

Appendix A: User Manual

Introduction

This software provides a backup instrumentation system for civil aircraft based on the Global Positioning System (GPS). The software interfaces a laptop computer and a GPS receiver in order to provide a pilot with 6 virtual instruments: an altimeter, an airspeed indicator, a VOR receiver, an ADF receiver, a DME receiver, and a compass. The software also includes a course tracker.

The software can also be used as a flight-training tool. Advantages of this software include its simplicity. With the capability to save flight data, the software can be used to save and retrieve flights. This data can then be used by other applications, including map programs. Further, this software is easier to upgrade and does not require upgrading expensive GPS equipment.

It is important to note that the Federal Aviation Administration forbids using this software or the GPS unit as a primary navigation instrument.

Overview of features

The software contains the following features:

- Compatible with any GPS receiver supporting the National Marine Electronics Association (NMEA) 0183 interface standard and a serial connection to a computer
- Compatible with any PC-computer/laptop
- User defined VOR/ADF data file.
- Save user flight path data
- Accuracy to within 10% for all instruments

System requirements

In order for this system to operate, the following components are necessary:

PC-Compatible Computer (Laptop preferred)
GPS receiver
Laptop/GPS Interface
Software

Computer System

The system requires a PC-compatible computer to operate on. A laptop is preferable since it can be easily installed in an aircraft. However, it is possible to load the program

onto a desktop computer system for use as a pure training tool. The computer system must have the following qualities:

Processing Speed - Pentium 100 or higher
Operating System - Windows 95
Memory - 32 MB memory
Hard Disk Space - 5 MB
Labview Professional Edition 4.0 or higher

It may be possible to run the program on a system with lower standards, however, the result may be degraded performance. Since this program is to be used in a critical application, it is highly recommended that only a computer system with the above minimum qualifications is used.

GPS Receiver

In order to use the backup instrument functions of this program, a GPS receiver is required. The GPS receiver must support the NMEA-0183 data interface standard. The GPS receiver must also have the ability to be interfaced to a standard computer serial port (RS-232 Compatible). For 3-dimensional flight, the GPS unit should be capable of measuring altitude. The program does not perform any calculations for altitude. GPS units lacking the altitude measuring capability can be used for 2-dimensional flight.

Since the GPS unit will be used in an aircraft, the GPS unit must be able to be powered by batteries or the aircraft's power. For safety, it would be better to have a battery powered GPS unit.

Installation

To install the system, it will be necessary to follow the following steps:

1. Make sure GPS unit and computer are off
2. Connect data interface cable to GPS unit
3. Connect data interface cable to computer's serial port (RS-232 port)
Note: It may be necessary to use a male/female or pin converter for the computer
4. Power GPS unit and computer – hardware installation is complete
5. Install Labview Professional Edition 4.0 or higher if necessary
6. With computer powered on, insert GPSProject Disk1 into floppy drive
7. Load Windows 95
8. Click on Start button



9. Click on Run...

10. Type *A:\install.bat* and press <Enter>. Follow instructions until program is successfully installed.

Operating instructions

Since the project runs under Labview, the project must adhere to the standards enforced by Labview. Data entry can only be performed using the mouse or the keyboard. Generally, it is necessary to use the mouse to click on the data object, enter the data, and then press the <enter> key to accept the key. Some data objects can be manipulated by clicking on the arrows next to them.

All output appears on the monitor. For best results and to view the entire virtual instrument panel, the monitor's resolution should be set to 1024 x 768 pixels. Please see the monitor's owner's manual for help in setting the resolution. If this resolution cannot be achieved, it may be necessary to resize the instruments or to adjust the scroll bars as necessary.

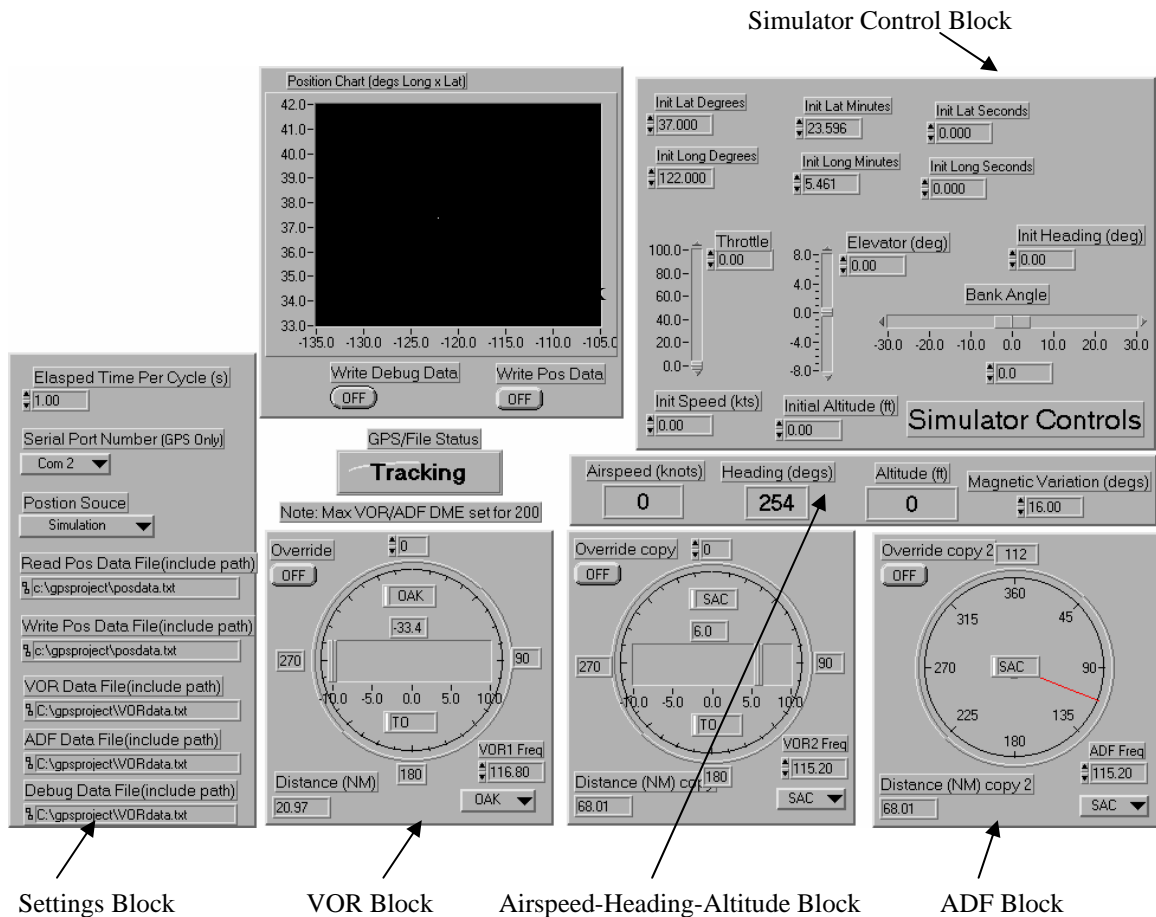
At present, the program does not support any other input accessories. A printer is supported using the settings setup in Windows.

To activate system, please perform the following:

1. Turn computer/laptop on
2. Load Labview
3. Click on File and click on Open
4. Select GPSProject.vi

After several minutes, all necessary components for this program will be loaded into memory. Any errors will become visible by an audible beep and a menu popping up.

Once the program has been successfully loaded, the following screen will appear:



This is the instrument panel view. The instrument panel is made up of 6 major sections:

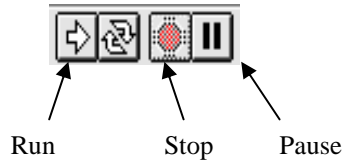
- Simulator Control Block
- VOR (2) Block
- ADF Block
- Settings Block
- Airspeed-Heading-Altitude Block

The program begins in the “Stop” mode. The following steps must then be performed:

5. Choose operation mode – Simulation, File, GPS Unit
6. For Simulation Mode only, enter initial position
For GPS Unit Mode only, choose serial port
For File Mode only, enter filename of position data file to be read
7. Click on "Run"

Note that the GPS unit is not necessary for operating the system in Simulation Mode or File Mode.

All file settings and position initializations for the simulator mode should be performed here before running the program. Once all settings are complete, the program can be run by clicking on the run icon from the Labview tool bar:



The program can be stopped or paused by clicking the appropriate icon on the tool bar.

System Overview

The program can operate in three modes:

1. Simulation
2. File
3. GPS Unit

The modes specify what method will be used to obtain the position information for the aircraft including latitude, longitude, and altitude. The implemented instruments and features independent of operation mode and are therefore available in all operation modes.

Simulation Mode

This mode relies on the user to enter the position data. All controls for this mode are found in the Simulation Controls Box. To access this mode, the user opens Labview and loads the project. While the project is in "Stop" mode in Labview, the user can enter the aircraft's initial position. Note that the initial position latitude and longitude must be entered with positive and negative values to represent North, South, East, and West. Positive values represent North (latitude) and West (longitude). Negative values represent South (latitude) and East (longitude). The user can also enter the initial airspeed, heading, and altitude. Once the simulator's initial data is complete, the user clicks on the "Run" button to activate the project.

An audible click is activated every second to alert the user that the system is in Simulation or File mode.

In this mode, the aircraft's simulated position is controlled by the Simulation Controls to achieve desired flight path. The Simulation Controls include the throttle, ailerons, and elevator. All three controls can be changed by clicking on the input box and then entering the desired value. The setting of the controls can also be changed by clicking on the slider bars and moving the slider bars in the appropriate direction. An input box for

each control indicates the exact setting.

The throttle is used to control the aircraft's speed. The throttle has a fixed acceleration ratio of 5 knots/cycle with a maximum of 500 NM. The throttle is adjusted to a percentage of the maximum speed with 100% as the full throttle and 0% as zero throttle. Each increase or decrease in 1% throttle represents an increase or decrease in speed of 5 knots. For example, setting the throttle to 50% will result in a cruise speed of 250 knots. No stall speed implemented. Therefore, the aircraft will not begin to descend if the airspeed is 0 knots.

Ailerons are used to control the horizontal movement, left and right turns. The ailerons can be adjusted to the desired rate of degree change in heading per cycle. For example, setting ailerons to 5 degs results in a turn rate of 5 degrees per seconds. A general formula for the rate of turn is $1 \text{ deg}/(\text{deg selected} * \text{cycle})$.

The elevator is used to control the vertical movement, ascent and descent. The elevator control is adjusted by degrees, which correspond to angle of ascent or descent. The rate of ascent/descent is dependent on speed.

In this mode, the user can change the time factor by setting the Elapsed Time Per Cycle control. This allows the user to speed up the simulation so that a long flight of several hours can be simulated in a few minutes. For example, increasing the time factor to 10 will result in the simulation appearing to simulate 10 seconds for 1 second of real time. For a real time simulation, the Elapsed Time Per Cycle should be set to 1.

This mode can be used by the user to test out possible flight paths and instrument settings for successful navigation.

File Mode

Before activating this mode, the user must enter the filename of the file containing the position data. This allows the user to fly a course based on the position data stored in the specified file. Note that the instrument settings are not retrieved from the file, therefore the user must set the instruments accordingly. This is a simulated mode in which the data file data is used as the source for the position data. It is important to remember that this is not a pre-recorded flight, but a pre-recorded flight path. Note that unless the data was saved using this program in the "Save Data" mode, the data file may need to be converted to be used in this program. This mode allows the user to fly a flight path that was previously saved in simulation or by the GPS unit. Also, note that the user does not have control of the flight path. However, the user still retains full control of navigation instruments. Once the data from the file has been exhausted (end of file), the project continues to run, but the Not Tracking light is illuminated.

GPS Mode

GPS mode is activated when the user wants to use the GPS unit for position information. For this mode to operate correctly, it is important that the GPS is activated, correctly connected to the laptop, and correctly tracking the satellites.

This mode requires a GPS unit capable of transmitting the position data using the NMEA-0183 Interface Guidelines and a serial port (RS-232). Before activating this mode, the user must choose the serial port to which the GPS unit is connected. Most laptops appear to have their external serial port connected to COM1, however, most desktop computers have their external serial port connected to COM2. Once the serial port is selected, Labview can be "Run".

Before relying on the project for navigation data, it is important to check that the system is tracking. The Not Tracking light will be illuminated for one of the following reasons:

- GPS unit is not connected to computer correctly
 - Check cable connection
 - Check serial port number
- GPS unit is not tracking satellites
- GPS unit is off
- GPS unit shows position of 0 latitude, 0 longitude

Note that GPS units which do not have altitude tracking abilities will cause the system to report an altitude of 0 ft. Note that the Elapsed Time Per Cycle control has no effect on GPS mode.

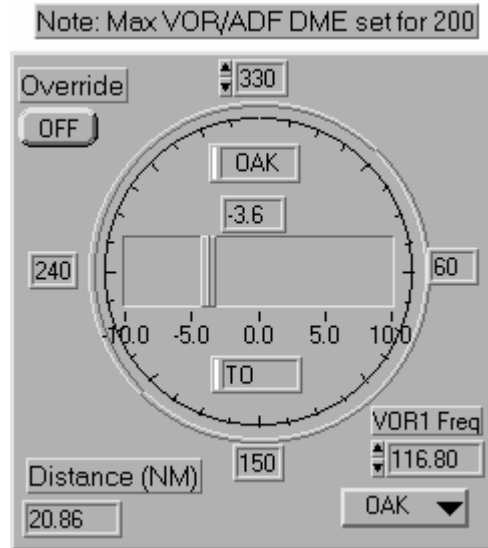
Navigation Instruments

The project supports 5 types of navigation instruments: VOR, ADF, Magnetic Compass, Airspeed Indicator, Track Record, and Altimeter.

The VOR, ADF, and Magnetic Compass represent their data in relation Magnetic North. Therefore, it is essential that the Magnetic Deviation is set to the correct value throughout the flight. Failure to update this control will result in false navigational data being reported by these instruments. The Track Record, however, displays its data on a distorted scale in reference to True North, which is at the top of the scale.

VOR

The project is equipped with two VOR displays due to their popularity. The VOR is one of the most complex instruments since it displays a large amount of information. As a safety to prevent accidentally tracking the wrong station, the VORs display an OFF status if the station being tracked is more than 200 NM away and the Override Switch is OFF. Note that this instrument relies on the Magnetic Variation.



The VOR has the following inputs:

Station frequency - used to select frequency. This control must be set before attempting to set the Station ID since the Station ID is dependent on this frequency. Although not realistic, any frequency from 000.00 to 999.99 can be selected. This allows programming of a large number of user customized stations. All airports used for testing were set a frequency 777.77

Station ID – drop down box used to select desired station from a list of stations with selected frequency. If only there is only one station on that frequency, then only 1 station is displayed. If no stations available on that frequency, then no stations are displayed

OBS Heading - input used to set the desired radial heading to be tracked

Override - used to override the 200 NM setting

The VOR has the following outputs:

Station Identifier - indicates which station VOR is currently tracking.

If no stations are being tracked, then <<add picture>> appears in this location.

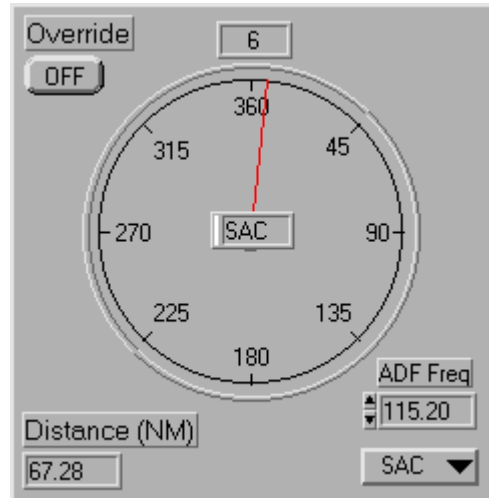
VOR Distance - indicates the distance to the VOR station in Nautical Miles. When VOR is OFF, this distance shows as 0 NM.

Deflection Needle - indicates the approximate number of degrees deflection from current track being tracked. Provides a visual display of a maximum of 10 degrees to the left or right. Has an additional box which displays the exact number of degrees deflection. This additional box displays a maximum of 90 degrees to the left or right. Negative numbers are displayed on the needle bar by deflections to the left.

Status Indicator - indicates the current status of the VOR receiver. OFF indicates that the station is more than 200 NM away or that an unused frequency has been selected. Unused frequencies default to 0⁰ latitude, 0⁰ longitude, where the Prime Meridian crosses the Equator. TO indicates that the radial currently being tracked is on a course to the VOR station. FROM indicates that the radial currently being tracked is on a course away from the VOR station. Note that TO and FROM do not indicate the aircraft's actual course of travel.

ADF

This project is equipped with only 1 ADF. The ADF instrument is much simpler than the VOR, with less controls. This instrument relies on the Magnetic Variation setting. The



ADF operates very similar to the VOR.

The ADF has the following inputs:

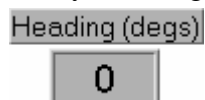
- Station frequency - see VOR
- Station ID - see VOR
- Override 200 NM setting - see VOR

The ADF also has the following outputs:

- Distance - see VOR
- Bearing Indicator - the needle points to the bearing of the station relative to the nose of the aircraft. The nose of the aircraft is aligned with 0 degs. When aircraft is stationary, needle points to last bearing based on aircraft's nose. The instrument may be inaccurate at low speeds.

Magnetic Compass

The compass represents the magnetic heading of the aircraft. This instrument uses the Magnetic Variation setting. Note that this instrument is only accurate while the aircraft is moving. When the aircraft is stationary, the magnetic compass displays the last heading.



The instrument may be inaccurate at low speeds.

Airspeed Indicator

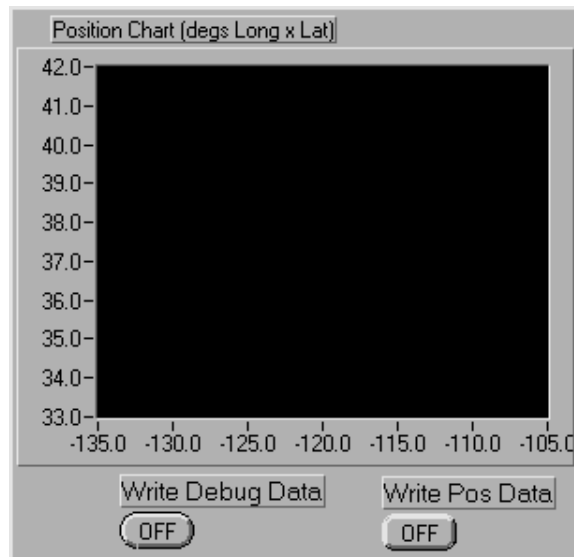
The airspeed indicator displays the aircraft's ground speed in knots. Since the indicator



relies on GPS measurements, which are not affected by wind speeds, the instrument cannot display true airspeed.

Track Record

The Track Record displays the aircraft's flight path flown. The flight path is displayed on a graph with the x-axis representing longitude and the y-axis representing latitude. Note that this graph is rectangular, while the earth's shape is spherical, therefore some



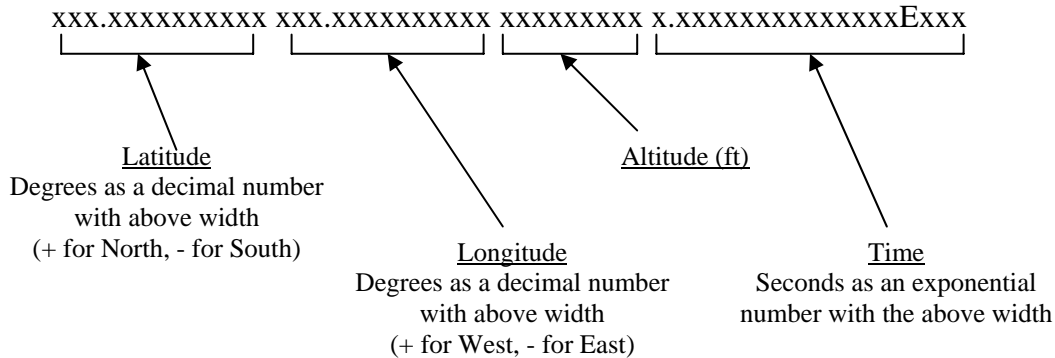
distortion will be present. The graph's x-axis is lined up with the Equator and the y-axis is lined up with the Prime Meridian.

Position Data Files

During File Mode, the program reads position and altitude data from file specified by Read Pos Data File input in the Settings Block. In all three modes, the current position data can be recorded to the file specified in Write Pos Data File input in the Setting Block. Both files are stored in ASCII format and can be edited with a standard text editor.

To record the current position data, the program must be in “Run” mode. Setting Write Pos Data to “On” will begin recording the data to the current file. If the file exists, the data will be appended to the existing file. However, if the file cannot be found, a new file will be created. Setting Write Pos Data to “Off” will stop recording the current position. Note that the full path names for both of these files must be specified when appropriate.

File Mode requires the data in the Read Pos Data File to follow a specific format. This is the same format used by Write Pos Data File to save the data to a data file. The following format is used:



A data file for VOR stations and a data file for ADF stations have been included. In the VOR station data file, all airports have been assigned the arbitrary frequency of 777.7. For a complete listing of stations in either of the files, please see the Appendix.

Appendix A1 – VOR Stations in VORData.txt (User Manual)

Name	ID	Freq	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
Airport	OAK	777.70	N037	43.273	W122	13.240
Airport	SAC	777.70	N038	30.754	W121	29.549
Airport	SFO	777.70	N037	37.145	W122	22.489
Airport	SJC	777.70	N037	21.716	W121	55.741
Avenal	AVE	117.10	N035	38.800	W119	58.700
Battleground	BTG	116.60	N045	44.900	W122	35.400
Big Sur	BSR	114.00	N036	10.900	W121	38.500
Clovis	CZQ	112.90	N036	53.100	W119	48.900
Dalles	DLS	112.30	N045	42.800	W121	00.600
Dortmund	DOM	112.70	N051	42.700	E007	35.300
Eugene	EUG	112.90	N044	07.300	W123	13.300
Fillmore	FIM	112.50	N034	21.400	W118	52.800
Frankfurt	FFM	114.20	N050	03.300	E008	38.300
Friant	FRA	115.60	N037	06.300	W119	35.700
Hoquiam	HQM	117.70	N046	56.800	W124	8.9000
Klamath Falls	LMT	115.90	N042	09.200	W121	43.600
Lakeview	LKV	112.00	N042	29.600	W120	30.400
Lethbridge	YQL	115.70	N049	38.100	W112	40.000
Linden	LIN	114.80	N038	04.500	W121	00.200
Los Angeles	LAX	113.60	N033	56.000	W110	25.900
Lovelock	LLC	116.50	N040	07.500	W118	34.600
Luxembourg	LUX	112.25	N049	37.300	E006	12.200
Manteca	ECA	116.00	N037	50.000	W121	10.200
Medford	OED	113.60	N042	28.800	W122	54.700
Mendocino	ENI	112.30	N039	03.200	W123	16.400
Mission Bay	MZB	117.80	N032	46.900	W117	13.500
Mustang	FMG	117.90	N039	31.900	W119	39.300
Oakland	OAK	116.80	N037	43.600	W122	13.400
Oceanside	OCN	115.30	N033	14.400	W117	25.000
Olympia	OLM	113.40	N046	58.300	W122	54.000
Pamus	PAM	117.80	N052	20.200	E005	05.600
Paradise	PDZ	112.20	N033	55.100	W117	31.800
Point Reyes	PYE	113.70	N038	04.800	W122	52.000
Red Bluff	RBL	115.70	N040	05.900	W122	14.100
Rome	REO	112.50	N042	35.400	W117	52.000
Roseburg	RBG	108.20	N043	11.000	W123	21.100
Sacramento	SAC	115.20	N038	26.600	W121	33.000
Salinas	SNS	117.30	N036	39.800	W121	36.100
San Francisco	SFO	115.80	N037	37.100	W122	22.500
San Jose	SJC	114.10	N037	21.700	W121	55.700
San Marcus	RZS	114.90	N034	30.600	W119	46.200
Seal Beach	SLI	115.70	N033	47.000	W118	03.200
Seattle	SEA	116.80	N047	26.100	W122	18.500
Shafter	EHF	115.40	N035	29.100	W119	05.800
Strasbourg	FRA	115.60	N048	30.300	E007	34.400
Tatoosh	TOU	112.20	N048	18.000	W124	37.600
	999	999.90	N000	00.000	W000	00.000

Appendix A2 – ADF Stations in ADFData.txt (User Manual)

Name	ID	Freq	Latitude (degrees)	Latitude (minutes)	Longitude (degrees)	Longitude (minutes)
Alturas	ARU	215.00	N041	28.300	W120	33.500
Carlsbad Escondido	EKGF	374.00	N033	09.400	W117	05.100
China Lake	NID	348.00	N035	41.200	W117	41.500
Chino Swan Lake	LKA	257.00	N033	58.500	W117	33.100
Columbia	CUF	404.00	N038	01.900	W120	24.800
Compton	CPM	378.00	N033	53.300	W118	14.800
Corcoran Slayer Farms	COR	205.00	N036	05.100	W119	32.700
El Monte	EMT	359.00	N034	05.300	W118	01.900
Fort Hunter	HGT	209.00	N035	56.300	W121	09.700
Fort Ord/Monterey	OAR	236.00	N036	38.400	W121	40.900
Fresno Chandler	FCH	344.00	N036	43.400	W119	50.000
Lakeport Lampson	LOP	217.00	N038	59.700	W122	53.000
Lancaster Gen William J Fox	GWF	282.00	N034	44.300	W118	13.000
Livermore Reiga	LV	374.00	N037	41.500	W121	41.000
Lompoc	LPC	223.00	N034	39.900	W120	27.800
Marysville Halow	MY/	222.00	N039	10.200	W121	36.600
Montague	MOG	382.00	N041	43.600	W122	28.900
Oroville	OVE	212.00	N039	29.700	W121	37.300
Pacoima	PAI	370.00	N034	15.600	W118	24.800
Red Bluff Roberta	PBT	338.00	N040	06.800	W122	14.200
Salinas Chualar	UAD	263.00	N036	29.500	W121	28.500
San Bernadino Petis	SB	397.00	N034	03.400	W117	22.000
San Clemente Island	NUC	350.00	N033	01.600	W118	34.300
San Jacinto	SJY	227.00	N033	47.700	W116	60.000
San Nicolas Island	NSI	203.00	N033	14.200	W119	27.000
Santa Ana El Toro	NZJ	410.00	N033	40.900	W117	43.900
Santa Ynez	IZA	394.00	N034	36.400	W120	04.600
Sharpe Army Depot	LRO	282.00	N037	49.700	W121	16.300
Watsonville Pajar	AY	327.00	N036	54.800	W121	48.500