
</tr>
<tr>
<td>CLK</td>
<td>Clock Data</td>
</tr>
<tr>
<td>COL</td>
<td>Data Collector Type (TerraSync)</td>
</tr>
<tr>
<td>DDB</td>
<td>Data Dictionary Block Start</td>
</tr>
<tr>
<td>DDE</td>
<td>Data Dictionary Block End</td>
</tr>
<tr>
<td>DDR</td>
<td>Data Dictionary Record</td>
</tr>
<tr>
<td>DDS</td>
<td>Data Dictionary Symbol Record</td>
</tr>
<tr>
<td>DOP</td>
<td>DOPs Data (PDOP, HDOP, VDOP)</td>
</tr>
<tr>
<td>EPH</td>
<td>Ephemeris Data</td>
</tr>
<tr>
<td>HDR</td>
<td>SSF (Standard Storage Format) File Header</td>
</tr>
<tr>
<td>IOD</td>
<td>IODE Data (Issue Of Data Ephemeris)</td>
</tr>
<tr>
<td>ION</td>
<td>Ionspheric Data</td>
</tr>
<tr>
<td>MDS</td>
<td>Measurement Data Synchronized</td>
</tr>
<tr>
<td>MHS</td>
<td>Measurement Header (Synchronized)</td>
</tr>
<tr>
<td>MMT</td>
<td>Measurement Data (Raw GPS measurement record)</td>
</tr>
<tr>
<td>NAV</td>
<td>Navigation Data</td>
</tr>
<tr>
<td>NUM</td>
<td>Numeric Data</td>
</tr>
<tr>
<td>OFF</td>
<td>OFFSET Data</td>
</tr>
</tbody>
</table>

**Abbreviations Used in Trimeble Data Files**

- **COL**: Each satellite broadcasts an ephemeris, which is a set of Keplarian orbital elements that can be used to compute the position of the satellite at any given time.
- **IOD**: Both the rover and reference station must use the same Issue of Data Ephemeris (IODE) when computing orbital positions; otherwise corrections computed at the reference station will not correlate with errors experienced at the rover.
- **ION**: Has to do with alpha & beta particle induced scintillations (speed variations) to the carrier signals (L1 & L2).
  - The numbers on the SSF printout refer to these quantities in mega electron volts (MeV)...bigger = bad.
- **MDS**: Measurements made by GeoXT are synchronized with base station collections. Older units didn’t do this = bad.
### Access to Ancillary

#### ABBREVIATIONS USED IN TRIMBLE DATA FILES

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFF</td>
<td>OFFSET Data</td>
</tr>
<tr>
<td>POS</td>
<td>Position Records (X, Y, Z of rover)</td>
</tr>
<tr>
<td>VEL</td>
<td>Velocity Record (2D &amp; 3D motion of receiver)</td>
</tr>
<tr>
<td>SGM</td>
<td>Position Sigma (1 Sigma errors: X, Y, Z)</td>
</tr>
<tr>
<td>PRN</td>
<td>PRN Data (Satellite identifier) Ex: 10 21 24 26 29 (Overdetermined) …..or Ex: 10 21 24 26 (3D)</td>
</tr>
<tr>
<td>PSD</td>
<td>Pseudorange Data</td>
</tr>
<tr>
<td>PSH</td>
<td>Pseudorange Header</td>
</tr>
<tr>
<td>RT1</td>
<td>Real Time 1</td>
</tr>
<tr>
<td>RT2</td>
<td>Real Time 2</td>
</tr>
<tr>
<td>RTH</td>
<td>Real Time Header</td>
</tr>
<tr>
<td>RXC</td>
<td>Receiver Configuration (Machine ID: Geo XT 2005, Users Channels: 12)</td>
</tr>
<tr>
<td>RXV</td>
<td>Receiver Version</td>
</tr>
<tr>
<td>STS</td>
<td>Statistics Record</td>
</tr>
<tr>
<td>SSSF</td>
<td>Standard Storage Format</td>
</tr>
<tr>
<td>SVS</td>
<td>Survey Station</td>
</tr>
<tr>
<td>TIM</td>
<td>Time Tags (System Time)</td>
</tr>
<tr>
<td>TXT</td>
<td>Notes (time logging stopped)</td>
</tr>
<tr>
<td>USN</td>
<td>Sensor (Uninterpreted)</td>
</tr>
</tbody>
</table>

Each time you collect a feature these are recorded...
Simple Offsets

With Distance, Compass Direction, & Inclination

• Set Offset Format:  **Slope/Inclination** (Horizontal/Vertical also possible)

• Set North Reference to:  **Magnetic** or **True**

• Set distance units to:  **Meters**

• Collect Feature → Options → Offset  ...and enter...
  
  Compass bearing in degrees
  
  Slope distance in meters
  
  Inclination in degrees (+ or –)

---

**Magnetic Declination Setup/Units Settings**

Using a compass that does not correct for declination (Suunto):

- North Reference:  **Magnetic**
- Magnetic Declination:  **Auto** or a known declination

Using the rangefinder or a compass that is correcting already:

- North Reference:  **True**
- Magnetic Declination:  **0.0**
Complex Offsets

<table>
<thead>
<tr>
<th>Offset Options</th>
<th>GPS pts</th>
<th>Requires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance - Bearing</td>
<td>1</td>
<td>1 Slope distance and 1 compass bearing</td>
</tr>
<tr>
<td>Distance - Distance</td>
<td>2</td>
<td>2 Distances and left vs. right setting</td>
</tr>
<tr>
<td>Triple Distance</td>
<td>3</td>
<td>3 Distances</td>
</tr>
<tr>
<td>Bearing – Bearing</td>
<td>2</td>
<td>2 Compass bearings</td>
</tr>
<tr>
<td>Triple Bearing</td>
<td>3</td>
<td>3 Compass bearings – must have an error check</td>
</tr>
</tbody>
</table>

Considerations for complex offsets

Using more than one GPS point to find a desired feature point employs triangles, either using triangulation or trilateration methods.

Triangles work best when they are not too skinny, with the ideal shape being equilateral with each corner at 60°. So, you should try to spread your points out.

With three points, you should try to surround your feature on all sides. This is the same issue as with GPS where we minimize the PDOP by collecting when satellites are spread apart.
Complex Offset: Distance-Distance

To capture features using the Distance-Distance method:

1. **Setup/Units**: Offset format: Slope distance/Inclination.

2. Before creating a point, when in collection mode, select the Log Later option (Options).

3. Create a point feature, but before starting logging, use the Options button to change the Offset method to Distance - Distance.

4. This will start up a process which is somewhat self-explanatory on the screen:
   a. Move to a suitable GPS point (1) and press Log to start logging the reference position.
   b. Press Next (and the position collection) and you will be prompted to enter the first distance (A): you’ll pace the distance, then enter the result in the slope distance field. Leave the Inclination at zero for reasonably flat areas, or measure it.
   c. Press Next and follow instructions to move to the next GPS point (2) you’ll probably be pacing from the feature, so go ahead and figure out the distance.
   d. Resume to collect that second GPS point, then Next to enter the distance.
   e. After the last point, you will also need to enter the direction of the feature from the line you travelled between 1 and 2.
   (In the above figure, it would be Left.)
   f. Ok the result and close the feature the normal way, once you’ve entered any necessary attributes.
To capture features using the triple distance method:
1. **Setup/Units**: Offset format: **Slope distance/Inclination**.
2. Before creating a point, when in collection mode, select the **Log Later** option (Options).
3. Create a point feature, but before starting logging, use the Options button to change the Offset method to **Triple Distance**.
4. This will start up a process which is somewhat self-explanatory on the screen:
   a. Move to a suitable GPS point and press Log to start logging the reference position.
   b. Press **Next** (and the position collection) and you will be prompted to enter the distance: you'll pace the distance, and use the calculator to multiply your paces by your pace distance, then enter the result in the **slope distance** field. Leave the Inclination at zero unless you’ve measured it.
   c. Press **Next** and follow instructions to move to the next GPS point (you’ll probably be pacing from the feature, so go ahead and figure out the distance.)
   d. **Resume** to collect that second GPS point, then **Next** to enter the distance.
   e. Repeat for the third point. You'll want to pace from the feature to that point: all three distances are from the feature to the GPS point in question, or vice versa.
   f. Ok the message saying the position has been calculated.
   g. You should be back at the feature creation point, where you can close it once you’ve entered your attributes.
Complex Offset:  B-B & Triple B

Bearing-Bearing & Triple Bearing Offsets

- handy when you can’t actually get to the point in question. Maybe there’s too much poison oak, or there are monsters or steep cliffs between you and the feature.

- Only limitation is that compass measurements are not very accurate (though they are probably as accurate as pacing).

- To capture other features using either the Bearing-Bearing or Triple Bearing methods, you use the compass to shoot from the GPS points to the feature. Note: with three points the GPS unit is able to detect errors, and it may not like the accuracy of the bearings you input if they don't intersect well.

1. **Setup/Units**: Set the North Reference to Magnetic unless you are working with a compass that provides true azimuth.
2. Before creating a point, when in collection mode, select the Log Later option (Options).
3. Create a point feature, but before starting logging, use the Options button to change the Offset method to Bearing – Bearing or Triple Bearing, depending on how many points you’ll be using.
4. This will start up a process which provides pretty clear steps on-screen.
   a. Move to a suitable GPS point and press Log to start logging the reference position.
   b. Press Next (and the position collection) and you will be prompted to enter the azimuth, so measure this and enter it.
   c. Press Next and follow instructions to move to the next GPS point.
   d. Resume to collect that second GPS point, then Next to enter the azimuth from this point.
   e. If doing Triple Bearing, repeat for the third point. After the last point, you will see a message that the position has been calculated, and you can Ok it.
   f. Close the feature after entering attributes.
Exporting to GIS

We must do this export correctly to ensure the data have the attributes we want and are in the correct projection. To export, go to **Utilities/Export…** to bring up the **Export** window.

**Properties**
You will need to go to the Export Setup Properties to control the export projection, attributes and other properties. Access the various properties through the tabs:

**Projection:** Pathfinder can export the native Geographic Coordinate System (GCS) WGS84 coordinates into whatever coordinate system we want to use, but we need to not only specify it, but also select a projection file to go along with it:

- **Export Coordinate System:** You can select any projected coordinate system, or datum, GCS, that the program knows about. You can either specify an “Export Coordinate System”, or reference the “Current Coordinate System”.

- **Projection File:** You need to also specify a projection file corresponding to your export coordinate system. **Why the program doesn’t do this for you automatically I don’t know.** The way this works, it would be possible to select the wrong one.
PFO does not create a projection file (*.prj)
So, you may search for an existing one that matches...

.prj  ...is a one-line record with the following:

PROJCS["NAD_1983_UTM_Zone_15N",GEOGCS["GCS_North_America_n_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-93.0],PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_Of_Origin",0.0],UNIT["Meter",1.0]]
PFO – Shapefile Export Information
PFO – Shapefile Export Information
# PFO – Shapefile Export Information

<table>
<thead>
<tr>
<th>FID</th>
<th>Shape</th>
<th>Comment</th>
<th>Max_PDOP</th>
<th>Max_HDOP</th>
<th>Corr_Type</th>
<th>Rcvr_Type</th>
<th>GPS_Date</th>
<th>GPS_Time</th>
<th>Update_Status</th>
<th>Feat_Name</th>
<th>DataFile</th>
<th>Unfit_Pos</th>
<th>Fit_Pos</th>
<th>Data_Dict</th>
<th>GPS_Week</th>
<th>GPS_Second</th>
<th>GPS_Area</th>
<th>GPS_Perime</th>
<th>GPS_3DPeri</th>
<th>Avg_Vert_P</th>
<th>Avg_Horz_P</th>
<th>Worst_Vert</th>
<th>Worst_Horz</th>
<th>Area_ID</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>Polygon ZM</td>
<td>poly-1</td>
<td>7</td>
<td>4.7</td>
<td>Postprocessed Code</td>
<td>GeoXT 2005</td>
<td>2/27/2012</td>
<td>02:07:30pm</td>
<td>New</td>
<td>Area_gen</td>
<td>H022714A.cor</td>
<td>17</td>
<td>17</td>
<td>Generic</td>
<td>1677</td>
<td>158664</td>
<td>0.079</td>
<td>0.132</td>
<td>0.136</td>
<td>1.796</td>
<td>1.719</td>
<td>2.733</td>
<td>2.632</td>
<td>4.428</td>
</tr>
<tr>
<td>1</td>
<td>Polygon ZM</td>
<td>poly-2</td>
<td>7</td>
<td>4.9</td>
<td>Postprocessed Code</td>
<td>GeoXT 2005</td>
<td>2/27/2012</td>
<td>02:11:18pm</td>
<td>New</td>
<td>Area_gen</td>
<td>H022714A.cor</td>
<td>15</td>
<td>15</td>
<td>Generic</td>
<td>1677</td>
<td>159092</td>
<td>0.003</td>
<td>0.027</td>
<td>0.029</td>
<td>1.941</td>
<td>2.367</td>
<td>3.315</td>
<td>4.426</td>
<td>4.426</td>
</tr>
</tbody>
</table>

---

![Image of software interface with data tables and shapefile related configuration options.](attachment:image.png)

---

**Software Interface Details:**
- **Data Tables:** Contains fields such as FID, Shape, Comment, Max_PDOP, Max_HDOP, Corr_Type, Rcvr_Type, GPS_Date, GPS_Time, Update_Status, Feat_Name, DataFile, Unfit_Pos, Fit_Pos, Data_Dict, GPS_Week, GPS_Second, GPS_Area, GPS_Perime, GPS_3DPeri, Avg_Vert_P, Avg_Horz_P, Worst_Vert, Worst_Horz, Area_ID.
- **Configuration Options:** Includes settings for coordinate system, units, attributes, and filter features.

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**Additional Information:**
- Shapefile export settings and parameters configured through the software interface to ensure accurate data transfer and appropriate spatial and attribute data representation.
Shapefile Export: Other Stuff

Bounding Box...

Min/Max Easting
Min/Max Northing
Using Trimble’s Planning Software

Saturday 3 March
Using Trimble’s *Planning* Software

Sunday 4 March
Class Exercise

What percent of the sidewalk area is not illuminated...

1) With bulbs that illuminate to a radius of 20 meters?
2) With bulbs that illuminate to a radius of 30 meters?

Sidewalk is 2 meters wide.

<table>
<thead>
<tr>
<th>PROPERTIES</th>
<th>$m^2$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sidewalk_2m</td>
<td>3045.547</td>
<td></td>
</tr>
<tr>
<td>30m Illumination</td>
<td>2321.285</td>
<td>76.2%</td>
</tr>
<tr>
<td>20m Illumination</td>
<td>1632.895</td>
<td>53.6%</td>
</tr>
<tr>
<td>Not illuminated @ 30m</td>
<td>724.2623</td>
<td>23.8%</td>
</tr>
<tr>
<td>Not illuminated @ 20m</td>
<td>1412.652</td>
<td>46.4%</td>
</tr>
</tbody>
</table>