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Plot-Flight User's Manual

Version 1.0

John L. Tenney

Prepared by
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Version 1.0

John L. Tenney
Assessment Technologies Department
Sandia National Laboratories
Albuquerque, New Mexico 87185

Abstract

DOE contracted with Sandia to install a radar acquisition system (RAMS) to gather aircraft flight data near the Pantex Plant in Amarillo, TX. To support this effort, data reduction tools were needed to help analyze the radar data. Plot-flight is one of several data reduction tools that comprise the Sandia Airspace Recording System (SARS). The radar data is needed to support the Pantex Environmental Impact Study.

Plot-flight is a DOS-based plot program that allows analysts to replay pre-recorded air traffic over Albuquerque and Amarillo. The program is flexible enough to permit replay of daily flights either sequentially, by range, or by Beacon ID.

In addition to replay, the program is setup for data entry. Analysts can correlate electronic aircraft flight data to the green strip flights logs obtained from the local air traffic control center. The green strips are used by air traffic controllers to record each scheduled flight. The green strips have information not available electronically such as aircraft type and aircraft ID. This type of information is necessary to accommodate the current models used in aircraft crash analysis. Plot-flight correlates the hand-written information from the green strips to the recorded aircraft flight.

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Tom Lin and Abencio Sanchez of Sandia National Laboratories and Chris Puroff of DOE, Pantex, provided endless hours of program testing and they added valuable input for improvements.

David Skogmo of Sandia National Laboratories provided hardware, software, and configuration support for the SARS project.

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1. Introduction

This documentation is part of the Zone 4 SARS (Sandia Airspace Recording System). The SARS consists of hardware for data collection and post-processing software for analysis. This report identifies the procedures used to post-process the Beacon radar data and specifies the format of important input and output files. The main purpose of this document is to identify the methodology, display, and data entry procedure for the plot-flight program. Plot-flight is not site specific. It can be installed at any FAA location.

2. Overview of SARS Radar Post Processing Software

Figure 1 depicts the composition of the SARS project.

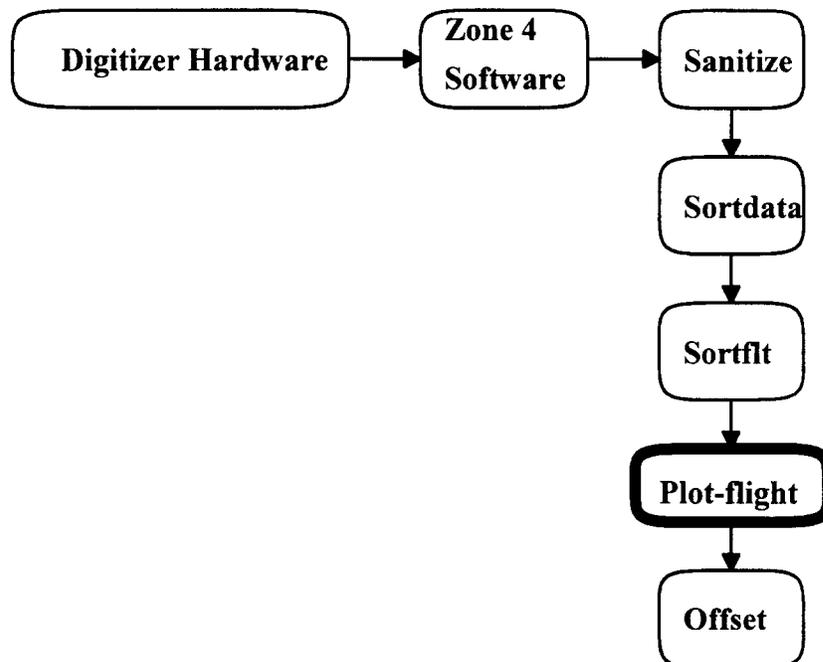


Figure 1. SARS Program Set

The digitizer hardware is located at the FAA facilities in Albuquerque and Amarillo. The digitizers are connected to the FAA Beacon and Primary radar. The signal is processed and sent through cables to a PC collection system. The radar data is then post-processed into ASCII format by the Zone 4 software.

The real-time Beacon data is written sequentially to an ASCII file. The format of the name is `BYMMDD.DAT` (e.g., `B940201.DAT`). With this convention, all radar files will be unique. At the end of the day, the radar collection program closes the current day and opens up the next radar day according to the system clock on the recording computer.

The same software can accommodate both Albuquerque and Amarillo flight data. This relieves project personnel from maintaining two similar sets of software. The first program is named SANITIZE. It checks to see if all flight records for a given day are fixed length 49 bytes. The next program is called SORTDATA. Its function is to convert a raw radar file into a sorted radar file. For example, the command SORTDATA B940201.DAT converts the raw file (.dat) into a sorted file B940201.SRT. This is necessary for plotting and further analysis. The next program is called SORTFLT; it generates the Beacon ID index file. This file is needed for green strip attachment and plotting. The last program is named OFFSET. This program calculates the closest flight offset for two target areas at Pantex (Zone 4 and Zone 12). The target areas have not been chosen for the Albuquerque area.

3. SARS Processing Procedure

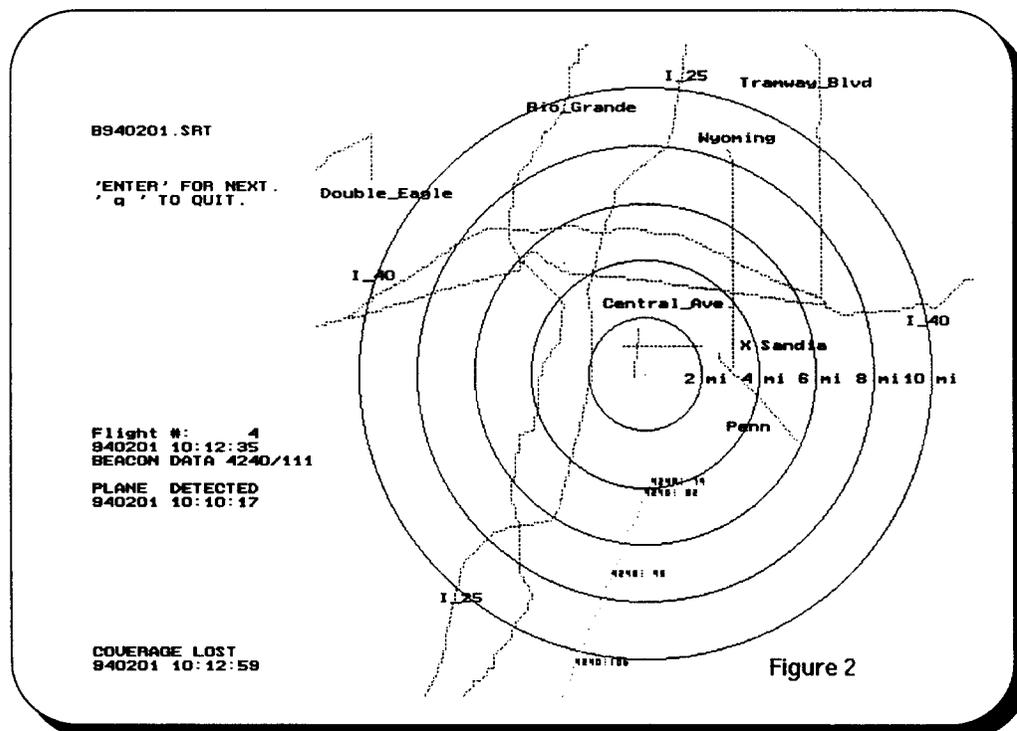
The following procedure is used to post-process the radar data for both Albuquerque and Amarillo. These commands are typed in at the keyboard from a PC. The programs and data are assumed to reside in the same directory and they must be run in the following sequence:

```
SANITIZE B940520.DAT (VALIDATE DATA)
SORTDATA B940520.DAT (CONVERTS .DAT FILE TO .SRT)
SORTFLT B940520.SRT (GENERATES .IDX AND .BID FILES)
PLOTFLT B940520.SRT (DISPLAY PLOT)
OFFSET B940520.SRT B940520.BID (CALCULATE OFFSET TO TARGET)
```

Plot-flight is written in the C language. The Turbo C++ 3.0 compiler is required to compile the program. To compile the plotflt program type in the following command:

```
TCC -ml PLOTFLT.C GRAPHICS.LIB
```

The -ml switch invokes the large library model from Borland. Once this process is completed, the analyst may display a particular flight path. Figure 2 shows the departure of flight 4240 on February 2, 1994, at the Albuquerque airport.



4. Radar File Formats

4.1 Sorted Radar File Format

The following flight data is a segment of a recorded sorted Beacon file. It represents one complete flight on February 1, 1994 over Albuquerque. The Amarillo flight data format is identical to Albuquerque data format.

```
940201101301S 101335 +5.05e+04 -3.89e+04 3241 279
940201101301P 101340 +4.69e+04 -4.03e+04 3241 279
940201101301P 101345 +4.37e+04 -4.00e+04 3241 279
940201101301P 101349 +4.11e+04 -4.02e+04 3241 278
940201101301P 101354 +3.77e+04 -4.05e+04 3241 277
940201101301P 101358 +3.39e+04 -4.05e+04 3241 277
940201101301P 101403 +3.08e+04 -4.13e+04 3241 276
940201101301P 101408 +2.79e+04 -4.14e+04 3241 275
940201101301P 101412 +2.45e+04 -4.13e+04 3241 274
940201101301P 101417 +2.07e+04 -4.19e+04 3241 273
940201101301P 101422 +1.74e+04 -4.26e+04 3241 273
940201101301P 101426 +1.32e+04 -4.21e+04 3241 272
940201101301P 101431 +1.01e+04 -4.27e+04 3241 271
940201101301P 101435 +7.03e+03 -4.24e+04 3241 270
940201101301P 101440 +3.30e+03 -4.30e+04 3241 269
940201101301P 101445 -1.07e+03 -4.30e+04 3241 268
940201101301P 101449 -4.67e+03 -4.28e+04 3241 267
940201101301P 101453 -8.19e+03 -4.27e+04 3241 266
940201101301P 101458 -1.20e+04 -4.25e+04 3241 265
940201101301P 101503 -1.53e+04 -4.19e+04 3241 265
940201101301P 101507 -1.94e+04 -4.10e+04 3241 264
940201101301P 101512 -2.26e+04 -4.11e+04 3241 263
940201101301P 101517 -2.62e+04 -4.09e+04 3241 262
940201101301P 101522 -2.92e+04 -4.06e+04 3241 261
940201101301P 101526 -3.24e+04 -4.02e+04 3241 260
940201101301P 101531 -3.60e+04 -4.03e+04 3241 260
940201101301P 101535 -3.89e+04 -3.98e+04 3241 260
940201101301P 101540 -4.19e+04 -3.94e+04 3241 260
940201101301P 101545 -4.56e+04 -3.93e+04 3241 260
940201101301P 101550 -4.90e+04 -3.92e+04 3241 260
940201101301P 101554 -5.14e+04 -3.87e+04 3241 260
940201101301P 101558 -5.48e+04 -3.89e+04 3241 260
940201101301P 101603 -5.73e+04 -3.87e+04 3241 260
940201101301E 101621 +0.00e+00 +0.00e+00 0000 0
```

The flight records are structured as follows:

- Column (1:2) Year
- Column (3:4) Month
- Column (5:6) Day
- Column (7:8) Start hour of flight (GMT)
- Column (9:10) Start min. of flight (GMT)
- Column (11:12) Flight sequence number (00 through 99)
- Column (13:13) (S)tart, (P)rogressive point, or (E)nd of flight
- Column (15:16) Time 1 - hour of flight
- Column (17:18) Time 1 - min. of flight
- Column (19:20) Time 1 - seconds of flight
- Column (22:30) X coordinate - true north (in feet)
- Column (32:40) Y coordinate - true north (in feet)
- Column (42:45) Beacon ID or squawk code
- Column (47:49) Elevation * 100 (in hundreds of feet)

Columns 1 through 13 are referred to as the unique ID of the flight. Every recorded flight will have one unique ID. This unique string is useful for sorting data.

Column 13 determines the complete path of a flight. The S(start), P..P..P..., E(end) sequence must be set for a good flight. The first 13 characters of each record (e.g., 940201101301S) are used throughout the programs as a unique identifier. The flight sequence number ranges from 00 through 99. This means 100 maximum flights can be recorded at one time.

The first record from the example flight listed above is identified by its individual components.

940201101301S 101335 +5.05e+04 -3.89e+04 3241 279

- Column 1:2 - (94) -> Year
- Column 3:4 - (02) -> Month
- Column 5:6 - (01) -> Day
- Column 7:8 - (10) -> Start hour of flight (GMT)
- Column 9:10 - (13) -> Start minute of flight (GMT)
- Column 11:12 - (01) -> Sequence number of flight
- Column 13 - (S) -> Start of flight
- Column 15:16 - (10) -> Time 1 recorded hour of data point (GMT)
- Column 17:18 - (13) -> Time 1 recorded minute of data point (GMT)
- Column 19:20 - (35) -> Time 1 recorded second of data point (GMT)
- Column 22:30 - (+5.05e+04) -> X coordinate true north (in feet)
- Column 32:40 - (-3.89e+04) -> Y coordinate true north (in feet)
- Column 42:45 - (3241) -> Beacon ID or squawk code of aircraft
- Column 47:49 - (279) -> Elevation * 100 = 27,900 ft.

4.2 Beacon ID Index File Format

One of the output files generated by the SORTFLT program is the Beacon ID index file. The index file gives a quick summary of all aircraft flights for an entire day. Start time, end time, start and end elevation, and BID data are kept in the index file. This scheme allows a quick search of the sorted file for a particular flight, and it shows which flights were matched up to the green strips. This type of

information is useful for the analyst. The output file is created with an .IDX extension; this file is sorted by flight number (e.g., B940201.IDX). Another file is created with a BID extension (e.g., B940201.BID). The BID file is sorted by squawk code. These two files are used for the PLOTFLT program, which allows users to display individual aircraft flights for a given day. Currently, the BID and IDX files are both fixed length 138 byte records. These are ASCII files that can be printed or edited manually. A sample BID file (sorted by BID: 5th column) generated for February 2, 1994, (Albuquerque) is listed in Figure 3.

```

10 206 218 940201101009 0461 101036 101126 -20 -20 0 1 2 # ##### # # 0 ###
21 569 585 940201101601 0461 101645 101755 -20 -20 0 2 2 # ##### # # 0 ###
 7 164 179 940201101006 0473 101017 101121 -20 -20 0 1 1 # ##### # # 0 ###
 2  9  68 940201101001 0475 101017 101458 68 121 0 1 1 # ##### # # 0 ###
12 253 264 940201101100 0510 101154 101240 260 260 0 1 2 # ##### # # 0 ###
15 349 357 940201101302 0510 101340 101412 260 260 0 2 2 # ##### # # 0 ###
11 219 252 940201101010 0741 101054 101322 65 134 0 1 1 # ##### # # 0 ###
 3  69  98 940201101002 0764 101017 101226 -20 -20 0 1 1 # ##### # # 0 ###
 6 138 163 940201101005 1200 101017 101208 64 54 0 1 2 # ##### # # 0 ###
13 265 314 940201101300 1200 101312 101653 58 55 0 2 2 # ##### # # 0 ###
 1  1  8 940201101000 1202 101017 101045 53 50 3 1 1 # ##### # # 0 ###
20 561 568 940201101600 1310 101635 101703 388 391 0 1 1 # ##### # # 0 ###
16 358 392 940201101303 2660 101349 101621 83 55 0 1 1 # ##### # # 0 ###
 8 180 193 940201101007 2667 101017 101113 111 117 0 1 1 # ##### # # 0 ###
14 315 348 940201101301 3241 101335 101603 279 260 0 1 1 I SWA456 B747 E 1013 1 JLT
17 442 482 940201101500 4206 101507 101808 -20 56 2 1 2 # ##### # # 0 ###
18 483 503 940201101501 4206 101507 101635 120 86 0 2 2 # ##### # # 0 ###
 9 194 205 940201101008 4234 101017 101103 95 95 0 1 1 # ##### # # 0 ###
 4  99 130 940201101003 4240 101017 101235 79 111 0 1 1 # ##### # # 0 ###
19 504 23 940201101502 4250 101540 101703 49 49 0 1 1 # ##### # # 0 ###
 5 131 137 940201101004 7262 101017 101040 280 280 0 1 1 # ##### # # 0 ###

```

Figure 3. B940201.BID

4.2.1 Beacon ID Field Definitions

In the example listed in Figure 3, flight number 14 (bold text) is used as reference for the field definitions. The green strip input fields (right side) listed above (### ...) are updated when the data input function of the plotflt program is run.

- Column(1:8) Flight Number - this is the sequence flight number. This number is generated by the SORTFLT program. Each flight is assigned a unique integer. In the example listed above, the bold text for #14 means that this was the 14th recorded aircraft flight on Feb 2.
- Column(9:15) Start flight record - this field identifies the record for the start of a flight in the radar file (.srt file). In other words flight number 14 start at record 315 in the B940201.SRT file.
- Column(16:24) End flight record - end of flight record in radar file (record 348).
- Column(26:37) Unique ID for flight (e.g., 940201101301) Note: this matches the unique ID in the sorted radar file.
- Column(39:42) Beacon ID or squawk code (e.g., 3241)
- Column(44:49) Start Time of flight in HHMMSS (GMT) (e.g., 10:13:35)
- Column(51:56) End Time of flight in HHMMSS (GMT) (e.g., 10:16:03)
- Column(58:60) Start elevation of flight (x 100) (e.g., 279*100 = 27900 ft.)

Column(62:64) End elevation of flight (x 100) (e.g., 260*100 = 26000 ft.)

Column(66:66) Flight indicator field. The flight indicator field is defined as follows:

0 - good flight, no BID change.

1 - BID changed from 1200 to another number.

2 - Any BID number changed to any other number.

3 - BID 1200 changed to another number then changed to another number again.

In our sample flight, the flight indicator is set to 0 (no BID change). This information is important when attaching green strips to electronic data.

Column(71:71) Sequence number of BID (e.g., 1 of 1 total). If there is more than 1 BID for a given day, this field will have the proper BID sequence.

Column(76:76) Total count of BID's for this file (e.g., 1).

Column(78:78) VFR/IFR/Unknown indicator (green strip input field). Three choices are allowed in this field: U-Unknown, I-Instrument, V-Visual

Column(80:91) Aircraft ID (green strip input field) (e.g., SWA456).

Column(93:104) Aircraft Type (green strip input field) (e.g., B747).

Column(106:106) Time prefix E(fly over), P(departure), or A(arrival) (green strip input field) (E)

Column(108:111) Time - 24 hr. format (GMT) (green strip input field) (e.g., 1013).

Column(113:113) Match indicator (green strip input field) 0-not matched; 1-matched (e.g., 1). If the green strip matches the electronic data then this field is set to 1; otherwise it stays at 0.

Column(115:117) Initials of operator (green strip input field) (e.g., JLT).

Column(119:138) Blank spaces (reserved for future use).

5. Display Mode

The plot-flight program supports two modes of operation: display and data entry. Display mode allows a "view only" mode of the aircraft flights. BID file data cannot change in display mode. Data entry mode permits viewing, updating, and attachment of green strip information to electronic data.

5.1 Software Flow Diagram

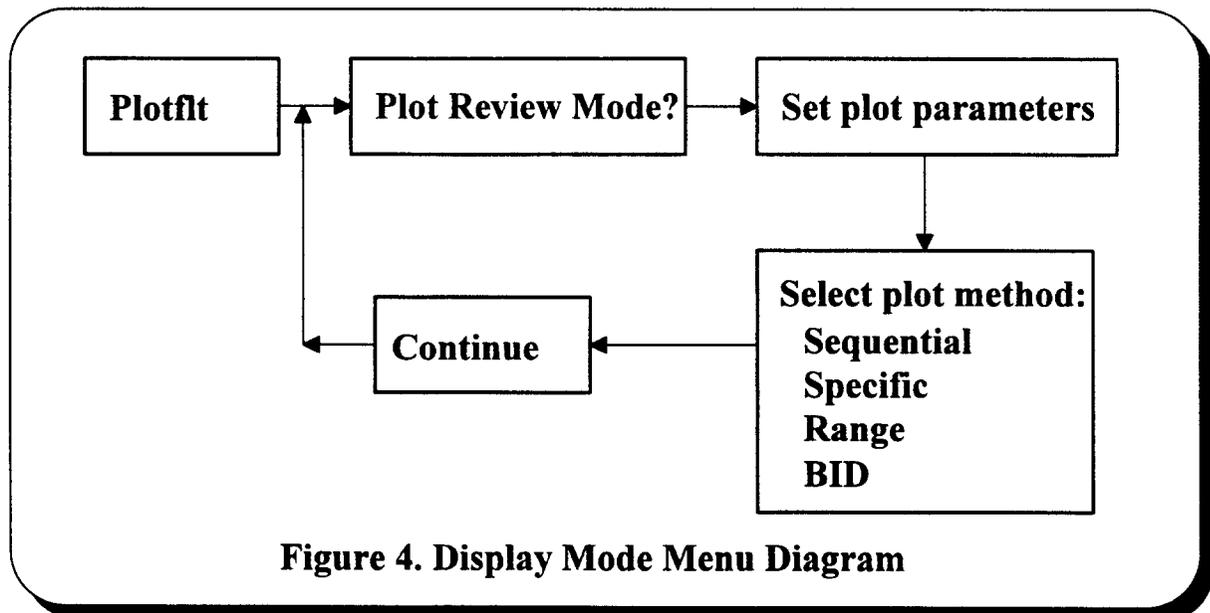


Figure 4. Display Mode Menu Diagram

Figure 4 shows the flow diagram for plot display mode. For plot display mode, the .IDX file is used because it is sorted by flight number. This allows a sequential replay of the current flight day.

5.2 Sample Execution of Display Mode

5.2.1 Plot Review Mode

The following example shows the sequence for viewing a flight with a specific Beacon ID. The courier font represents the output from the program; the bold text represents input from the user. The specific screens (Figures 5, 6, 7, and 8) are the actual output the user will see on the VGA display. See section 6.3 for the list of configuration files required before using plot review mode.

From the DOS prompt, invoke the plot-flight program and type in: **PLOTFLT**

The first screen (Figure 5) displays a welcome message and prompts the user for a filename (the filename must be a sorted radar file with a .SRT extension).

```
Welcome to plotflt. This program allows you to view the
aircraft flight paths for the local airport.

Please use .SRT extension for filename.
Enter name of the radar file for plotting (e.g. B940508N.SRT):
B940201.SRT

Plotflt has three modes. You may review the data
one flight at a time, plot all flights for a day or use
the green strips for data input. Please select an option.
To quit the program enter 0.
Review mode enter 1; Composite: 2; Data input enter 3.

0. -> Quit program
1. -> Plot Review mode
2. -> Plot Composite mode
3. -> Data Input mode

Enter your choice: 1
```

Figure 5. VGA Display Screen

Next, the user is presented with a menu (Figure 6) for changing the plot parameters. These options are documented in section 5.3. The defaults are sufficient in most cases.

File name : B940201.SRT

Current mode selected : Plot Review

Plotflt has multiple plot options. You may choose to display the text, circles and streets of the local city. You may also erase the flights after plotting if you are in plot review only.

CURRENT PLOT SETTINGS ARE :

Erase mode: YES
Display labels: YES
Display streets: YES
Display circles: YES
Plot speed: MEDIUM

Do you want to change the current values? (y or (n or <cr>): N

Figure 6. Menu for Changing Plot Parameters

The next screen (Figure 7) shows the available options for display.

File name : B940201.SRT

Current mode selected : Plot Review

Plotflt has multiple plot options. You may plot all flights sequentially, plot a specific flight, plot a range of flights, or plot by Beacon ID. For sequential mode enter 1, for specific flight enter 2, for a range, enter 3 and for Beacon ID enter 4.

- 0. -> Quit program
- 1. -> Plot all flights sequentially
- 2. -> Plot a specific flight
- 3. -> Plot a range of flights
- 4. -> Plot by Beacon ID

Enter your choice: 4

Enter Beacon ID for plotting (q to quit): 3241

Figure 7. Available Options for Display

The first option (sequential) will display all the aircraft flights for February 1 in sequence. The first flight of the day may start after midnight (GMT) and may end at 23:59 GMT. This option is not frequently used since there may be as many as 700 flights in an Albuquerque flight day. Option 2 will prompt the analyst for a specific flight number. This number is the sequence number for that flight. For instance a flight after midnight will have a sequence number of 1. The flight numbers are obtained from the BID and IDX index files. Option 3 will allow the user to select a range of flights for display. The end flight must be greater than the start flight number, or an error message will print out. The last option, plot by Beacon ID is the option we selected. Enter a four digit number for Beacon ID unless the number is less than 1000. In this case, the digit(s) can be entered directly (e.g., for BID 789 enter 789).

The output from the last menu is displayed in Figure 8 (BID 3241).

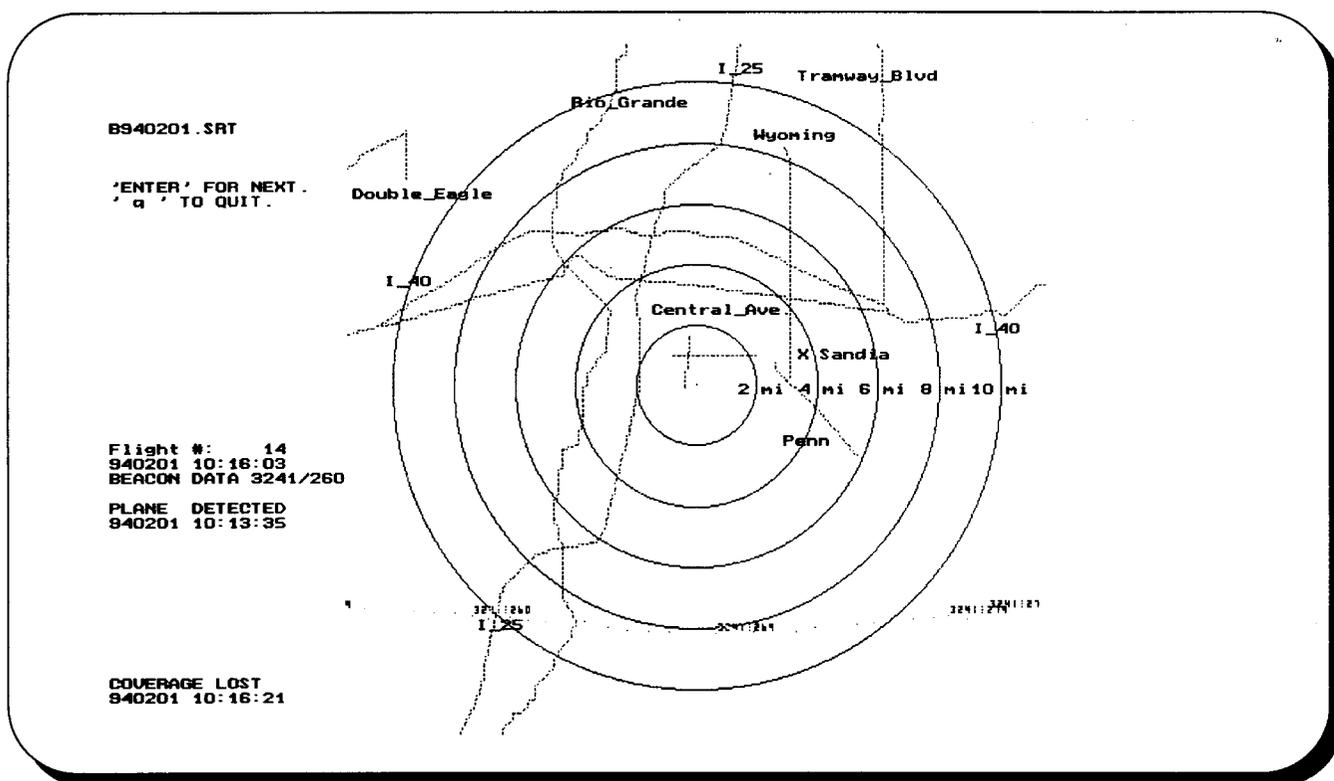


Figure 8. Example of Fly-Over Flight

This flight is a fly-over going from the east to the west. The plot is the output from the data listed in section 4.1. The output window is the same for all display mode plots. In the upper left corner of the screen, the file name is printed (B940201.SRT). This is the same name typed in when the program was started. Below that is the text, "Enter for next, q to quit". In most cases, if the RTN key is pressed the next flight will plot; otherwise, if the user presses q, the program will exit to the main menu. The next line on the left side of the screen is the text, Flight #: 14. Beacon ID 3241 was the fourteenth flight of this day. Below the start time is the Beacon ID and current elevation (3241:260). This text changes with each plotted data point. Next the text "940201 10:16:03" is printed. This represent the year, month, day, hour, min., sec (GMT) of the flight. The last line is the time flight coverage was ended in GMT. On the plot, the streets, landmarks, and radii from radar center are plotted. The flight on the south of the map shows the individual points with Beacon ID and elevation for the given point displayed (e.g., 3241: 279).

The elevation is multiplied by 100; in this case 27,900 feet. To reduce clutter, every twelfth point is plotted with the Beacon ID and elevation.

5.2.2 Plot Composite Mode

In addition to plot review, plot composite mode (Option 2) is available from the main menu:

- 0. -> Quit program
- 1. -> Plot Review mode
- 2. -> Plot Composite mode
- 3. -> Data Input mode

This permits viewing the whole flight day at once. There are no options available for composite mode. All flights plot in the same color. This is useful for analysts because it shows flight traffic patterns graphically. An example is shown in Figure 9.

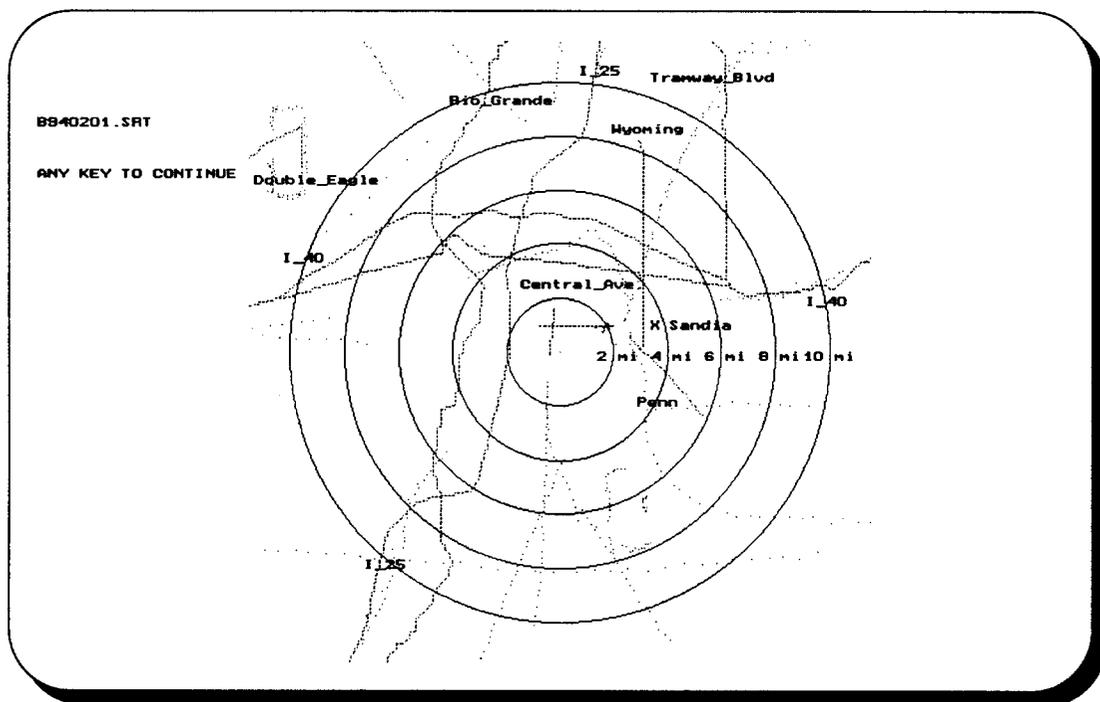


Figure 9. Flight Traffic Patterns

5.3 Plot Parameters

The plot settings can be changed before each flight. The following screen appears:

CURRENT PLOT SETTINGS ARE :

Erase mode: YES
Display labels: YES
Display streets: YES
Display circles: YES
Plot speed: MEDIUM

Do you want to change the current values? (y or (n or <cr>): Y

If the response is "Yes" to the question regarding plot settings, then the menu in Figure 10 will appear.

```
0. -> Quit plot setup
1. -> Toggle erase mode (plot review only)
2. -> Toggle label text
3. -> Toggle street display
4. -> Toggle circles
5. -> Change plot speed

Enter your choice: 5
1. -> Fast plot speed
2. -> Medium plot speed
3. -> Slow plot speed
Enter your choice (1, 2, or 3): 1

CURRENT PLOT SETTINGS ARE :

        Erase mode: YES
        Display labels: YES
        Display streets: YES
        Display circles: YES
        Plot speed: FAST

Do you want to change the current values? (y or (n or <cr>): N
```

Figure 10. Plot Settings Screen

Option 1, toggle erase mode, will erase each plot after it is displayed if it is set. Otherwise, every viewed plot will concatenate in the same window. This option is useful if an analyst wants to plot flights with the same Beacon ID on the same window. Option 2 will turn on/off the text labels for the plot; Option 3 is the toggle for the streets; and Option 4 is a toggle switch for the circles. Option 5 controls the speed of the flight. This makes it easier for the analyst to determine the offsets and direction of the flight path. In Figure 10, the speed menu has been selected and the user is given three choices for speed: fast, medium, and slow. Fast plots have no delay between flights; medium has a one second delay and slow a two second delay.

If the current settings are listed as follows, then the screen will look similar to that in Figure 11:

```
CURRENT PLOT SETTINGS ARE :

        Erase mode: YES
        Display labels: NO
        Display streets: NO
        Display circles: YES
        Plot speed: MEDIUM
```

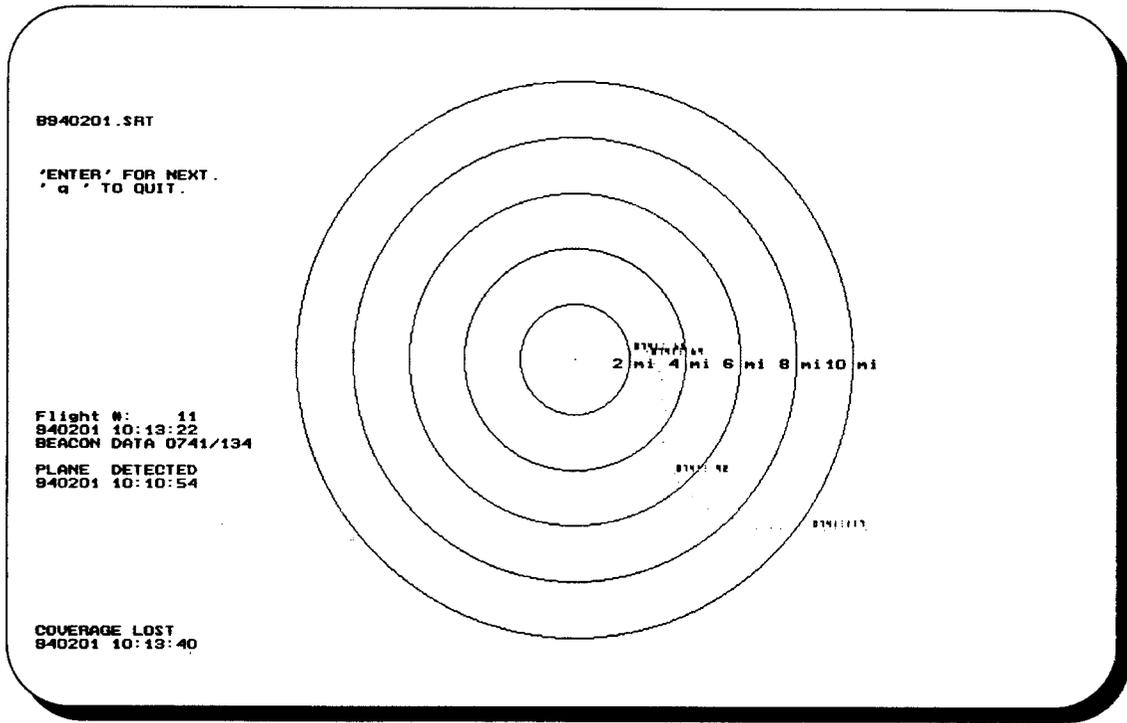


Figure 11. Sample Plot Without Labels

It is better to eliminate the streets and text while in data input mode. Less clutter makes it easier to attach green strips to the flights.

6. Data Input

6.1 Green Strip Overview

Green strips are used by local air traffic controllers to monitor and record both scheduled and unscheduled flights. Green strips (also called flight progress strips) are also used to post current data on air traffic and clearances required for control and other air traffic control services. The local air traffic control center monitors low altitude flights (e.g., takeoffs, landings, and flights under 17,000 feet). For high altitude aircraft (above 17,000 feet), the regional center monitors the traffic and uses its own green strips. For the SARS project, the green strips have required information for individual flights which is not available in electronic form. The aircraft type is required for the current models used in aircraft crash analysis. The PLOTFLT program captures this information and updates the BID index file.

6.1.1 Arrival Strip with Example

A sample flight arrival strip is shown in Figure 12. The square boxes on the right of the strip are used by air traffic controllers for local airport markings (runway configuration, arrival time updates or changes). Standardization of these fields on the right are not practical because of regional and local variations in operating methods (e.g., single fix, multiple fix, radar, tower en route control, etc.).

Arrival Strip						
1 Aircraft ID	5 Beacon #	8 Estimated Time of Arrival	9 Remarks			
2 Revision #	6 Prev. Fix					
3 Aircraft Desc.	7 Coord. Fix			9A Destination		
4 Computer ID			Min Fuel			
			Adj info			

Figure 12. Arrival Strip

An example of a filled-in flight arrival strip is shown in Figure 13.

Arrival Strip						
TWA297	2126	A1638	IFR			
T/B727/A	LVS					
516	FRIHO			ABQ		

Figure 13. Filled In Arrival Strip

In Figure 13, the computer ID is TWA297; the revision number is left blank; the aircraft description or type is T/B727/A; the computer ID is 516; the Beacon ID or squawk code is 2126; the previous fix is LVS; the coordination fix is FRIHO; the estimated time of arrival is 16 hr. 38 min. GMT; the remarks are IFR (instrument flight rules); and the destination airport is ABQ (Albuquerque).

For data input purposes, all fields are not entered. The important fields are aircraft type, Beacon ID, and estimated time of arrival. The Beacon ID (field 5) and estimated arrival time (field 8) are needed to locate the corresponding electronic flight, and the aircraft type (field 3) is saved for modeling purposes. The A prefix in the time field indicates the flight is a arrival. These are the required fields for data entry.

6.1.2 Departure Strip with Example

Figure 14 shows the layout of a departure strip.

Departure Strip						
1 Aircraft ID	5 Beacon #	8 Departure Airport	9 Route, Desinat and remarks			
2 Revision #	6 P.D. Time					
3 Aircraft Desc.	7 Request Altitude					
4 Computer ID			9A Adjustment Information			

Figure 14. Departure Strip

An example of a filled-in departure strip is shown if Figure 15.

Departure Strip						
SWA812	4202	ABQ	+RV ABQ260R ZUN+ ABQ ZUN FOS PHX			
T/B73S/A	P0120					
186	350					

Figure 15. Filled-In Departure Strip

This flight strip represents a Southwest Airline departure from Albuquerque to Phoenix. The aircraft ID is SWA812; the revision number is blank; the aircraft type is T/B73S/A; the computer ID is 186; the Beacon ID is 4202; the proposed departure time is 01:20 GMT; the requested altitude is 35,000 feet; the departing airport is ABQ (Albuquerque); and the route and destination is RV PHX.

Each airport has a unique abbreviation. The square boxes on the right are specific to each local airport. Once again, the important fields for data entry are Field 3: aircraft type, Field 5: Beacon ID, and Field 6: proposed departure time. The "P" prefix in the time field indicates the flight is a departure. The time and Beacon ID are used to locate the electronic flight data, and the aircraft type is saved for modeling purposes.

6.1.3 Fly-Over Strip with Example

Figure 16 shows the layout of a fly-over strip.

Fly-Over Strip						
1 Aircraft ID	5 Beacon #	8 ETA Coord. Fix	9 Altitude and route thru term area 9A Adjustment Information			
2 Revision #	6 Coord Fix					
3 Aircraft Desc.	7 Overflight Indicator					
4 Computer ID						

Figure 16. Fly-Over Strip

Figure 17 shows an example of a fly-over strip filled in.

Fly Over Strip						
N5514Q	4326	E1704	100 LRU./V19 SAF			
MO20/A	ONM					
380	ZCA					

Figure 17. Filled In Fly-Over Strip

In this example the aircraft ID is N5514Q; aircraft type is MO20/A; the computer ID is 380; the Beacon ID is 4326; the coordination fix is ONM; the overflight indicator is ZCA; the estimated time of arrival is 17:04 GMT; the altitude is 100*100 = 10,000 feet; and the adjustment info is LRU./V19 SAF.

The important fields for fly-over flights are Field 3: aircraft type, Field 5: Beacon ID, and Field 8: estimated time of arrival. The "E" prefix in the time field indicates the flight is a over-flight. The Beacon ID and time are used to locate the electronic flight, and the aircraft type is saved for modeling purposes.

6.2 Green Strip Input Process Description

The green strip input process is complicated compared to display mode. The interactive process requires the user to type in mandatory fields (listed in section 6.1) from the physical green strip. The plotflt program will attempt to find a match in the electronic data file (.srt file). The match is based on Beacon ID and time. If a match is found, the user has the option to attach the data entry fields (e.g., aircraft type, flight time) to the individual flight. If attachment is chosen, then the program will update the BID file with the new information. Attachment is done in graphics mode. If too many flights are displayed at once, the user has the option to replay the flight. This will occur when a flight has duplicate Beacon ID's

within a day. If a match of the green strip to recorded data is not found, then the program will save the newer information to an unresolved file. Provisions are provided for the cases in which the green strips are already attached and instances when the Beacon ID changes within the flight. In many cases the attachment process is subjective. Figure 18 depicts the entire green strip input process.

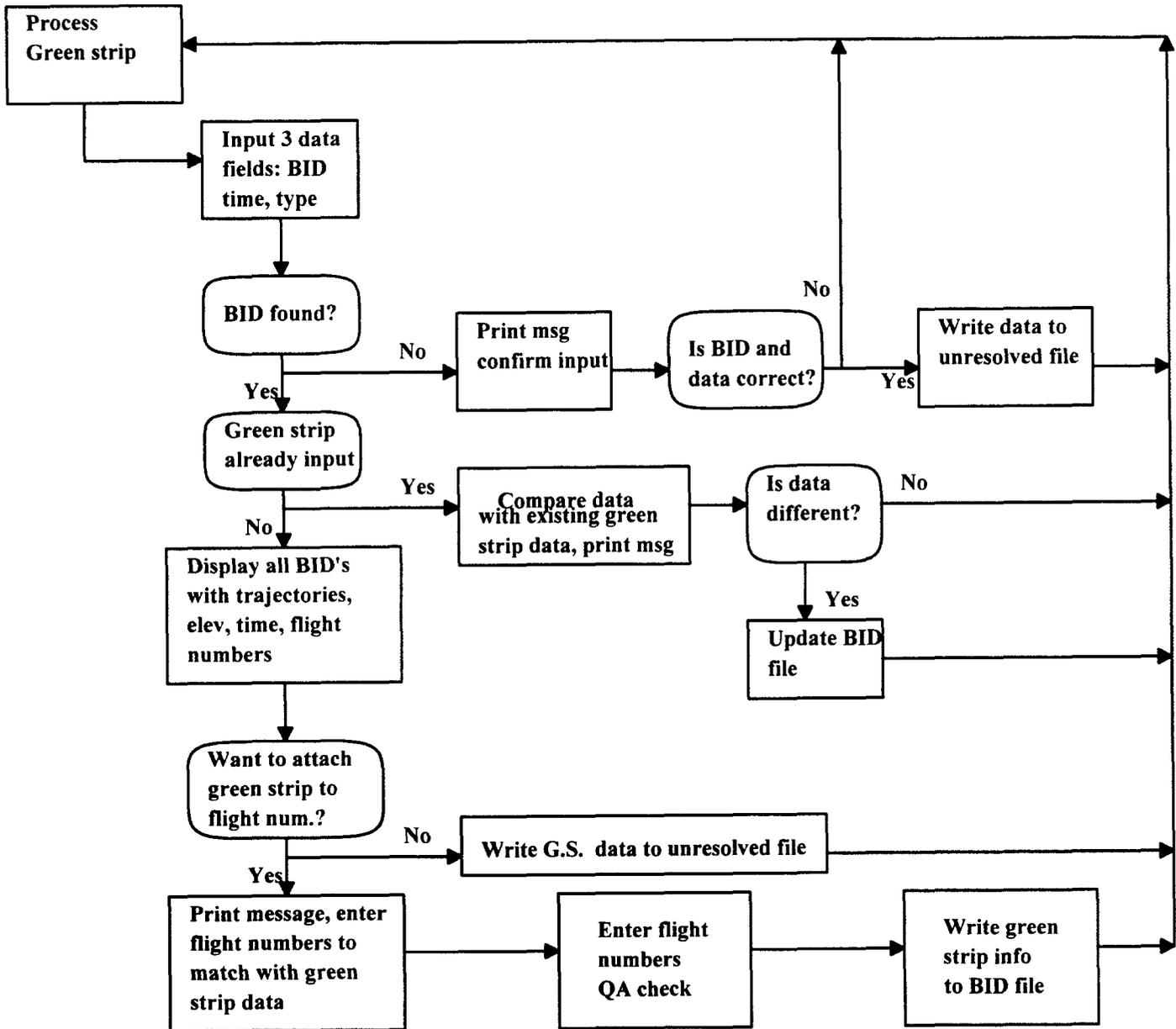


Figure 18. Green Strip Input Process

6.3 Configuration Files

Before using the data input or display mode options the user must have the following configuration files present in the current working directory:

PSMAP.CFG	- contains maximum radius for display
PSMAP.MAP	- graphics file for local airport and streets
PSMAP.TXT	- text file for labels
EGAVGA.BGI	- Borland graphics driver
ABQPTX.CFG	- Configuration file for data input mode

The psmap and egavga.bgi files should not be edited by users. The psmap files are unique to every site. The abqptx.cfg file is user configurable and can be changed with a common text editor such as EDIT. The format of the abqptx file is:

```
0 ;vfr/ifr prompt 0 -> disable prompt, 1 -> enable prompt
0 ;aircraft id prompt 0 -> disable prompt, 1 -> enable prompt
0 ;G_miles -> flights outside this range are ignored, if 0 -> disable filter
```

The leading integer 0 or 1 enables or disables the filter. The first line is a switch that will enable or disable the VFR/IFR prompt. The air traffic control center usually groups the green strips based on visual flight rules (VFR) or instrument flight rules (IFR). If enabled, the second line prompts the user for the aircraft ID. The VFR/IFR and aircraft ID are not required for modeling or data entry. It is best to leave these disabled to speed up data entry. The third line (in miles) determines if aircraft outside a certain radius from a known target will display on the screen. This should be disabled at this time because there is much debate on where the targets are and how the offsets to these targets should be calculated.

6.4 Sample Execution of Data Input Mode

The green strips are not sorted in any manner except VFR/IFR grouping. When a Beacon ID number is entered, the program will attempt to find a match. If a match of the BID is found, then all flights with that particular beacon number will display on the screen. It is up to the user to select and attach the best match for the green strip.

The following examples demonstrate the capabilities, limitations, and subjectivity involved with data entry. Figure 19 is the standard startup menu for the plotflt program. Option 3 is selected for data entry. Figure 20 is the standard menu for changing the default plot settings. To change these defaults, see section 5.3. These two screens will appear each time data entry mode is selected.

The examples were taken from the recorded data over the Albuquerque airport on May 9, 1994. In most of the examples, the green strip is displayed along with the BID file "before" and "after" update.

Welcome to plotflt. This program allows you to view the aircraft flight paths for the local airport.

Please use .SRT extension for filename.
Enter name of the radar file for plotting (e.g. B940508.SRT):
B940509N.SRT

Plotflt has three modes. You may review the data one flight at a time, plot all flights for a day or use the green strips for data input. Please select an option. To quit the program enter 0.
Review mode enter 1; Composite: 2; Data input enter 3.

- 0. -> Quit program
- 1. -> Plot Review mode
- 2. -> Plot Composite mode
- 3. -> Data Input mode

Enter your choice: 3

Figure 19. Startup Menu

File name : B940509N.SRT

Current mode selected : Data Input

Plotflt has multiple plot options. You may choose to display the text, circles and streets of the local city. You may also erase the flights after plotting if you are in plot review only.

CURRENT PLOT SETTINGS ARE :

Erase mode: NO
Display labels: NO
Display streets: NO
Display circles: YES
Plot speed: FAST

Do you want to change the current values? (y or (n or <cr>): N

Figure 20. Plot Parameter Menu

6.4.1 Example 1

This is a simple example of an arrival strip attachment. The strip is shown below.

Arrival Strip						
TWA297	2126	A1638	IFR			
T/B727/A	LVS					
516	FRIHO					

The record for this green strip in the BID file before attachment is shown below.

```
565 24583 24701 940509163700 2126 163708 164609 110 54 01 1 # #####
```

After the first two screens are displayed (Figures 19 and 20), a series of prompts will appear. These questions and responses are the minimum required to match the input data with the flight data file and update the BID file. The Beacon ID is the key needed to find the match in the BID file. It is field 5 in the record listed above (2126). Figure 21 shows the required dialog for this green strip.

```
***** Welcome to Green Strip Input *****  
  
Please enter your initials (3 max): jlt  
  
Do you want to enter data from the keyboard or a file?  
Press <cr> or k for keyboard entry; f for file entry.  
Enter (f), (k) or <cr>: k
```

Figure 21. Welcome Screen

Figure 21 shows the first screen needed for data input. The program prompts the user for the initials. Since many people use the plotflt program concurrently, it is desirable to keep track of the responsibility of green strip input. This question appears only once. As the program runs, the initials are stored in memory and written out to the BID for each updated record. The next question relates to batch or interactive mode. Batch mode will allow personnel to key in the three required fields from the green strip into a spreadsheet or text file without attaching data to the flights. Upon completion, higher trained personnel may replay and attach the flights directly from the text file or spreadsheet. This relieves higher level users from the labor intensive task of entering the information from the green strips. Batch mode is a future enhancement at this time. Until batch mode is enabled, use interactive mode (press k for keyboard or <cr>).

Figure 22 shows the second required screen for data input. Only three prompts are required. The abqptx.cfg file controls this. This screen is displayed every time a new green strip is entered.

```
***** Green Strip Input *****  
  
Enter Beacon ID (0 thru 9999) (type -1 to quit, -999 if unknown): 2126  
You entered 2126  
  
Enter aircraft type (e.g. C130/R : 12 char. max): T/B727/A  
You entered T/B727/A  
  
Use one of the following formats for the flight time.  
HHMM, AHHMM, EHHMM, PHHMM  
Enter flight time (5 char. max, 4 char. min): A1638  
You entered A1638
```

Figure 22. Data Entry Screen

Data input is case insensitive; either capital or lower or any combination may be entered. When the BID file is updated, everything is converted to capital letters. Every response to a question is echoed to the user. This technique reduces typing mistakes.

The first question prompts for the Beacon ID. This text is located in the same spot on all green strips (hand written strips too) regardless of arrival, departure, or fly-over. If the user wishes to end data input, enter -1. If the Beacon ID is unknown or illegible, then enter -999. Although it won't be possible to replay a flight with an unknown Beacon ID, the aircraft type and flight time will be saved to the unresolved file.

The next question prompts for the aircraft type. Like the Beacon ID, it is located in the same field on all green strips. A user may type in a maximum of 12 characters.

The last question prompts for the time. The time listed on the green strip is GMT (UCT) time. Enter this time only; do not convert to local time or any other time. The time usually has a leading prefix. A leading "A" would mean arrival, "P" means departure, and "E" means fly-over. If there is no leading character, then the flight must be plotted in order to determine the type of flight. The time must be entered with 4 or 5 digits. The following forms are acceptable: HHMM, AHHMM, EHHMM, PHHMM. If the time has a leading 0, it should not be dropped. For instance, if the time is 0912, then enter 0912, not 912. If the time is A0912, then enter A0912. Do not enter A912. Do not enter a colon to separate the hours and minutes.

After answering these three questions, the screen will toggle to graphics mode and the flight will be displayed (Figure 23).

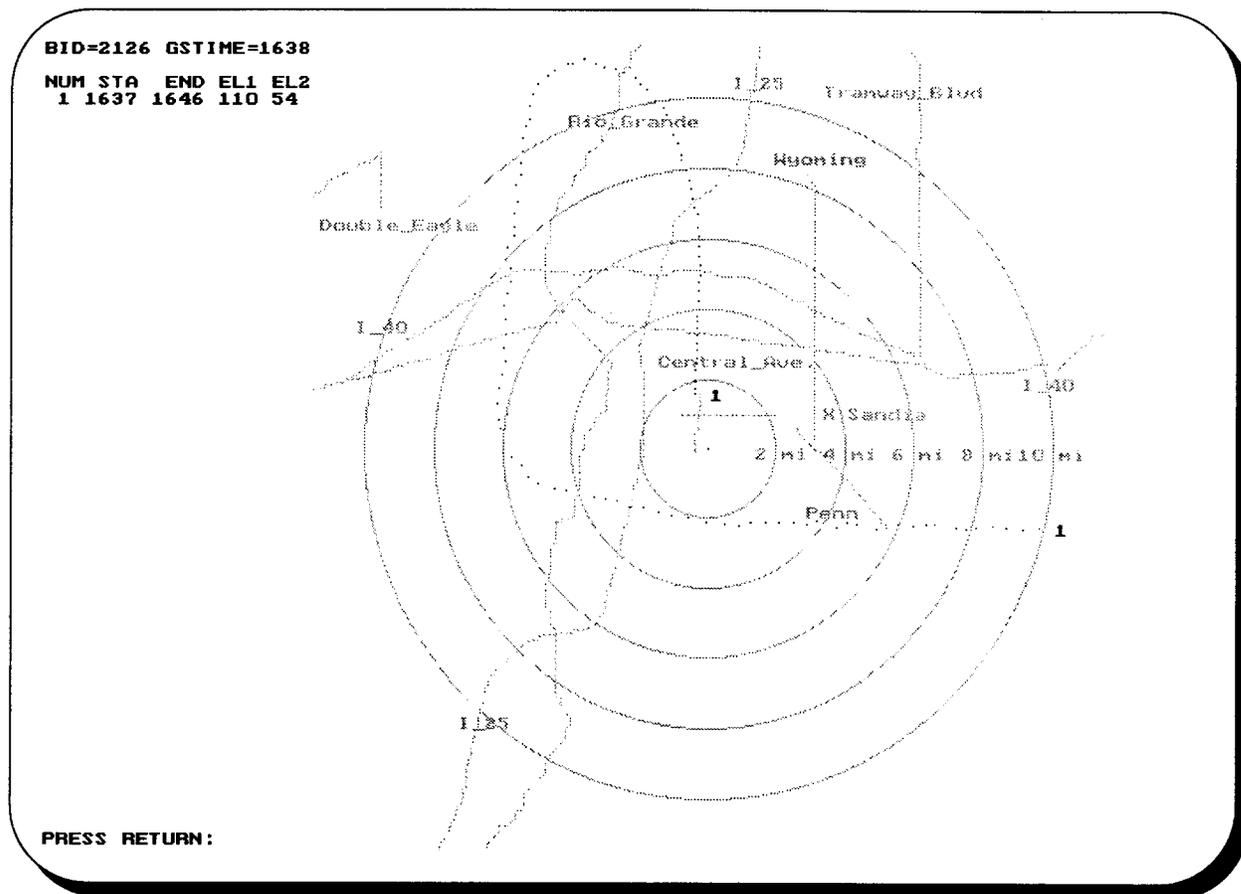


Figure 23. Data Input Fly-Over Example

In the upper left corner of the screen, the BID and time are displayed. These are the times entered from the strip. The line below shows the flight number (NUM: 1), start time (STA: 16:37 GMT), end time (END: 16:46 GMT), start elevation (EL1: 110*100=11,000 feet, and end elevation (EL2: 54*100=5,400 feet). These values are retrieved from the BID file for this flight. These values help the user match up the green strip time with the recorded flight time. In this case, the green strip time is 16:38 and the recorded start time is 16:37. This is close enough for a match. This flight is an arrival since the trajectory starts from the east and lands on the north/south runway. The elevation decreases from 11,000 feet to 5,400 feet. The number "1" plotted on the screen with the trajectory corresponds with the flight number "1" listed in the upper left corner of the display.

Figure 23 is a graphics screen. The attachment occurs after the user presses the return key and toggles back to text mode. This is shown in Figure 24.

```
BID=2126 G.S.TIME=1638 ACFT ID=UNKNOWN ACFT TYPE=T/B727/A

NUM STA END EL1 EL2
1 1637 1646 110 54

0. -> Quit - do not save G.S. info; start over.
1. -> Attach green strip to plot numbers.
2. -> Write green strip info to unresolved file.
3. -> Replay plot.

Enter your choice: 1

Attach green strip information to plot numbers listed above.
Select plot numbers from the NUM column above.
Enter integer list (30 max) separated by spaces:
1
```

Figure 24. Attachment Screen

Most of the information listed in Figure 24 is a repeat of Figure 23 except it is in text mode. Text mode makes it easier to handle keyboard input and error handling. The green strip information is listed on the first line. The aircraft ID (i.e., TWA297) prompt was turned off in this case (see abqptx.cfg file), so its default value is unknown. The recorded data is printed two lines below. As stated previously, the times match and the flight is an arrival based on the visual approach and difference in elevation. Option 0 allows the user to start this green strip over if there are errors or start a new green strip. It is recommended to enter all green strips regardless of attachment. Option 1 allows attachment and updates the BID file. Option 2 will save the keyed in information to an unresolved file. If time permits, some flights can be resolved from the unresolved file. This takes time and consultation from a knowledgeable person. Option 3 replays the plot (Figure 23). This is useful for viewing multiple flights with the same Beacon ID.

Select Option 1 to attach. Enter the single digit 1 from the flight number list. This entry is checked for illegal characters and digits. For instance, the "Enter integer" prompt will appear again if a "2" is entered instead of a "1". If there are 5 flights, you may attach all flights by entering all digits separated by spaces (e.g., 1 2 3 4 5). You can attach just 3 out of 5 flights by entering 1 2 3. However if you enter 4 5 6, the number 6 exceeds the maximum flight number, so an error message is printed and the prompt will appear again. Letters are not permitted for the integer list. A maximum of 30 flights can be attached at once but the screen will be cluttered with 30 flights displayed. If there are more than 30 flights, attach the first group of flights and start the BID entry again (Fig. 22), and attach the next group of 30, and so on.

The green strip information for this example will be saved to the BID file and the prompt for the next green strip will appear (Figure 22). The saved BID record will appear as follows:

BID file before update

565 24583 24701 940509163700 2126 163708 164609 110 54 01 1 # ##### # ##### # ##### 0 ###

BID file after update

565 24583 24701 940509163700 2126 163708 164609 110 54 01 1 U UNKNOWN T/B727/A A 1638 1 JLT

The "1" on the right column next to the initials indicates this record is now attached.

6.4.2 Example 2

This strip is an example of a departure flight from Albuquerque.

Departure Strip						
NRG310	4276	ABQ	+ABQ024R			
DH6/A	P1600					
740	100			ABQ ABQ0240		

The menu shown in Figure 22 is used to input the three required fields. In this case, the BID is 4276; the aircraft type is DH6/A; and the time is P1600. The "P" indicates it is a departing flight. The flight is displayed in Figure 25.

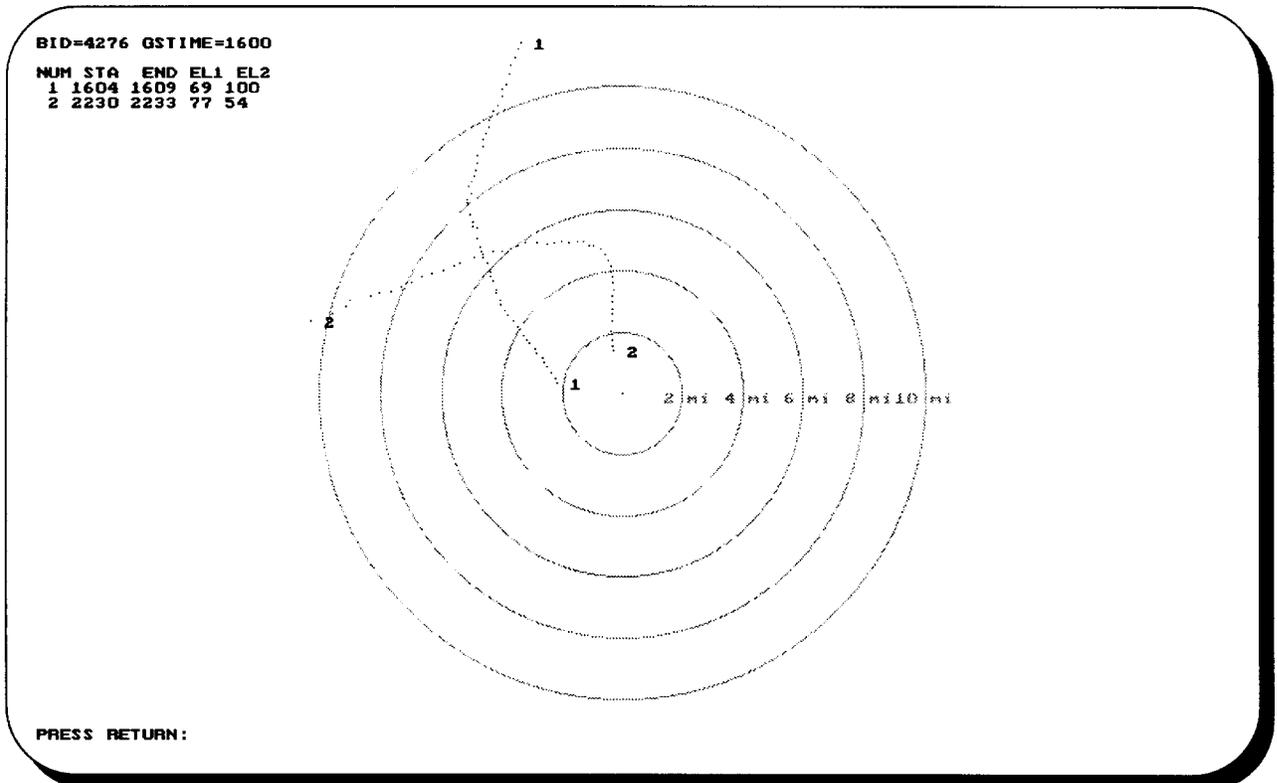


Figure 25. Data Entry Departure

In this case, two flights are plotted without the streets or labels. The first is a takeoff from the airport near the center of the screen (16:04 GMT) and the direction is to the north. The second flight is an arrival from the west at 22:30 GMT. The attachment should be made to the first flight because the time is close and the prefix for the time is P (takeoff). In general, if the times (green strip and recorded) are within a one hour interval, then the strip may be attached to the electronic flight.

Since the green strips are not sorted and collected randomly, it is possible to receive a duplicate green strip. The only change may be the time or the computer ID. The air traffic controllers may update the green strip or generate a new strip for the same flight. In the case where the green strip was already attached and nothing changed in the 3 keyed in fields, the text line for that flight will plot in yellow. This gives the user a visual confirmation that the green strip was already attached. Figure 26 shows the output if a duplicate green strip is entered (the italics for Flight 1 is yellow in the program).

```
BID=4276 G.S.TIME=1600 ACFT ID=UNKNOWN ACFT TYPE=DH6/A

NUM STA END  EL1 EL2
  1 1604 1609 69 100
  2 2230 2233 77 54

0. -> Quit - do not save G.S. info; start over.
1. -> Attach green strip to plot numbers.
2. -> Write green strip info to unresolved file.
3. -> Replay plot.
Enter your choice: 1

Attach green strip information to plot numbers listed above.
Select plot numbers from the NUM column above.
Enter integer list (30 max) separated by spaces:
1

Green strip flight path #: 1 already processed.
Typed data matches existing data.
Please enter next green strip. Press return:
```

Figure 26. Green Strip Already Attached

Since the new green strip matches the old one, the BID file will not be updated, and the screen for the new green strip will be displayed.

There are instances where the green strip fields will change slightly and the user will have the option of updating the BID file with the new information or leaving the old information as it is. Usually the change occurs in the time field; the aircraft ID and Beacon ID will stay the same. For example, if the new green strip is entered with a time of P1620 instead of P1600, then the user will select one of the options listed in Figure 27.

The green strip flight path #: 1 was already processed.
 However the new data does not agree with the old data. You
 may choose to write the new data to the unresolved file
 or over-write the old data.

BID=4276

OLD DATA: ACFT ID=UNKNOWN ACFT TYPE=DH6/A TIME=1600
 NEW DATA: ACFT ID=UNKNOWN ACFT TYPE=DH6/A TIME=1620

1. -> Replace old data with new data.
2. -> Write green strip info to unresolved file.
3. -> Replay plot and re-enter flight numbers.

Enter your choice (1, 2, or 3): 1

Figure 27. Attachment Choices

The only difference between the two strips is 20 minutes. Since the time is later (16:20 vs. 16:00) on the new strip, it is safe to update the BID record with the new time. In general, the time field is not critical for crash analysis, but it is important for the attachment. Option 2 will save the new strip information to the unresolved file, and Option 3 will replay the entire flight over (Figure 25).

BID file before update (the first record is flight 1, the second record is flight 2)

```
505 22599 22655 940509160401 4276 160450 160903 69 100 0 1 2 # #####
1005 43141 43190 940509223000 4276 223007 223348 77 54 0 1 2 # #####
```

Bid file after 2nd update (the 2nd record remains unchanged - nothing is attached to it)

```
505 22599 22655 940509160401 4276 160450 160903 69 100 0 1 2 U UNKNOWN DH6/A P 1620 1 JLT
1005 43141 43190 940509223000 4276 223007 223348 77 54 0 1 2 # #####
```

6.4.3 Example 3

This is another example of an arrival strip. The green strip is listed below.

The required fields for this strip are 1750 for BID, DA20/R for aircraft type, and A1558 for the time. When this information is entered, the output is displayed in Figure 28.

Arrival Strip						
N289MM	1750	A1558	IFR			
	LVS 315/0					
	545			FRIHO	AEG	
DA20/R						

BEACON ID 1750 NOT FOUND.

Current green strip input fields and values:

VFR/IFR selection : UNK
 Beacon ID : 1750
 Aircraft ID : UNKNOWN
 Aircraft Type : DA20/R
 Time of flight : A1558

Is data correct? (y or (n or <cr>): Y

Unresolved data saved. Press return:

Figure 28. Arrival Strip Example

The Beacon ID was not found in the sorted file. The newest information is echoed back and the user now has the choice of re-entering the green strip or saving it to the unresolved file. If the data is correct, then use selection Y; if not, select N and start over. In some cases, the green strips will not match the electronic data. Sometimes the flight may be delayed and the Beacon ID will change. The flight may be out of the recording range of the local radar collection program (10 mile record range is typical). There could be mistyped information on the teletype green strip. Regardless of the reason for the mismatch, save the information to the unresolved file. The details of the unresolved file are explained in Section 6.5.

6.4.4 Example 4

This next example is an arrival strip, but the plot shows multiple flights on the display (Figure 29). The strip is shown below. The BID is 4222; aircraft type is T/B73S/A; and the time is A1615.

Arrival Strip						
SWA702	4222	A1615	IFR			
	SJN					
	LAVAN					
T/B73S/A			ABQ			
463						

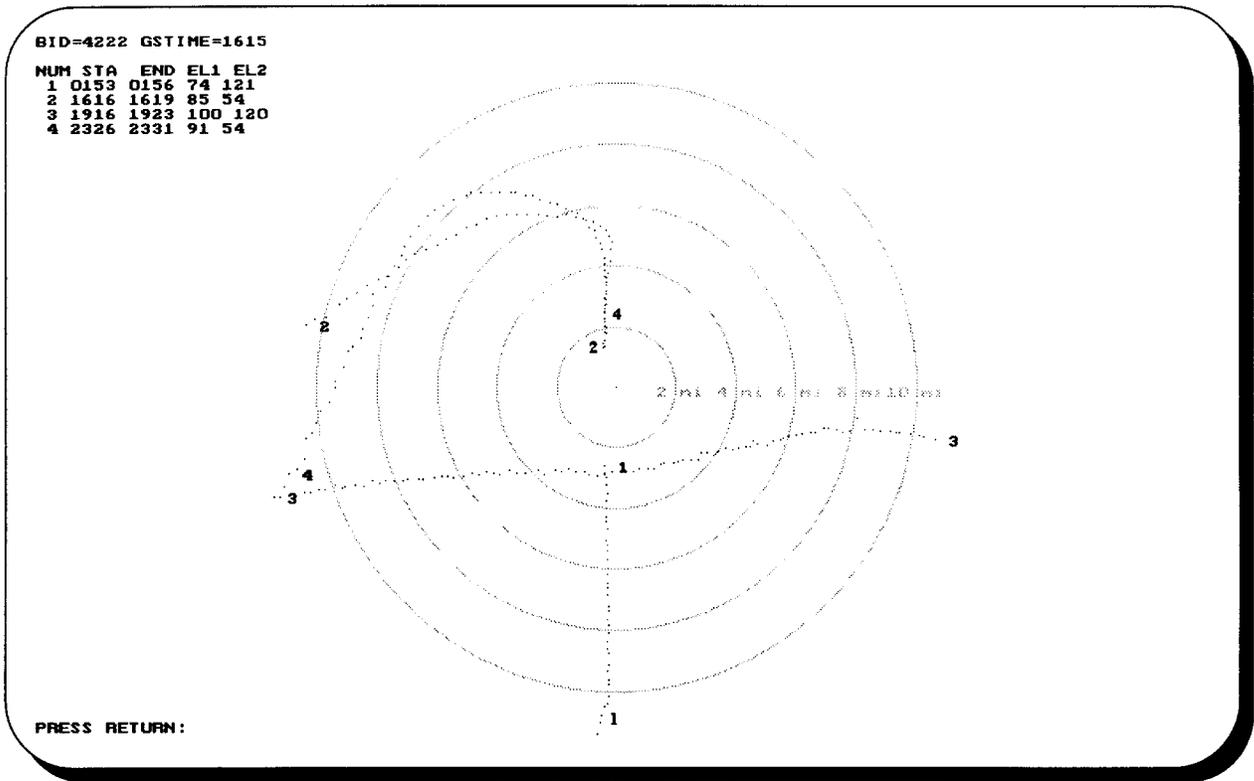


Figure 29. Arrival Strip With Multiple Flights

In this example, four matches are found with Beacon ID 4222. Flight 1 is a takeoff going from north to south; flights 2 and 4 are arrivals at different times; flight 3 is a fly-over going from east to west. Since the screen is cluttered, it is recommended to replay the flights before attachment. The flight which matches the green strip is the arrival for flight 2. Notice the elevation decreases from 8500 feet to 5400 feet at time 16:15 GMT.

BID file before update

```
536 23472 23522 940509161601 4222 161613 161959 85 54 0 2 4 # #####
```

Bid file after update

```
536 23472 23522 940509161601 4222 161613 161959 85 54 0 2 4 U UNKNOWN T/B73S/A A 1615 1 JLT
```

Although not shown, the other 3 flights with Beacon ID 4222 records remain unchanged until attached.

6.4.5 Example 5

The next example shows a strip and plot (Figure 30) with three flights.

Fly-Over Strip					
N5514Q MO20/A 380	4326	E1704	100		
	ONM		LRU./V19 SAF		
	ZCA				

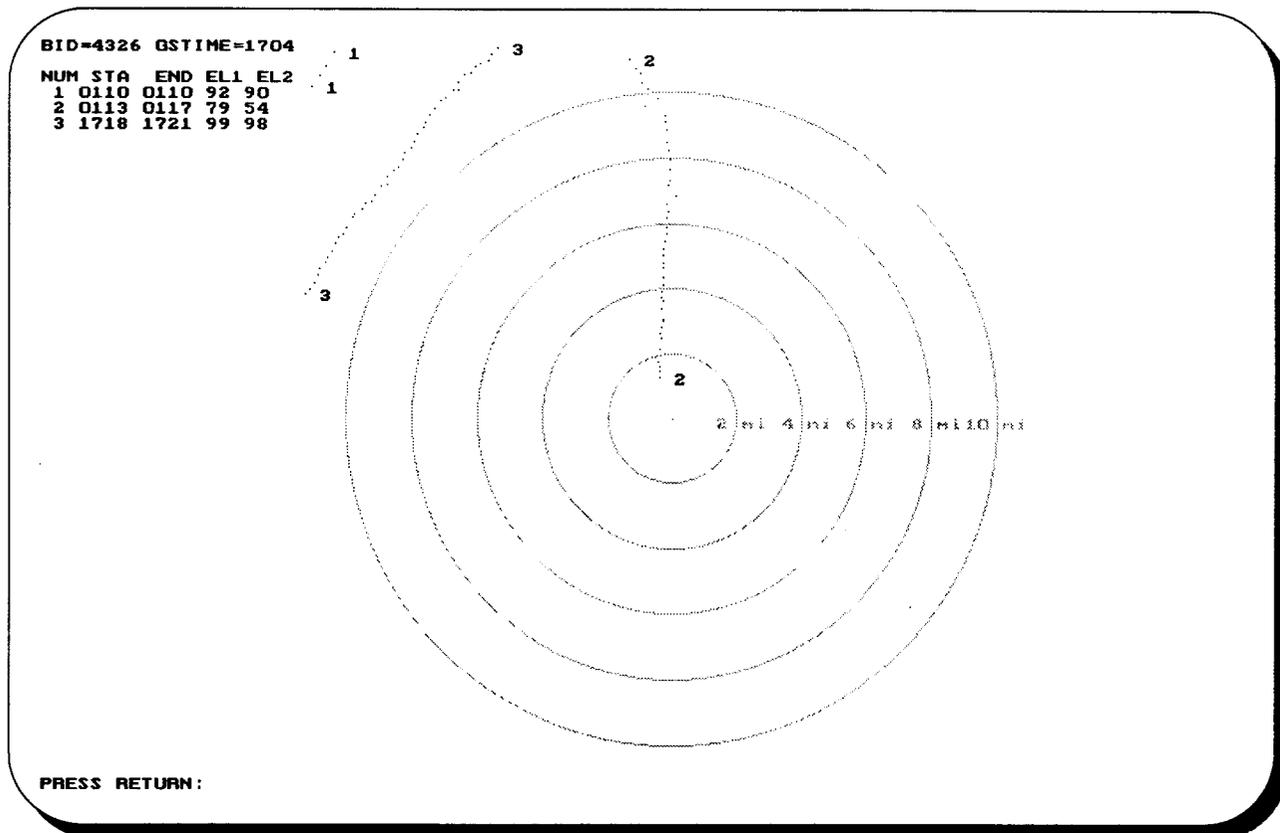


Figure 30. Fly-Over of BID 4326

In this case, the attachment is made to flight 3 because the time is close and the flight is a fly-over which corresponds to the E-prefix in the green strip. The third Beacon record will be updated. Flight 1 starts in the southwest and goes off the screen to the north. Flight 2 starts from the north, continues south and lands. When replayed, it seems that flight 1 is a fly-over; flight 2 is an arrival, and flight 3 is another fly-over. However, the end time of flight 1 is 0110 GMT and the start time of flight 2 is 0113 GMT. If there was a green strip for BID 4326 near time 0110 GMT, then flights 1 and 2 should be joined. Flight 1 is the beginning of flight 2. It is clipped from the screen and it is counted as a unique flight. The radar collection program has a finite radius of about 10 miles. If the flight goes off the screen then the program will end the first flight segment. If the flight path comes into the 10 mile radius again, then it is counted as another flight. It is up to the user to connect the flight segments or there may be an over-count in the number of flights. This may affect some of the calculations used in aircraft crash analysis.

6.4.6 Example 6

Another example of a fly-over strip is shown below and in the plot in Figure 31.

Fly Over Strip						
N4435V BE35/A 251	0774	E0446	VFR PXR0390030 SA			
	ABQ 276					
	ZCA					

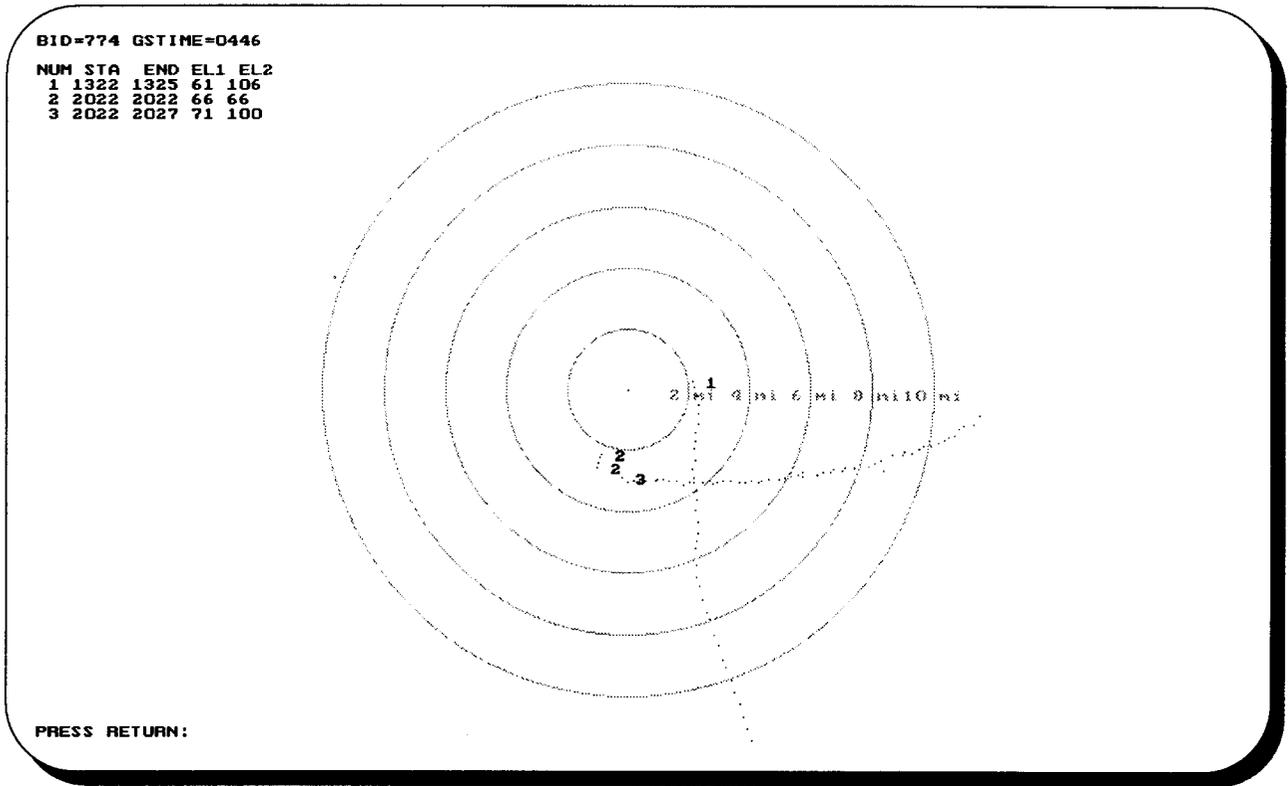


Figure 31. Fly-Over Example

In this example, the BID is 0774; the aircraft type is BE35/A; and the time is E0446. Flight 1 (from north heading south) is a takeoff at time 13:22 GMT. Flight 2 is a takeoff at 20:22 GMT. Flight 3 (heading east) is a continuation of flight 2, and they should be joined if there is a green strip. The time entered is E0466. The closest time is 13:22, nine hours difference. Therefore, this flight cannot be connected to any of the plotted trajectories unless more information is known. Save the information to the unresolved file.

Sometimes the air traffic controllers will manually update the green strip if a plane has a significant delay. The new time may be hand-written on the right side of the green strip. Each FAA facility uses its own markings on the green strip. It would take additional training in interpreting green strip markings for a user to make further judgment for the difficult flights.

6.4.7 Example 7

Another fly-over strip is shown below and in the plot in Figure 32.

Fly Over Strip						
NITER41	2327	E1707	190B200			
	ABQ 269/0					
	ZCA					
H/B1/R			DYS./INW0440			
009			MARSA CEL			
			W/NITER42			

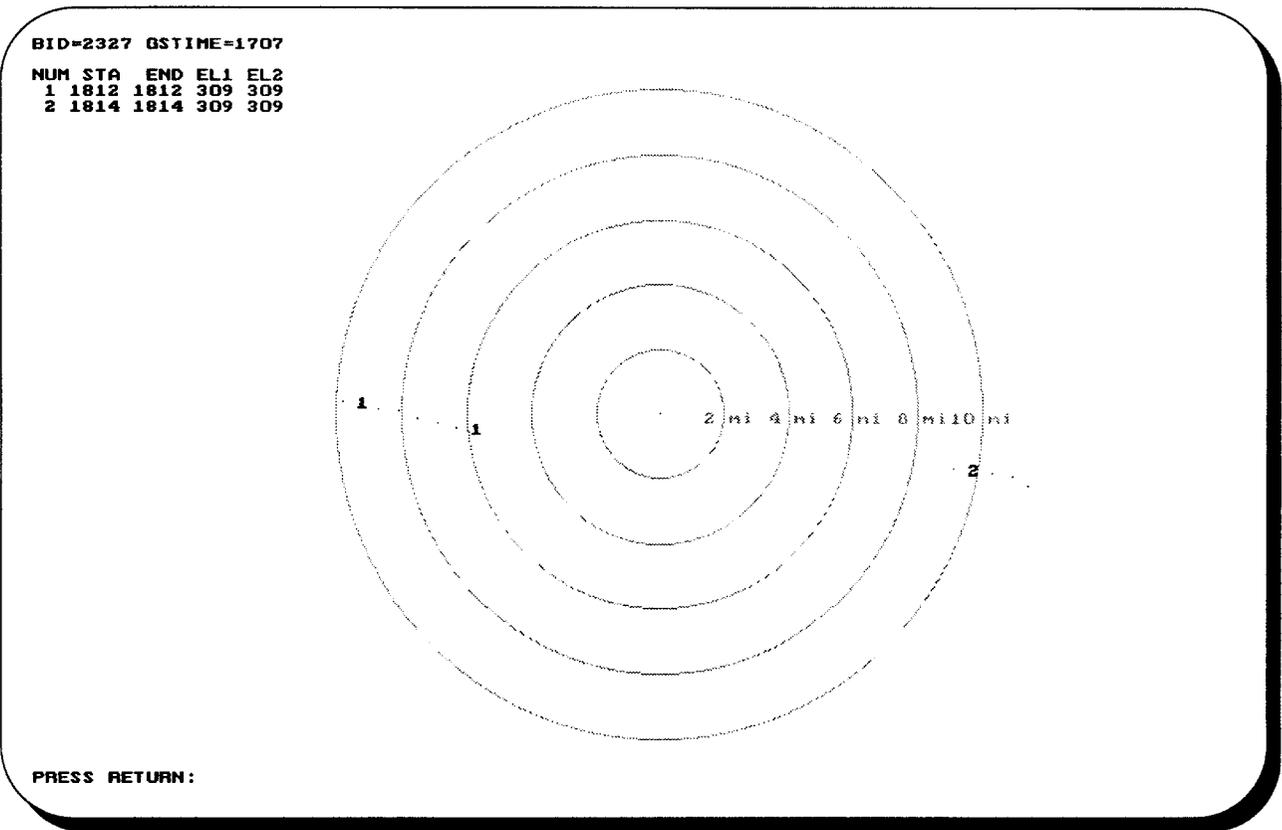


Figure 32. Fly-Over of BID 2327

The BID is 2327; the aircraft type is H/B1/R; and the time is E1707 GMT. This is a fly-over flight at high altitude (30,900 feet). There is a gap in the trajectory over the center of the airport and radar site. This occurs because of the "cone of silence." Most radar systems have a blind spot directly above the radar antenna. The mathematical model of the blind spot can be estimated with a right circular cone starting at the center of the radar and projecting upward in space. A 6 to 8 mile gap is not unusual at an elevation of 30,000 feet. The gap is more noticeable at high altitude directly above the radar.

The time entered is 17:07 GMT; the recorded time for flight 1 is 18:12 GMT; and 18:14 GMT for flight 2. Since both flights are at the same elevation, and the end time of flight 1 (18:12) is less than the start time of flight 2 (18:14) these flights would normally be joined. However, in this instance, no flights should be attached for two reasons. First, the time differential between the green strip and recorded data is too great. More information is needed before attachment.

The second reason for not attaching these flights involves the local and regional air traffic operations. The local airports track aircraft typically below 20,000 feet. (including takeoffs and landings). They keep these aircraft under surveillance throughout the flight while in the local airspace. The local center has the green strips for these low altitude aircraft. The regional air center controls air traffic above 20,000 feet. They have their own set of green strips for the high altitude aircraft and they use their own radar facility. If a high altitude aircraft approaches for landing, it is handed off to the local center. The green strip input process is being developed for regional air strips.

In our example, the aircraft elevation is 30,900 feet. Since this is a regional flight, the local center does not have the green strip; therefore the information should be saved to the unresolved file.

6.4.8 Example 8

The last example is a difficult fly-over strip. The plot is shown in Figure 33.

Fly Over Strip						
BANDIT9	4264	E1703	150			
6						
F117/R	ABQ 042/0		HMN./ABQ051			
182	ZCA		RACE./MARSA			
			W/MAG***			

The Beacon ID for the flight is 4264; the aircraft type is F117/R; and the estimated time of arrival is 17:03 GMT. Based on the aircraft type (F117) and the distance between flight dots, this is a high speed military flight.

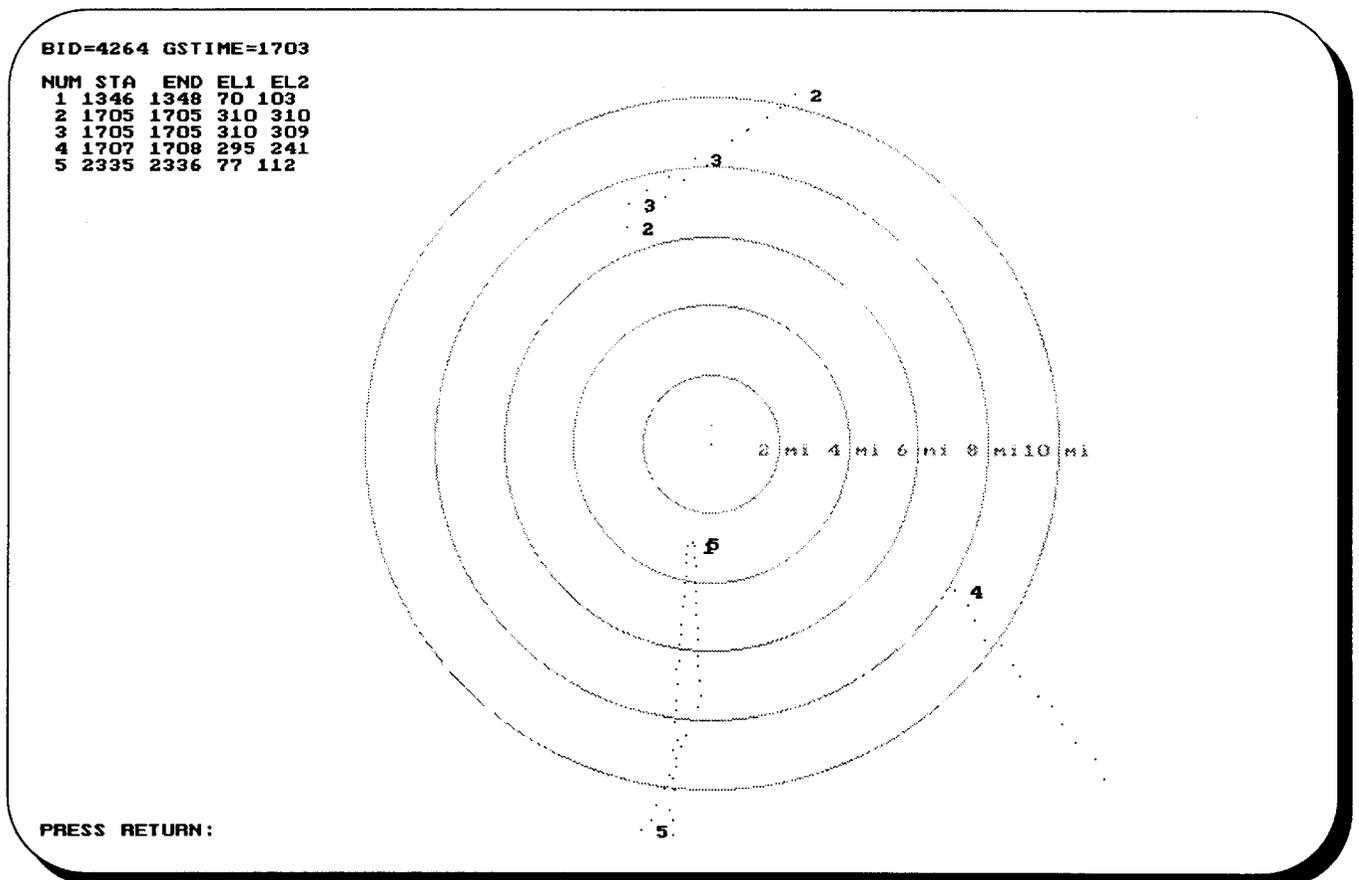


Figure 33. Join of BID 4264

There is a total of 5 flights for Beacon ID 4264. The question is which flight(s) to join. Eliminating the flights outside the given time will make them easier to attach. Flights 1 and 5 are departures from the center of the screen heading south. Both times are different from the green strip time, so these flights can be eliminated. Flights 2, 3, and 4 are fly-overs all within the same time frame. Flights 2 and 3 originate from the northeast and travel toward the west. Flight 4 starts in the southeast and tails off the

screen in the southeast. Flights 2 and 3 run parallel to each other with flight 3 having fewer data points. This occurs because many military flights will have multiple jets fly in tandem. The resolution of the radar is about 300 ft. If the jets separate by more than this, then more data points will occur. If the jets are in formation, usually only one of the jets will have the Beacon transponder turned on. Many pilots turn off the transponder near the air traffic control center. This reduces the noise clutter between the jets and the air traffic control center. However, this will reduce the number of aircraft counted. Sometimes, if the air traffic control center knows the number of jets flying in formation, they will precede the aircraft type with an integer that reflects the actual count of aircraft (e.g., 4/F117/R means four F117 aircraft are on a sortie).

Based on the evidence, flight 3 is not a continuation of flight 2 since the points are displayed in parallel. However, flight 4 may or may not be a continuation of flight 2 or flight 3. Since flight 3 has more data points than flight 2, the conservative approach is to attach the green strip to flight 3 only. A more liberal attachment is all three flights (2, 3, and 4) (see Fig. 34). Since flight 3 and flight 2 are on the same mission (it is essentially a single aircraft); flight 4 could be a continuation of either the flight 2 or flight 3 segment. This type of attachment would include giving the analyst more data points to work with.

Attaching green strips to flight data is an imperfect science. It is subjective in some difficult cases. In these situations, it is best to be conservative until someone with more expertise can help interpret the flight path.

```
BID=4264 G.S.TIME=1703 ACFT ID=UNKNOWN ACFT TYPE=F117/R
```

```
NUM STA END EL1 EL2
```

```
1 1346 1348 70 103
```

```
2 1705 1705 310 310
```

```
3 1705 1705 310 309
```

```
4 1707 1708 295 241
```

```
5 2335 2336 77 112
```

```
0. -> Quit - do not save G.S. info; start over.
```

```
1. -> Attach green strip to plot numbers.
```

```
2. -> Write green strip info to unresolved file.
```

```
3. -> Replay plot.
```

```
Enter your choice: 1
```

```
Attach green strip information to plot numbers listed above.
```

```
Select plot numbers from the NUM column above.
```

```
Enter integer list (30 max) separated by spaces:
```

```
2 3 4
```

Figure 34. BID 4264 Attachment

The "Before" and "After" update records are shown for Beacon ID 4264:

BID file before update

```
322 14716 14740 940509134600 4264 134636 134822 70 103 0 1 5 # ##### # ##### # #### 0 ###
615 27166 27177 940509170500 4264 170509 170555310 310 0 2 5 # ##### # ##### # #### 0 ###
616 27178 27182 940509170501 4264 170536 170550310 309 0 3 5 # ##### # ##### # #### 0 ###
620 27424 27437 940509170700 4264 170704 170800295 241 0 4 5 # ##### # ##### # #### 0 ###
107145989 46013 940509233500 4264 233509 233655 77 112 0 5 5 # ##### # ##### # #### 0 ###
```

BID file after update

```
322 14716 14740 940509134600 4264 134636 134822 70 103 0 1 5 # ##### # ##### # #### 0 ###
615 27166 27177 940509170500 4264 170509 170555310 310 0 2 5 U UNKNOWN F117/R E 1703 1 JLT
616 27178 27182 940509170501 4264 170536 170550310 309 0 3 5 U UNKNOWN F117/R E 1703 1 JLT
620 27424 27437 940509170700 4264 170704 170800295 241 0 4 5 U UNKNOWN F117/R E 1703 1 JLT
107145989 46013 940509233500 4264 233509 233655 77 112 0 5 5 # ##### # ##### # #### 0 ###
```

Records 1 and 5 remain unchanged since they were not attached.

6.5 Unresolved File Description

The unresolved file allows data entry personnel to save the typed in information to a file when it is not possible to attach the green strip data to the flight path. If time and resources are available, then further analysis may be allocated to resolve the unresolved flights. There are many branches throughout the plotflt data entry module where the user has the option to save to the unresolved file. This file has a .UNR extension (e.g., B940509N.UNR) and it is created if it does not exist. If the file exists, then new data is appended to the old file. A sample unresolved file is shown below:

```
675 IFR UAL699 T/B73S/R 1559 A 1
2656 IFR N6784N MO20/A 1524 A 1
1750 UNK UNKNOWN DA20/R 1558 A 1
774 UNK UNKNOWN BE35/A 0446 E 2
2327 UNK UNKNOWN H/B1/R 1707 E 2
4264 UNK UNKNOWN F117/W 1703 E 3
```

The unresolved file is fixed length 43 byte records. The format and length is listed below:

Column (1:5) Beacon ID
Column (6:14) VFR/IFR/UNKNOWN indicator
Column (15:22) Aircraft ID
Column (23:35) Aircraft type
Column (36:40) Time in GMT
Column (41:42) Time prefix
Column (43) Unresolved path

The first six fields are saved directly from the green strips. The last column indicates the path in the plotflt program where the unresolved file was saved. Path number 1 means no Beacon ID match was found, but the information from the green strip is correct. This path is shown in Example 3, Figure 28. Path number 2 occurs when a Beacon match is found, but an attachment is not possible because of time differences. This occurs in Example 6, Figure 31. Path number 3 will occur when a Beacon match is found and the green strip data changes slightly, but the user may not want to overwrite the existing data. This would occur in Example 2, Figure 27 if the user selected Option 2.

7. Future Enhancements

Developing the plot flight program was a process, not a job. As project personnel gained knowledge about air traffic patterns and green strip markings, the program evolved and features added accordingly. If resources are available, then future enhancements to this program will include:

1. Develop a batch mode process to automate data entry.
2. Develop a Microsoft windows interface for the plot flight program.
3. Add hot keys for context sensitive help (e.g., F1 function key).
4. Add feature to read green strips or electronic data from the regional air traffic control center.

8. Software Requirements

The plot flight program must meet the following general requirements:

The interface must be user friendly (no obscure keystrokes or commands).

The user interface will be DOS and the program will be written in the C language.

The program will utilize existing graphics libraries (i.e., Turbo C).

The program must be compatible with the SARS program set (see Figure 1).

The program must support both flight replay and data input modes.

The flight paths must be plotted quickly. Users will have the option to control the speed of the flights.

All green strip information (i.e. entered information) must be saved permanently. This program will use index files and unresolved files to save this information.

The program must be written to be versatile enough to support flight data from different air traffic centers (e.g., Albuquerque, Amarillo, etc.). The same radar file format will be supported for all air traffic centers.

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