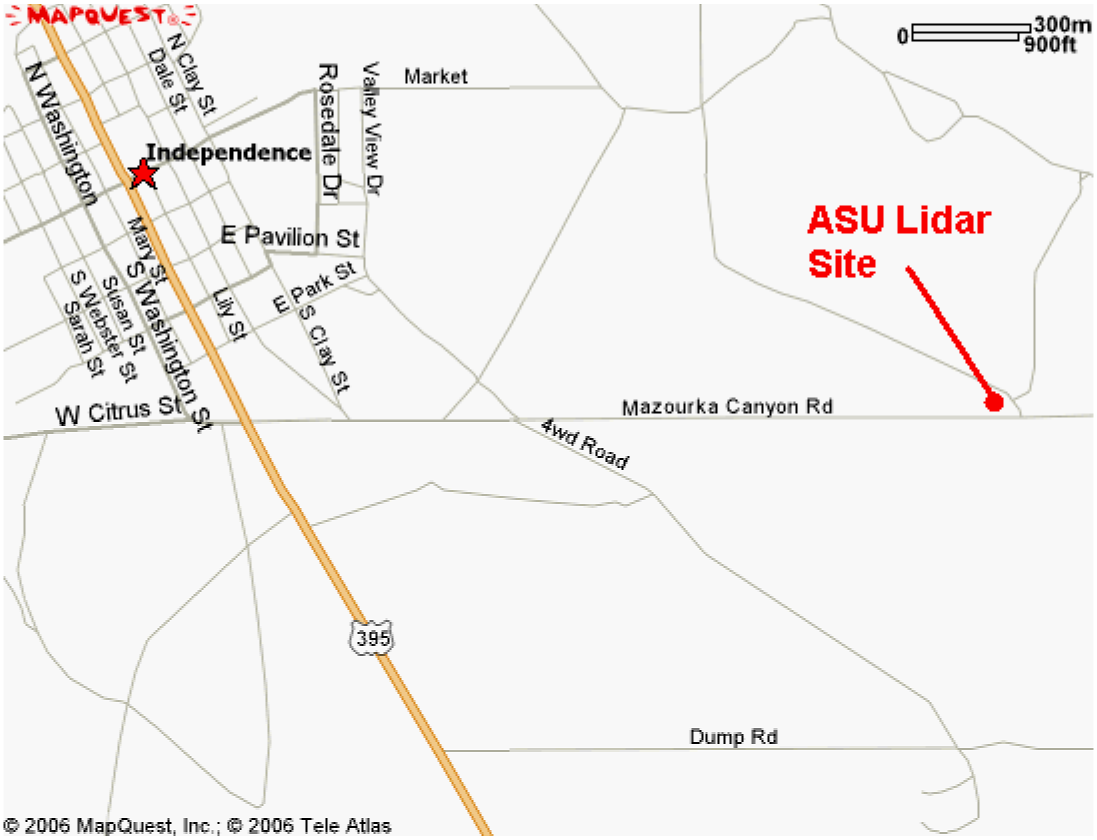
ASU Lidar Matlab Users Guide

1) Introduction

This document contains information about the Matlab scripts used by Arizona State University's Lidar team to manipulate data acquired in the Terrain Induced Rotor Experiment experiment in Independence, CA. The ASU Lidar acquired data from March 1st to April 29th. These data sets are stored in the CTI data format, but can be manipulated by using the Matlab code included with the ASU Data submission. The ASU lidar was situated on Mazourka Canyon rd, approximately 1.5km from highway 395. The lidar was continuously operational with the exception of March 4 and March 22 through 23 due to repairs.


MAPQUEST
0
300m
900ft
N Clay St
Dale St
Rosedale Dr
Valley View Dr
Market
N Washington
Independence
E Pavilion St
Mary St
S Washington St
S Webster St
Susan St
Sarah St
Lily St
E Park St
S Clay St
W Citrus St
Mazourka Canyon Rd
4wd Road
ASU Lidar Site
395
Dump Rd

2) Matlab Files

There are 16 files that are required to use the ASU Matlab method for manipulating the data. The files required are:

- asu_lidar
- characteristics
- CTImake_sweep_ASU
- CTIplot_sweep_ASU
- File_Cleaner_ASU
- RecoveryOp
- VME_Extract_Products_ASU
- VME_GetLOSRanges
- VME_GetStartPos
- VME_ParseTxt
- VME_Read_DSPResSpecial
- VME_Read_FloatArr
- VME_Read_Rec
- VME_Read_RecHeader
- VME_Read_RecSpecial
- VME_Read_TextHeader

These files must be installed in the same directory to function. Please confirm that you have all 16 files installed before attempting to extract the data.

2.1) File Descriptions

- asu_lidar.m

This file is the main Matlab script that calls all other scripts necessary to process the data. From this script, the user can navigate through a directory structure to select a desired file for processing. This script then calls all necessary function scripts to read the data into a directory structure (detailed in Section 3 of this document) and convert it from the CTI data format. When reading is complete or the maximum number of records (see Section 4 of this document) is reached, the script gives the option of filtering the data in Matlab memory with a function script. Finally, the option to plot one of more sweeps using another function script is given. ***IMPORTANT NOTE: Every execution of this file clears the data structure! All previous data will be lost upon execution of*** **asu_lidar.m** ***for a new data file!!!***

- Characteristics.m

Each PRD file contains multiple sweeps by the Lidar scanner over the period of the data file. This function separates the characteristics for the sweeps into a more easily used format. The separation is transparent to the user and appears in the final data structure. See Section 3 of this document for details of the structure.

- CTImake_sweep_ASU.m

This function parses the beam data by angle and links the beam data into individual sweeps based on the angular motion of the previous sweep and the angle of the current sweep. This function is transparent during execution.

- CTIplot_sweep_ASU.m

Once the data is stored in Matlab's memory and the filtering option is complete, this function allows the user to plot sweeps. The function is called if the user selects to plot a sweep while in asu_lidar.m.

- File_Cleaner_ASU.m

This function will filter the data based on CFAR, Maximum or Minimum velocity, and SNR level. It is called if the user selects to filter the data while in asu_lidar.m. For information on setting the filter values, see Section 4 of this document.

- RecoveryOp.m

This function was written to correct an occasional glitch in Lidar data from the Salt Lake City experiment.

- VME_Extract_Products_ASU.m

Once a data file has been selected, this function parses the data, converts it from CTI format, and stores it into the directory structure described in Section 3 of this document. This function is transparent to the user. All of the following functions are called from this script.

- VME_GetLOSRanges.m
- VME_GetStartPos.m
- VME_ParseTxt.m
- VME_Read_DSPResSpecial.m
- VME_Read_FloatArr.m
- VME_Read_Rec.m
- VME_Read_RecHeader.m
- VME_Read_RecSpecial.m
- VME_Read_TextHeader.m

3) Data Structure

The data structures employed by these files are multi-tiered arrays. Elements within one array of data can be another array or a single value. This is useful for Lidar data because it is then possible to create an array to hold the data, while having elements in that array be separate arrays linking data from individual sweeps together and separating them within the structure.

When a file is read into memory, cleaned, and a sweep plotted, these structures are placed into Matlab's memory.

- BeamAZ - The azimuthal angles of the individual beams. Arranged as (# of sweeps , # of beams per sweep)

- BeamDeltaAZ - Changes in azimuthal angles between the beams. Arranged as (# of sweeps , # of beams per sweep)

- BeamDeltaEL - Changes in elevation angles between the beams. Arranged as (# of sweeps , # of beams per sweep)

- BeamDeltaT - Changes in time between the beams (seconds). Arranged as (# of sweeps , # of beams per sweep)

- BeamEL - Elevation angles of the beams. Arranged as (# of sweeps , # of beams per sweep)

- BeamTimes - Time Stamps of the beams (in seconds). Used to calculate BeamDeltaT

- Data - Main Data Structure that contains the data for each beam that was processed
  - Data{1,1} - File Name

  - Data{2,1}.RecordNum(1,Beam#)- The number of the beam

  - Data{2,1}.Hour(1,Beam#) - Hour of time stamp of the beam

  - Data{2,1}.Minute(1,Beam#) - Minute of time stamp of the beam

  - Data{2,1}.Sec(1,Beam#) - Second of the time stamp of the beam

- Data{2,1}.Msec(1,Beam#) - Millisecond of the time stamp of the beam

- Data{2,1}.Az(1,Beam#) - Azimuthal angle of the beam

- Data{2,1}.El(1,Beam#) - Elevation angle of the beam

- Data{2,1}.Rvel(Range Gate #,Beam#)- Radial velocity for each range gate of each beam

- Data{2,1}.SNR(Range Gate #,Beam#)- Signal to noise ratio for each range gate of each beam

- Data{2,1}.CFAR(Range Gate #,Beam#)- Constant False Alarm Rate value for each range gate of each beam

- Data{2,1}.BackScatter(Range Gate #,Beam#)- Backscatter value for each range gate of each beam
  - *For more information on SNR, CFAR, and Backscatter, see WT_Data_User_Manual.doc*

- DeltaR - Change in range from range gate to range gate

- EndTimes - End Time of each sweep. Arranged as [Hour, Minute, Sec, Msec]

- Header - Header information for selected file
  - *For detailed information on Header structure contents, see comments in asu_lidar.m, lines 100-342*

- InitialRange - Range of center of 1st range gate (m)

- RadialVelocity- Radial Velocity Value (m/s) for each range gate of each beam, separated into sweeps. Arranged by [# of sweep {# of range gates, # of beams per sweep}]

- Ranges - Ranges of the center of each range gate

- StartAZ - Starting azimuthal angles for each sweep

- StartEL - Starting elevation angle for each sweep

- StartTime - Starting time for each sweep

- SweepArray - Internal storage variable
- SweepBeams - Links individual beams to sweeps. Arranged as {# of sweeps , # of beams per sweep}
- SweepSize - The number of beams in each sweep
- SweepTime - Time of each sweep, from start of current sweep to current beam
- bad_beam_id - Internal Variable, used in CTIplot_sweep.m
- sweep - Array that characterizes sweeps.

  Arranged as sweep{1, sweep #, *X*} Where:
  - *X* = 1 –> Sweep #
  - *X* = 2 – >File Name
  - *X* = 3 – >Sweep Type
  - *X* = 4 –> Constant Angle of the sweep (elevation for PPI, Azimuth for RHI)
  - *X* = 5 –> Beam numbers that make up this sweep

4) Options

There are several options built into the Matlab files that can affect the processing of the Lidar data.

1) MaxMem & MaxRecs

- These options can be found in lines 47 & 48 of asu_lidar.m. They limit the maximum number of records (beams) that will be processed into Matlab's memory and the maximum amount of memory that can be devoted to the data structure. Adjust these as necessary to match your systems performance. Large numbers of beams cause the system to slow as the amount of memory occupied increases.

2) Filtering Options

- In File_Cleaner_ASU, there are options to set the level of filtering. Lines 16-18 will allow the user to adjust the Maximum Velocity, Minimum Velocity, and Minimum SNR cutoff values. When the user selects to filter the data, range gates with velocity values greater than the Max_Velocity value, less than the Min_Velocity value, or SNR levels below the SNR_cutoff value will be set to a value of "NaN" and not considered in the plotting functions. Adjusting these values will adjust the level of filtering performed.

3) Plot Color Values

- The ends of the color spectrum used when plotting sweeps can be easily adjusted in line 195 of CTIplot_sweep.m. By adjusting the number values in the command "`caxis([-20 20])`", the end points of the color scale can be set to a user-selected value.

5) Example of Data File Processing

In Matlab, set the Current Work Directory to the directory in which the files are installed. For example, *C:\LIDAR\TREX\matlab files*. Run the script *asu_lidar.m* by typing asu_lidar into the Matlab command window. The Command Window should display output similar to this:

```
-------------------------------------------------------
(1) .     (directory)
(2) ..     (directory)
(19) old     (directory)
-------------------------------------------------------
Enter number to choose:
```

(2) will move up a directory. Use the number options onscreen to navigate to the directory where the ASU Lidar data is stored. Directories are noted in the on-screen prompts with (directory) after the directory name. Only files with the extension ".prd" will be recognized while navigating.

Once in the proper directory, a list of ".prd" files will be displayed. Select the desired file by entering the number (##) corresponding to that file.

```
-------------------------------------------------------
(1) .     (directory)
(2) ..     (directory)
(3) 20030707_125837_base.prd
(4) 20030707_132837_base.prd
(5) 20030707_134831_base.prd
(6) 20030707_135333_base.prd
(7) 20030707_135837_base.prd
(8) 20030707_142837_base.prd
(9) 20030707_144832_base.prd
(10) 20030707_145333_base.prd
(11) 20030707_145837_base.prd
(12) 20030707_152837_base.prd
(13) 20030707_154831_base.prd
(14) 20030707_155333_base.prd
(15) 20030707_155837_base.prd
(16) 20030707_162837_base.prd
(17) 20030707_164831_base.prd
(18) 20030707_165333_base.prd
(19) 20030707_165838_base.prd
(20) 20030707_172838_base.prd
(21) 20030707_174834_base.prd
(22) 20030707_181834_base.prd
(23) 20030707_184834_base.prd
(24) 20030707_191834_base.prd
(25) 20030707_194834_base.prd
(26) 20030707_201834_base.prd
(27) 20030707_204834_base.prd
```

```
(28) 20030707_211834_base.prd
(29) 20030707_214834_base.prd
--------------------------------------------------------
Enter number to choose: 3
```

Once the desired file is selected, a confirmation prompt will appear. Enter the appropriate response.

```
Process the file "20030707_125837_base.prd"? (y/n, q to quit): y
```

The Command Window will display a progress report.

```
Process the file "20030707_125837_base.prd"? (y/n, q to quit): y
--------------------------------------------------------
Extracting Data...
.........................250
.........................250
.........................250
.........................250
.........................250
.........................250
................
```

When the end of the file is reached, the Command Window will display a list of sweeps.

```
--------------------------------------------------------
Parsing data into sweeps
PPI sweep....1-8...file#1
RHI sweep....9-64...file#1
PPI sweep....65-70...file#1
RHI sweep....71-126...file#1
PPI sweep....127-132...file#1
RHI sweep....133-188...file#1
PPI sweep....189-194...file#1
```

If the command window shows the following above the list of sweeps, you will need to adjust the MaxRecs as described in Section 4 of this document to process the entire data file.

```
.........................250
Maximum number of records have been acquired

Extract Done, Total Number of Records was 5000
--------------------------------------------------------
```

After parsing the data into sweeps, the Command Window will display a prompt for the filtering of the data. If filtering is desired, see Section 4 to adjust the filtering values. Enter the desired input.

```
RHI sweep....4901-4957...file#1
PPI sweep....4958-4972...file#1
RHI sweep....4973-5000...file#1
--------------------------------------------------------
Filter the Data? (y/n): y
```

A progress report will be displayed.

```
RHI sweep....4973-5000...file#1
--------------------------------------------------------
Filter the Data? (y/n): y

Filtering.........................................
```

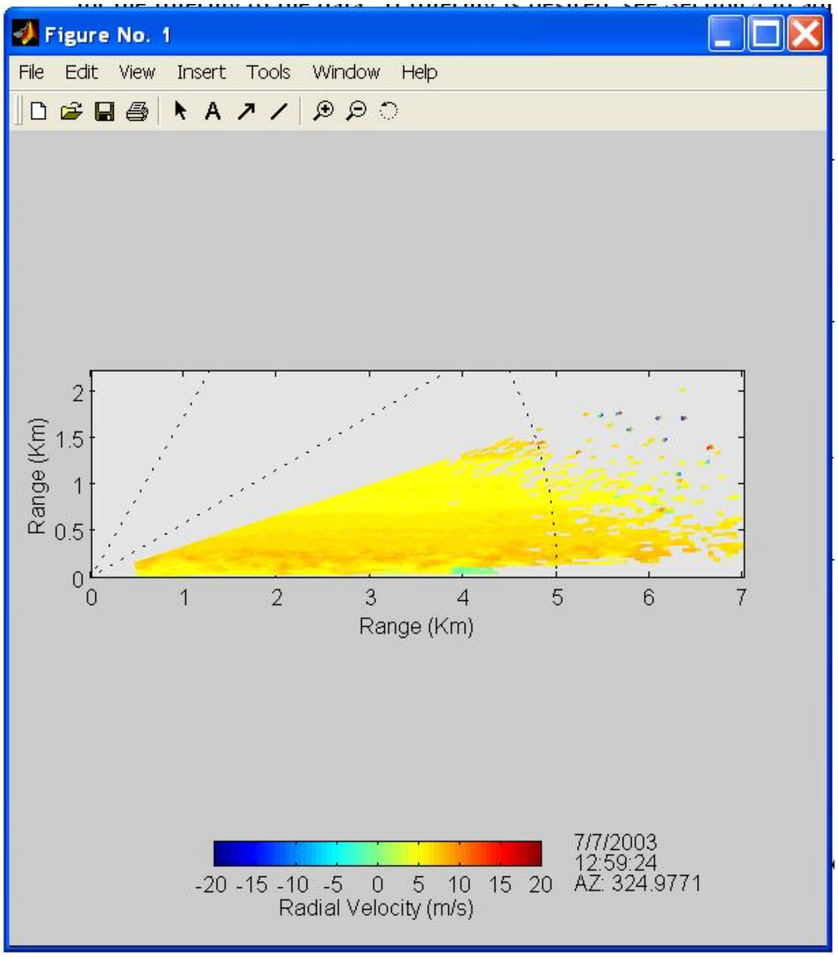
When the filtering is complete, the prompt to plot a sweep will be displayed. Enter the desired input.

```
Filtering....................................
--------------------------------------------------------
Plot a sweep? (y/n): y
```

Select the number of the sweep you would like to plot.

```
------------------------------------------------------------------------
Which sweep # do you want to plot?...1,2,3...
8
------------------------------------------------------------------------
```

A new Figure window should pop up containing the plot of the selected sweep.



The command window will display the plot prompt again. Select the appropriate option. Selecting “n” will end the script *asu_lidar.m*’s execution. If you would like to plot more sweeps, run the script CTIplot_sweep_ASU.m.