SIEVE

40 λ Filtering Software
User's Manual Version 1.3

Coyote Sieve User Manual

Introduction

The Coyote Sieve is installed on a Laptop or Desktop PC® running MS Windows XP SP2. The Coyote Sieve software for your laptop or desktop is contained on the included CD-ROM. Insert this CD-ROM into your PC and you will be prompted to install the software.

Coyote Sieve User Manual

The Coyote Sieve uses Dr. Lee's 40-Lambda technique to create an ASCII output file with averaged samples. It can be loaded to the customer's own analysis software. It can also generate a KML file to map out the raw data samples on GoogleEarth™.

Control Buttons in the Panel

The control panel of this software is shown in the following figure. It has 4 functional sections to guide the generation of an output file or a KML file. The first section (1) is to select input and output files. Input files are Coyote log files (KLF). Usually when the input file is selected, the output file will be named after the input file with an extension ".out". When a KLF file is saved in a CF card, the size of the file is equal to that of the CF card. Usually it is much larger than the file's real size. When this file is loaded to process, a dialog box (see Figure 2) will be popped up to ask if the file needs to be truncated to its real size. Figure 3 shows the error message for an input file collected with an old version coyote firmware. The KLF file collected with the old-version firmware is short of important information for post processing. Please contact BVS for upgrading the Coyote firmware. Figure 4 shows the error message for a KLF file collected with incorrect operations. Please follow the two-page step-by-step procedures (Notes for Drive Study with Coyote Receiver) to ensure that the file is collected correctly.

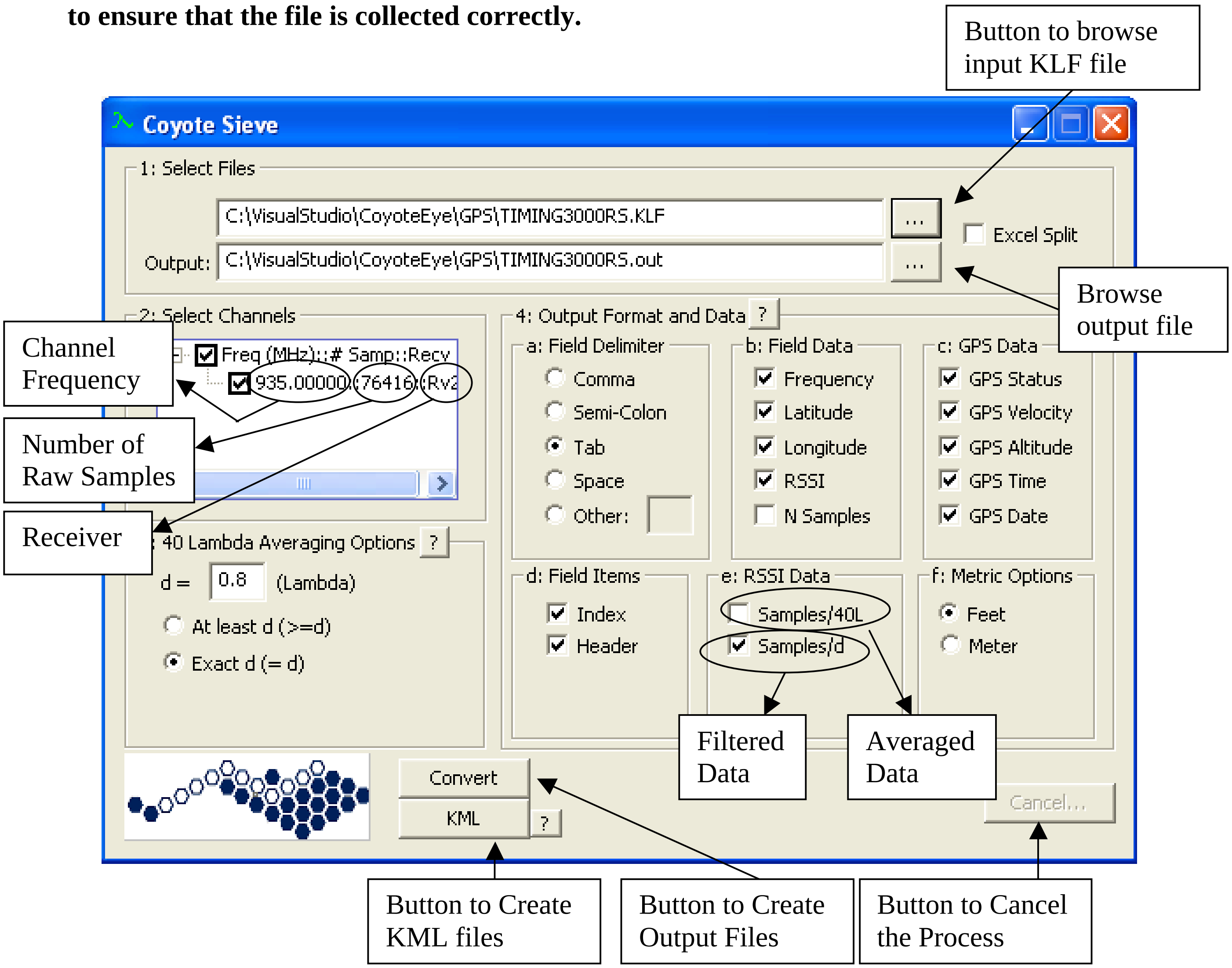


Figure 1: Buttons on the Panel

Figure 2: Save a CF card file to a file with its real size

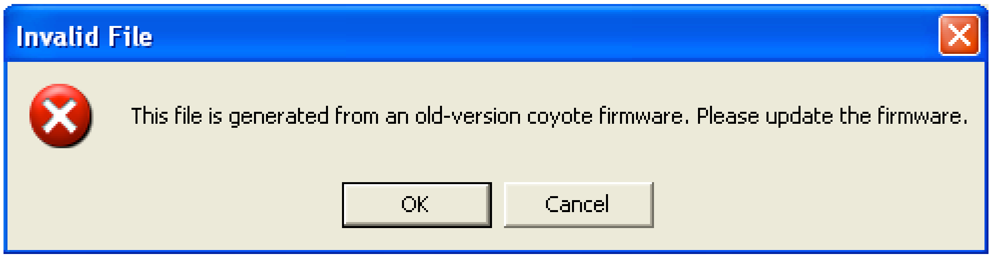


Figure 3. Error message for old-version firmware.

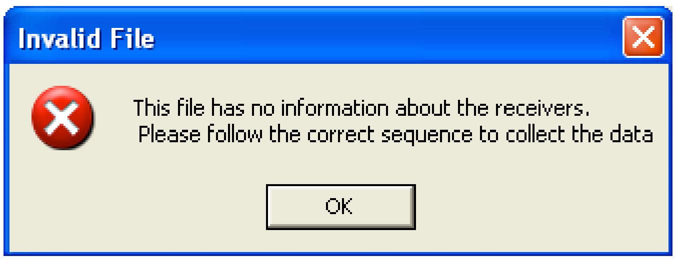


Figure 4. Error message for incorrect operation to collect data.

After a KLF file is selected, the Coyote Sieve begins loading and processing the data. If the box before "Excel Split" is checked, the output files will be saved in the folder which is named after the output file without the extension "out". The size of each file will be less than 61000 samples. Therefore each file can be read by Microsoft Excel. The second section (2) is to select the channel to do the conversion by placing a check mark "√" on the frequency to be converted. The algorithm will do the averaging based on the wavelength of the signals. The channel frequency, the number of raw data, and receiver number will be shown on the screen, where "Rv1" represents receiver 1 and "Rv2" represents receiver 2.

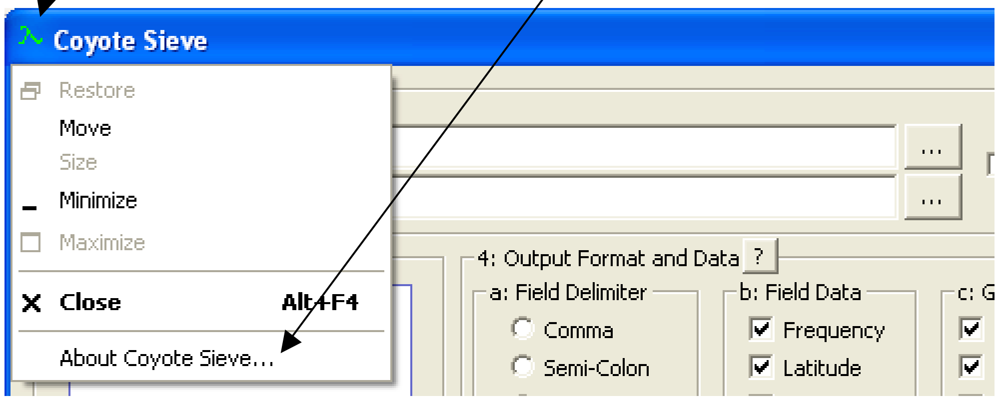
The third section (3) is to select the averaging options that include the input of "d" (distance) based on Lambda. The fourth section (4) is to select the output file format and data. Section 4a in the fourth part is the selection of the delimiter to separate the data. Section 4b is to select the output data fields. Section 4c is to select the GPS data in the output file. GPS status relates to how the GPS information is calculated. Section 4d is to select if the index and header should be included in the output file. Section 4e is the selection of RSSI data in the output file. If the box before "samples/40L" is checked, the 40 Lambda averaged data will be written into the output file. If the box before "samples/d" is checked, the filtered data will be in the output file. Here filtered data means the data are obtained after filtering out the redundant (correlated) data. They are at least d apart depending on the averaging options. Section 4f is concerned with the metric. Feet are the default option.

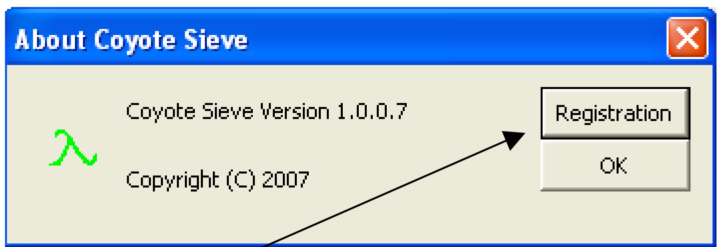
The velocity and altitude in the Section 4c is shown as MPH (Miles per Hour) and Ft (feet). If Meter is selected in Section 4f, the velocity and altitude will be shown as KPH (Kilometer Per Hour) and M (Meter). The "Convert" button starts the data processing after all the selections have been made. The "Cancel" button is used to stop the process of loading input file, converting the data, or creating a KML file.

Note: In Section 4c-GPS Data, when dead reckoning system is used for positioning, GPS status and altitude are not available.

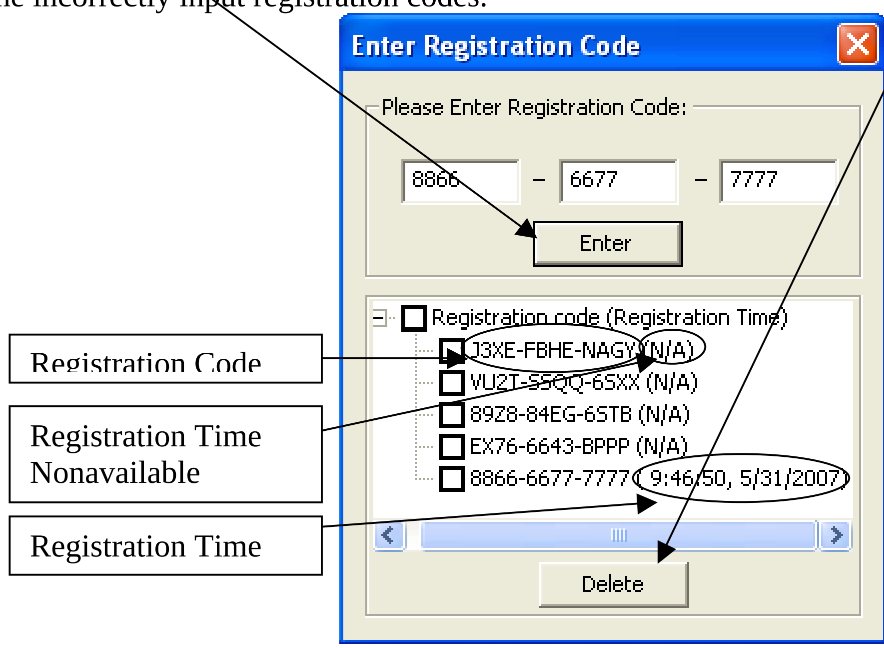
Enter Registration Codes

Click on the “” logo and then click on the “about Coyote Sieve…” to pop up “About Coyote Sieve” dialog box.





Then click on the Registration button to pop up the dialog box to enter registration code. Please press Enter button to enter the registration code and use the Delete button to delete the incorrectly input registration codes.



Averaging Options

The program bases its calculations on the actual frequency being measured and allows the user to select the independent distance (d) for averaging in 40 wavelengths. The averaging technique requires that the samples being averaged are at least the uncorrelated distance apart (uncorrelated with respect to Rayleigh fading). The uncorrelated sample averaging eliminates the need for signal strength interpolation and has a rich mathematical treatment in the relevant literature. In essence, a predetermined number of uncorrelated samples are averaged within 40 wavelengths to provide an unbiased estimate of the mean. The processing block diagram is shown in Figure 5. There are two filtering stages. The first stage is to filter out the redundant data from the input file. It means the selection of the independent samples. Then the filtered data will be used to get the 40 Lambda-averaged data.

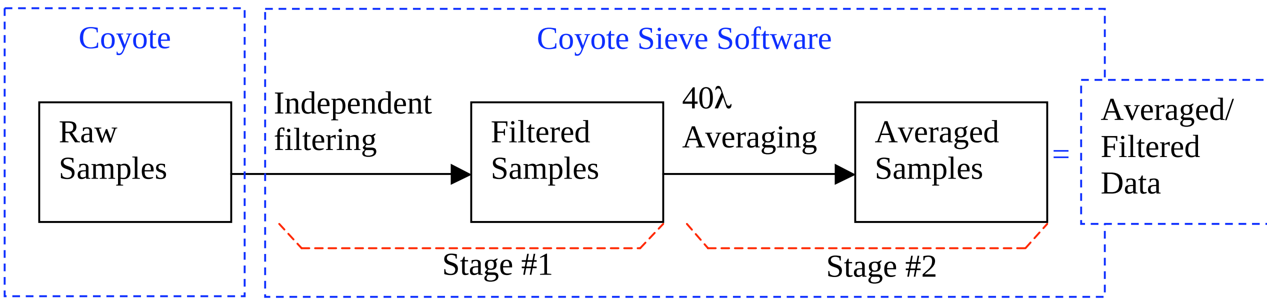


Figure 5: 40 Lambda averaging process

Note: When the Sieve output data will be used with a 3rd party mapping software that is capable of its own 40 Lambda calculations, please select the "Samples/d" option only at Section 4e on the panel where d means independent filtering (Stage #1).

This software provides two options for averaging. The default distance *d* for independent samples is 0.38 wavelength (Lambda) according to Bessel correlation function with respect to Rayleigh fading. Therefore, the *d* that is input has to be greater than 0.38. The first option is to average the samples that are spaced at least d Lambda apart. For the second option - exact *d*, interpolation will be preformed between samples using an inverse distance weighted average, as follows:

$$s = s_1\left(\frac{\frac{1}{(x-x_1)^2}}{\frac{1}{(x-x_1)^2}+\frac{1}{(x-x_2)^2}}\right)+s_2\left(\frac{\frac{1}{(x-x_2)^2}}{\frac{1}{(x-x_1)^2}+\frac{1}{(x-x_2)^2}}\right), \text{ Where } x\in[x_1,x_2] \quad (1)$$

Where $x = nd$, $n = 1, 2,....$ Only these samples spaced *d* wavelength apart are used in the average. This provides exactly 40 Lambda sampling and averaging as described by Lee.

For example, for a requirement of 50 samples per 40 wavelengths, the selected samples need to be spaced exactly 0.8 wavelengths apart. At 50 Km/h (13.9 m/s), a Coyote sampling at 256 samples per second would have samples spaced 0.45 wavelengths apart.

One the other hand, while driving at 10 Km/h, under the same conditions the samples would be spaced 0.09 wavelengths apart. The position of each of the samples is interpolated from the one-second GPS report. This is done assuming a constant velocity during the one second GPS reporting interval. The interpolation equation is

$$P_{0,i} = \frac{(P_1 - P_0)i}{N} + P_0 \text{, Where } P_0 \text{ and } P_1 \text{ are known GPS positions and } i = 0,1\ldots M \qquad (2)$$

Here M = 256. Figure 6 demonstrates the difference for the two averaging options. For averaging option 1 – at least d (d = 0.8), sample at $P_{0,2}$ will be selected and the one at $P_{0,1}$ will be deleted. The next selected one will be at $P_{0,4}$. Thus there will be totally 45 samples selected for averaging ($P_{0,i}$, i =0, 2, … 90) and 45 samples will be filtered out ($P_{0,i}$, i =1, 3, … 89) in 40 Lambda from P_0 to P_1. If averaging option 2 is selected, the samples at $P_{0,1}$ and $P_{0,2}$ will be used to interpolate the signal power at 0.8λ using equation (1). Here, x = 0.8, $x_1 = P_{0,1}$, $x_2 = P_{0,2}$. Thus there will be exactly 50 samples after filtering.

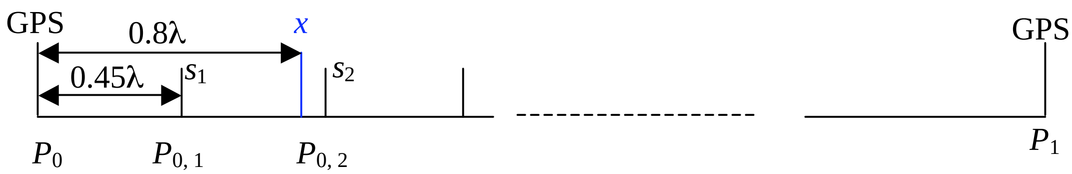


Figure 6. Difference of two averaging options.

If d is too large, driving speed is too fast, or the sample rate of the Coyote is too low, there will not be enough filtered data for averaging. This will result in unreliable averaged data. The default maximum value for d is 1. If d > 1, an information window will pop up to ask for reducing the value of d. If the software still detects the unreliable data, it will pop up a window to ask if this unreliable data should be excluded in the output file. When d = 1, the number of filtered samples $N = 40/d = 40$. This is the minimum number of filtered samples for averaging in this software. If averaged RSSI is S and the real RSSI is S_0 dBm, When N = 40, the averaged RSSI S has 90% possibility belonging to [S_0-1.45, S_0+1.45] dBm. An example of warning message is shown in Figure 7. In this case, the average data with N < 40 will be regarded as the unreliable data. Figure 7 shows that there are 26 out of 11893 averaged data with N < 40.

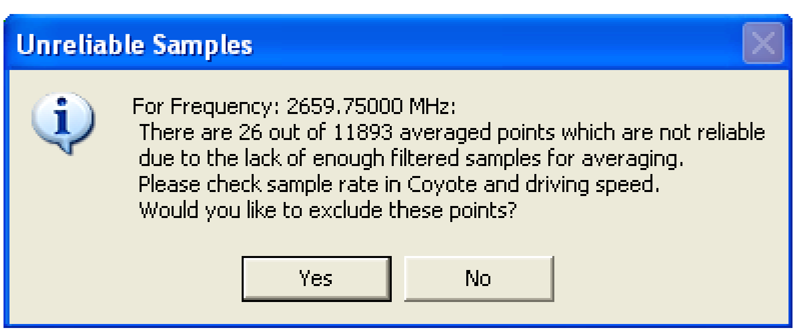
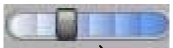
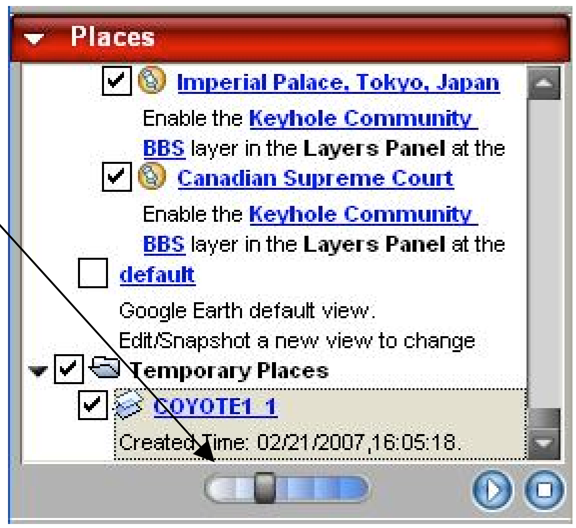


Figure 7. Warning message box for averaging.

Creating a KML File

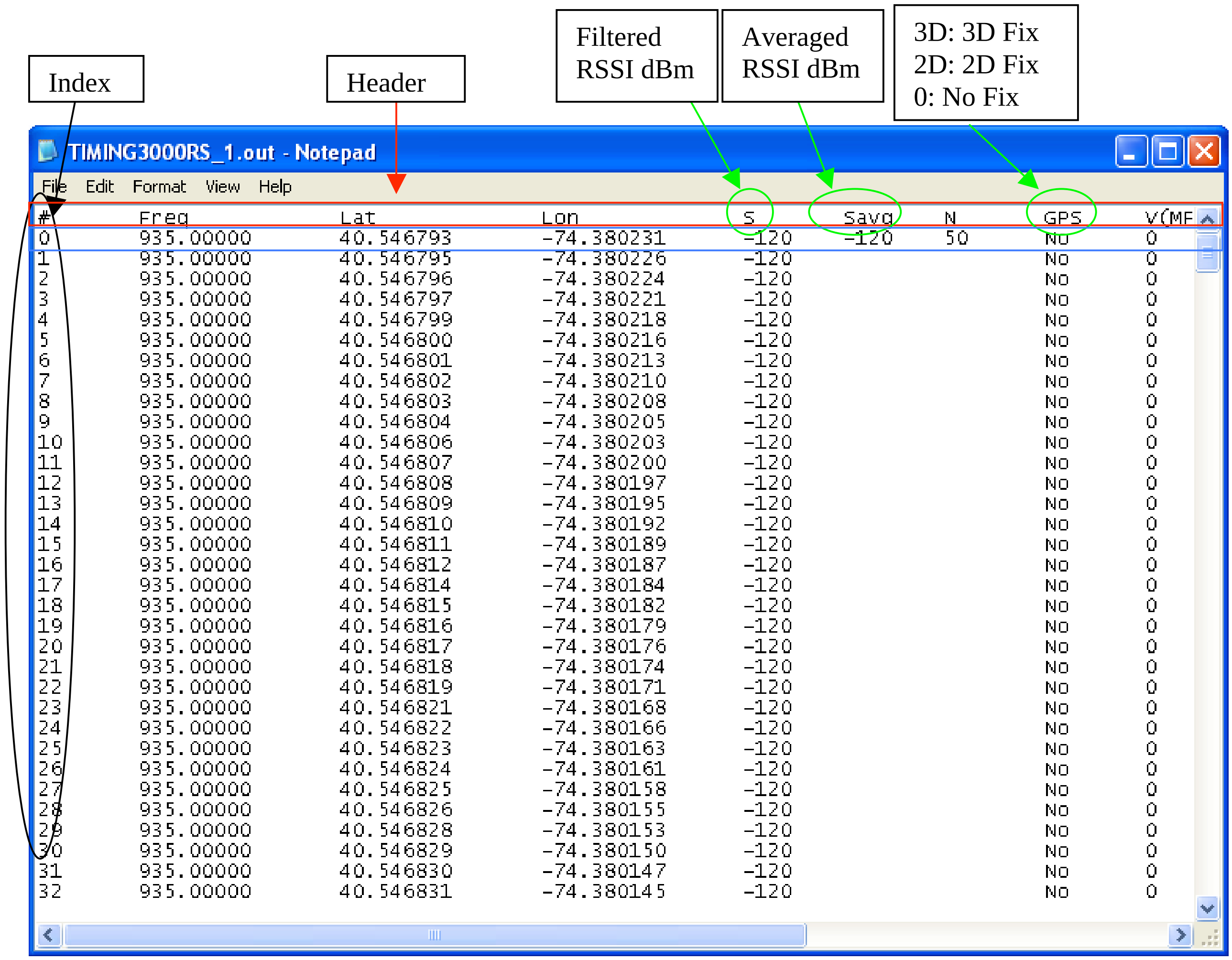
Keyhole Markup Language (KML) files can be opened by [Google Earth] and the current view will be shown on top of the GoogleEarth image. After loading the input file, click on the KML button to generate a KML file which can map the survey data (raw data) onto GoogleEarth.

After creating a KML file, right click on the file and select "GoogleEarth" to open it. Pull down the scroll button at "Places" to the bottom, check the box before the name, the view will be shown on top of GoogleEarth and the transparency can also be adjusted by the slider control underneath. It can also be saved in "My Places". The transparency slider  **is used to adjust the transparency of the overlapped image.**

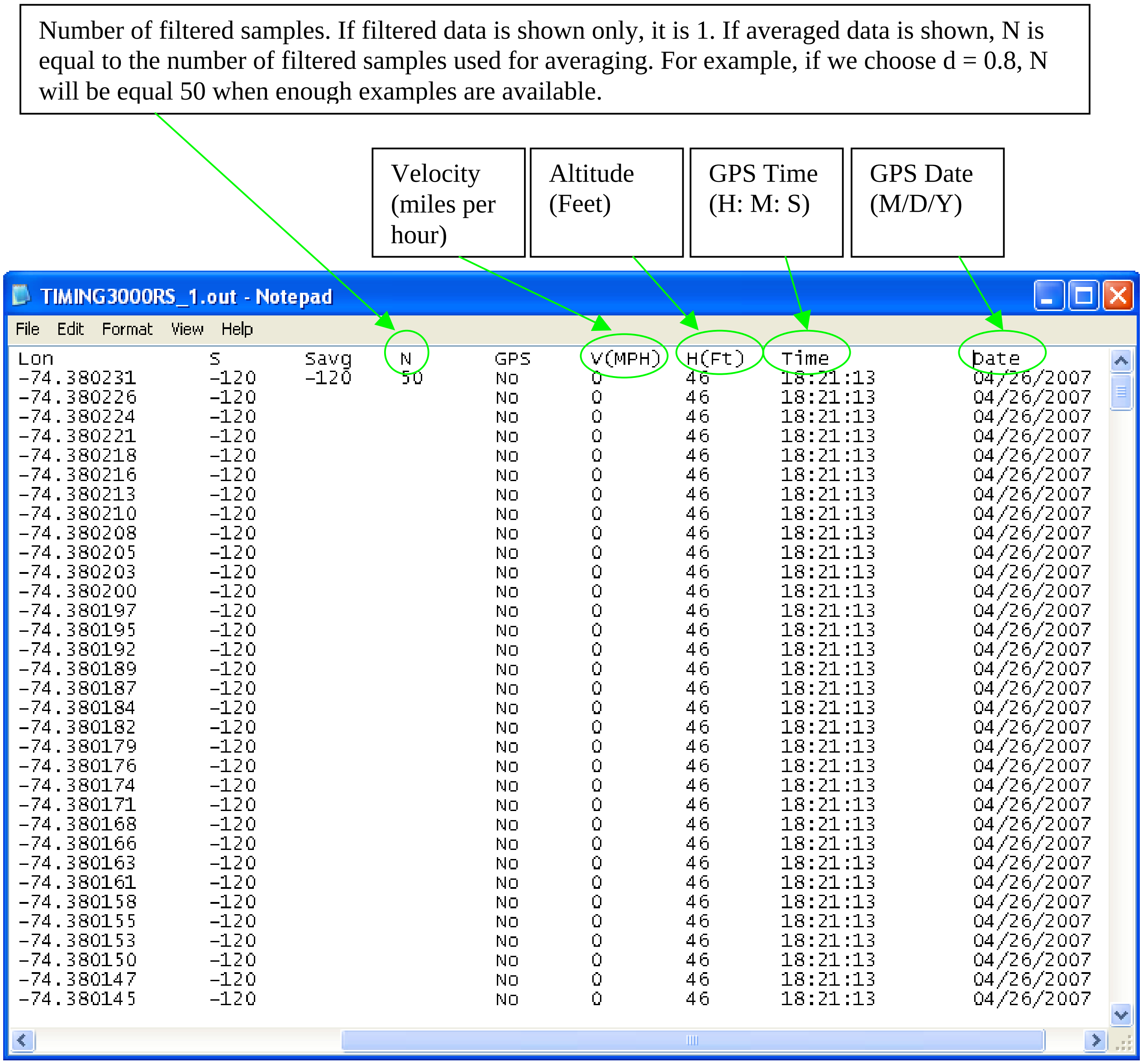


An Output File Example

One output file example is shown in the following figures. In this example output file, all the items (Sections 4a-4f) are checked in the output file format. The averaged RSSI can be compared to the filtered RSSI. N means the number of filtered samples for the averaged sample. The averaged sample will be shown in the position of M_1 in the Index column (#), where M_1 is the starting index of the samples used for this averaged data. For example, the first averaged data (Savg = -120) used the filtered samples with Index number from 0 to 49. Therefore, $M_1 = 0$. The averaged data is shown at Index number 0.



#	Freq	Lat	Lon	S	Savg	N	GPS	V(MF
0	935.00000	40.546793	-74.380231	-120	-120	50	No	0
1	935.00000	40.546795	-74.380226	-120			No	0
2	935.00000	40.546796	-74.380224	-120			No	0
3	935.00000	40.546797	-74.380221	-120			No	0
4	935.00000	40.546799	-74.380218	-120			No	0
5	935.00000	40.546800	-74.380216	-120			No	0
6	935.00000	40.546801	-74.380213	-120			No	0
7	935.00000	40.546802	-74.380210	-120			No	0
8	935.00000	40.546803	-74.380208	-120			No	0
9	935.00000	40.546804	-74.380205	-120			No	0
10	935.00000	40.546806	-74.380203	-120			No	0
11	935.00000	40.546807	-74.380200	-120			No	0
12	935.00000	40.546808	-74.380197	-120			No	0
13	935.00000	40.546809	-74.380195	-120			No	0
14	935.00000	40.546810	-74.380192	-120			No	0
15	935.00000	40.546811	-74.380189	-120			No	0
16	935.00000	40.546812	-74.380187	-120			No	0
17	935.00000	40.546814	-74.380184	-120			No	0
18	935.00000	40.546815	-74.380182	-120			No	0
19	935.00000	40.546816	-74.380179	-120			No	0
20	935.00000	40.546817	-74.380176	-120			No	0
21	935.00000	40.546818	-74.380174	-120			No	0
22	935.00000	40.546819	-74.380171	-120			No	0
23	935.00000	40.546821	-74.380168	-120			No	0
24	935.00000	40.546822	-74.380166	-120			No	0
25	935.00000	40.546823	-74.380163	-120			No	0
26	935.00000	40.546824	-74.380161	-120			No	0
27	935.00000	40.546825	-74.380158	-120			No	0
28	935.00000	40.546826	-74.380155	-120			No	0
29	935.00000	40.546828	-74.380153	-120			No	0
30	935.00000	40.546829	-74.380150	-120			No	0
31	935.00000	40.546830	-74.380147	-120			No	0
32	935.00000	40.546831	-74.380145	-120			No	0



Lon	S	Savg	N	GPS	V(MPH)	H(Ft)	Time	Date
-74.380231	-120	-120	50	No	0	46	18:21:13	04/26/2007
-74.380226	-120			No	0	46	18:21:13	04/26/2007
-74.380224	-120			No	0	46	18:21:13	04/26/2007
-74.380221	-120			No	0	46	18:21:13	04/26/2007
-74.380218	-120			No	0	46	18:21:13	04/26/2007
-74.380216	-120			No	0	46	18:21:13	04/26/2007
-74.380213	-120			No	0	46	18:21:13	04/26/2007
-74.380210	-120			No	0	46	18:21:13	04/26/2007
-74.380208	-120			No	0	46	18:21:13	04/26/2007
-74.380205	-120			No	0	46	18:21:13	04/26/2007
-74.380203	-120			No	0	46	18:21:13	04/26/2007
-74.380200	-120			No	0	46	18:21:13	04/26/2007
-74.380197	-120			No	0	46	18:21:13	04/26/2007
-74.380195	-120			No	0	46	18:21:13	04/26/2007
-74.380192	-120			No	0	46	18:21:13	04/26/2007
-74.380189	-120			No	0	46	18:21:13	04/26/2007
-74.380187	-120			No	0	46	18:21:13	04/26/2007
-74.380184	-120			No	0	46	18:21:13	04/26/2007
-74.380182	-120			No	0	46	18:21:13	04/26/2007
-74.380179	-120			No	0	46	18:21:13	04/26/2007
-74.380176	-120			No	0	46	18:21:13	04/26/2007
-74.380174	-120			No	0	46	18:21:13	04/26/2007
-74.380171	-120			No	0	46	18:21:13	04/26/2007
-74.380168	-120			No	0	46	18:21:13	04/26/2007
-74.380166	-120			No	0	46	18:21:13	04/26/2007
-74.380163	-120			No	0	46	18:21:13	04/26/2007
-74.380161	-120			No	0	46	18:21:13	04/26/2007
-74.380158	-120			No	0	46	18:21:13	04/26/2007
-74.380155	-120			No	0	46	18:21:13	04/26/2007
-74.380153	-120			No	0	46	18:21:13	04/26/2007
-74.380150	-120			No	0	46	18:21:13	04/26/2007
-74.380147	-120			No	0	46	18:21:13	04/26/2007
-74.380145	-120			No	0	46	18:21:13	04/26/2007

Appendix A: 40λ Averaging Technique

There are two types of fading that are relevant to performing coverage measurements, fast fading, also know as Rayleigh fading, and terrain based fading due to obstructions and propagation loss. The goal of coverage measurement is to measure the local signal strength in presence of terrain based fading.

Rayleigh fading is due to close in reflections. It produces drops in signal strength that are only a fraction of a wavelength in size (often on the scale of inches). These fades always exist and are only of interest in the sense that coverage measurements must be made in a manner that rejects Rayleigh fading, so that accurate measurements of terrain-based fading can be made.

It is important to realize that Rayleigh fading is a spatial phenomenon not a time one. The averaging is intended to be done over a distance of forty wavelengths. Most people performing coverage analysis average samples spatially after they are collected. That is to say, all the samples within a grid on a map are averaged to produce one point. To insure rejection of Rayleigh fading, the grid size must be larger or equal than forty wavelengths.

William C. Y. Lee derived a well-accepted criterion for removing Rayleigh fading and retaining slower terrain based fading, known as 40 Lambda averaging [1]. In order to remove Rayleigh fading, you should average data for a time period equal to the time it takes to traverse 40 wavelengths in your measurement vehicle and you should have no less than 36 to 50 points in that time. It makes the averaged value very close to the real value (within several dB's) λ . David Parsons derived another criteria for removing Rayleigh fading. If we have *N* samples during the drive study, which are at least 0.38λ apart. The sum of these *N* samples can average out the Rayleigh fading. The accuracy of the averaging depends on the number if samples, *N* [2].

In the following test we will give a mathematic description of the two criteria. William Lee analyzed the performance of averaging with respect to the grid size, where the continuous fading in the space was considered. In real life measurement, we get the discrete number of samples. Assuming the received signal's power is $r(x)$, William Lee analyzed

$$m_0 = \int_0^L r(x)dx = \int_0^L m(x)q(x)dx = m_1 \int_0^L q(x)dx \qquad \textbf{(A1)}$$

Where m_0 is the estimated value, $m(x)$ represent terrain based fading, $q(x)$ is Rayleigh fading. Assuming the terrain base fading is constant in L, which is m_1. The analysis shows that m_0 will be within ±1 dB of m_1 when L = 40λ. David Parsons gave analysis for the discrete samples [2]. Assume we have *N* independent samples in 40 Lambda, $r_n = r(x_n)$, n = 0, 1, …,*N*-1. The mean value is

$$m_0 = \sum_{n=0}^{N-1} r_n = m_1 \sum_{n=0}^{N-1} q(x_n) \qquad \textbf{(A2)}$$

The analysis shows that m_0 has a 90% probability to be within ±1 dB of m_1 when N = 57. Here m_0 is expressed linearly. If the analysis is done in dB,

$$\log_{10}(m_0) = \log_{10}\left(\sum_{n=0}^{N-1} r_n\right) = \log_{10}(m_1) + \log_{10}\left(\sum_{n=0}^{N-1} q(x_n)\right) \quad \textbf{(A3)}$$

In this case, 85 samples (N = 85) are needed to make $\log_{10}(m_0)$ that has a 90% probability to be within ±1 dB of $\log_{10}(m_1)$. The minimum independent distance d is 0.38λ. Thus it needs 33λ and 22λ for logarithm and linear averaging, respectively.

[1]. William C. Y. Lee, Mobile Communication Engineering: Theory and Applications, second edition, McGraw-Hill Telecommunications, 1997.
[2]. David Parsons, The Mobile Radio Propagation Channel, John Wiley &Sons, New York, 1992.