GPS Pilot Project

PHASE TWO: GSP UNIT COMPARISON, FIELD TESTS, AND MARKET ANALYSIS

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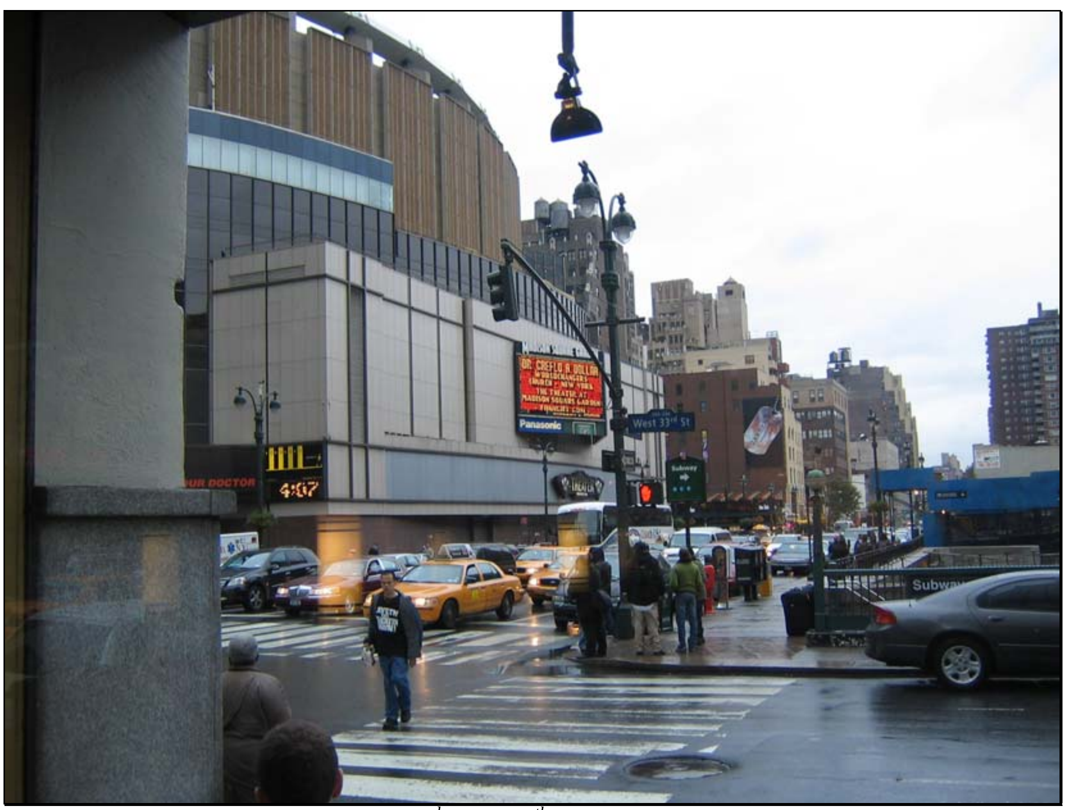
Project Overview: Phase Two

The **GPS Pilot Project (Phase Two)** is designed to test the feasibility of using Global Positioning Systems (GPS) technologies for the upcoming NYMTC Household Travel Survey efforts. In Phase One, the research team examined previous applications of GPS technology to collect 'passive' data on travel behavior and integrate the data into household travel survey efforts by (1) conducting a scan of various agencies and organizations that have used GPS technology in their travel surveys and review the existing literature on their experience; (2) evaluating the most recent 'off-the-shelf' person-based GPS units available, and (3) researching GPS and GIS software interface and hardware data exchange.

In Phase Two, the research will conduct a series of "controlled" experiments using two "off-the-shelf" GPS units: the GlobalSat and the i-Blue. These two units, compared with other available units, appear to have sufficient capabilities to operate in the Manhattan environment, a highly dense area with an urban canyon effect. The results of these experiments will guide the research team in their recommendations for attempting to use GPS for collecting data for "mixed mode" travel. In addition, an analysis using the 1997/98 Regional Travel Household Interview Survey data will attempt to identify special population segments for future GPS unit deployment.

The tests are structured to compare the following factors: the ease of use and durability of the GPS hardware under field test conditions; the ease of installation and application of the software interface using data collected during the tests; and the analysis of the output. The outcomes of these factors will be used to make recommendations for further advancement of the "Proof-of-Concept" of using GPS for travel survey data collection in the New York Metropolitan Region.



Picture 1.1 Madison Square Garden 33rd St and 8th Ave

Section One: GPS Unit Comparisons

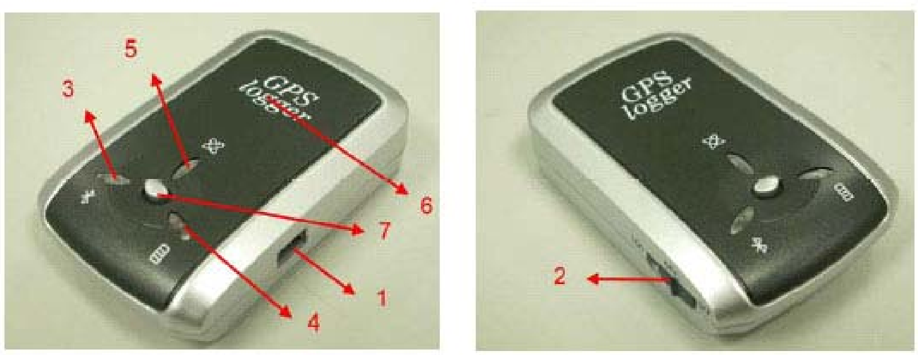
The initial analysis of available "off-the-shelf" GPS units guided the research team's decision to purchase two types of units: the *GlobalSat* and the *i-Blue 747*. Both of these units contain chipsets claiming to be capable of providing sufficient spatial data in an urban environment. Ten units of each type of GPS units were purchased to administer the necessary experiments. Characteristics of the two units and their functional processes are described in this section.

The i-Blue 747 (iBT-GPS logger)

i-Blue Features

According to the manufacturer, the i-Blue 747 has the following features and capabilities:

- MTK 32 Channel GPS chipset
- At least 20 hours operation time
- Embedded 16Mb memory capable of recording up to 100,000 way points record
- Three (3) recording methods: (1) by time, (2) by distance or (3) by speed
- WAAS[1] and EGNOS[2] supported for better accuracy
- Support NMEA-0183 GGA, GSA, GSV, RMC, VTG and GLL



1. DC jack (mini USB type)
2. Mode switch (Power off/ Navigation&log/ Pure log)
3. Bluetooth status LED (blue)
4. Battery status LED (red/green)
5. GPS status LED (orange) / Push to log LED (blue)
6. Internal GPS antenna
7. Push Button

Figure 1.1 i-Blue GPS Unit: a stream-line device, only 2" wide by 3" long

The capability of the chip was the key factor in determining the feasibility of using GPS technologies for a travel survey in the Manhattan area. The MTK GPS chipset is expected to function in a high density urban canyon environment.

[1] Wide Area Augmentation System - a satellite based differential GPS system

[2] European Geostationary Navigation Overlay Service - a satellite maintained by the European community

The current deployment strategy for a travel survey requires at least one day of passive data collection. The i-Blue 747 has an operational battery life of at least 20 hours and should be sufficient for collecting data from activities of a survey participant. The storage capacity of the device is fixed however the amount of data collected may vary depending on the travel patterns of each individual since GPS data notation depends on each recorded 'way points record'. The research team will need to estimate the space requirements for data being collected by each survey participant.

GPS data notation produces NMEA[3] sentences which is a string of ASCII text indicating the stored 'way point record', the standard protocol use by GPS receivers to transmit data. This data includes the recorded time, latitude and longitude, number of satellite units tracking the point, along with other information which is described Appendix I. Biba (2007) reports that the most important *NMEA* sentences include the GGA[4] which provides the 'fix data' information, the RMC[5] which provides the 'minimum GPS sentences information', and the GSA[6] which provides the 'satellite status' data. Examples and an explanation of typical NMEA sentences are provided in Appendix I.

Of the three methods available for recording trip purposes, the research team intends to use 'time' as the interval specified for data capture. To maximize the potential for data exploration, the research team will use a one second interval for recording data during the experimental phase of this research.

The survey burden associated with a GPS deployment includes the respondent burden (the survey participant) and the deployment burden (the data retrieval and transmittal staff). The deployment burden includes providing participants with adequate instructions for operating the GPS unit under normal conditions. Appendix II provides an example of the GPS instructions used in the controlled experiments.

The i-Blue unit contains a built-in lithium rechargeable battery. The unit can be charged by plugging the USB cable into the power source. The charging time is about 3 to 4 hours. The first use requires a full charge. During a battery charge the LED light on the unit blinks green. The LED turns red when the battery is low. Since the interface is a 'mini-USB,' any mini-USB service outlet can be used to charge the unit, including cell phone chargers. The survey participant will be responsible for understanding the charging requirements of each GPS unit in a survey household. If any of the units are not charged properly, the data collection process could be spoiled. In addition, each GPS unit user will need to be able to turn on the GPS logger when they begin their day and be capable of waiting for the units to lock on to a "fixed" satellite signal (*see Appendix I*).

Accompanying Software

After the data is collected, the burden of downloading and handling the data falls on the deployment team. Prior to distributing the GPS units, the deployment team must install the software provided on a CD by the manufacturer. The driver must be loaded from the "CP210x folder" via the "CP210xVCPInstaller.exe". A complete installation requires the user to restart their computer. The corresponding virtual COM Port needs to be verified.

The installation process for the data logging software requires "Datalog.exe" be located on the CD. The utility has a series of screens to allow the user to configure the connection. The scan button is designed to shorten the time needed to search for the approach COM Port, however, the user may need to check the MS Windows' device manager to determine the Virtual Com Port number. The COM port is a

[3] National Marine Electronics Association
[4] Global Positioning System Fix Data
[5] Recommended Minimum Specific GPS/TRANSIT Data
[6] GPS receiver operating mode

holdover from previous versions of the GPS unit that used a serial port. This can be confusing and should be upgraded in future versions of the software as the computer used for downloading should be able to easily connect to a USB port without needing a driver.

The deployment team will be able to set the NMEA output and can select a time interval, a distance interval or a speed interval as an autolog option. As indicated above, in the first experiment, the research team used a one second time interval for recording the data.

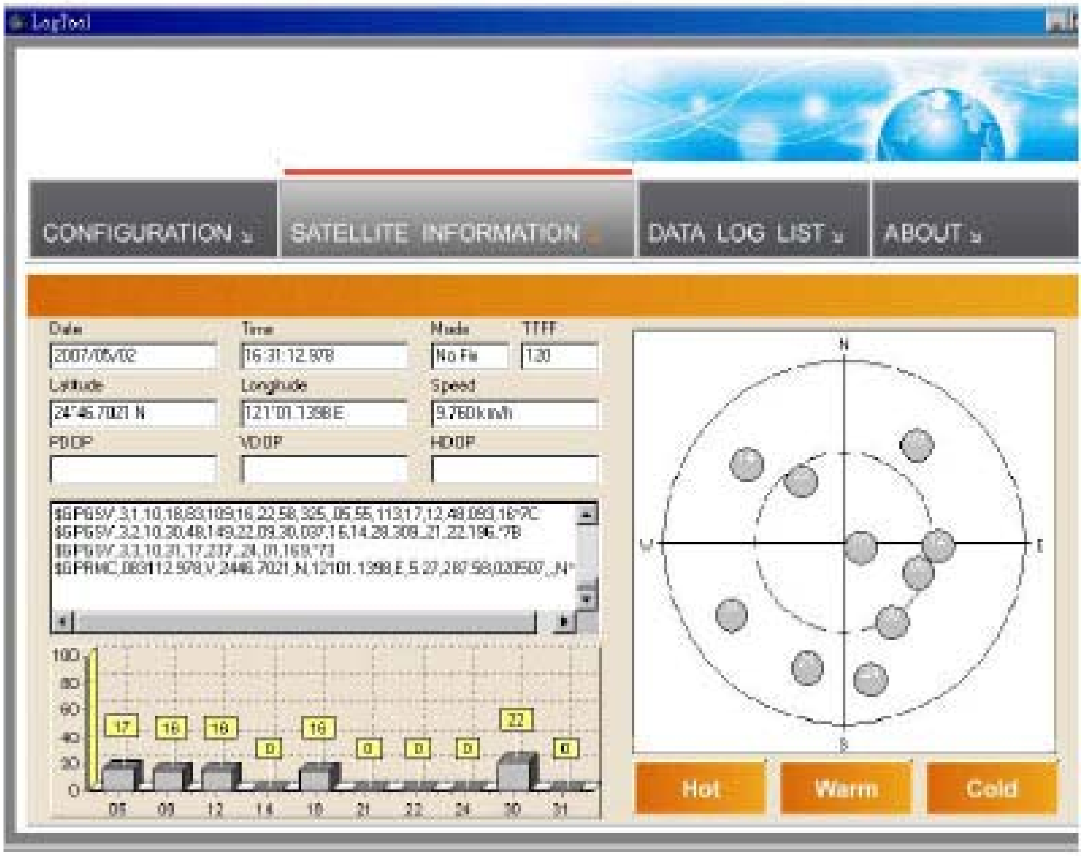


Figure 1.2 Satellite Information Screen

The deployment team is able to view a representation of the available satellites and the recording activities using the various screen options in the software interface.

The deployment team will need to use the Data Log List (see Figure 1.3) screen function to start the logging process (Start Log) for each unit used in the survey. After the GPS units are returned to deployment team, the data log can be viewed after clicking “Stop Log”. This is necessary because the unit was previously turned on (start) and can log data whenever the log slide switch is used. After the unit is stopped, the deployment team can download the data to the computer using the “Download” function. The “Erase” function clears all the data from the unit. The “Save” function allows the deployment team to save the data as a KML or a CSV file. The “Read” function allows the user to load CSV or BIN data into the program. The “Draw Map” function opens a dialogue box where the deployment team can choose which points will be imported into Google Earth. There is a limit of 5,000 data points in this version of the software. If there are more than 5,000 points, the rest of the path is approximated. When the data is pulled into Google Earth, the user can control the line characteristics.

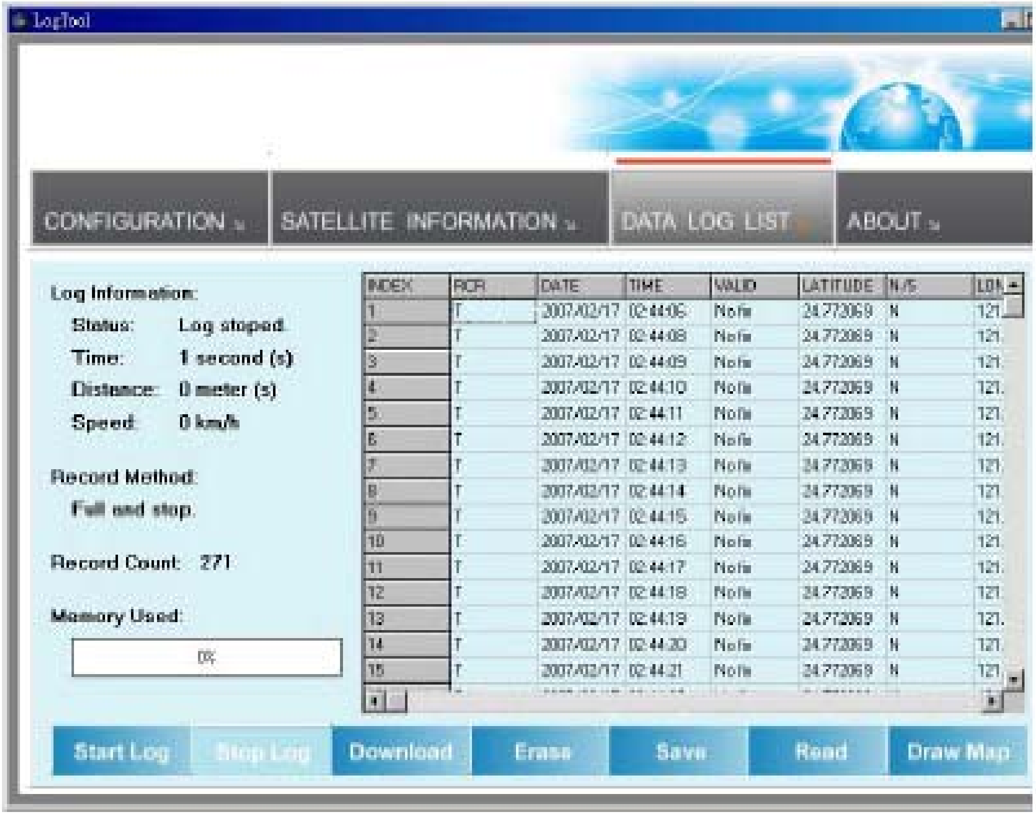


Figure 1.3 Data Log List Screen

During the period of the research project, a new version of the software interface was released (see http://www.transystem.com.tw/p-gps-iblue.htm). Before installing the new version, the user must uninstall both the driver and the datalog program. New features included are the mph to km/h conversion and a daylight savings time adjustment. Table 1.1 displays the data fields available in the CSV format.

Table 1.1 Data Fields Available from i-Blue GPS Unit

INDEX	RCR	DATE	TIME	VALID	LATITUDE	N/S	LONGITUDE	E/W	SPEED (km/h)	HEADING	HDOP	NSAT (USED/ VIEW)
21	T	8/11/2007	17:15:18	SPS	40.64006	N	73.9646	W	0.183	249.3091	1.39	7(8)
22	T	8/11/2007	17:15:28	SPS	40.64009	N	73.96457	W	1.010	40.16812	1.39	7(8)
23	T	8/11/2007	17:15:38	SPS	40.64012	N	73.96452	W	0.980	34.61172	1.39	7(8)
24	T	8/11/2007	17:15:48	SPS	40.64008	N	73.96437	W	0.709	122.9366	1.39	7(8)
25	T	8/11/2007	17:15:58	SPS	40.64006	N	73.96428	W	2.421	203.3809	1.39	7(8)
26	T	8/11/2007	17:16:08	SPS	40.64001	N	73.96429	W	2.540	199.2032	1.39	7(8)
27	T	8/11/2007	17:16:18	SPS	40.63995	N	73.9643	W	2.888	235.5113	1.38	7(8)
28	T	8/11/2007	17:16:28	SPS	40.64002	N	73.96427	W	1.939	18.20333	1.8	6(8)
29	T	8/11/2007	17:16:38	SPS	40.64001	N	73.96428	W	1.856	240.1452	2.4	6(7)
30	T	8/11/2007	17:16:48	No fix	40.63997	N	73.96434	W	2.196	231.1725	99.99	0(7)
31	T	8/11/2007	17:16:58	No fix	40.63998	N	73.96431	W	0.038	230.6398	99.99	0(6)
32	T	8/11/2007	17:17:08	No fix	40.63998	N	73.96431	W	0.000	230.6398	99.99	0(5)
33	T	8/11/2007	17:17:18	No fix	40.63998	N	73.96431	W	0.000	230.6398	99.99	0(3)

The GlobalSat DG-100 Data Logger GPS Unit

GlobalSat Features

Figure 1.4 displays the GlobalSat GPS unit. It is larger than the i-Blue, approximately 3.15"H x 2.75"W x 0.7"D. According to the manufacturer, it has the following features and capabilities:

- SiRF StarIII chipset 20 channels
- At least 20 hours operation time
- Capable of storing up to 60,000 points
- Three preset saving intervals (time/distance) activated by a slide switch
- Support NMEA-0183 GGA, GSA, GSV, RMC, GLL, with VTG optional

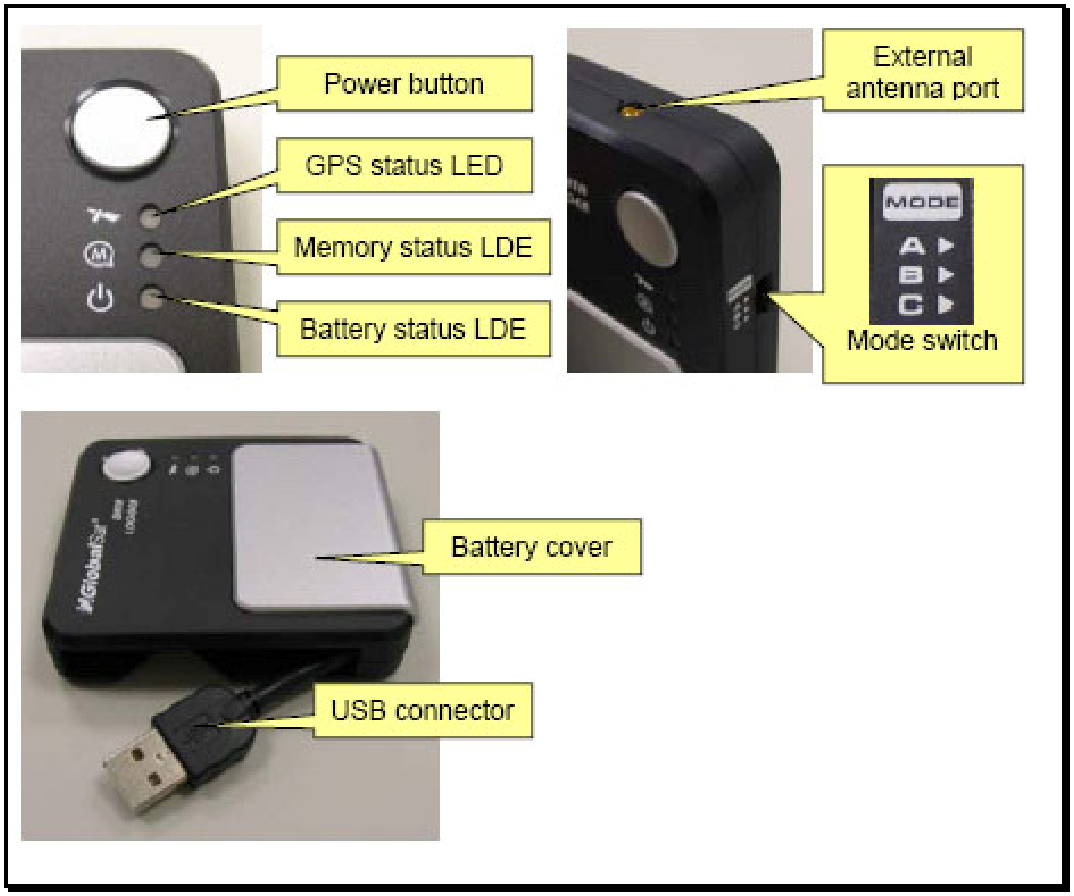
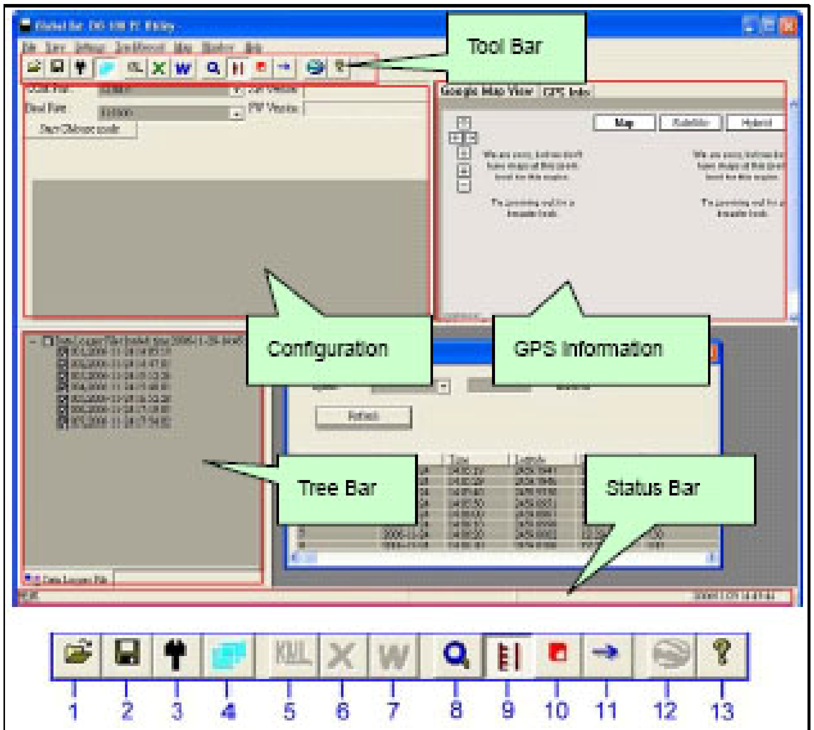


Figure 1.4 GlobalSat Unit

The unit requires two AA size batteries, either rechargeable NiMh or disposable. To recharge the NiMh batteries, the unit can be charged by plugging the USB cable into a computer or a USB converter. The charging time is about 7 hours. The LED battery status is solid red when the power is on. The LED flashes red when the battery is low. The LED is amber during recharging. Depending on the deployment plan and the needs of the deployment team, the survey participant could receive the GlobalSat unit with disposable batteries already loaded, or they could be responsible for replacing batteries or recharging batteries. The survey participant will be required to turn on the unit using the ON/OFF button and wait for the unit to lock on to a “fix” satellites signal (see Appendix II).

Accompanying Software

The deployment team will need to use the CD provided with the unit that contains an installation program. It is designed to start automatically when the CD in inserted in the computer. If the installation does not start, the user must double-click the “auto.exe” file. The deployment team will be required to click on the “Install USB Driver” button. When the GlobalSat is first connected, it is necessary to check the COM port by looking in the Device Manager.



1	Open a training file.	8	The Configuration for GPS device.
2	Save training information to a file.	9	Metric system.
3	Preference	10	Delete records.
4	Select all files.	11	Load Track Points.
5	Export training information to the KML format.	12	Export to Google Earth.
6	Export to CSV file.	13	Display program information, version number and copyright.
7	Export to the text file.		

Figure 1.5 Download Window for the GlobalSat

Figure 1.5 illustrates the functions available in the software interface provided for the GlobalSat unit. The data can be exported as a CSV file, a text file, or to Google Earth. Table 1.2 displays the data fields from the GlobalSat.

Table 1.2 Data Fields Available from the GlobalSat Unit

Record No.	Date	Time	Latitude	Longitude	Speed(km/hour)	Altitude(meter)
1	8/12/2007	15:01:31	4045.694	-7358.75	0.5	
2	8/12/2007	15:01:41	4045.688	-7358.75	1.1	
3	8/12/2007	15:01:51	4045.681	-7358.76	2.7	
4	8/12/2007	15:02:01	4045.678	-7358.76	1.9	
5	8/12/2007	15:02:11	4045.671	-7358.78	1.7	
6	8/12/2007	15:02:21	4045.673	-7358.78	1	
7	8/12/2007	15:02:31	4045.679	-7358.77	4.4	
8	8/12/2007	15:02:41	4045.682	-7358.77	0.5	
9	8/12/2007	15:02:53	4045.679	-7358.77	2.8	
10	8/12/2007	15:03:03	4045.679	-7358.77	1.2	
11	8/12/2007	15:03:13	4045.679	-7358.77	1.9	
12	8/12/2007	15:03:23	4045.681	-7358.77	1.9	
13	8/12/2007	15:03:33	4045.68	-7358.77	1.6	
14	8/12/2007	15:03:43	4045.677	-7358.78	0.8	

GPS Unit Comparison

The research team used the following evaluation factors: data accuracy and reliability; unit weight; ease of use; respondent burden; cost; and public response to using a GPS unit. These factors provide the foundation for moving forward with the GPS pilot experiments. 'Data Accuracy' measures the precision of the data generated by the GPS unit and includes: time, speed, and longitude and latitude. 'Reliability' examines the range of accuracy under a variety of circumstances. Table 1.3 compares the features and functionalities of the two GPS units. The unit weight; ease of use; respondent burden; and cost are compared in section two of this report.

In summary, the units are very comparable with respect to the manufacturer's specifications. The next step is to determine any differences revealed during field condition testing.

Table 1.3 Comparison of GPS unit features and functionalities

		i-Blue	**Global Sat (DG-100)**
Electrical Characteristics	GPS Chipset	MTK	SiRF Start III
	Frequency	L1, 1575.42 MHz	L1, 1575.42 MHz
	C/A Code	1.023 MHz	1.023 MHz chip rate
	Channels	32 channels	2-channel all-in-view tracking
Accuracy	Position Horizontal	3.0 meters, 2DRMS	10 meters, 2D RMS
	Velocity	0.1 m/sec.	0.1m/sec.
DATUM		N/A	Default: WGS-84
Acquisition Rate	Hot start	1 sec.	1 sec.
	Warm start	33 sec.	38 sec.
	Cold start	36 sec.	42 sec.
	Reacquisition	N/A	0.1 sec.
Protocol	GPS Protocol	NMEA 0183	NMEA 0183
	GPS Output Format	GGS (1sec.), GSA (1sec.), GSV (5sec.), RMC (1sec.) GLL, VTG optional	GGS (1sec.), GSA (1sec.), GSV (5sec.), RMC (1sec.) GLL, VTG optional
Dynamic Condition	Acceleration Limit	4g max.	Less than 4g
	Altitude Limit	18,000 meters max.	18,000 meters (60,000 feet) max.
	Velocity Limit	515 meters/sec. max.	515 meters/sec. (1,000 knots) max.
	Jerk Limit	N/A	20 m/sec.**3

Section Two: Field Tests

Field Test One: Walking in Midtown and Downtown

Field Test One: Description

To test how urban canyons in Manhattan may affect the accuracy of person-based GPS, we conducted a walking test in Midtown and Downtown. A Midtown and a Downtown path (see Figure 2.1) were selected to include many tall buildings and narrow streets along the paths. Five students at Hunter College were hired to walk the Midtown and Downtown paths six times each during the weekend of August 11 and 12, 2007, a total sample of 30 times for each path. Each student carried two GPS units, i-Blue 747 and GlobalSat DG-100GPS[7], which were set to record locations every 10 seconds. Students were instructed (see Appendix II for instructions) to turn on the GPS units when they left their residence and turn them off when they returned to their residence. When the field test was done, they turned in the two GPS units; a data sheet and a report (see Appendix III).

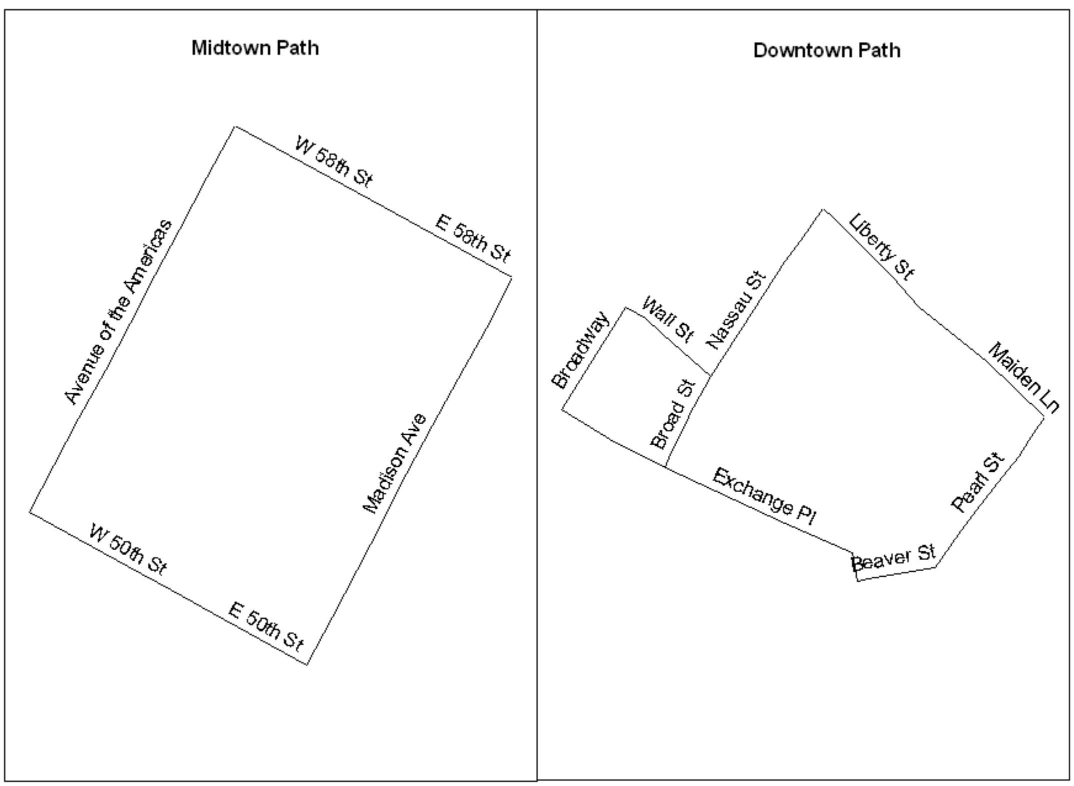


Figure 2.1 Paths of Midtown and Downtown Walks by Five Hunter Students

[7] The i-Blue 747 and GlobalSat DG-100GPS have "GPS logger" and "GlobalSat" printed on the front respectively and therefore were called GPS logger and GlobalSat in the instructions to students.

Field Test One: Details

Their travel data were downloaded from the GPS units in .kml and .csv formats and were brought into Google Earth and ArcGIS. Figure 2.2 shows one of the walks in Google Earth (see Appendix III Student #4 for their travel report), while Figure 2.3 shows another in ArcGIS (see Appendix III Student #3 for their travel report). Except for the parts of subway travel that were underground, the GPS units captured their travel paths well, whether walking, on a bus, crossing a bridge, or on an above-ground subway train. The Midtown and Downtown walks, because of tall buildings and/or narrow streets, were less accurate compared to the rest of the trip data. They were extracted out for further analyses.

Figure 2.2 One of the Walks by Hunter College Students, shown in Google Earth

Two methods were used to measure the accuracy of the GPS data for the Midtown and Downtown walks. One is to buffer the streets in 25-meter intervals in ArcGIS and count the signal points falling within each buffer (see Table 2.1). A higher percentage of signal points falling within the first buffer (<25-meter) or second buffer (25- to 50-meter) indicates more accuracy, while a higher percentage of signal points beyond the buffers indicates less accuracy. Another method is to calculate the shortest distance between each signal point and the streets, representing the deviation of the signal point away from the actual street, and then take an average distance for all the signal points in a walk (see Table 2.2). A shorter average distance indicates better accuracy.

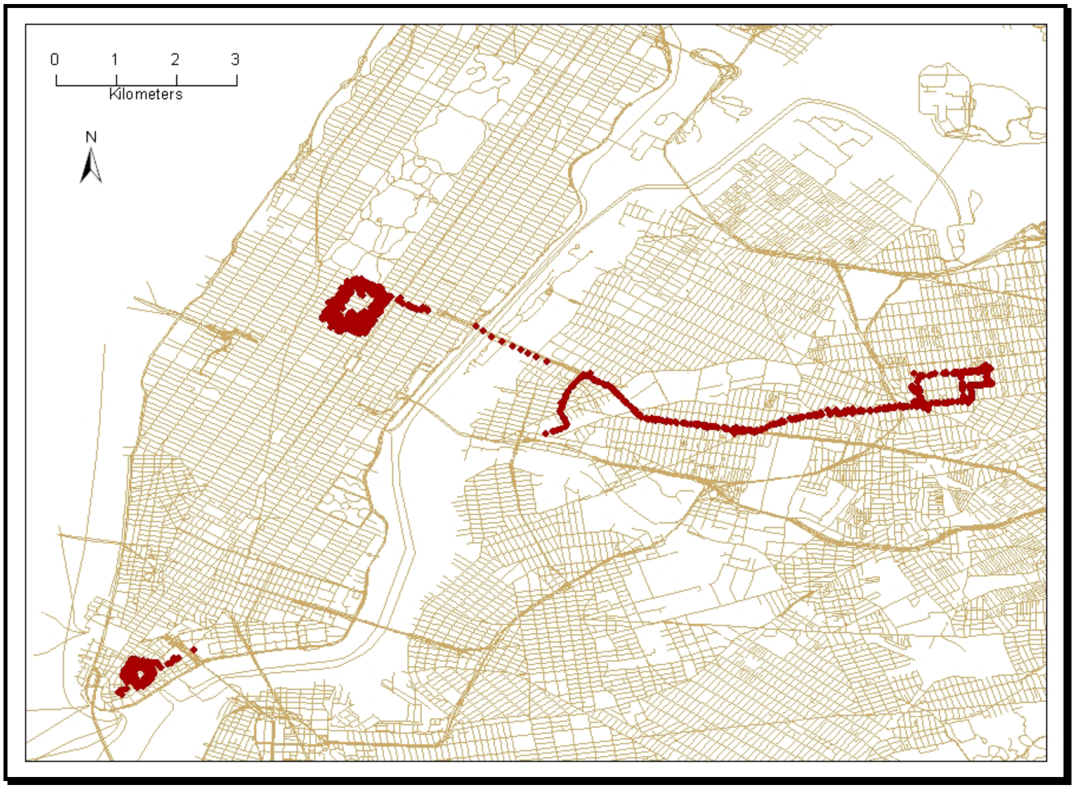


Figure 2.3 One of the Walks by Hunter College Students, shown in ArcGIS

Table 2.1 shows that the i-Blue GPS units recorded many more signal points than the GlobalSat GPS units. This is consistent with students' report that the i-Blue units were more sensitive and blinked more, indicating signal reception, than the GlobalSat units during the walking test. The GlobalSat units did not record locations when it was stationary. There were no records in the data output with the speed of zero. Additionally, GlobalSat did not record locations when data quality was below certain criteria, although it is not clear what criteria were used. The i-Blue units recorded signals every 10 seconds, even though the GPS units did not get a satellite fix on the location or there was a poor signal. However, i-Blue provides many variables to choose in the data output, so analysts have the option of removing signal points of low quality, however the analysts choose to define data quality. In the results reported in Tables 2.1 and 2.2, signal points have been removed when the variable VALID has a value of "no fix", number of satellites used in calculating the location was less than 3, and the variable HDOP[8] has a value of 99.99 or above. Using more restrictive criteria could substantially reduce the number of signal points from i-Blue and increase the accuracy of the output data.

Field Test One: Analysis

In terms of accuracy, higher percentages of the signal points from GlobalSat, both in Midtown and Downtown, fall within the 0-25 meter and 25-50 meter buffers than those from i-Blue (Table 2.1). This indicates that GlobalSat had better accuracy than i-Blue. However, it is mostly likely due to the fact that there is 30% to 50% more signal points from the i-Blue units than the GlobalSat units. I-Blue allows the analysts to apply their own criteria in selecting the signal points as final results, while GlobalSat does not provide this flexibility.

Table 2.2 shows that on average, the locations recorded in the i-Blue units were closer to the Midtown streets (indicating better accuracy) than the GlobalSat units. The t-test of the means for i-Blue and GlobalSat is significant at the 0.1 level (two-tailed significance of 0.089 in Table 2.3). For Downtown walks, however, the i-Blue units were farther away from Downtown streets (indicating less accuracy) than the GlobalSat units, with the t-test significant at the 0.01 level (Table 2.4). When both Midtown and Downtown walks are combined, the average deviation for i-Blue (46.009 meters in Table 2.5) is slightly better than that of GlobalSat (46.350 meters), but the t-test shows that the difference is not significant (two-tailed significance of 0.899 in Table 2.5). The result of comparing the accuracies of i-Blue and GlobalSat is therefore inconclusive. Standard deviation and the maximum distance, however, were smaller for i-Blue than GlobalSat in both Midtown and Downtown (Table 2.3), indicating that the data from i-Blue were more consistent and accurate than the data from GlobalSat.

In addition to the 30 runs of Midtown and Downtown walks by students from Hunter College, a student from City College also conducted a Midtown and a Downtown walk, once, following a slightly different paths (see Figure 2.4). Two i-Blue 747 units, set to record locations every second, and two GlobalSat DG-100GPS units, one set at one second and another at 10 second time intervals, were used in the test (see Appendix III Student #6 for this report). Figure 2.5 shows the signal points collected for the Midtown walk and Figure 2.6 for the Downtown walk.

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[8] HDOP stands for horizontal dilution of precision, an index to describe how the satellites are arranged in the sky at the time a signal point was recorded. A high value indicates poor quality of data.

Table 2.1 Number of GPS Signal Points in Each Buffer

	Buffer (meter)					
	0-25	26-50	51-75	76-100	> 100	Total
i-Blue						
Midtown total	2840	1838	1063	608	486	6835
Midtown %	41.55	26.89	15.55	8.90	7.11	100.00
Downtown total	1688	1058	655	347	315	4063
Downtown %	41.55	26.04	16.12	8.54	7.75	100.00
i-Blue total	4528	2897	1718	956	801	10900
i-Blue %	41.54	26.70	15.68	8.82	7.26	100.00
GlobalSat						
Midtown total	1892	1337	617	257	252	4355
Midtown %	43.45	30.68	14.17	5.90	5.79	100.00
Downtown total	1187	547	248	100	122	2204
Downtown %	53.88	24.78	11.26	4.54	5.54	100.00
GlobalSat total	3079	1884	865	357	374	6559
GlobalSat %	45.53	29.52	13.58	5.63	5.74	100.00

Table 2. 2 Deviation of the recorded locations

Distance (meter)	i-Blue 747		GlobalSat	
	Midtown	Downtown	Midtown	Downtown
Mean	42.58	51.78	49.26	40.60
Count	6835	4063	4354	2203
Sum	291034.60	210374.56	214475.23	89441.26
Minimum	0.00	0.01	0.00	0.01
Maximum	1592.43	2420.10	15973.10	3488.74
Standard Deviation	48.73	90.17	318.70	100.71

Figure 2.4 Paths of Midtown and Downtown Walks by One City College Student

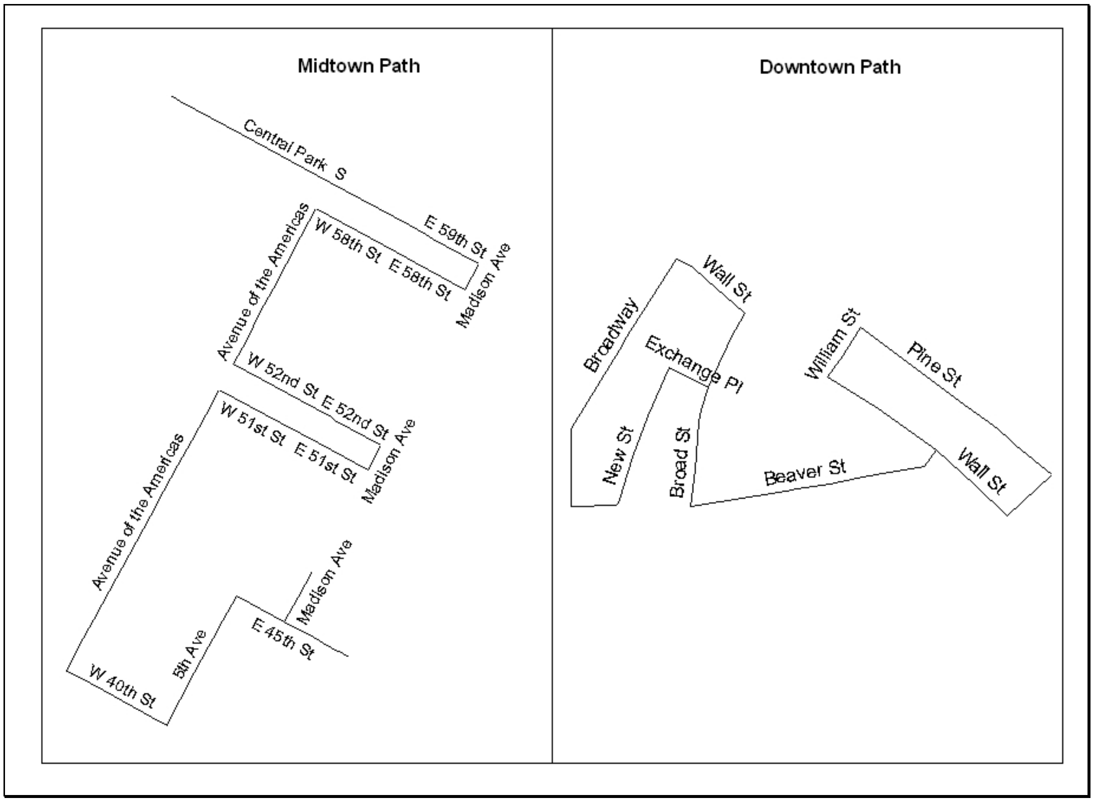


Table 2.3 T-test on the deviation of the Midtown walks between i-Blue and GlobalSat

	Mean	Levene's Test for Equality of Variances		t-test of Equality of Means Assuming Equal Variances		
i-Blue	42.580	F	Sig.	t	df	Sig. (2-tailed)
GlobalSat	49.259	7.864	0.005	-1.702	11187	0.089

Table 2.4 T-test on the deviation of the Downtown walks between i-Blue and GlobalSat

	Mean	Levene's Test for Equality of Variances		t-test of Equality of Means Assuming Equal Variances		
i-Blue	51.778	F	Sig.	t	df	Sig. (2-tailed)
GlobalSat	40.600	10.775	0.001	4.493	6264	0.000

Figure 2.5 Locations Recorded by four GPS units in the Midtown Walk by City College Student

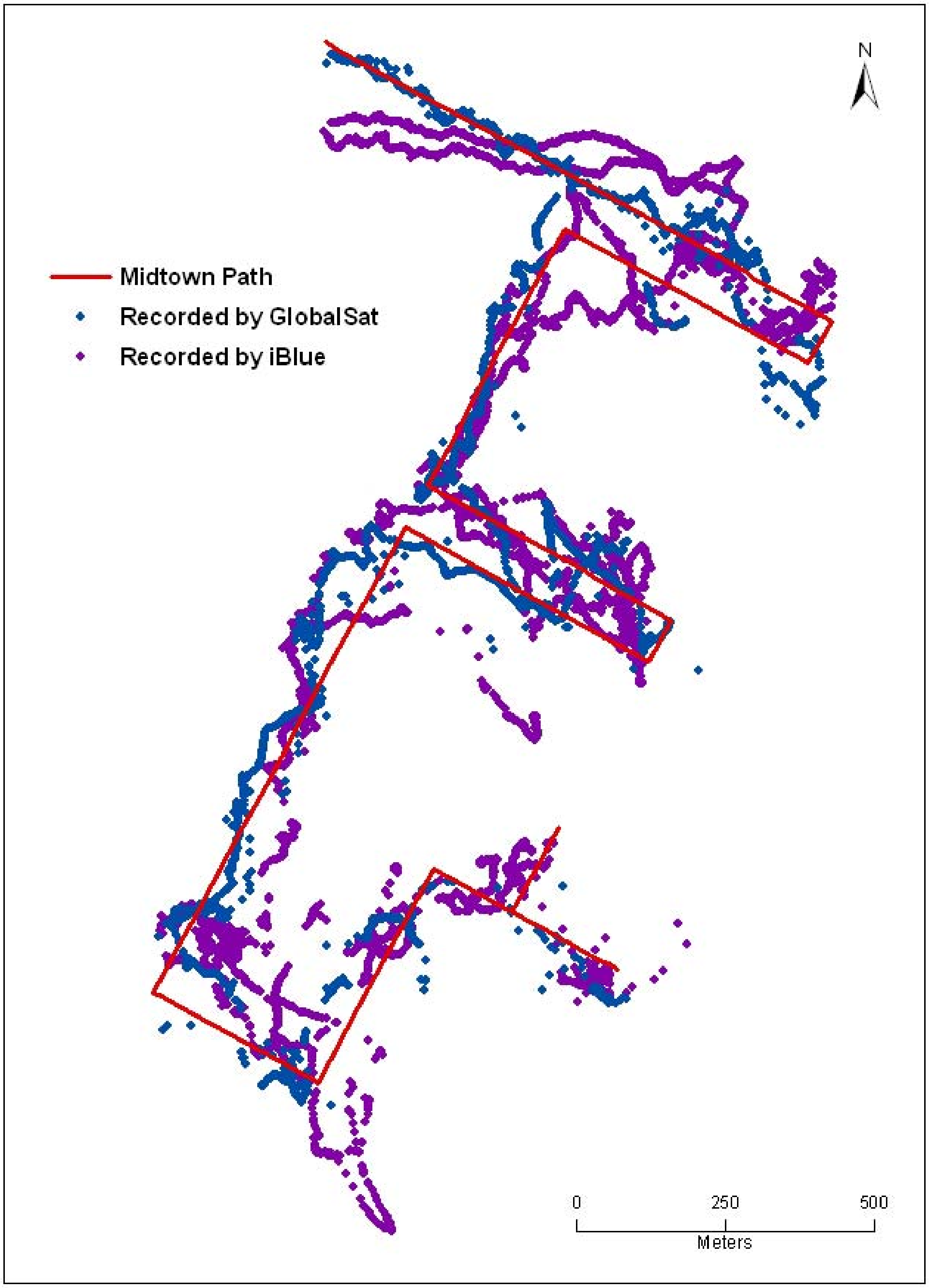


Figure 2.6 Locations Recorded by Four GPS Units in the Downtown Walk by City College Student

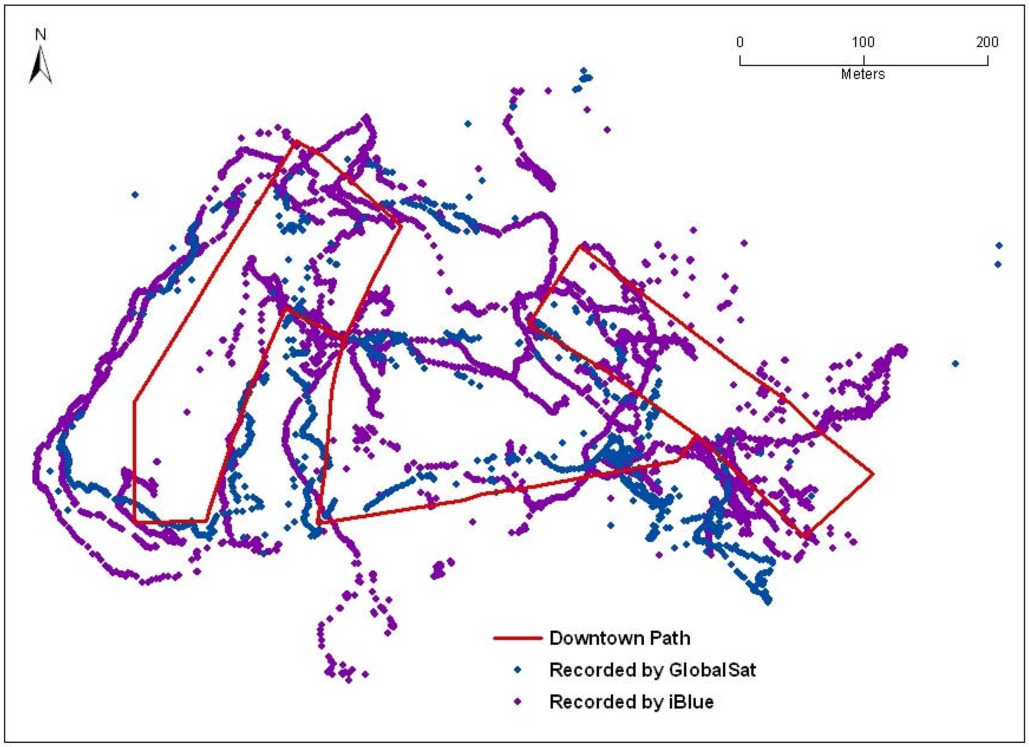


Table 2.5 T-test on the deviation of Midtown /Downtown Walks between i-Blue & GlobalSat

	Mean	Levene's Test for Equality of Variances		t-test of Equality of Means Assuming Equal Variances		
i-Blue	46.009	F	Sig.	t	df	Sig. (2-tailed)
GlobalSat	46.350	2.926	0.087	-0.127	17453	0.899

Table 2.6 Number of Signal Points in Each Buffer for the Single Walk

	Buffer (meter)					
	0-25	26-50	51-75	76-100	> 100	Total
i-Blue						
Midtown total	2960	1964	1060	949	591	7524
Midtown %	39.34	26.10	14.09	12.61	7.85	100.00
Downtown total	2571	1247	354	113	31	4316
Downtown %	59.57	28.89	8.20	2.62	0.72	100.00
i-Blue total	5531	3211	1414	1062	622	11840
i-Blue %	46.71	27.12	11.94	8.97	5.25	100.00
GlobalSat						
Midtown total	1534	835	259	101	3	2732
Midtown %	56.15	30.56	9.48	3.70	0.11	100.00
Downtown total	681	304	154	3	14	1156
Downtown %	58.91	26.30	13.32	0.26	1.21	100.00
GlobalSat total	2215	1139	413	104	17	3888
GlobalSat %	56.97	29.30	10.62	2.67	0.44	100.00

Table 2.7 Deviation of the Recorded Locations for the Single Walk

Distance (meter)	i-Blue 747		GlobalSat	
	Midtown	Downtown	Midtown	Downtown
Mean	45.41	24.71	26.05	25.86
Count	7524	4316	2732	1156
Sum	341675.94	106633.43	71169.72	29892.74
Minimum	0.01	0.00	0.00	0.00
Maximum	276.78	135.53	106.78	207.00
Standard Deviation	40.30	21.08	20.71	22.36

According to Table 2.6, the i-Blue units have less accuracy in the Midtown run and better accuracy in the Downtown run than the GlobalSat units. When comparing both the Midtown and Downtown runs together, the GlobalSat units have better accuracy. For the average distance deviated from the streets and the standard deviation in Table 2.7, the results are quite similar. The i-Blue units have less accuracy in the Midtown run (two-tailed significance of 0.000 in Table 2.8). The i-Blue has better accuracy in the Downtown run than the GlobalSat units, but the difference is not significant (two-tailed significance of 0.116 in Table 2.9). For both Midtown and Downtown walks combined, GlobalSat is significantly more accurate than i-Blue (two-tailed significance of 0.000 in Table 2.10).

Table 2.8 T-test on the deviation of the Single Midtown walk between i-Blue and GlobalSat

	Mean	Levene's Test for Equality of Variances		t-test of Equality of Means Assuming Equal Variances		
i-Blue	45.411	F	Sig.	t	df	Sig. (2-tailed)
GlobalSat	26.050	664.089	0.000	23.982	10254	0.000

Table 2.9 T-test on the deviation of Single Downtown walks between i-Blue and GlobalSat

	Mean	Levene's Test for Equality of Variances		t-test of Equality of Means Assuming Equal Variances		
i-Blue	24.707	F	Sig.	t	df	Sig. (2-tailed)
GlobalSat	25.859	1.303	0.254	-1.574	1743.805	0.116

Table 2.10 T-test on the deviation of Single Midtown /Downtown Walks between i-Blue & GlobalSat

	Mean	Levene's Test for Equality of Variances		t-test of Equality of Means Assuming Equal Variances		
i-Blue	37.864	F	Sig.	t	df	Sig. (2-tailed)
GlobalSat	25.993	534.568	0.000	19.494	15726	0.000

In summary, the urban canyon effect is obvious in the walking test. While the manuals of both types of GPS units claim an accuracy of 10 meters, our test results show that most of the recorded locations are 25 meters or farther away from the streets in the selected Midtown and Downtown paths. For analyses and modeling that require accurate location information, urban canyon effect in some areas of Manhattan will place a limit.

However, if the Traffic Analysis Zone (TAZ) is the unit for analyses and modeling, urban canyon effect would not be much problem. Table 2-11 lists information about the distance among TAZs in Manhattan. The average distance among centroids of TAZs in Manhattan is about 248 meters, much longer than the average deviations (ranging from 24.71 to 51.78 meters) listed in Tables 2.2 and 2.7. All centroid connectors in Manhattan, a total of 1023, were used in the calculation.

Table 2-11 Distance among TAZs in Manhattan

	Distance
Minimum	1.78 meter
Maximum	1827.23 meter
Mean	247.76 meter
Standard Deviation	150.64

Source: NYMTC's Best Practice Model.

Table 2.12 lists the number of signal points that falls within the same TAZ as the closest street segments, in the TAZs next to the closest street segments, and in the rest of the TAZs for the Midtown and Downtown walks by the five Hunter College students. Most of the signal points fall within the same TAZs, 83.13% for i-Blue and 85.96% for GlobalSat. These are also the accuracy for i-Blue and GlobalSat if TAZs are used as the unit for analyses and modeling. The rest of the signal points (16.34% for i-Blue and 13.51% for GlobalSat) almost all fall in the neighboring TAZs. Only 0.53% of the signal points fall in neither the same TAZs nor the neighboring TAZs.

Table 2.12. Number of GPS signal points in TAZs for the walks by Hunter College students

	Within Same TAZ	Neighboring TAZs	Rest TAZs	Total
i-Blue				
Midtown total	5780	1043	12	6835
Midtown %	84.56	15.26	0.18	100.00
Downtown total	3279	738	46	4063
Downtown %	80.70	18.17	1.13	100.00
i-Blue total	9059	1781	58	10898
i-Blue %	83.13	16.34	0.53	100.00
GlobalSat				
Midtown total	3758	575	21	4354
Midtown %	86.31	13.21	0.48	100.00
Downtown total	1878	311	14	2203
Downtown %	85.25	14.12	0.63	100.00
GlobalSat total	5636	886	35	6557
GlobalSat %	85.96	13.51	0.53	100.00

Comparing all tables, there is no clear conclusion regarding which of the two kinds of GPS units has better accuracy; keeping in mind that Tables 2.1 and 2.2 are the results of 10 GPS units for 30 runs while Tables 2.6 and 2.7 are the results of 4 GPS units for a single run. However, i-Blue consistently recorded more signal points, everything else being equal, than GlobalSat. I-Blue also provides flexibility in the software to process the output data and has the potential to improve accuracy by removing signal points of poor quality.

The largest difference is the format of the data output – where the i-Blue provides more variables for additional analysis as indicated by comparing Table 1.1 and 1.2. Specifically, the i-Blue includes variables *Heading*, *HDOP* and the *NSAT* (used/view) elements. These additional variables provide a higher quality of data for understanding the location of the individual and the electronic infrastructure responsible for recording this location.

Person-based GPS units: weight

'Weight' consists of the sum of the loads between the GPS receiver and any other accessories that are required to be carried when traveling. Both GPS units are small and can be carried in a pocket or a purse. The i-Blue is the smaller of the two, however. It also has the ability to sit on a dashboard without slipping. There appears to be no weight burden associated with either of these GPS units. In addition, people are now carrying cell phones, PDAs, and other devices of similar size on a day basis. That said, having to carry an additional device to one's cell phone could be considered bothersome.

Ease of Use/Respondent Burden

'Ease of Use' and 'Respondent Burden' assesses the usability of the person-based GPS unit. 'Ease of Use' indicates how user-friendly the GPS unit is, while 'Respondent Burden' indicates the level of involvement the GPS unit places on a participant of a travel survey. Several dimensions were considered in measuring these criteria including the skills-level required by a participant to operate a computer and the GPS technology and the amount of time and the number of tasks required to report a trip.

As the instructions for use indicate (see Appendix II), the i-Blue requires the user to switch the Mode Switch from "OFF" to "LOG", while the GlobalSat requires pressing the silver button until the red power light and the green status light are steady. Both units require the user to pay attention to the brief period of time required for the GPS units to begin receiving a signal. It is unclear whether the general public is willing to wait for the units to work. The amount of time can vary depending on the available satellite coverage in the sky. This technical issue may require training the general public on how to use the equipment.

During the field tests, both pieces of equipment revealed problems. Student # 4 (see Appendix III) reported the ease of accidentally turning off the GlobalSat unit by pressing the silver on button. Student # 5 (see Appendix III) reported the battery cover popping off during the field test. There were also several reports of the switch on the i-Blue unit breaking while being used. These are serious design issues for both units. There is a risk of no data being collected due to an accidental pushing of the GlobalSat power button and the breaking of the switch to log data on the i-Blue.

Costs

There are several costs associated with including a GPS component to a travel surveying deployment including the asset costs associated with the units themselves and then the cost of operating the logistics of equipment distribution. The retail prices for the i-Blue and the GlobalSat are approximately $70 and $85, respectively. As with other electronic devices, the prices can be expected to decline over time. At this time, there is not a significant difference between these two units. Both units would require the same treatment with respect to the second set of costs associated with survey deployment. If the population participating in the survey requires special instruction to operate the equipment properly, the cost associated with unit distribution, training, and retrieval could be substantial. If, on the other hand, the equipment can be mailed out (e.g., similar to NetFlix); survey participants can understand the instructions and successfully operate the equipment; and be trusted and "encouraged" to return the equipment in a self-addressed envelope, the costs would be lower. Thus, it will be imperative to determine the ability of potential survey participants and the type of deployment required to guarantee a successful data collection effort for that population.

When the controlled experiment was conducted, the students all received written instructions and were given training. Further research will be needed to determine any differences in performance between individuals who receive training or those who rely completely on their own ability to read and follow instructions to calculate realistic deployment costs.

Public Response

The students participating in the controlled experiment did provide some feedback on their response to the units, but not the overall concept of being asked to carry the device. To determine public willingness to use a GPS may require a focus group strategy, where individuals are introduced to the device and a description of the experience. Comments, objections, and statements made by the focus group participants would inform to future use of the device with similar populations. The point of this exercise is to determine objections and provide mitigation strategies to encourage participation in a GPS deployment. Another approach would use only volunteers for the deployment, rather than attempting to use a random sample. Although using volunteers could result in some bias in the data, it would be possible to compare potential difference between those who did and those who did not volunteer to adjust the data. The issues surrounding public willingness to participate in a GPS deployment will require further investigation as this aspect of any survey effort could impact the costs and success of the survey effort in general.

Conclusion

The results of the controlled experiment are encouraging with respect to the feasibility of using GPS in future travel surveying efforts. As noted, the urban canyon effect can be detected, but may not pose a serious problem depending on the exact use of the data. It should also be clear that the i-Blue unit produces the preferred array of data fields, which will allow for the greatest data quality review and improvement of the recorded data quality using filtering techniques.

Section Three: Analysis of 1997 Data

Introduction

In this section, results of the analysis on the 1997/98 Regional Travel Household Interview Survey data are reported. The objective of this set of analyses is to identify special population segments that deem special attention in future surveys.

The files used in this assessment include the following:

Users' Guide:

- RT-HIS Regional Travel – Household Interview Survey: Data Users' Manual, Prepared by Nustats International and Parsons Brinckerhoff Quade & Douglas Inc. February 2000.

Data files:

- Audit: a file documenting interim data cleaning steps.
- Plac0831: a trip place file for each surveyed member in the household. Each record in the file is a location. The first and the last location is often home. The number of locations for each person is one more than the number of trips made by the surveyed person. For example, a daily trip pattern from home to work and then back to home will be recorded having three locations: home, work, and home.
- Hh0831: a household file for each surveyed household.
- Per0831: a person file for each surveyed person in the household.

Transit User: a respondent in a survey is defined as a transit user if he or she has taken at least one of the following modes on the survey day: standard local bus, school bus, commuter van/shuttle bus/employer bus/group contract (no fare paid), commuter van or jitney (fare paid), express bus, charter bus, airport line, Amtrak/greyhound/airline, subway, path, Newark city subway, ferry, and commuter rail.

Role of Proxy

A substantial number of transit records had to be "updated" before they could be analyzed or used for modeling purposes. These updates were based on the assumption that the original survey participant inaccurately reported their travel. The updated transit trips were flagged in the data set. Determining the source of these "mis-reported" trips is a primary focus of this research. Because proxies (people who report the trip diaries for their household members) play an important role in the survey, it potentially raises an important question for a transit user: are the records reported by a proxy more likely to be updated than those self-reported? To answer this question, we selected all transit users, or 5,710 respondents in the survey. The number of proxies that one household has can be 0, 1, 2, or 3. Almost seventy eight percent of the transit users (4,427 out of 5,710) have only one proxy for the household. We only present the information for this group in the main text. Tables of the other three groups are presented in Appendix IV, Tables 1, 2, and 3.

Table 3.1 Number of Proxy and Non-Proxy Transit Users Whose Records are Updated or Not during Update Pass 1 (when the number of proxies = 1)

	Not a proxy		Proxy		Total
	Freq.	%	Freq.	%	
Not updated during pass 1	354	14.6	2065	85.4	2419
Updated during pass 1	788	39.2	1220	60.8	2008
Total	1142		3285		4427

Transit records are updated during two passes. These two passes are highly correlated. In other words, a record that was updated during pass 1 is highly likely to be also updated during pass 2. Table 1 presents the percentage of respondents whose records are (not) updated during pass 1 for those reported by themselves and by a proxy. The numbers in Table 1 suggest that for those people whose records were not updated, 15% of them were not reported by a proxy and 85% of them were reported by a proxy; for those people whose records were updated, 39% of them were not reported by a proxy and 61% of them were reported by a proxy. These numbers rejected our hypothesis. On the contrary, they tend to suggest that transit records reported by a proxy tend to be of better quality than those not reported by a proxy. The User's Guide lacks sufficient details in specifying the kinds of transit problems discovered during the data cleaning process and the types of updating actions taken for each uncovered problem during their two sequential transit record updating processes. The lack of details prohibits us from probing further to explain the numbers in Table 3.1.

Characteristics of the Transit-flagged Respondents vs. Non-transit-flagged Respondents

Here, we compare the characteristics of two transit groups, those without flags on their transit records and the other are those with flags. Those cases with transit flags incorrectly reported their transit trip. A potential use of the GPS device is to help such individuals more accurately record their travel, thus avoiding the expense and time-consuming steps of reviewing and correcting their original mis-reported transit trip. The following series of analyses are intended to help identify this special segment of the transit population. For variables including age, total number of vehicles, household size, and number of workdays in a week, means are statistically evaluated to determine whether there exists a significant difference between the two groups. For other categorical variables, frequencies are examined and chi-square tests are conducted to determine whether the distribution of one group significantly differs from the other group. More specifically in the columns for categorical variables, two pieces of information are shown, including observed frequency and column percentage.

Table 3. 2 Age, Number of Vehicles, Household Size, and Number of Workdays between Transit-flagged and Non-transit-flagged Groups

Variables	Non Transit flagged		Transit flagged		t-test result (α=0.05)
	Mean	N	Mean	N	
Age	21.75	2,789	37.16	2,738	Significant
Household size	3.82	2,851	2.62	2,859	Significant
Number of vehicles	1.7	2,851	0.86	2,859	Significant
Number of workdays	4.65	709	4.78	2,068	Marginally significant

Table 3.2 shows the mean values of age, number of vehicles, household size, and number of workdays between transit-flagged and non-transit-flagged groups and the corresponding t-test results. All are significant at 5% significance level. Compared with the transit-flagged group, the non-transit-flagged group is younger, have larger household size, and more household vehicles.

Table 3.3 Gender Distribution for Transit-flagged and Non-transit-flagged Groups

Gender	Non transit flagged		Transit flagged	
	Freq	%	Freq	%
Male	1399	49.1	1473	51.5
Female	1448	50.8	1407	48.4

Chi-square test: **non-significant**

Table 3.3 shows the gender distribution between transit-flagged and non-transit-flagged groups. The difference between the two groups is not significant.

Table3.4 Income Distribution for Transit-flagged and Non-transit-flagged Groups

Income	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
<$10k	79	3.5	102	4.5
$10k - < $15k	93	4.1	130	5.8
$15k - < $25k	164	7.3	162	7.2
$25k - < $35k	262	11.7	219	9.7
$35k - < $50k	298	13.3	378	16.8
$50k - < $75k	589	26.3	508	22.6
$75k - < $100k	374	16.7	328	14.6
$100k - < $125k	176	7.8	151	6.7
$125k - < $150k	67	3.0	85	3.8
$150k+	133	5.9	176	7.8

Table 3.4 shows the income distributions of transit-flagged and non-transit-flagged groups. Over 20% of the cells are missing,[9] therefore, statistical test results are not reported here. Despite this, the distributions in Table 3.4 still suggest a difference in the income distribution between the two groups. There seems to be more transit-flagged households with income levels under $15k, between $35k and $50k, and greater than $125k, and fewer of them in ranges between 25k and $35k and between $50k and $125k.

[9] The missing cell refers to those cells that have no value. SAS will execute the analysis and thus the result may not be reliable. Because of the concern of the reliability issue, we do not report the chi-square test results for those variables with 20% or more missing cells.

Table 3.5 County Distribution for Transit-flagged and Non-transit-flagged Groups

County fipscode	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
9001 (Fairfield)	70	2.4	25	0.8
9009 (New Haven)	30	1.0	1	0.0
34003 (Bergen)	79	2.7	84	2.9
34013 (Essex)	115	4.0	65	2.2
34017 (Hudson)	120	4.2	183	6.4
34019 (Hunterdon)	80	2.8	11	0.3
34021 (Mercer)	96	3.3	26	0.9
34023 (Middlesex)	90	3.1	45	1.5
34025 (Monmouth)	139	4.8	38	1.3
34027 (Morris)	68	2.3	20	0.7
34029 (Ocean)	86	3.0	2	0.0
34031 (Passaic)	40	1.4	16	0.5
34035 (Somerset)	66	2.3	7	0.2
34037 (Sussex)	109	3.8	6	0.2
34039 (Union)	42	1.4	26	0.9
34041 (Warren)	71	2.4	6	0.2
36005 (Bronx)	91	3.1	156	5.4
36027 (Dutchess)	86	3.0	8	0.2
36047 (Kings)	156	5.4	346	12.1
36059 (Nassau)	85	2.9	67	2.3
36061 (New York)	222	7.8	1198	41.9
36071 (Orange)	119	4.1	7	0.2
36079 (Putnam)	91	3.1	24	0.8
36081 (Queens)	66	2.3	172	6.0
36085 (Richmond)	275	9.6	233	8.1
36087 (Rockland)	115	4.0	6	0.2
36103 (Suffolk)	145	5.0	25	0.8
36119 (Westchester)	99	3.4	56	1.9

Chi-square test: **significant**

Table 3.5 shows the county distributions of transit-flagged and non-transit-flagged groups. The chi-square test suggests that the distributions of the two groups are significantly different. Or, there appears to be a connection between the probability of being transit-flagged and his or her county residence. For example, a Manhattan resident appears to be most likely transit-flagged, followed by Kings (Brooklyn) county, Queens, Bronx, and Hudson county in New Jersey. These areas are all transit-intensive, which may result in recording complexities for a survey company located outside of the area.

Map 3.1 reinforces the above findings. The map displays a county distribution of a set of ratios, obtained by dividing the percentages of transit-flagged respondents (transit users whose records were updated during pass 1 or pass 2) in each county by those non-transit-flagged transit respondents (whose records were not updated during pass 1 or pass 2). The darker the color is on the map, the more transit record updated users the corresponding county. The map shows that the New York City area, especially Manhattan, is concentrated with transit users with corrected records.

Map 3.1 County Distribution of the Percentages of Transit-flagged People Divided by the Percentages of Non-transit-flagged Groups

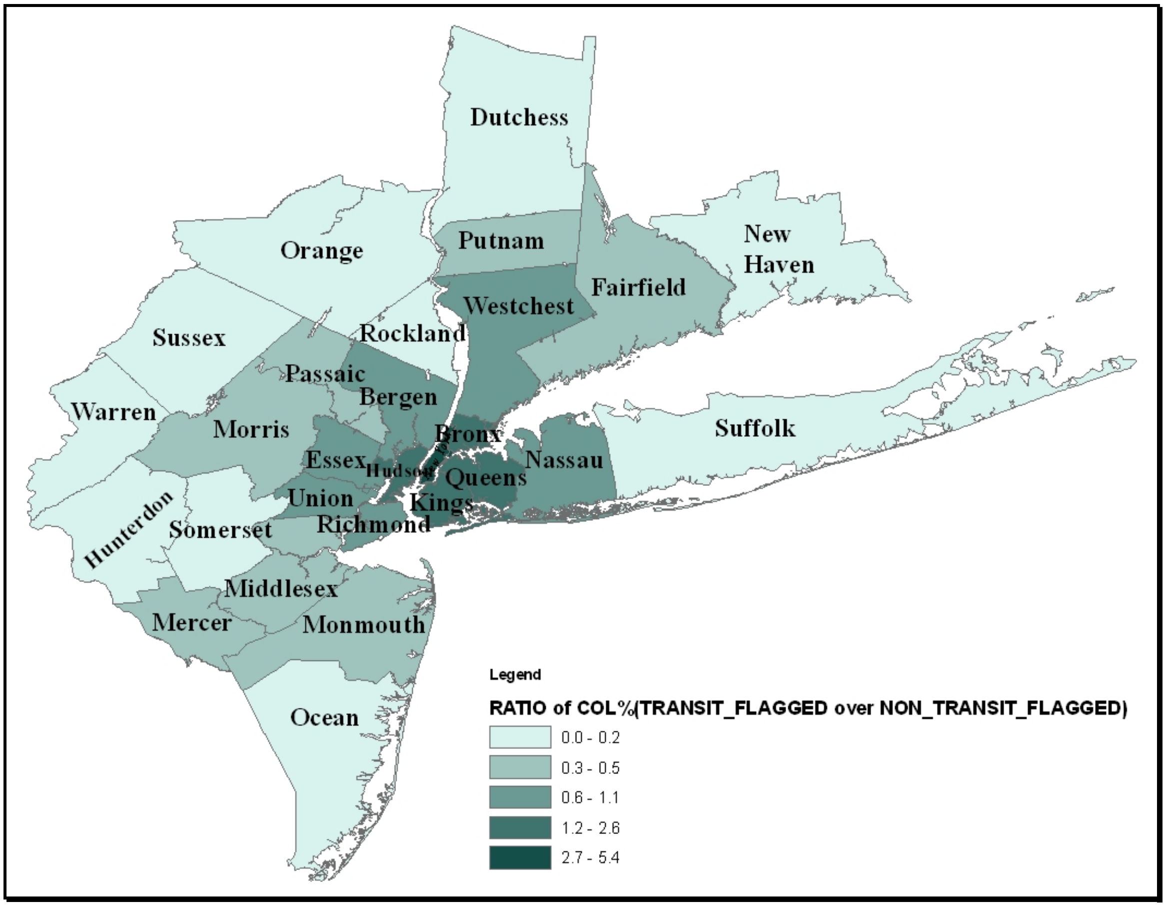


Table 3.6 Driver's License Distribution for Transit-flagged and Non-transit-flagged Groups

Drivers' License	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
With license	653	53.8	1914	73.0
Without license	560	46.1	706	26.9

Table 3.6 shows the driver's license distributions of transit-flagged and non-transit-flagged groups. Within the transit-flagged group, 73% of them have driver's license, compared with 54% in the non-transit-flagged group. This suggests people without driver license may take public transit on a regular basis and thus are less prone to transit reporting errors.

Table3. 7 School Enrollment for Transit-flagged and Non-transit-flagged Groups

School Enrollment	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
Enrolled in school	1892	66.7	564	19.8
Not enrolled in school	946	33.3	2274	80.1

Chi-square test: **significant**

Table 3.7 shows the school environment status for the two groups. Among the transit-flagged group, only 20% are enrolled in schools, compared with 67% in the non-transit-flagged group. This suggests students are a better transit record reporting group, compared with the non-student group.

Table 3.8 Employment Status for Transit-flagged and Non-transit-flagged Groups

Employment Status	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
Full-time	595	48.7	1863	71.1
Part-time	134	10.9	241	9.2
Unemployed	492	40.2	514	19.6

Table 3.8 shows the employment status for the two groups. More people (71%) in the transit-flagged group are full-time employees and fewer than 20% are unemployed, compared with the non-transit-flagged group. This may suggest that transit recording errors are more likely to happen to people with a busy daily schedule.

Table3.9 Relationship for Transit-flagged and Non-transit-flagged Groups

Relationship	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
Self	611	21.7	1606	56.4
Spouse	211	7.5	574	20.1
Son/daughter	1756	62.4	399	14.0
Father/mother	42	1.5	65	2.2
Brother/sister	83	2.9	65	2.2
Grandparent	1	0.0	2	0.0
Grandchild	46	1.6	7	0.2
Live-in help	2	0.0	2	0.0
Roommates/non-related	24	0.8	82	2.8
Other related	37	1.3	42	1.5
Tenant/boarder/renter	0	0.0	1	0.0

Table 3.9 shows the relationship for the transit-flagged and the non-transit-flagged groups. Over 50% of the people in the transit-flagged group are reported by themselves compared with 22% in the non-transit-flagged group. About 62% of the people in the non-transit-flagged group are sons/daughters, compared with 14% in the transit-flagged group. This finding is consistent with the finding in Table 3.1 on proxy reporting. Self-reporting does not appear to improve the quality of transit records.

Table 3.10 Number of Jobs for Transit-flagged and Non-transit-flagged Groups

Number of jobs	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
Have more than 1 job	34	4.6	118	5.6
Not having more than 1 job	691	95.3	1979	94.3

Table 3.10 shows the distributions of the number of jobs for the two groups. The two groups are similar with each other.

Table 3.11. Employer Distribution for Transit-flagged and Non-transit-flagged Groups

Employer	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
Private company	529	74.7	1481	71.6
Government	102	14.4	252	12.2
Self-employed	54	7.6	240	11.6
Other	23	3.2	93	4.5

Table 3.11 shows employer distribution for the two groups. Slightly more people in the transit-flagged group (12%) are self-employed compared with those in the non-transit-flagged group (8%).

Table 3.12. Industry Distribution for Transit-flagged and Non-transit-flagged Groups

Industry	Non transit flagged		Transit flagged	
	Freq.	%	Freq	%
Agriculture, forestry, fisheries	2	0.2	4	0.2
Mining	2	0.2	2	0.1
Construction	14	2.0	43	2.1
Manufacturing-non-durable goods	9	1.3	25	1.2
Manufacturing-durable goods	14	2.0	27	1.3
Transportation	19	2.7	37	1.8
Communications, other public utilities	42	6.0	177	8.6
Wholesale trade	16	2.3	48	2.3
Retail trade	61	8.7	99	4.8
Finance, insurance or real estate	81	11.6	337	16.5
Business and repair services	40	5.7	85	4.1
Personal services	72	10.3	142	6.9
Entertainment and recreation services	21	3.0	71	3.4
Health services	71	10.2	150	7.3
Educational services	42	6.0	152	7.4
Other professional and related services	70	10.0	298	14.6
Public administration	22	3.2	48	2.3
Others	96	13.8	291	14.2

Table 3.12 shows the industry distribution for the two groups. More people in the transit-flagged group tend to be in finance/insurance/real estate and other professional services and fewer of them are in retail trade, personal services, and health services, compared with the numbers in the non-transit-flagged group.

Table 3.13. Ethnicity Distribution for Transit-flagged and Non-transit-flagged Groups

Ethnicity	Non transit flagged		Transit flagged	
	Freq.	%	Freq.	%
Black, non-Hispanic	409	14.6	410	14.7
White, non-Hispanic	1877	67.1	1723	62.1
Asian/Pacific Islander	95	3.4	164	5.9
American Indian	9	0.3	22	0.7
Hispanic	250	8.9	305	10.9
Other	155	5.5	150	5.4

Chi-square test: **significant**

Table 3.13 shows the ethnicity distribution for transit-flagged and non-transit-flagged groups. Chi-square test suggests that the two are significantly different. Slightly more Asian/Pacific Islanders and Hispanic people have their transit records flagged. Language could have been an issue during the interview process.

Table 3.14 shows the mean income category by industry and transit flags. In almost all cases, the mean income category of the transit-flagged groups is higher than that of the non-transit flagged group. The two exceptions are: transportation and other professional and related services.

Table 3.14. Mean Income Category by Industry and Transit Flags

Industry	**Mean Income Category**	
	Non transit flagged	Transit flagged
Agriculture, forestry, fisheries	4.0	6.75
Mining	3.0	8.5
Construction	4.17	5.65
Manufacturing-non-durable goods	4	5.95
Manufacturing-durable goods	5.09	5.53
Transportation	6.07	5.61
Communications, other public utilities	5.94	6.11
Wholesale trade	4.25	6.11
Retail trade	5.25	5.51
Finance, insurance or real estate	6.36	6.91
Business and repair services	5.61	6.05
Personal services	5.47	5.92
Entertainment and recreation services	5.69	6.08
Health services	5.20	5.50
Educational services	5.5	5.93
Other professional and related services	6.3	6.05
Public administration	5.56	5.66
Others	5.71	6.02

* 1: <$10k; 2: 10k-15k; 3: 15k-25k; 4: 25k-35k; 5: 35k-50k; 6: 50k-75k; 7: 75k-100k; 8: 100k-125k; 9: 125k-150k; 10: >150k.

In summary, those individuals who most frequently mis-reported their transit trips appear to have the following characteristics as compared to those transit riders who reported correctly. These characteristics include: being older; living in small-sized households; having fewer vehicles; most likely earning $35k to $50k; living in those counties immediately surrounding Manhattan or in Manhattan itself; holding a driver's license; not enrolled in school; having a full-time job; reporting for themselves; and working in the finance, insurance or real estate (FIRE) industry or other professional services. In other words, there are a substantial number of persons who used transit for their travel during the survey period, but who most likely are not completely knowledgeable with regards to the transit system. It can be assumed that giving these individuals the option to use GPS to record their transit travel would result in better data.

To determine whether there are spatial variations within counties, further research will be conducted to compare the distribution of the home locations of the transit flagged individuals with 2000 census population distributions. This analysis is intended to reveal any spatial components to the differences at geographical scale below county level.

Characteristics of 'Those with Speed violations' and 'Those without by Transit and Non-transit Users'

The flag for speed violations (*spdviol*) appears in file plac0831. There can be three possibilities for speed violations: 1) acceptable outliers; 2) violation likely caused by time rounding; and 3) cause unknown. A person is considered speed-violation-flagged if any of his/her records has an indication of one of these three cases.

Table 3.14 Age, Number of Vehicles, Household Size, and Number of Workdays between Those with Speed Violations and Those Without (non-transit users)

Variables	Non-speed-flagged		Speed-flagged		t-test result (α=0.05)
	Mean	N	Mean	N	
Age	39.0	13580	38.5	7243	Non-significant
Household size	3.11	14183	3.19	7475	Significant
Number of vehicles	1.91	14183	2.02	7475	Significant
Number of workdays	4.69	6891	4.63	4185	Significant

Table 3.15 Age, Number of Vehicles, Household Size, and Number of Workdays between Those with Speed Violations and Those Without (transit users)

Variables	Non-speed-flagged		Speed-flagged		t-test result (α=0.05)
	Mean	N	Mean	N	
Age	29.9	2730	28.8	2797	Significant
Household size	3.20	2824	3.22	2886	Non-significant
Number of vehicles	1.32	2824	1.24	2886	Significant
Number of workdays	4.76	1504	4.73	1273	Non-significant

Tables 3.14 and 3.15 show mean values of age, number of vehicles, household size, and number of workdays between those with speed violations and those without for non-transit users and transit users. The two groups (speed violators and non-speed violators) are quite similar for both non-transit users and transit users, although t-tests indicate that there exist some significant differences. In both cases, the speed violators tend to be slightly younger and have larger household size. The speed violators in the non-transit users group tend to have more vehicles, while those in the transit users group tend to have fewer.

Table 3.16 Gender Distribution for Those with Speed Violations and Those Without (non-transit users)

Gender	Non speed flagged		Speed flagged	
	Freq	%	Freq	%
Male	6735	47.5	3578	47.9
Female	7399	52.3	3880	52.0

Chi-square test: **non-significant**

Table 3.17. Gender Distribution for Those with Speed Violations and Those Without (transit users)

Gender	Non speed flagged		Speed flagged	
	Freq	%	Freq	%
Male	1500	53.1	1372	47.6
Female	1321	46.8	1509	52.3

Chi-square test: **significant**

Tables 3.16 and 3.17 show the gender distributions of the two groups for non-transit users and transit users. No significant difference is detected for the non-transit users group. For transit users, more females tend to be speed violators.

Table 3.18. Income Distribution for Those with Speed Violations and Those Without (non-transit users)

Income	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
<$10k	355	3.3	123	2.1
$10k-<$15k	428	3.9	122	2.1
$15k-<$25k	757	7.1	368	6.4
$25k-<$35k	1078	10.1	543	9.4
$35k-<$50k	1809	16.8	1018	17.6
$50k-<$75k	2906	27.1	1606	27.8
$75k-<$100k	1689	15.8	976	16.8
$100k-<$125k	763	7.1	485	8.4
$125k-<$150k	338	3.1	209	3.6
$150k+	592	5.5	330	5.7

Table 3.19. Income Distribution for Those with Speed Violations and Those Without (transit users)

Income	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
<$10k	69	3.1	112	4.9
$10k-<$15k	111	5.0	112	4.9
$15k-<$25k	167	7.5	159	7.0
$25k-<$35k	235	10.6	246	10.9
$35k-<$50k	352	15.8	324	14.3
$50k-<$75k	524	23.6	573	25.4
$75k-<$100k	370	16.7	332	14.7
$100k-<$125k	155	6.9	172	7.6
$125k-<$150k	85	3.8	67	2.9
$150k+	148	6.7	161	7.1

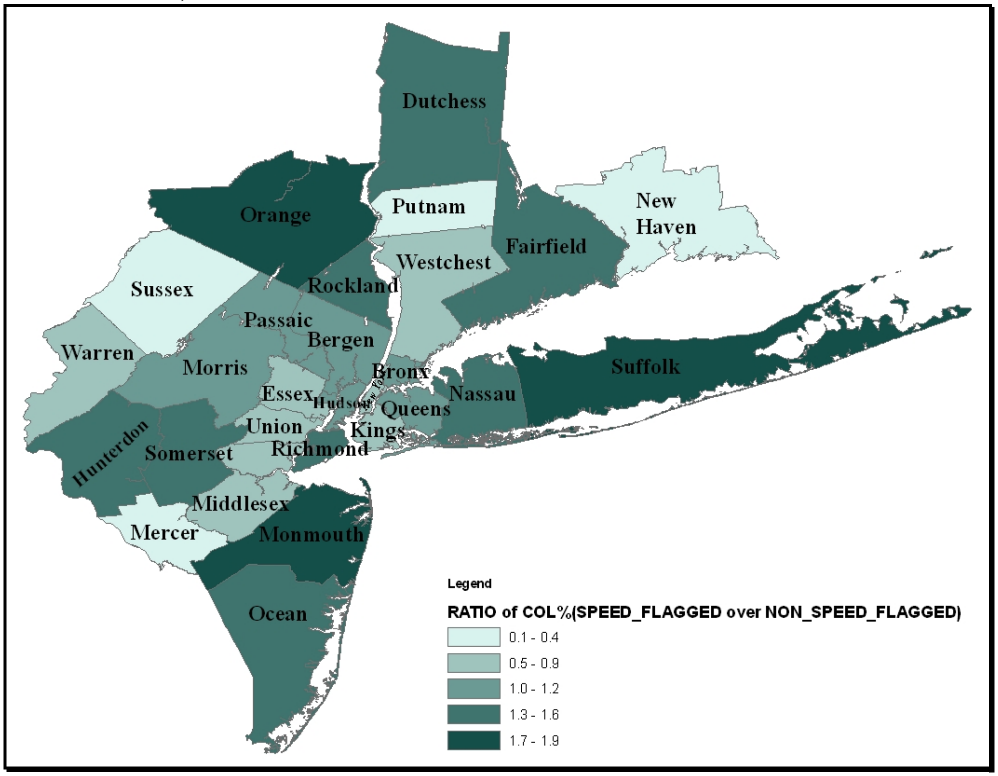
Tables 3.18 and 3.19 show income distributions of the two groups for non-transit users and transit users. The differences displayed between the speed violators and non-speed violators appear to be relatively small.

Table3. 20. County Distribution for Those with Speed Violations and Those Without (non-transit users)

County fipscode	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
9001 (Fairfield)	323	2.2	234	3.1
9009 (New Haven)	309	2.1	6	0.8
34003 (Bergen)	946	6.7	577	7.7
34013 (Essex)	682	4.8	268	3.5
34017 (Hudson)	542	3.8	331	4.4
34019 (Hunterdon)	399	2.8	291	3.8
34021 (Mercer)	826	5.8	66	0.9
34023 (Middlesex)	615	4.3	247	3.3
34025 (Monmouth)	490	3.4	474	6.3
34027 (Morris)	433	3.1	269	3.6
34029 (Ocean)	352	2.5	290	3.9
34031 (Passaic)	407	2.8	240	3.2
34035 (Somerset)	345	2.4	271	3.6
34037 (Sussex)	620	4.4	50	0.6
34039 (Union)	480	3.4	143	1.9
34041 (Warren)	455	3.2	221	2.9
36005 (Bronx)	271	1.9	146	1.9
36027 (Dutchess)	341	2.4	272	3.6
36047 (Kings)	557	3.9	235	3.1
36059 (Nassau)	472	3.3	356	4.7
36061 (New York)	952	6.7	411	5.5
36071 (Orange)	314	2.2	303	4.0
36079 (Putnam)	548	3.8	33	0.4
36081 (Queens)	280	1.9	169	2.2
36085 (Richmond)	940	6.6	629	8.4
36087 (Rockland)	341	2.4	233	3.1
36103 (Suffolk)	512	3.6	504	6.7
36119 (Westchester)	431	3.0	206	2.7

Chi-square test: **significant**

Map 3.2 County Distribution of the Percentages of Speed Violators divided by the Percentages of Speed Violators (Non-Transit Users)



Map 3.3 County Distribution of the Percentages of Speed Violators divided by the Percentages of Speed Violators (Transit Users)

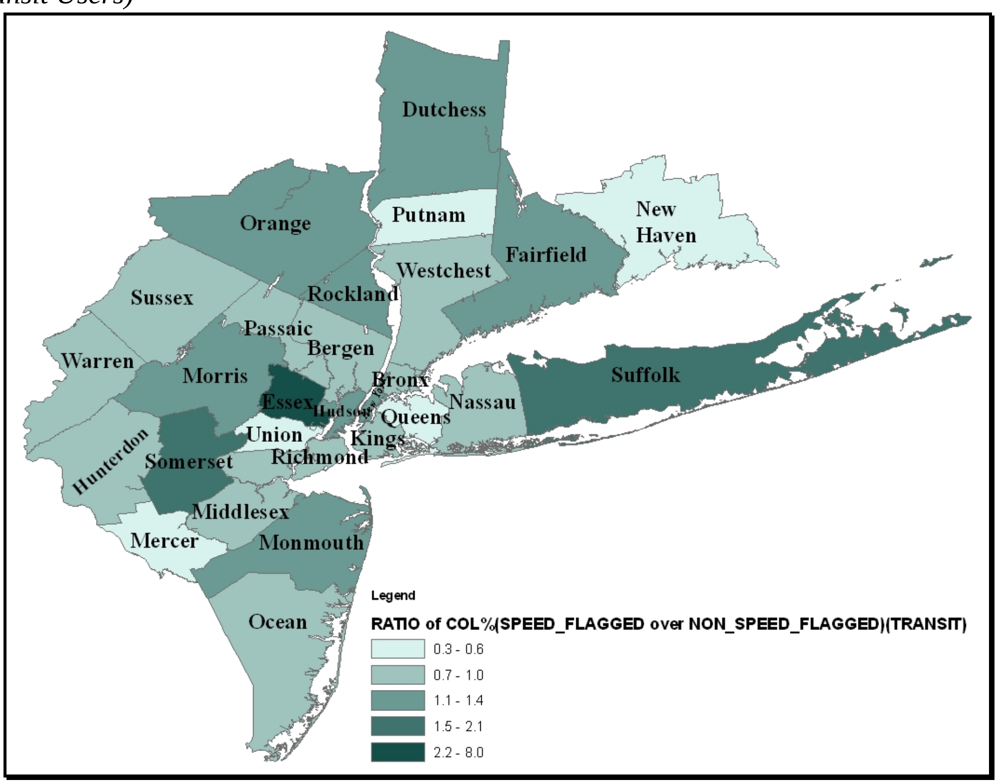


Table 3.21 County Distribution for Those with Speed Violations and Those Without (transit users)

County fipscode	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
9001 (Fairfield)	46	1.6	49	1.7
9009 (New Haven)	24	0.8	7	0.2
34003 (Bergen)	94	3.3	69	2.4
34013 (Essex)	98	3.5	82	2.8
34017 (Hudson)	126	4.4	177	6.1
34019 (Hunterdon)	47	1.7	44	1.5
34021 (Mercer)	77	2.7	45	1.6
34023 (Middlesex)	65	2.3	70	2.4
34025 (Monmouth)	77	2.7	100	3.5
34027 (Morris)	37	1.3	51	1.8
34029 (Ocean)	47	1.7	41	1.4
34031 (Passaic)	29	1.0	27	0.9
34035 (Somerset)	27	0.9	46	1.6
34037 (Sussex)	66	2.3	49	1.7
34039 (Union)	41	1.5	27	0.9
34041 (Warren)	40	1.4	37	1.3
36005 (Bronx)	125	4.4	122	4.2
36027 (Dutchess)	43	1.5	51	1.8
36047 (Kings)	248	8.8	254	8.8
36059 (Nassau)	82	2.9	70	2.4
36061 (New York)	630	22.3	790	27.4
36071 (Orange)	57	2.0	69	2.4
36079 (Putnam)	78	2.7	37	1.3
36081 (Queens)	148	5.2	90	3.1
36085 (Richmond)	269	9.5	239	8.3
36087 (Rockland)	57	2.0	64	2.2
36103 (Suffolk)	54	1.9	116	4.0
36119 (Westchester)	92	3.3	63	2.2

Chi-square test: **significant**

Tables 3.20 and 3.21 show county distributions of the percentages of speed violators divided by the percentages of non-speed violators for non-transit users and transit users. Places that tend to generate more speed violators for the non-transit-user group (Table 3.20) include Monmouth, Morris, Ocean, Passaic, Somerset, Dutchess, Nassau, Richmond and Suffolk. Places that tend to generate more speed violators for the transit user group (Table 3.21) include Hudson, Monmouth, and New York. The inclusion of New York (Manhattan) in the latter group is particularly interesting, as Manhattan also generates a large number of respondents whose records are transit-flagged. The differences depicted in Tables 3.20 and 3.21, however, are not as pronounced as the county distribution for transit-flagged groups.

Maps 3.2 and 3.3 are created to show the patterns geographically. Map 3.2 is a county distribution of a set of ratios, obtained by dividing the percentages of non-transit users with speed violations in each county by those without. Map 3.3 is a similar set for transit users. In both maps, the darker the color is, the more speed violators that the corresponding county will have.

Table 3.22 Driver's License Distribution for Those with Speed Violations and Those Without (non-transit users)

Drivers' License	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
With license	9911	86.1	5754	92.6
Without license	1597	13.8	458	7.4

Table 23. Driver's License Distribution for Those with Speed Violations and Those Without (transit users)

Drivers' License	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
With license	1356	68.9	1211	64.8
Without license	610	31.0	656	35.1

Tables 3.22 and 3.23 show the driver's license distributions of the two groups for both non-transit users and transit users. For non-transit users, more people in the speed violators have a driver's license than the non-speed violator group. The distribution appears similar for the transit users' group.

Table 3.24 School Enrollment for Those with Speed Violations and Those Without (non-transit users)

School Enrollment	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Enrolled in school	2587	18.4	1475	19.9
Not enrolled in school	11442	81.5	5948	80.1

Chi-square test: **significant**

Table 3.25 School Enrollment for Those with Speed Violations and Those Without (transit users)

School Enrollment	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Enrolled in school	1138	40.6	1318	45.8
Not enrolled in school	1664	59.4	1556	54.1

Chi-square test: **non-significant**

Tables 3.24 and 3.25 show school enrollment distributions of speed violators and non-speed violators for non-transit users and transit users. Chi-square test suggests a significant association between speed violations and school enrollment for non-transit users, but insignificant for transit users. Contrary to the findings for the transit users with their records updated or not, those who enrolled in school tend to be speed violators for both non-transit users and transit users.

Table 3.26 Employment Status for Those with Speed Violations and Those Without (non-transit users)

Employment Status	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Full-time	5933	51.5	3450	55.8
Part-time	1156	10.0	820	13.3
Unemployed	4428	38.4	1914	30.9

Table 3.27 Employment Status for Those with Speed Violations and Those Without (transit users)

Employment Status	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Full-time	1344	68.2	1114	59.6
Part-time	185	9.4	190	10.2
Unemployed	442	22.4	564	30.2

Tables 3.26 and 3.27 show the distributions of employment status of speed violators and non-speed violators for non-transit users and transit users. Slightly more speed violators in the non-transit users' group are full-time and part-time employees, compared with the non-speed violators group. For transit users, more speed violators tend to be unemployed.

Table 3.28 Relationship for Those with Speed Violations and Those Without (non-transit users)

Relationship	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Self	5672	40.6	3374	45.5
Spouse	3473	24.8	1850	24.9
Son/daughter	3374	24.2	1706	22.9
Father/mother	617	4.4	192	2.6
Brother/sister	272	1.9	113	1.5
Grandparent	33	0.2	4	0.0
Grandchild	109	0.8	24	0.3
Live-in help	17	0.1	6	0.0
Roommates/non-related	192	1.4	87	1.2
Other related	200	1.4	63	0.8
Tenant/boarder/renter	5	0.0	2	0.0

Chi-square test: **significant**

Table 3.29 Relationship for Those with Speed Violations and Those Without (transit users)

Relationship	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Self	1112	39.8	1105	38.5
Spouse	409	14.6	376	13.1
Son/daughter	1000	35.8	1155	40.3
Father/mother	62	2.2	45	1.6
Brother/sister	77	2.7	71	2.5
Grandparent	2	0.0	1	0.0
Grandchild	22	0.8	31	1.0
Live-in help	4	0.1	0	0.0
Roommates/non-related	56	2.0	50	1.7
Other related	47	1.6	32	1.1
Tenant/boarder/renter	1	0.0	0	0.0

Tables 3.28 and 3.29 describe the relationship distributions of the two groups for non-transit users and transit users. For the non-transit users group, more speed violators are self and fewer of them are father/mother relationships. For transit users, more are sons/daughters.

Table 3.30 Number of Jobs for Those with Speed Violations and Those Without (non-transit users)

Number of jobs	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Have more than 1 job	396	5.6	256	6.0
Not having more than 1 job	6671	94.4	3998	93.9

Table 3.31 Number of Jobs for Those with Speed Violations and Those Without (transit users)

Number of jobs	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Have more than 1 job	69	4.5	83	6.4
Not having more than 1 job	1455	95.4	1215	93.6

Tables 3.30 and 3.31 show the distributions of the number of jobs of speed violators and non-speed violators for non-transit users and transit users. The distributions appear to be similar for non-transit users. Slightly more speed violators in the transit users group tend to have more than one job.

Table 3.32 Employer Distribution for Those with Speed Violations and Those Without (non-transit users)

Employer	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Private company	4664	67.5	2691	64.2
Government	1188	17.2	728	17.4
Self-employed	840	12.2	610	14.5
Other	222	3.2	161	3.8

Table 3.33 Employer Distribution for Those with Speed Violations and Those Without (transit users)

Employer	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Private company	1129	75.4	881	69.0
Government	201	13.4	153	11.9
Self-employed	115	7.7	179	14.0
Other	53	3.5	63	4.9

Tables 3.32 and 3.33 show employer distributions of speed violators and non-speed violators for non-transit users and transit users. In both cases, fewer speed violators tend to be employed by the private company and more tend to be self-employed.

Table 3.34. Industry Distribution for Those with Speed Violations and Those Without (non-transit users)

Industry	Non speed flagged		Speed flagged	
	Freq.	%	Freq	%
Agriculture, forestry, fisheries	33	0.5	32	0.8
Mining	5	0.0	5	0.1
Construction	307	4.5	205	4.9
Manufacturing-non-durable goods	143	2.1	73	1.8
Manufacturing-durable goods	215	3.2	79	1.9
Transportation	275	4.0	155	3.7
Communications, other public utilities	462	6.8	257	6.2
Wholesale trade	153	2.3	103	2.5
Retail trade	446	6.6	300	7.2
Finance, insurance or real estate	517	7.6	278	6.7
Business and repair services	368	5.4	175	4.2
Personal services	501	7.4	342	8.3
Entertainment and recreation services	174	2.6	74	1.8
Health services	658	9.7	464	11.2
Educational services	740	10.9	476	11.5
Other professional and related services	866	12.7	495	11.9
Public administration	162	2.4	106	2.6
Others	785	11.5	522	12.6

Table 3.35 Industry Distribution for Those with Speed Violations and Those Without (transit users)

Industry	Non speed flagged		Speed flagged	
	Freq.	%	Freq	%
Agriculture, forestry, fisheries	3	0.2	3	0.2
Mining	2	0.1	2	0.0
Construction	33	2.2	24	1.9
Manufacturing-non-durable goods	23	1.6	11	0.8
Manufacturing-durable goods	19	1.3	22	1.8
Transportation	31	2.1	25	1.9
Communications, other public utilities	129	8.7	90	7.2
Wholesale trade	30	2.0	34	2.7
Retail trade	87	5.9	73	5.8
Finance, insurance or real estate	247	16.7	171	13.6
Business and repair services	75	5.1	50	3.9
Personal services	108	7.3	106	8.5
Entertainment and recreation services	38	2.6	54	4.3
Health services	120	8.1	101	8.1
Educational services	94	8.1	100	7.9
Other professional and related services	194	13.1	174	13.9
Public administration	35	2.4	35	2.8
Others	208	14.1	179	14.3

Tables 3.34 and 3.35 show industry distributions of speed violators and non-speed violators for non-transit users and transit users. In both case, the differences appear to be minor.

Table 3.36 Ethnicity Distribution for Those with Speed Violations and Those Without (non-transit users)

Ethnicity	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Black, non-Hispanic	1246	9.0	500	6.8
White, non-Hispanic	10432	75.5	5841	80.1
Asian/Pacific Islander	472	3.4	210	2.8
American Indian	52	0.3	40	0.5
Hispanic	1079	7.8	446	6.1
Other	531	3.8	248	3.4

Chi-square test: **significant**

Table 3.37 Ethnicity Distribution for Those with Speed Violations and Those Without (transit users)

Ethnicity	Non speed flagged		Speed flagged	
	Freq.	%	Freq.	%
Black, non-Hispanic	406	14.7	413	14.6
White, non-Hispanic	1746	63.5	1854	65.7
Asian/Pacific Islander	150	5.4	109	3.8
American Indian	17	0.6	14	0.5
Hispanic	275	10.0	280	9.9
Other	155	5.6	150	5.3

Chi-square test: **non-significant**

Tables 3.36 and 3.37 describe ethnicity distributions of speed violators and non-speed violators for non-transit users and transit users. For non-transit users, the records of White and non-Hispanic people tend to be more likely flagged with a speed violation. No significant differences are detected for transit users.

Tables 3.38 and 3.39 show the mean income category by industry, speed violations, and status of being a transit user or not. The T-test results suggest that for non transit users, the mean income category for the two groups is significantly different at 5% significance level and for transit users, however, the difference is not significant. For non transit users, the mean income category for the speed violators (5.92) is slightly higher than the non speed violators (5.70). The higher mean income categories are shown in the following industries: construction, retail trade, business and retail services, personal services, other and professional services, and public administration.

Table 3.38 Mean Income Category by Industry and Speed Violations (non transit users)

Industry	**Mean Income Category**	
	Non-speed flagged	Speed flagged
Agriculture, forestry, fisheries	6.2	5.65
Mining	6.5	6.0
Construction	5.9	5.93
Manufacturing-non-durable goods	6.26	6.16
Manufacturing-durable goods	6.08	6.05
Transportation	5.93	5.83
Communications, other public utilities	6.58	6.36
Wholesale trade	6.25	5.77
Retail trade	5.74	5.93
Finance, insurance or real estate	6.93	6.82
Business and repair services	6.05	6.10
Personal services	5.79	5.97
Entertainment and recreation services	6.11	5.81
Health services	6.33	6.31
Educational services	6.43	6.37
Other professional and related services	6.40	6.45
Public administration	5.89	6.13
Others	6.06	6.09
T-test result	Significant at 5%	

* 1: <$10k; 2: 10k-15k; 3: 15k-25k; 4: 25k-35k; 5: 35k-50k; 6: 50k-75k; 7: 75k-100k; 8: 100k-125k; 9: 125k-150k; 10: >150k.

Table 3.39 Mean Income Category by Industry and Speed Violations (transit users)

Industry	Mean Income Category	
	Non-speed flagged	Speed flagged
Agriculture, forestry, fisheries	5.33	6.33
Mining	6.5	7.0
Construction	4.81	6.11
Manufacturing-non-durable goods	5.37	5.22
Manufacturing-durable goods	5.77	5.06
Transportation	5.72	5.77
Communications, other public utilities	5.93	6.28
Wholesale trade	5.59	5.69
Retail trade	5.32	5.51
Finance, insurance or real estate	6.76	6.85
Business and repair services	5.85	5.97
Personal services	5.76	5.76
Entertainment and recreation services	6.12	5.91
Health services	5.65	5.13
Educational services	5.8	5.87
Other professional and related services	5.99	6.2
Public administration	5.39	5.91
Others	5.93	5.95
T-test result	Not significant at 5%	

* 1: <$10k; 2: 10k-15k; 3: 15k-25k; 4: 25k-35k; 5: 35k-50k; 6: 50k-75k; 7: 75k-100k; 8: 100k-125k; 9: 125k-150k; 10: >150k.

In summary, there does not appear to be any systematic characteristics of those who received speed violation flags, except for the possible association with spatial variation. The next step in the research will be the determination of differences that form significant spatial clusters using geographic information systems (GIS).

Summary of Major Findings

Tables 3.40 and 3.41 summarize the major findings of the analyses in this section and list the results of the statistical tests under each of these items.

Table 3.40 Summary of Findings for Transit-flagged and Non-transit-flagged Groups

Tested Items	Findings	test results
age, number of vehicles, household size	The non-transit-flagged group is younger, have larger household size, and more household vehicles compared with the transit-flagged group	t-test significant
Gender Distribution	No significant difference between these two groups	Chi-square test non-significant
Income Distribution	It suggests more transit-flagged households with income levels under $15k, between $35k and $50k, and greater than $125k, and fewer of them in ranges between 25k and $35k and between $50k and $125k.	not reported [10]
County Distribution	It suggests that there appears to be a connection between the probability of being transit-flagged and his or her county residence. Manhattan, followed by Kings (Brooklyn) county, Queens, Bronx, and Hudson county in New Jersey, is transit-intensive.	Chi-square test: significant
Driver's License Distribution	It suggests people without driver license may take public transit on a regular basis and thus are less prone to transit reporting errors.	not reported
School Enrollment	It suggests students are a better transit record reporting group, compared with the non-student group.	Chi-square test: significant
Employment Status	It suggests that transit recording errors are more likely to happen to people with a busy daily schedule (full time employment).	not reported
Relationship	Self-reporting does not appear to improve the quality of transit records.	not reported
Number of Jobs	No significant differences.	not reported
Employer Distribution	Slightly more people in the transit-flagged group are self-employed compared with those in the non-transit-flagged group.	not reported
Industry Distribution	More people in the transit-flagged group tend to be in finance/insurance/real estate and other professional services and fewer of them are in retail trade, personal services, and health services, compared with in the non-transit-flagged group.	not reported
Ethnicity Distribution	Slightly more Asian/Pacific Islanders and Hispanic people have their transit records flagged. Language could have been an issue during the interview process.	Chi-square test: significant

[10] Statistical test results are not reported due to missing cells, also see footnote 1.

Table 3.41 Summary of Findings for Those w/ Speed Violations and Those without (by Transit & Non-transit Users)

Tested Items	Findings	test results
age, number of vehicles, household size	The speed violators tend to be slightly younger and have larger household size. Speed violators in the non-transit user group tend to have more vehicles while those in transit-user group tend to have fewer, compared with non-speed violators.	t-test significance: household size and number of vehicles for non-transit users age and number of vehicle for transit users
Gender Distribution	No significant difference is detected for the non-transit user group. For transit users, more females tend to be speed violators.	Chi-square test: non-significant for non-transit user significant for transit user
Income Distribution	The differences between the speed violators and non-speed violators appear to be relatively small for the non-transit user group.	not reported
County Distribution	Places that tend to generate more speed violators for the non-transit user group include Monmouth, Morris, Ocean, Passiac, Somerset, Dutchess, Nassau, Richmond and Suffolk, for the transit user group include Hudson, Monmouth, and New York(Manhattan).	Chi-square test: significant for non-transit users significant for transit users
Driver's License Distribution	More people in the speed violators have a driver's license than the non-speed-violator group for both non-transit users and the transit users.	not reported
School Enrollment	It suggests a significant association between speed violations and school enrollment for non-transit users. And those who enrolled in school tend to be speed violators for both non-transit users and transit users.	Chi-square test: significant for non-transit users non-significant for transit users
Employment Status	Slightly more speed violators in the non-transit users' group are full-time and part-time employees, compared with the non-speed violators group. For transit users, more speed violators tend to be unemployed.	not reported
Relationship	For the non-transit users group, more speed violators are self and fewer of them are father/mother relationships. For transit users, more are sons/daughters.	not reported
Number of Jobs	No significant difference for the non-transit users group. Slightly more speed violators in the transit users group tend to have more than one job.	not reported
Employer Distribution	In both groups, fewer speed violators tend to be employed by the private company and more tend to be self-employed.	not reported
Industry Distribution	There are no significant differences.	not reported
Ethnicity Distribution	For non-transit users, the speed violators tend to be more likely White and non-Hispanic people. No significant differences are detected for transit users.	Chi-square test: significant for non-transit users non-significant for transit users

Table 3.42 Statically Significance Summary for Transit & Non-transit Users

Tested Item	Non-Transit Users		Transit Users	
	Significant	Non-Significant	Significant	Non-Significant
Age*	x		x	
Household Size*	x		x	
Number of Vehicles*	x		x	
Number of workdays*	x		x	
Gender		x		x
Income Distribution	-	-	-	-
County Distribution	x		x	
Driver's License	-	-	-	-
School Enrollment	x		x	
Employment Status	-	-	-	-
Relationship	-	-	-	-
Number of Jobs	-	-	-	-
Employer Distribution	-	-	-	-
Industrial Distribution	-	-	-	-
Ethnicity Distribution	x		x	

Table 3.42 & 3.43 Notes:

1. Chi-square analysis was performed on variables reported except when indicated with "" where t-test analysis was performed.*

2. "-" indicates 'Not Reported''

Table 3.43 Statically Significance Summary for Those w/ Speed Violations and Those without (by Transit & Non-transit Users)

Tested Item	Non-Transit Users		Transit Users	
	Significant	Non-Significant	Significant	Non-Significant
Age*		x	x	
Household Size*	x			x
Number of Vehicles*	x		x	
Number of workdays*		x		x
Gender		x	x	
Income Distribution	-	-	-	-
County Distribution	x		x	
Driver's License	-	-	-	-
School Enrollment	x			x
Employment Status	-	-	-	-
Relationship	-	-	-	-
Number of Jobs	-	-	-	-
Employer Distribution	-	-	-	-
Industrial Distribution	-	-	-	-
Ethnicity Distribution	x			x

Section Four: Discussion

From the results of the controlled experiments and the analysis of 1997/98 survey data, the research team is able to provide additional responses to some of the issues highlighted for this research project:

Issues Relate to Research

Should a person-based-GPS survey be a part of the upcoming regional household travel survey?

From the results of the research thus far, it is clear that GPS will enhance the accuracy of the data and appears to be useable by citizens. This must be tested in the third experiment, however. If the GPS units are technically capable and practicable feasible based on the results of the third experiment, the answer to the above question "should a person-based-GPS survey be a part of the upcoming regional household travel survey?" requires a careful cost and benefit analysis. The benefit of having GPS data is that we will have more data points and a higher level of accuracy. The cost, on the other hand, is that additional effort needs to be made to collect additional information such as trip purpose and mode of transportation, which are not directly outputted from any GPS units. A careful benefit and cost analysis is outside of the scope of this project. It will require not only meetings with the modeling group, but a survey to assess the value of using these additional levels of details in the modeling efforts and the planning process.

What would be the minimum recommended sample size of the person-based GPS component of the regional household travel survey?

The true question is: what is the minimum sample size that is required for the additional benefit of the GPS component to be realized in the regional household travel survey. This requires the input from the modeling group. Calculation of the minimum sample size also depends on budget, the expected variance of the variable of interest, and the margin of error. This information is not available to the research team. Due to the limited information that the research team has at this time, we only recommend the use of GPS component as a data collection aid, not a data collection substitute.

How could the person-based GPS survey be used to improve and / or enhance current travel survey processes that have been used in the NYMTC Region?

Any GPS data collection will improve the accuracy of time of travel, the length of activity, the location of travel, the location of stops, the vicinity of travel (some issues with the spatial confidence interval, however, for modeling purposes, this appears to not be of consequence). GPS data collection also has the potential to reduce respondents' burden and improve response rate. Information on this latter part is expected to be inferred from the third experiment. In addition, more research will be needed if GPS is to be used as a substitute for data collection rather than an aid.

How could the person-based GPS survey help in addressing non-reported trips in the travel diaries?

The research team has not tested the correspondence between traditional trip data collection technologies (e.g., paper), however, the literature review suggests people who report well on paper also use GPS correctly (capturing all their trips). It is unclear whether people less capable of reporting on paper would do better using GPS. More research will be needed to clarify this issue.

How could the person-based GPS survey help in addressing the rounding of travel times, imprecise departure and arrival times reported in the travel diaries, and bad recollection of O-D locations by respondents for geocoding?

The GPS units will have precise travel times, including departures and arrivals, with the exception of people who don't wait for the unit to "fix" in their first attempt to travel. The data may miss up to a block of walking, for example, if people leave their house in a hurry. However, this may not be consequential for modeling purposes.

Would the person-based GPS survey help to improve the response rate from low response groups, such as young males?

It requires the original sampling plan and a detailed description of the survey process in order to answer this question. Up to today, the research team has not been provided with such information. The current interest in GPS technology may encourage use by young males, a group considered to be a low responding market. We are waiting to review the Chicago experience to determine if they were able to attract this market using GPS.

How could the person-based GPS help in improving the BPM modeling process?

Our discussions with the BPM modeling staff indicated that they would be able to use the higher quality origin and destination data at this time. They would also be able to use the better quality time data for estimation purposes. The actual routing data may be useful for auditing and validating model assignment in the future.

How would it be possible to track complex bus/subway transit rider paths in Manhattan?

The current research being conducted by ALK indicates the ability to "see" individuals moving from walking to bus, to subway, etc. Their work does not incorporate GIS, however. The spatial data can then be used in GIS with high accuracy of mode paths. This will be described in the Third Phase Report.

How to address "acquisition time" for GPS devices to start registering lat/long coordinates upon being turned on, as well as related "no signal" and "inconsistent signal" issues related to being near tall buildings, being within structures, and cloudy days?

The MTK chipset used in the i-Blue and the data output from these units is demonstrating the feasibility of overcoming previous issues of data quality due to the urban canyon effect (within a spatial confidence interval and using number of available satellites, etc.). To date, we have not seen issues with weather.

While there are strong indications of a special target market of those individuals who mis-reported their transit trips, further research is needed to strengthen our understanding of this market. A smaller market, partially revealed in the data analysis, appears to be in the lowest income groups. It is our understanding that low income households were under-represented in the initial sampling frame. More research is needed to substantiate this finding.

One interesting link between these two groups would involve a mixed methodology for collecting accurate travel data. The next step is to determine the feasibility of finding volunteers to participate in a test of a "self-training" GPS deployment. This would make it financially plausible to use GPS as an aid to data collection. This is particularly of interest, given the characteristics of those individuals who mis-reported their transit trips in the 1997/98 deployment. The test needs to establish the difference in the performance of the GPS equipment between those who are individually trained and those who train themselves. If successful, the GPS units used for an equipment mail-out/mail-back deployment could be used again for the more difficult target market of under-represented household members. These individuals would most likely need more education on the reason for participating in a travel survey, be encouraged to learn how to use the equipment, and be conducted through local community groups (i.e., Community Boards). Since most survey efforts, whether traditional or GPS-enhanced, report low participation rates for low income households, it seems reasonable to suggest testing a new form of outreach and data collection to increase participation rates.

Appendices: Phase Two Report

Appendix I. NMEA sentences – Examples and Explanation

Sources: Biba (2007) & Dale DePriest http://www.gpsinformation.org/dale/nmea.htm

A description of the different string section in a NMEA sentence includes:

GGA - essential fix data which provide 3D location and accuracy data.

> If the height of geoid is missing then the altitude should be suspect. Some non-standard implementations report altitude with respect to the ellipsoid rather than geoid altitude. Some units do not report negative altitudes at all. This is the only sentence that reports altitude.

Example 1 GGA:

NMEA sentence:

```
$GPGGA,123519,4807.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47

Where:
        NEMA Sentence   Description
        GGA             Global Positioning System Fix Data
        123519          Fix taken at 12:35:19 UTC
        4807.038,N      Latitude 48 deg
        01131.000,E     Longitude 11 deg 31.000'
        1               Fix quality:
                                0 = invalid
                                1 = GPS fix (SPS)
                                2 = DGPS fix
                                3 = PPS fix
                                4 = Real Time Kinematic
                                5 = Float RTK
                                6 = estimated (dead reckoning) (2.3 feature)
                                7 = Manual input mode
                                8 = Simulation mode
        08              Number of satellites being tracked
        0.9             Horizontal dilution of position
        545.4,M         Altitude, Meters, above mean sea level
        46.9,M          Height of geoid (mean sea level) above WGS84
ellipsoid
        (empty field)   time in seconds since last DGPS update
        (empty field)   DGPS station ID number
        *47             the checksum data, always begins with *
```

GSA - GPS DOP and active satellites. This sentence provides details on the nature of the fix. It includes the numbers of the satellites being used in the current solution and the DOP. DOP (dilution of precision) is an indication of the effect of satellite geometry on the accuracy of the fix. It is a unitless number where smaller is better. For 3D fixes using 4 satellites a 1.0 would be considered to be a perfect number, however for over determined solutions it is possible to see numbers below 1.0.

There are differences in the way the PRN's are presented which can effect the ability of some programs to display this data. For example, in the example shown below there are 5 satellites in the solution and the null fields are scattered indicating that the almanac would show satellites in the null positions that are not being used as part of this solution. Other receivers might output all of the satellites used at the beginning of the sentence with the null field all stacked up at the end. This difference accounts for some satellite display programs not always being able to display the satellites being tracked. Some units may show all satellites that have ephemeris data without regard to their use as part of the solution but this is non-standard.

Example 2 GSA:

NMEA sentence:

```
  $GPGSA,A,3,04,05,,09,12,,,24,,,,,2.5,1.3,2.1*39

Where:
     NEMA Sentence       Description
     GSA                 Satellite status
     A                   Auto selection of 2D or 3D fix (M = manual)
     3                   3D fix - values include:
                                 1 = no fix
                                 2 = 2D fix
                                 3 = 3D fix
     04,05...            PRNs of satellites used for fix (space for 12)
     2.5                 PDOP (dilution of precision)

     1.3                 Horizontal dilution of precision (HDOP)
     2.1                 Vertical dilution of precision (VDOP)
     *39                 the checksum data, always begins with *
```

RMC - NMEA has its own version of essential GPS PVT (position, velocity, time) data. It is called RMC, The Recommended Minimum, which will look similar to:

Example 3 RMC:

NMEA sentence:

```
$GPRMC,123519,A,4807.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A

Where:
     NEMA Sentence       Description
     RMC                 Recommended Minimum sentence C
     123519              Fix taken at 12:35:19 UTC
     A                   Status A=active or V=Void.

     4807.038,N          Latitude 48 deg 07.038' N
     01131.000,E         Longitude 11 deg 31.000' E
     022.4               Speed over the ground in knots
     084.4               Track angle in degrees True
     230394              Date - 23rd of March 1994

     003.1,W             Magnetic Variation
     *6A                 The checksum data, always begins with *
```

Note that, as of the 2.3 release of NMEA, there is a new field in the RMC sentence at the end just prior to the checksum.

VTG - Velocity made good. The GPS receiver may use the LC prefix instead of GP if it is emulating Loran output.

Example 4 VTG:

NMEA sentence:

```
  $GPVTG,054.7,T,034.4,M,005.5,N,010.2,K*33

where:
     NEMA Sentence     Description
        VTG            Track made good and ground speed
        054.7,T        True track made good (degrees)
        034.4,M        Magnetic track made good

        005.5,N        Ground speed, knots
        010.2,K        Ground speed, Kilometers per hour
        *33            Checksum
```

Note that, as of the 2.3 release of NMEA, there is a new field in the VTG sentence at the end just prior to the checksum.

GLL - Geographic Latitude and Longitude is a holdover from Loran data and some old units may not send the time and data active information if they are emulating Loran data. If a gps is emulating Loran data they may use the LC Loran prefix instead of GP.

Example 5 GLL:

NMEA sentence:

```
  $GPGLL,4916.45,N,12311.12,W,225444,A,*31

Where:
     NEMA Sentence     Description
     GLL               Geographic position, Latitude and Longitude
     4916.46,N         Latitude 49 deg. 16.45 min. North
     12311.12,W        Longitude 123 deg.
                       11.12 min. West
     225444            Fix taken at 22:54:44 UTC
     A                 Data Active or V (void)
     *31               checksum data
```

Note that, as of the 2.3 release of NMEA, there is a new field in the GLL sentence at the end just prior to the checksum.

GSV - Satellites in View shows data about the satellites that the unit might be able to find based on its viewing mask and almanac data. It also shows current ability to track this data. Note that one GSV sentence only can provide data for up to 4 satellites and thus there may need to be 3 sentences for the full information. It is reasonable for the GSV sentence to contain more satellites than GGA might indicate since GSV may include satellites that are not used as part of the solution. It is not a requirement that the GSV sentences all appear in sequence. To avoid overloading the data bandwidth some receivers may place the various sentences in totally different samples since each sentence identifies which one it is.

The field called SNR (Signal to Noise Ratio) in the NMEA standard is often referred to as signal strength. SNR is an indirect but more useful value that raw signal strength. It can range from 0 to 99 and has units of dB according to the NMEA standard, but the various manufacturers send different ranges of numbers with different starting numbers so the values themselves cannot necessarily be used to evaluate different units. The range of working values in a given GPS will usually show a difference of about 25 to 35 between the lowest and highest values, however 0 is a special case and may be shown on satellites that are in view but not being tracked.

Example 6 GSV:

NMEA sentence:

```
  $GPGSV,2,1,08,01,40,083,46,02,17,308,41,12,07,344,39,14,22,228,45*75

Where:
     NEMA Sentence     Description
      GSV              Satellites in view
      2                Number of sentences for full data
      1                sentence 1 of 2

      08               Number of satellites in view

      01               Satellite PRN number
      40               Elevation, degrees
      083              Azimuth, degrees
      46               SNR - higher is better

                       for up to 4 satellites per sentence
      *75              the checksum data, always begins with *
```

Appendix II: Instructions to Students for Field Test One

Instructions

1. On the day you are doing the GPS field test, after you walk outside of your residence and can see the sky, follow the instructions below to turn on the two GPSs:

For the smaller GPS logger, switch the Mode Switch on the side from “OFF” to “LOG”.

For the bigger GlobalSat Data Logger, press and hold the silver button on the front until a red power light and a green GPS status light are steady. Leave the Mode Switch on the side at “B”.

Stand still for a few minutes until the orange light on the GPS logger and the green light on the GlobalSat logger become blinking, indicating that they are receiving signals from satellites.

If either the orange light on the GPS logger or the green light on the GlobalSat logger does not blink even after 5 minutes, move to a more open space and stand still to wait for both the orange light and the green light blinking.

2. When both the orange light on the GPS logger and the green light on GlobalSat logger are blinking, you could start your trip of the day.

RECORD THE STARTING TIME OF YOUR TRIP ON THE DATA SHEET
RECORD THE MODE OF YOUR TRIP FROM YOUR HOUSE TO MANHATTAN

You could leave the GPSs in your bag or pocket. The orange light on GPS logger and the green light on GlobalSat should be blinking most of the day, except in underground subway when satellite signals are not available.

3. You need to walk both the Downtown path and the Midtown path (see the attached maps) 6 times. If any street section is closed to pedestrians during your walk, go around and continue the path.

RECORD THE MODE OF YOUR TRIP FROM DOWNTOWN TO MIDTOWN (OR FROM MIDTOWN TO DOWNTOWN)

4. When you are done with all the walking and arrive home, turn off the GPS logger by switching from “LOG” to “OFF” on the side and the GlobalSat logger by pressing the silver button until all three lights are off.

RECORD THE ENDING TIME OF YOUR TRIP
RECORD THE MODE OF TRIP FROM MANHATTAN TO YOUR HOUSE

5. We prefer that you finish both Downtown and Midtown path in one day. If you cannot finish both paths in one day, make sure that you turn off both GPSs when you get home on the first day.

If the battery is low (the green light on the GPS logger and the red light on the GlobalSat are blinking), turn the GPSs off and recharge them using the AC chargers. When the GPS logger is charging, the green light is steady. It will turn to blinking when it is full. When the GlobalSat logger is charging, the bottom light is orange.

On the second day, following the beginning of this instruction to turn on the GPSs, wait for both the orange light on the GPS logger and the green light on the GlobalSat logger blinking before you start the trip.

6. If you have any questions during the test, you could call me at my cell phone at NNN-NNN-NNNN.

7. Write a one-page report about the GPS testing, detailing the pros and cons of each GPS and the differences between the two GPSs. We intend to select one of them for use in a future regional travel survey.

DATA SHEET

1. Starting time of your trip:

Date (eg. 08/11/07):
Time (eg. 9:30 AM):

2. Mode from your house to Manhattan (eg. Walking, or taking Subway #7 and connect at Time Square to Bus # 42)

3. Mode from Downtown to Midtown/from Midtown to Downtown (eg. Walking, or taking Subway #6)

4. Mode from Manhattan to your house (eg. Walking, or taking Bus #42 and connect at Time Square to Subway #7)

5. Ending time of your trip:

Date (eg. 08/11/07):
Time (eg. 9:30 AM):

Appendix III: Data Sheet and Report from Students for Field Test One

DATA SHEET - STUDENT #1

DAY ONE:
1. Starting time of your trip:

Date: *08/12/07*
Time: *12:20 AM*

2. Mode from your house to Manhattan: *Q Subway Train from Cortelyou station to 57st train station near the Midtown path.*

3. Mode from Downtown to Midtown/from Midtown to Downtown: *N/A*

4. Ending time of your trip:

Date: *08/12/07*
Time: *6:20 PM*

5. Mode from Manhattan to your house: *Q Subway Train from 57 street train station to Cortelyou station in Brooklyn.*

DAY TWO (if you did not finish in one day):
Yes, I did not finish in one day.
1. Starting time of your trip:

Date: *08/13/07*
Time: *7:50 AM*

2. Mode from your house to Manhattan: *Q subway train from Cortelyou transfer to R train at Canal Street, R train taken downtown to Rector Street Station.*

3. Mode from Downtown to Midtown/from Midtown to Downtown: *N/A*

4. Ending time of your trip:

Date: *08/13/07*
Time: *10:50 AM*

5. Mode from Manhattan to your house: *I turned off the devices once I reached the Rector Street subway station.*

REPORT - STUDENT #1

Disregard the data collected on the 8/11/07, I turned on the devices with the intention to start the day of work but something came up and I turned the devices off.

On 8/12/07, I choose to do the midtown path and the both devices worked well. Although the GPS logger took an extra 5minutes than the global sat to pick up a signal.

The midtown path was obstructed by crowds of people, blocked off streets due to police security set in place for a parade. The first lap of the six is not a perfect lap, I found myself a bit lost in the crowds and went down wrong streets on a few occasions. But after lap two there should not be any inaccuracies. Also I never went outside of the path the wrong turns were with in the path.

Around 2:20-2:42pm I had lunch, I forgot the street but the restaurant was between 6^{th} and 5^{th} avenue. Also the devices were not receiving any signal with in the restaurant.

On 8/13/07, I began the financial district path. The global sat took an extra 10 minutes than the GPS logger to receive a signal. I took a detour around New Street via Broadway in the first of six laps and there after I walked through Broad street for the remaining 5 laps.

DATA SHEET - STUDENT #2

DAY ONE:

1. Starting time of your trip:

Date: *8/11/07*
Time: *1:52 pm*

2. Mode from your house to Manhattan:*4 train from Franklin Avenue in Brooklyn to Wall St.*

3. Ending time of your trip:

Date: *8/11/07*
Time: *5:18 pm*

4. Mode from Manhattan to your house: *4 train from Wall St. to Franklin Ave.*

DAY TWO:

1. Starting time of your trip:

Date: *8/12/07*
Time: *4:49 pm*

2. Mode from your house to Manhattan: *Franklin Ave. Shuttle from Park Place to Prospect Park, transfer to the Manhattan bound Q, transfer at Times Square to the N (running local), exit at 5th Avenue stop*

3. Ending time of your trip:

Date: *8/13/07*
Time: *1:15 am ****watched movie between 9:50 PM and 12:37 AM at union square, minus movie time I would have arrived home at 10:45 pm on 8/12/07*

4. Mode from Manhattan to your house: *N train (running local) from 5th Ave to Union Square, transfer to Brooklyn bound Q, transfer to Franklin Ave Shuttle at Prospect Park, exit at Park Place stop*

REPORT STUDENT #2

When I first turned on the GPS loggers the smaller GPS logger took less time to triangulate a signal than the larger GlobalSat logger. I found the smaller GPS logger to be easier to turn on and store in my handbag. Although we did not use the “point-of-interest” button on the smaller GPS logger I think it would be a useful and convenient feature but the GlobalSat does not have the same button. Also, if participants are driving a car and tracking their route the smaller GPS logger has a friction grip on the back of it so one can easily place it on the dashboard; again the GlobalSat does not.

On Saturday August 11th I walked the downtown route. The section of New St. between Exchange Place and Wall St. was closed so I walked on Broadway between Exchange Place and Wall St. instead. The smaller GPS logger continued to pick up a signal even when in narrow sections of downtown (such as Exchange Place between Hanover and Williams); however, the GlobalSat would often lose a signal in the same section. I noticed both loggers required that I stand still for at least a minute in an open area if a signal had just been lost in a narrow section.

On Sunday August 12th I walked the midtown route. I did not have to re-route and I did not notice any signal loss while walking through midtown.

DATA SHEET - STUDENT #3

DAY ONE:

1. Starting time of your trip:

Date: *8/11/07*
Time: *2:00pm*

2. *Walked from 34-41 85th St., Jackson Heights, 11372, south on 85th St. to 37th Ave. (a residential block, with 6 to 10 story apartment houses set back from the street and moderate to heavy tree cover), west on 37th Ave. to 82nd St., and one block south to the #7 line elevated station at 82nd St. (37th Ave and 82nd St are commercial strips, almost entirely with one and two story buildings and little tree cover. Took #7 line to Grand Central (entered East River tunnel at approximately 2.36 pm), transferred to #5 to Wall St. station, emerging at 3.15 pm. Walked down Wall St. to the designated path area; New St. was blocked by security fencing- began route at Wall and Broad, going counterclockwise. All paths therefore on Nassau and Broad from Liberty St. to Exchange Pl. First circuit marked by detour from Exchange and Broad to drug store at Exchange and Beaver and back again to buy batteries (see notes.)*

Took two stationary breaks, outdoors at 5.10-5.25 and indoors at 5.35-5.45 pm.

3. Ending time of your trip:

Date: *8/11/07*
Time: *9:00 pm*

4. *Completed last circuit at 7.15 at Broad and Wall. Walked to subway station at Wall and William Sts. Took #3 from Wall St. Station to Times Square, transferred to #7 to 74th St in Queens, transferred to Q19B bus routed north on 74th St. to 35th Ave, then east on 35th Ave to 84th St.. Walked from there, one block east and one half block north to home.*

{Extended travel times coming and going the result of subway and bus schedules and delays.}

DAY TWO (if you did not finish in one day):

1. Starting time of your trip:

Date: *8/12/07*
Time: *2:15 pm*

2. *Mode from your house to Manhattan (eg. Walking, or taking Subway #7 and connect at Time Square to Bus # 42)*

Walked to bus stop, 86th St. and 35th Ave., at 2.35 pm took Q19B west on 35th Ave, then south on 73rd St. to 74thSt./Roosevelt Ave. subway (_not_ elevated station) entrance at 37th Rd. and 73th St. Entered subway at 2.45 pm; took E train to Fifth Avenue station. Emerged at 53rd St. and Fifth Ave. at 3.10 pm; walked one block east to reach designated route at 53rd and Madison Ave., turned north and walked counterclockwise from that location.

Took an indoor stationary break from 5.05 to 5.30 pm, with an outdoor 5 minute rest stop each circuit.

3. Ending time of your trip:

Date 8/12/07
Time 10 pm

4. *Completed last circuit at 53rd and Madison at 9.10 pm. Took Q32 bus from 52nd and Madison at that time, north on Madison to 59th St., then east on 59th, over the Queensborough Bridge, then along Queens Blvd and Roosevelt Ave to 81st St. (note that from Queens Plaza to 81st St. this bus route is immediately alongside or under the #7 train.) Here bus turned north to 35th Ave, where I got off and walked four blocks east to 85th St and one half block north to home.*

REPORT - STUDENT #3

The smaller GPS Logger worked well at all times. The same can't be said for the larger Global Sat device. Both units had to be taken to a nearby intersection to acquire signal when I started. On both days, the GPS Logger acquired signal first- on the second day it was nine _minutes_ faster than the GlobalSat on a relatively open corner. In the tree and apt house environment of Jackson Heights, the Global Sat operated intermittently. Both units appeared to be operating at all times when on buses and above ground subways (I had window seats in all cases, with the devices either in a bag or my pockets at my side or at my feet- I didn't keep track of moving the device from my side to my feet, which perhaps should be done in the next round of tests.)

On day one, after coming up out of the subway at Wall St., GPS Logger quickly caught the signal, but I found the GlobalSat switched off. In retrospect, at some point after we went underground on the #7 line, a book in my bag probably hit the unprotected button and shut it down. This is a serious shortcoming in the device, if it is to be carried in pockets, pocketbooks, etc. Initially I couldn't restart it- I was repeatedly pushing the button, not holding it down (and forgetting the basic rule of e-life: when all else fails, read the manual.) I made a detour from the route, noted above, to buy batteries, but when changing these didn't work either, and given the information about the required route change regarding New St., at 3.45 I called in. I encountered Elizabeth at my second circuit at 4.15, who showed me how to push a button, and from that point on the Globalsat remained on, but had little acquisition until I decided to see how remaining stationary would affect it. Accordingly, I stopped and waited at the relatively open corner at Liberty and Nassau Sts. By 5.20 signal was acquired, and remained active if intermittent for the rest of the afternoon.

I also ran specific acquisition tests. On my last three circuits on day one, I stopped at 20 Exchange Place, located on a narrow street lined with very tall buildings, which had a relatively deep entry way (about 15 feet) and construction scaffolding in front, to test reception within the entryway. The small GPS Logger performed well, losing signal only once, in the deep recess of a revolving door at the back of the entry, and immediately reacquired on being brought to the front of the entry. On all three stops, the GlobalSat lost signal as I passed from the construction scaffolding into the entryway, and reacquired only when brought back into the street. On day two, I tested an indoor signal. While I was seated twenty feet inside a store with a large plate glass window facing Madison Ave., only GPS Logger held signal.

On day 2, after emerging from the subway, GPS Logger took 10 seconds to reacquire, while the large unit needed one minute. However, the pattern of faster acquisition for GPS Logger was not constant. On day one, when I timed reacquisition as the #7 train emerged from the East River tunnel, GlobalSat picked up the signal in ten seconds, while GPS Logger needed one minute forty seconds to do the same.

DATA SHEET STUDENT #4

DAY ONE:

1. Starting time of your trip:

Date: *August 11, 2007*
Time: *11:05 AM*

2. Mode from house to Manhattan: *Took the N from Atlantic Avenue Station to 49th Street Station; Walked from station to 50th Street and 6th Avenue to begin Midtown Loop.*

3. Mode from Midtown to Downtown: *Took the N Subway from 49th Street Station to Rector Street Station; Walked from station to Broadway and Exchange Place to begin the Downtown route.*

4. Ending time of your trip:
Date: *August 11, 2007*
Time: *7:06 PM*

5. Mode from Manhattan to your house: *Walked over the Brooklyn Bridge from Downtown to Brooklyn.*

DAY TWO: *N/A*

REPORT - STUDENT #1

When I started in the morning, it took *GPS logger* a bit longer time than *GlobalSat* to start up. But once it did, it pretty much worked well the entire time. The *GlobalSat*, on the other hand, was unpredictable. While starting with the Midtown loop, both GPS were blinking (although *GPS logger* was more consistent with its blinking than *GlobalSat*). Once I reached downtown, *GlobalSat* ceased to function. The green light was stagnant almost the entire time. I'm still not quite sure if it had actually picked up anything during the Downtown route. I would stop for minutes, or even walk in the middle of the street to just get it started again, but was unsuccessful in those attempts. *GPS logger* was again, working consistently with its light blinking while I walked through the narrow streets and paths. In addition, the size made it lighter to carry, and the switch on its side seemed to be more safely secured than the silver on/off button of *GlobalSat.* While I had both GPS in my bag the previous night, *GlobalSat* was accidentally turned on because it was squished inside. *GPS logger* was not affected because the switch on the side made it more difficult to accidentally switch it on or off.

New Street was blocked off on Saturday. To continue with the route, I extended the loop on Wall Street and Exchange Place, and walked through Broadway instead.

The batteries of both GPS held for the duration of the eight-hour walk. I did not have to make any battery replacements or recharge them during the day.

DATA SHEET - STUDENT #5

DAY ONE:

1. Starting time of your trip:

Date (eg. 08/11/07): *8/11/07*
Time (eg. 9:30 AM): *3:45PM*

2. Mode from your house to Manhattan (eg. Walking, or taking Subway #7 and connect at Time Square to Bus # 42)
Subway A to #2

3. Mode from Downtown to Midtown/from Midtown to Downtown (eg. Walking, or taking Subway #6)

4. Ending time of your trip:

Date (eg. 08/11/07): *8/11/07*
Time (eg. 9:30 AM): *8:55 PM*

5. Mode from Manhattan to your house (eg. Walking, or taking Bus #42 and connect at Time Square to Subway #7)
Subway #2 to A

DAY TWO:(if you did not finish in one day):

1. Starting time of your trip:

Date (eg. 08/11/07): *8/12/07*
Time (eg. 9:30 AM): *4:41PM*

2. Mode from your house to Manhattan (eg. Walking, or taking Subway #7 and connect at Time Square to Bus # 42)
Subway A to E

3. Mode from Downtown to Midtown/from Midtown to Downtown (eg. Walking, or taking Subway #6)

4. Ending time of your trip:

Date (eg. 08/11/07): *8/12/07*
Time (eg. 9:30 AM): *10:00PM*

5. Mode from Manhattan to your house (eg. Walking, or taking Bus #42 and connect at Time Square to Subway #7)
Subway E to A

REPORT - STUDENT #5

Both the larger and the smaller units started working within a few of minutes of being outside. Though both units seemed to periodically stop receiving the signal it happened with the larger unit more frequently and for longer intervals, both in downtown and in midtown. There were several problems with the GPS units. The battery cover of the larger unit popped off while I was walking, causing the battery to fall out. The switch of the smaller unit fell off. I had no problems charging either one.

I had to take an alternate path downtown because New St was closed between Wall St. and Exchange Pl, and therefore I went around it via Broadway.

Report - Student # 6

[A.] The places included in this trip test are:

Downtown:
Wall Street, Pine Street, Beaver Street,
Broadway, New Street, and Broad Street between Beaver and Pine Street.

Grand Central Station.

Midtown:
6th Avenue between West 41st Street and West 58th Street
West 51st, West 52nd, and West 58th Street between Madison and 6th Avenue

I set the one Global sat units have a 10s interval (01034) and 1s for the other (01035) as compare. Both the two iBlue units (04003 & 04007) are set to time interval of 1s.

[B.]The test shows that:

1. First start: Outside the engineering building of CCNY, the iBlues took about 1 min to get my location and one of the global sat with signal time interval of 1s spent more than 2 minutes to pick me up. The 10s interval Global sat took nearly 4 minutes to began blinking.

2. When out of subway to Wall Street, as the surrounding tall buildings, I have to change several locations to receive the signals. It took the iBlue units more than 2 minutes to pick me up again, and nearly 4 minutes for the Global sat.

3. During my walking trips on both downtown and midtown, the urban canyon (tall buildings) does not influence the GPS signal very much. Once a while, the GPS lost me, and it would pick me up again after a few seconds.

4. Both iBlues and Global sats are not working inside buildings. None of them can receive signals inside The Grand Central terminal building. Even inside the engineering building at CCNY, none of them would blink.

5. Along the trip, the iBlue units appear to be more sensitive to the satellites. It is faster when one needs to pick up the signal again; when Global sat lost signal somewhere, sometimes the iBlues are still blinking.

6. For the iblue units, it appears that the time on the data records are problematic. During the procedure of picking up, the time shows different than it real was.

For example: the time shows:

8/14/2007 0:00:14
8/14/2007 0:00:16

……………………….
8/14/2007 0:03:12
8/14/2007 0:03:13
8/14/2007 2:55:42
8/15/2007 1:04:08
………………………..

Even after the picking-up period, the time is still different from the reality. However, the Global sats shows the accurate time as blow.

8/14/2007 21:05:34
………………………..

7. Comparing the time interval of 1s iBlue with Global sat, the number of point records are 13600 vs. 4646. The total trip takes between 3.5 hours and 4 hours, mainly equals 13600 seconds. This comparison shows: the iBlue units take records every second, the Global sat only take records when speed is greater than 0. In the case of using subway and lost underground, the Global sat can save record space without lost sufficient information.

It is supposed that the influence of different time intervals will also be test in this trip. It shows that the 10s interval unit is not as sensitive as the 1s interval unit. However, since these two are different even set to same time interval, this might just be the difference of equipment itself, not caused by the time interval issue.

8. Looking at the 125th No. 1 train station, it actually shows two things: first, both types of the GPS units are all able to pick up signal when train runs aboveground; second, the Google earth shows that the GPS can get quite accurate location information when set the signal time interval to be 1s: the GPS track points match the train track on map.

[C.]Other issues of using the units include:

1. It is very hard to change battery of Global sat.

2. The plastic piece on the switch of the iBlue unit drops off from the body easily. It would be difficult to use the switch without that.

3. Connecting the Global set to a desktop with the USB and recharging the battery seems convenient to me, however may not suit for everyone.

4. When install the software along with the Global sat, it requires my computer to restart twice in order to read data appropriately. The one with iBlue didn't cause this problem.

5. Connecting and transferring data between the computer and the GPS takes much longer time than other storage units and my expectation. I even miss delete one test data without saving because of the misunderstanding about the software interface.

6. There are miss-connecting between the software for Global sat and the Google earth: click on draw the map can not connect direct to the Google earth.

Appendix IV: Number of Proxy and Non-Proxy Transit Users Tables

Table 1: *Number of Proxy and Non-Proxy Transit Users Whose Records are Updated or Not during Update Pass 1 (when the number of proxies = 0)*

	Not a proxy		Proxy		Total
	Freq.	%	Freq.	%	
Not updated during pass 1	242	100	0	0	242
Updated during pass 1	664	100	0	0	664
Total	906		0		906

Table 2: *Number of Proxy and Non-Proxy Transit Users Whose Records are Updated or Not during Update Pass 1 (number of proxies = 2)*

	Not a proxy		Proxy		Total
	Freq.	%	Freq.	%	
Not updated during pass 1	13	7.0	172	93.0	185
Updated during pass 1	25	13.5	160	86.5	185
Total	38		332		370

Table 3: *Number of Proxy and Non-Proxy Transit Users Whose Records are Updated or Not during Update Pass 1 (number of proxies = 3)*

	Not a proxy		Proxy		Total
	Freq.	%	Freq.	%	
Not updated during pass 1	0	0	5	100	5
Updated during pass 1	0	0	2	100	2
Total	0		7		7