

Travel Time Survey Pilot Study

Technical Report

GPS Travel Time Data Collection on the Route 419 Corridor

Prepared by the

Roanoke Valley Area Metropolitan Planning Organization

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ROANOKE VALLEY AREA
MPO METROPOLITAN
PLANNING
ORGANIZATION



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Chapter 1

Introduction

The average American commuter spends over 186 hours a year commuting to and from work. Add shopping trips, school related trips and recreational trips, and it is not hard to understand why travel time is an important factor in our busy lives. The objective of a traffic engineer is to move people and goods efficiently and safely in an environmentally friendly way. This is often accomplished by adding lanes, adding traffic lights, promoting carpooling, identifying alternative modes of transport, building new roads and by making more efficient cars. However, as traffic volume increases because of these new efficiencies, new residential and commercial development often follows, which adds to the cycle of sprawl and traffic congestion. The Roanoke Valley is no exception. We all have a perception that traffic is bad, but how bad is it, and why? Some studies actually suggest that commute times decreased since the 1960's because sprawl has allowed jobs and suburban homes to be closer together.

1.1 Study Purpose

The primary purpose of this study was to identify an effective methodology for measuring the travel time through a particular urban corridor. Specifically, the methodology should accomplish the following:

- Measure travel time, running time and delay time for each segment of the corridor in non-peak and peak travel times.

- Allow an interpreter to identify segments or intersections that have consistent problems maintaining an average travel speed for the corridor.
- Allow the study to serve as a benchmark that could be repeated in the future to determine how travel times may change over time.

Understanding the movement of traffic by measuring its time elements can facilitate traffic management and the prioritization

1.2 Other Studies and Definitions

Research has shown that travel time studies should have a sample size anywhere from two to six or more runs for each time period and corridor studied. Resource constraints did not allow for such rigorous statistical sampling in this pilot study. Similar studies from the Hampton Roads and Richmond Regional Planning Districts were obtained and reviewed by staff. Several key terms emerged and are defined as follows:

- ❖ *Travel Time* is defined as the time it takes to move the distance between two points of interest. Travel time is made up of two basic components, running time and stopped delay time.
- ❖ *Running Time* is the time period when the vehicle or person is in motion.
- ❖ *Stopped Delay Time* is the time period when the object or person has stopped moving or has almost stopped moving (typically less than 5mph according to federal guidelines). An example of *Stopped Delay Time* is the time period when a vehicle is stopped at a stoplight.

For more information on definitions and sampling methods, refer to the *Travel Time Data Collection Handbook*, March 1998 (Federal Highway Administration, Report Number FHWA-PL-98-035).

1.3 Study Area Selection

The Route 419 (Electric Road) corridor was chosen for this pilot study (see Map 1). This corridor is approximately 10 miles long and extends from US 220 near Tanglewood Mall, to Route 311 near Hanging Rock. The corridor travels through Roanoke County, Salem City and Roanoke City. The road is primarily a four-lane highway with a grassy median. The land use is primarily commercial retail and office use. Some sections have residential and undeveloped parcels. Speed limits are usually 35 or 45 miles per hour. The corridor has 21 signalized intersections.

Map 1 goes here

Chapter 2

Methodology

The first step of the study required staff to review literature on travel time surveys and other studies that utilized Global Positioning System (GPS) technology. At the same time, staff used the GPS unit in the field to determine the proper settings. Several test runs were made with different settings to assess what type of GPS data and velocity records should be collected in the field. When a final methodology was achieved, it was documented and then tested completely in the field. As with any GPS measuring, the leaf-off months (winter) are the best time to use the equipment. Heavy leaf cover can block the satellites' signals.

2.1 GPS Setup

A Trimble Pro XL 12 Channel GPS receiver with a TDC-1 (a type of data entry keypad) was used to conduct this study. The following settings were used on the unit: (see Appendix B)

1. PDOP mask was set to 20. This setting was made to insure the unit recorded continuously while on the vehicle. In early test runs, the PDOP mask was set on 6, which is a more standard setting. However, the unit would occasionally not record a segment or line if the segment (F3) button was pressed while the PDOP was above 6. This occurred primarily in the downtown area because of tall buildings. Since the GPS was used more as a timer, than accurate mapping tool, a higher PDOP mask should not affect the study results.

2. The feature recording time was set on one second. This setting allows interpolated line breaks (signalized intersections) to more closely represent actual ground locations.
3. Power for the unit was supplied through the vehicles 12 volt system. The antenna was placed on the left side of the roof of the vehicle. The antennae cable was placed through an open window, since closing a door on the cord could damage it.
4. To accurately record velocity data, the velocity interval was set as one second.

2.2 Driving Technique

It is important to maintain a consistent driving style. In general, the driver should match the flow of traffic. If no traffic is present, the posted speed limit should be followed.. Pass about the same number of cars that are passing you. Do not block traffic in the left lane. In other words, if no one is in front of you and there are cars behind you, move to the right lane. If the group of cars is going over the speed limit, stay with the group, but do not pass anyone. A good technique is to pick a vehicle and match it's speed or follow it at a close, but safe distance. Do not drive aggressively or follow too closely. To avoid distractions to the driver, a second person can operate the GPS unit.

2.3 GPS Recording Procedure

The following recording procedure was used:

1. Set up the receiver as indicated above.
2. Place the TDC-1 in an accessible place.
3. Park in a safe location near the start of the segment.

4. Fill out the log sheet. (see Appendix A)
5. Turn on the GPS unit, and wait until the unit has found enough satellites for the PDOP to be under 20. This may take several minutes.
6. From the Main Menu, choose DATA CAPTURE <enter>
7. From the Data Capture Menu, choose CREATE ROVER FILE <enter>
8. Press OK twice to accept the next two screens of settings.
9. Use the down arrow to select LINE_GENERIC from the Start Feature Menu
10. Press OK to bypass the Antennae Options
11. The unit should now be recording a line feature. The number of points recording will be showing up in the lower right corner of the screen.
12. If the unit is recording properly, begin driving to the start of survey run (beginning of the defined survey corridor).
13. While driving with the flow of the traffic, press F3 (the SEG button) to break the line segment at the start of the first segment in the defined corridor.
14. Press F3 at the center of each signalized intersection as you pass (or other major point if defined in the study). If you are stopped at a light, do not press F3 until you have moved into the center of the intersection. (If you are forced to stop in the center of an intersection due to traffic, press F3 at the beginning of your stop and do not press it again until the next signalized intersection.)
15. Continue this procedure of pressing F3 at each signalized intersection until you reach the end of your survey run. Press F3 at end of the survey (the last defined intersection).

16. Find a safe place to park and leave the car running. Press the OK button. (This will end the recording session. It is necessary to record the last segment (from the last intersection in the study corridor to your parking location) because the start time of this segment is actually the end time for the survey run, and it will be needed for future calculations.
17. Press OK and Exit Data Capture
18. Press CLEAR-ON/OFF
19. Press F2 for “yes, exit data capture”
20. Press FUNC
21. Press CLEAR-ON/OFF to turn off the power
22. Complete Log Sheet

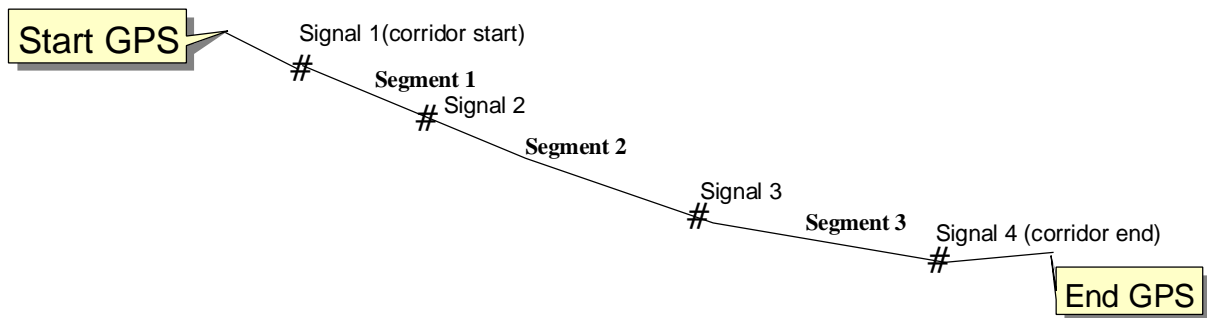
2.4 GPS File Post-Processing

The GPS file was transferred from the TDC-1 collection unit to a PC. Differential Correction data can be obtained from Radford University’s GPS site. Differential correction was not used for this study, since precise location information was not required. Data was output in ArcView Shape (ESRI Inc.) file format using Trimble’s Pathfinder Office Software. [Note: Features (positions and attributes) and velocity data were exported. Critical attributes to export included TIME RECORDED and LENGTH. TIME RECORDED refers to the start time of the segment. See Appendix C for more details.] This process yielded a digital map (ArcView Shape file) and feature database in DBASE format.

If editing is required, it can be accomplished in ArcView (ArcView is Geographic Information System (GIS) software that is made by ESRI, Inc.) The first segment in the survey can be deleted. This first segment should be the segment from when the unit started recording to the first time F3 was pressed: at the beginning of the study corridor. If a segment break (signalized intersection) was missed in the field it can be added by comparing the corridor map to another run (ArcView shapefile) that has the break. As mentioned previously, the last segment recorded a data from the end of the survey corridor to the point where the GPS unit was turned off. The start time of that last segment is required because it is the end time for the travel survey run. Thus, the last segment can be deleted since it is outside the corridor, but it is important to note the start time of that segment. The DBASE GPS line file was opened in Microsoft Excel. The file consisted of a record for each segment recorded (see Figure 1). The time field was converted manually to “hh:mm:ss” format. A template with equations was set up to calculate the elapsed time for a segment and the average travel speed. The start and end times for a segment were noted. The velocity file DBASE file was opened in Microsoft Excel and the records were divided up for each segment, based on the start and stop times for each segment (see Figure 2). Because velocity data were recorded before and after the actual study corridor, some records at the beginning and end of the file were not used. The velocity records with speeds less than 5mph were tagged manually in the spreadsheet as stopped delay times. The total running time and total stopped delay time for each segment was then tallied. In the following example, Segment 1 (between Signal 1 and Signal 2) has a running time of two seconds and a stopped delay time of three seconds.

The running times and stopped times can be added to the Segment table (Figure 1) to calculate the average running speed (not shown in Figure 1). By using an estimated

Figure 1-Sample GPS run and files



Sample GPS line file

| Start Location | START GPSTIME | LENGTH | |
|----------------|---------------|--------|---------------------------------------|
| Start GPS | 12:15:42 | 456 | (delete) |
| Signal 1 | 12:18:22 | 522 | (segment 1) |
| Signal 2 | 12:18:43 | 1023 | (segment 2) |
| Signal 3 | 12:19:03 | 984 | (segment 3) |
| Signal 4 | 12:19:21 | 420 | (start time is end time of segment 3) |

Sample segment EXCEL file with completed calculations

| Segment | Elapsed Time | Length (ft) | Length (miles) | Average Speed (mph) |
|------------|------------------------------------|-------------|----------------|----------------------|
| Signal 1 | | | | |
| >Segment 1 | (12:18:43 - 12:18:22) = 25 seconds | 522 | 522/5280=.098 | .098/(25/60/60)=14.1 |
| Signal 2 | | | | |
| >Segment 2 | (12:19:03 - 12:18:43) = 20 seconds | 1023 | 1023/5280=.194 | .194/(20/60/60)=34.9 |
| Signal 3 | | | | |
| >Segment 3 | (12:19:21 - 12:19:03) = 18 seconds | 984 | 984/5280=.186 | .186/(18/60/60)=37.2 |
| Signal 4 | | | | |

distance traveled, which is computed by using the speed at each velocity point, an elapsed distance column was created for graphing purposes (see Figure 2). A graph was then created with speed on the Y axis and elapsed distance the X axis. Key landmarks can be marked on the X axis based their distance, and intersections or other delay points can easily be identified based on speed. For complete examples, see the Chapter 3.

Figure 2-Sample Velocity file

| Sample modified Velocity file in EXCEL | | | | | | | |
|---|----------|------------------------|-----------------|------------------|-------------------------------|---------------------------------|-------------------|
| Speed | GPS Time | Intersection Locations | Running Time(s) | Stopped Time (s) | Estimated Distance Moved (ft) | Estimated Elapsed Distance (ft) | Elapsed Dist (mi) |
| 21.961 | 12:08:00 | Signal 1 | | | | | |
| 15.532 | 12:08:01 | | 1 | | 32.209 | 32 | 0.006 |
| 5.231 | 12:08:02 | | 2 | | 22.780 | 55 | 0.010 |
| 2.211 | 12:08:03 | | | 1 | 7.672 | 63 | 0.012 |
| 0.232 | 12:08:04 | | | 2 | 3.243 | 66 | 0.012 |
| 0.231 | 12:08:05 | | | 3 | 0.340 | 66 | 0.013 |
| 8.542 | 12:08:06 | Signal 2 | 1 | | 0.339 | 67 | 0.013 |
| 18.232 | 12:08:07 | | 2 | | 12.528 | 79 | 0.015 |

| with visible equations | | | | | | | |
|-------------------------------|----------|------------------------|-----------------|------------------|-------------------------------|---------------------------------|-------------------|
| Speed | GPS Time | Intersection Locations | Running Time(s) | Stopped Time (s) | Estimated Distance Moved (ft) | Estimated Elapsed Distance (ft) | Elapsed Dist (mi) |
| 21.961 | 12:08:00 | Signal 1 | | | | | |
| 15.532 | 12:08:01 | | 1 | | $21.961/60/60*5280=32$ | $0+32=32$ | $32/5280$ |
| 5.231 | 12:08:02 | | 2 | | $15.532/60/60*5280=23$ | $32+23=56$ | $56/5280$ |
| .. | .. | .. | .. | .. | .. | .. | .. |

Chapter 3

Route 419 Study Results

3.1 Travel Time Survey Runs

Four survey runs were conducted for this study along the 10 mile Route 419 corridor. Before conducting the actual survey (GPS) runs, several trips were required to identify the signalized intersections, speed limits and access points. When the corridor was defined and blank tables were created in a spreadsheet, the survey (GPS) runs were conducted. Two survey runs were conducted during peak traffic, one in each direction, and two were conducted during non-peak traffic. The following runs were completed:

| | | | |
|------------------------|---------------|-------------------|---------------|
| 1. Northbound Peak | June 7, 2000 | 5:31PM to 5:55PM | Table/Graph 1 |
| 2. Southbound Peak | July 12, 2000 | 5:02PM to 5:25PM | Table/Graph 2 |
| 3. Northbound Non-Peak | May 5, 2000 | 12:43PM to 1:06PM | Table/Graph 3 |
| 4. Southbound Non-Peak | May 5, 2000 | 1:08PM to 1:29PM | Table/Graph 4 |

Tables 1-4 display the data collected for each run. Likewise, Graphs 1-4 show the actual speeds of the test vehicle through the corridor. Each stop at a signalized intersection is labeled on the graph.

3.2 Survey Results

With only one run completed for each time period in each direction, it is hard to claim the each run is a representative sample of normal conditions. It can be stated that each run is a random sample of travel time conditions. It is recommended that a more detailed study of a corridor should utilize more samples as discussed in Chapter 1, Section 1.2.

Call for complete report.

Table 5 shows the overall average speed and elapsed time for each survey run. The peak time runs were slightly slower than the non-peak surveys. As the table indicates, travel speed and time were slightly slower during the peak travel period. However, over the 10 mile corridor, this difference between peak and non-peak travel time only amounted to one or two minutes. Northbound times were slightly longer than southbound times.

Table 5-Overall Average Speed and Elapsed Time*

| Travel Run | MPH | Minutes |
|---------------------|------------|----------------|
| Northbound Non Peak | 28.1 | 23 |
| Northbound Peak | 26.9 | 24 |
| Southbound Non-Peak | 29.1 | 21 |
| Southbound Peak | 27.5 | 23 |

*includes running and stopped times

Table 6 shows the longest stop delayed times. The Colonial Avenue stop was lengthed about 10 seconds as vehicles (from Southbound 419-turning left on Colonial) backed up behind a left turning vehicle on Colonial and blocked the northbound lanes of Route 419. The Midland Road stop was for two traffic light cycles. The first cycle did not allow all southbound traffic to pass through. Staff noted a large backup at this light on another occasion which seems unusual for a low flow cross street. However, this segment of Route 419 carries an estimated 35,000 vehicles per day (see Table 10), which is the second highest volume segment in the corridor.

Table 6-Longest Signal Stops

| Travel Run | Intersection | Seconds |
|---------------------|---------------------|----------------|
| Northbound Peak | Colonial Avenue | 94 |
| Southbound Peak | Midland Road | 88 |
| Northbound Peak | Brambleton Avenue | 68 |
| Northbound Non-Peak | Apperson Drive | 66 |
| Northbound Non-Peak | Braeburn Drive | 61 |

Table 7 lists the slowest travel segments. These average speeds include both running and stopped delay times. The area in front of Tanglewood Mall has some of the slowest overall travel speeds. These segments are also some of the shortest in the study corridor.

Table 7-Overall Slowest Travel Segments*

| Travel Run | From/To | MPH |
|---------------------|------------------------|-----|
| Southbound Peak | Elm View/Tanglewood | 6.1 |
| Southbound Peak | Midland/Apperson | 6.6 |
| Northbound Non-Peak | Elm View/Ogden | 6.7 |
| Northbound Non-Peak | Keagy Road(n)/Braeburn | 7.5 |
| Northbound Peak | Tanglewood/ElmView | 7.7 |

*includes running and stopped times

Table 8 lists the slowest running travel segments. Since these times only reflect moving speed (delays caused by stops are not measured), they could be considered a partial indication of congestion, especially when the average moving travel speed is much less than the posted speed limit. The area in front of Tanglewood Mall had the lowest moving speeds. The southbound approach to Apperson Road also had a low speed. The length of these segments obviously plays a role in travel speed because the data indicates that closer signalization (shorter segments) slows traffic in neighboring segments. These segments also have some of the highest traffic volumes in the corridor (see Table 10).

Table 8-Slowest Running Travel Segments*

| Travel Run | From/To | MPH | Speed Limit |
|---------------------|---------------------|------|-------------|
| Southbound Peak | Elm View/Tanglewood | 16.6 | 35 |
| Northbound Peak | US 220/Tanglewood | 19.7 | 35 |
| Southbound Peak | Midland/Apperson | 21.1 | 35 |
| Northbound Peak | Elm View/Ogden | 21.3 | 35 |
| Southbound Non-Peak | Elm View/Tanglewood | 21.7 | 35 |
| Northbound Non-Peak | Tanglewood/Elm View | 21.7 | 35 |

*includes running time only (does not include stopped delay time)

Table 9 shows the fastest travel segments. The I-81/East Main Street segment is the longest and most “rural” segment in the corridor. Both the I-81/East Main Street and McVitty/Postal segments have long, straight sloping grades and lower traffic volumes (see Table 10), which may also explain why traffic tends to move faster.

Table 9-Fastest Travel and Running Segments*

| Travel Run | From/To | MPH | Speed Limit |
|---------------------|-----------------------|------------|--------------------|
| Northbound Peak | East Main Street/I-81 | 50.1 | 45/35 |
| Southbound Peak | I-81/East Main Street | 46.7 | 35/45 |
| Northbound Non-Peak | Postal/McVitty | 46.2 | 45 |
| Northbound Non-Peak | East Main Street/I-81 | 46.1 | 45/35 |
| Southbound Peak | McVitty/Postal | 44.8 | 45 |

*no stop delays occurred in these segments

Table 10-1997 VDOT Traffic Volume Estimates

| Segment End | Segment End | AADT* |
|---------------------|---------------------|--------------|
| US220 | Starkey Road | 39,000 |
| Starkey Road | Brambleton Avenue | 29,000 |
| Brambleton Avenue | Salem City Limits | 27,000 |
| Salem City Limits | Apperson Drive | 31,000 |
| Apperson Drive | Roanoke-Salem Blvd. | 35,000 |
| Roanoke-Salem Blvd. | Texas Street | 21,000 |
| Texas Street | East Main Street | 22,000 |
| East Main Street | Salem City Limits | 15,000 |
| Salem City Limits | I-81 | 14,000 |
| I-81 | Route 311 | 12,000 |

*[Annual] Average Daily Traffic

Table 11 and 12 show the highest and lowest number of access points per mile. Access points are defined as an intersecting un-signalized road, business entrance or other point allowing vehicles to exit or enter the main corridor. Curb cuts to an undeveloped parcel were not counted.

Table 11-Highest Number of Access Points Per Mile

| Direction | Segment From | Segment To | Access/Per Mile |
|------------|---------------------|------------------|-----------------|
| Southbound | Starkey Road | Ogden Road | 43.4 |
| Northbound | Ogden Road | Starkey Road | 32.4 |
| Southbound | Roanoke-Salem Blvd. | Midland Road | 26.1 |
| Northbound | Starkey Road | Chaparral Drive | 25.5 |
| Southbound | East Main Street | Springfield Ave. | 22.7 |
| Southbound | Ogden Road | Elm View Rd. | 22.7 |

Table 12-Lowest Number of Access Points Per Mile

| Direction | Segment From | Segment To | Access/Per Mile |
|------------|--------------------|-----------------|-----------------|
| Northbound | Keagy Road (North) | Braeburn Drive | 0 |
| Northbound | Tanglewood Mall | Elm View Road | 0 |
| Southbound | Postal Drive | Brambleton | 0 |
| Southbound | Colonial Avenue | Chaparral Drive | 1.8 |
| Southbound | Brambleton Avenue | Colonial Avenue | 1.9 |

For reference purposes, Tables 13 and 14 display the shortest and longest segments in the study corridor.

Table 13-Shortest Segments

| Segment End | Segment End | Miles |
|------------------|--------------------|-------|
| Ogden Road | Elm View Road | 0.13 |
| Elm View Road | Tanglewood Mall | 0.14 |
| East Main Street | Springfield Avenue | 0.18 |
| Braeburn Drive | Keagy Road (North) | 0.18 |
| Tanglewood Mall | US 220 ramp | 0.20 |
| Postal Drive | Brambleton Avenue | 0.20 |

Table 14-Longest Segments

| Segment End | Segment End | Miles |
|--------------------|---------------------|-------|
| I-81 Bridge | East Main Street | 1.89 |
| Grandin Road | McVitty Road | 1.16 |
| Keagy Road (N) | Keagy Road (S) | 0.93 |
| Lynchburg Turnpike | Roanoke-Salem Blvd. | 0.80 |
| Colonial Avenue | Chaparral Drive | 0.55 |

Chapter 4

Evaluation of Study Methodology

4.1 Conclusions

The methodology provided in this document works well for measuring travel time for a given corridor. In particular, the GPS unit can provide accurate measurements of distance, time and vehicle speed, which would be very difficult to measure with traditional manual methods. The digital data can easily be transferred from the GPS unit to computer spreadsheets for calculations and analysis. This study achieved its primary objective, which was to develop a repeatable methodology for conducting travel time surveys (see Chapter 1).

4.2 Recommendations for Future Studies

Setting up the spreadsheets with equations from scratch can be time consuming. It would be useful to use the templates created from the pilot study and just change the intersection and time data. It was discovered that corridors with tree cover would best be studied in the leaf-off season since heavy foliage can interfere with satellite signals. Finally, while a minimum number of runs (one for each time period in each direction) can provide random and general benchmark samples for a corridor, multiple runs (3-6 or more for each time period and direction) should be used to identify patterns or specific problem areas in within study corridor.

Appendix A

GPS Logsheet

Surveyor's Name _____

Date _____

File Name _____

Estimated Start Time _____ AM PM

Corridor or Route Name _____

Beginning Intersection _____

Ending Intersection _____

Direction of Travel _____

Weather _____

Special Conditions _____

Approximate Ending Time _____ AM PM

Office Use Only

Transferred to PC Post Processed Complete Intersections Done

Associated Filenames _____

Processed by _____

Appendix B

Trimble GPS Rover Configuration

CONFIGURATION MENU

GPS

Rover Options

| | |
|-------------------|-----------------|
| Logging intervals | |
| Point Feature: | 1s |
| Line/area: | 1s |
| Not in feature: | None |
| Velocity: | 1s |
| Minimum posns: | 1 |
| Carrier Phase | |
| Minimum time: | 10mins |
| Pos. mode: | Manual 3D |
| Elev. mask: | 15° |
| SNR mask: | 6.0 |
| PDOP mask: | 20.0 |
| PDOP switch: | 6.0 |
| Audible click: | Yes |
| Log DOP data: | Yes |
| Dynamics code: | Land |
| Initial position | |
| Lat: | 37d 16'48.097"N |
| Lon: | 79d 56'27.434"W |

CONFIGURATION MENU

Units and display

| | |
|-----------|------------|
| Units: | |
| | |
| | |
| Velocity: | miles/hour |
| | |
| etc. | |

Appendix C

Trimble Pathfinder Office Export Setup

