SUMMARY OF SCAQS UPPER AIR MEASUREMENTS

PERFORMED BY THE STI AIRCRAFT

FINAL REPORT

ENSR, formerly ERT, is currently compiling and validating the SCAQS data base. The final data base is scheduled for release to the public and project participants by late spring 1989 and can be obtained from Bart Croes of the ARB. Mr. Croes can be reached at (916) 323-1534.

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SUMMARY OF SCAQS UPPER AIR MEASUREMENTS PERFORMED BY THE STI AIRCRAFT

FINAL REPORT

STI 97010-902FR

CARB Agreement No. A6-098-32

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ABSTRACT

During the summer and fall of 1987, the Southern California Air Quality Study (SCAQS) was performed in the Los Angeles Basin. Extensive ground level and airborne sampling was performed on a total of 17 intensive study days during two summer and one fall study periods. The summer sampling periods were June 15 to July 24, 1987 and August 18 to September 4, 1987. The fall study period began November 9 and continued to November 18. After a break for Thanksgiving, the program resumed December 2 and continued until December 12, 1987.

Airborne sampling described in this report was performed by Sonoma Technology, Inc. (STI). The STI aircraft sampled during all three study periods. The aircraft used by STI was instrumented to make real time measurements of various meterological and air quality parameters and to collect integrated filter samples as well as various grab samples.

The objectives of the aircraft measurements were:

- to document, on study days, the three dimensional distribution of ozone, aerosols, and their precursors throughout the study area, and

- to document the chemical composition of the aerosol, hydrocarbons, and selected other species which required integrated sampling at selected locations aloft.

During the three study periods, the STI aircraft flew a total of 267 spirals and 35 orbits during 37 flights on 16 of the 17 intensive study days. A spiral is a vertical sounding flown over a fixed ground location during a climb or descent of the aircraft. A series of spirals during each flight were used to characterize the spatial and temporal distribution of pollutants at various locations around the Basin. Orbits were flown for the purpose of collecting integrated samples. During an orbit, the aircraft would circle a fixed ground location at a constant altitude while samples were being collected.

During sampling, 35 sets of integrated filter samples were exposed. The filters were analyzed for organic, elemental, and total carbon, PAN, nitrate-nitric acid, sulfate (for SO_2), aerosol mass, sulfate, nitrate, chloride, ammonium (for NH_3), and aldehydes. In addition to the integrated filter sets, 67 canister samples (for hydrocarbons), 116 bag samples (for perfluorocarbon tracers), and 148 syringe samples (for SF_6 tracer) were collected.

This report documents the sampling activities of the STI aircraft and summarizes the sampling that was performed and samples collected.

ACKNOWLEDGEMENTS

The work described in this report was funded by the California Air Resources Board (CARB). The work was directed by the Research Division of the CARB, and the project officer was Mr. Chuck Bennett. His suggestions and comments were greatly appreciated.

The denuder difference sampling system that was operated aboard the aircraft was supplied by Mr. Jack Horrocks of the ARB El Monte office. Dr. Rei Rasmussen of Biospherics Research Corporation provided the hydrocarbon sampling system used aboard the aircraft. The use of their equipment and their suggestions were appreciated.

Dr. Peter McMurry and Dr. Susanne Hering performed a special calibration of the ASASP-X optical counter that was used during the program. Their efforts and the late hours required to complete the calibration are also appreciated.

A program of the size and complexity of SCAQS sampling program required the efforts, cooperation, and involvement of many individuals that are not specifically named. Their efforts contributed to the success of the SCAQS program and to the STI airborne sampling portion of the program. We wish to thank them also.

This report was submitted in fulfillment of ARB contract #A6-098-32 by Sonoma Technology, Inc. under the sponsorship of the California Air Resources Board. The work was completed as of March 2, 1989.

DISCLAIMER

The statements and conclusions in this report are those of the contractor and not necessarily those of the California Air Resources Board. The mention of commercial products, their source or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products.

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GLOSSARY OF ABBREVIATIONS

Locations

AMTRA	Name of an intersection of aeronautical airways.
BUR	Burbank Airport
CCB	Cable Airport
EMT	El Monte Airport
FUL	Fullerton Airport
HHR	Hawthorne Airport
ONT	Ontario Airport
PADDR	Name of an intersection of aeronautical airways.
RAL	Riverside Airport

Other

agl	Altitude above ground level
cc	Cubic centimeter
lpm	Liters per minute
msl	Altitude above mean sea level
ppb	Parts per billion
ppm	Parts per million
STP	Standard Temperature & Pressure (25^{o}C and 760 torr (29.92"Hg)

1. INTRODUCTION

During the summer and fall of 1987, the Southern California Air Quality Study (SCAQS) was performed in the Los Angeles Basin. Extensive ground level and airborne sampling was performed on a total of 17 intensive study days during two summer and one fall study periods. The purpose of these measurements was to characterize the spatial and temporal distribution and chemical composition of pollutants in the Los Angeles Basin. The primary objective of SCAQS is to provide a data base to support the development and testing of air quality simulation models, especially those for ozone and PM-10.

Airborne sampling was performed by both the University of Washington (U. of W.) and Sonoma Technology, Inc. (STI). Both organizations operated aircraft during the first study period (June 15 to July 24). During the two subsequent study periods (August 18 to September 4 and November 9 to December 12), all airborne sampling was performed by the STI aircraft.

The objectives of the aircraft measurements were:

- to document, on study days, the three-dimensional distribution of ozone, aerosols, and their precursors throughout the study area, and;
- to document the chemical composition of the aerosol, hydrocarbons, and selected other species which required integrated sampling at selected locations aloft.

This report documents the sampling activities of the STI aircraft and summarizes the sampling performed and samples collected by the 37 STI sampling flights performed during the three SCAQS study periods. The U. of W. will report their activities and data separately.

Data tapes containing "final processed data" from the real time analyzers operated aboard the STI aircraft have been delivered to the SCAQS data manager for inclusion in the SCAQS data archive. Numerous filter samples were collected during the airborne sampling. These filters were delivered to various laboratories for analysis. As of the date of this report, not all of the analyses have been completed. When they are complete, the analytical results will be combined with sample volume data, and the results will be reported to the SCAQS data manager for inclusion in the data archive. As a complement to the data on magnetic media, a data report entitled "A Report of STI Airborne Data Collected during the SCAQS Sampling Program" has been prepared. The data report contains detailed summaries of the flight times, sampling locations, flight maps, tables of the filter results, and plots of the continuous measurements for each flight. This data report will be delivered to the SCAQS data manager and the California Air Resources Board (CARB) project officer when the filter sample analyses are finished.

Section 2 of this report presents a summary of the STI airborne sampling. The sampling summary provides a quick reference to the days and times flown and the numbers and types of integrated samples collected.

Following the sampling summary are hydrocarbon, tracer, and filter sampling summaries that outline the general location and sample identification for each integrated and grab sample that was collected. The summaries contained in this section are intended to provide an overview of the sampling that was performed and to aid users of the data by providing an inventory of the data available in the SCAQS data archive.

Section 3 discusses the types of flight patterns that were used during sampling. Section 4 details the sampling platform and instrumentation used. Section 5 reviews the sampling methodology. Quality assurance procedures are discussed in Section 6, and data processing procedures used to ensure the accuracy of the data that are reported in Section 7. Section 8 details data reporting formats and comments on the data that have been reported.

2. PROGRAM OVERVIEW AND SAMPLING SUMMARIES

2.1 PROGRAM OVERVIEW

The SCAQS sampling program was separated into three study periods. The first two have been identified as summer sampling periods and were:

- June 15 to July 24, 1987 and,
- August 18 to September 4, 1987.

The fall study period began November 9 and continued to November 18. After a break for Thanksgiving, the program resumed December 2 and continued until December 12, 1987.

Both airborne and ground level sampling were performed during the three study periods. Airborne sampling was performed by STI throughout all three study periods, and the University of Washington aircraft sampled only during the first summer period. Both aircraft were equipped to make real time measurements of various meterological and air quality parameters, and each plane collected integrated filter samples as well as various grab samples. Each group will report the results of their sampling separately.

The STI aircraft was a twin engine Piper Aztec. The sampling pattern flown by STI to characterize the spatial and temporal distribution of pollutants included a series of vertical spirals at various airports around the Basin. A spiral is a vertical sounding flown over a fixed ground location during a climb or descent of the aircraft. Each flight also included a spiral about halfway between Long Beach and Santa Catalina Island at an aerial location called the PADDR Intersection. Most late summer and fall flights also included two "orbits" at fixed locations over the ground for the purpose of collecting integrated samples. During an orbit, the aircraft circles at a constant altitude, while samples are collected. The flight patterns used by STI are discussed in more detail in Section 3.

During the two summer study periods, STI typically flew three flights each study day. The flights normally began at about 0500 PDT (called the early morning or AM flight), 1000 PDT (called the midday or MD flight), and 1400 PDT (called the afternoon or PM flight). Spirals on these flights generally were made from about 1500 meters above mean sea level (m msl) down to within about 10 meters of the surface.

During the fall study period, STI flew two flights each study day. The flights typically started at about 0500 PST (AM flight) and 1300 PST (PM flight). Mixing during the fall study was often confined near the surface, and spirals flown during this study period were made all the way to the ground. This was accomplished by doing a "touch and go" at each airport. The over-water spiral was flown to as low an altitude as weather and safety permitted.

During the first study period, the U. of W. aircraft was used to collect integrated filter samples and hydrocarbon grab samples for later chemical analysis. To obtain filter samples with loadings sufficient for analysis, the aircraft would orbit for about 30 minutes while the samples were being collected. A U. of W. chemistry sampling flight consisted of a set of orbits flown within the Basin with one set of samples taken during each orbit. Typically the U. of W. flew two flights each sampling day and the flights began about 0500 and 1400 PDT.

During the second summer study period, orbits were added to the early morning flight (0500 PDT) and the afternoon (1400 PDT) flights performed by STI. Orbits in the El Monte and Long Beach areas were flown during the early morning flight. During the afternoon flights, the orbits were flown in the El Monte and Riverside areas. No chemical sampling was performed during the midday (1000 PDT) flights. The sampling altitude that was selected was intended to be within the mixed layer or at an altitude of maximum ozone. Typically, these orbits were flown about 450 meters above ground level (m agl).

Only two flights per day were flown during the fall study period, and two orbits were included in each flight. The orbits were flown in the El Monte and Long Beach areas during both flights. The sampling altitude used for these orbits was selected based on maximum NO_x values, or as low to the surface as possible. Typically, these orbits were flown at about 300 m agl.

Hydrocarbon grab samples were collected aboard the U. of W. aircraft during the first summer study period and the STI aircraft during the remaining study periods. The samples were analyzed by both the Environmental Protection Agency (EPA) and Biospherics Research Corporation (Biospherics). They will report the results of their analyses separately to the SCAQS data archive. Identification (sample ID, date, time, altitude, and location) of the samples collected by STI is included in this report for reference purposes (see Section 2.2).

During the SCAQS program, two other sampling programs were also being performed in the L.A. Basin. Tracer Technologies performed a tracer program for Southern California Edison (SCE), and CalTech performed a separate tracer program for the California Air Resources Board (CARB). Perfluorocarbon releases were performed by Tracer Technologies and SF6 releases by CalTech. During tracer release periods, grab samples were collected aboard the STI aircraft while it was performing SCAQS sampling. The samples were delivered to either Tracer Technologies or Caltech for analysis. After analysis, each group will report their data to the SCAQS data manager for inclusion in the SCAQS data archive. Identification of tracer samples that were collected by STI is included in this report for reference purposes.

During the three study periods, the STI aircraft flew a total of 267 spirals and 35 orbits during 37 flights on 16 different days. Sampling was performed during 237 of the spirals and the remainder of the spirals were flown to document, for data processing purposes, the response of various gas monitors to pressure (altitude) changes. During sampling, 35 sets of integrated filter samples (normally 8 separate filter holders per individual set) were exposed, and 67 hydrocarbon canister samples, 116 tracer bag samples (for Tracer Tech), and 148 syringe samples (for CalTech) were collected.

2.2 SAMPLING SUMMARIES

This section provides a general inventory of the STI aircraft data. Tables 2-1 and 2-2 list the dates and times of the STI aircraft sampling flights.

Table 2-1 summarizes the STI aircraft sampling performed during the two summer study periods. This table is separated into two parts (dashed line) indicating the split between the two summer study periods. The number of hydrocarbon samples, integrated filter chemistry sets (normally eight filter holders per set), and tracer bags and syringes collected during each flight are summarized in the Table. In addition, a comments section provides information specific to each flight.

During the first summer study period (through July 15), the U. of W. aircraft performed all of the chemistry sampling flights while the STI aircraft measured the three-dimensional pollutant distribution around the Basin. During this study period, no filter chemistry samples were collected (Table 2-1) on the STI aircraft. The purpose of hydrocarbon grab samples collected on June 25 was to provide samples that could be compared with U. of W. samples collected the same day. During the second summer study period, the STI aircraft continued the three-dimensional characterizations, but also collected hydrocarbon samples and sets of integrated filter samples during orbits on the morning and afternoon flights.

Table 2-2 summarizes the airborne sampling performed by STI during the fall study period. In the fall, the aircraft flew twice each study day. The flights included three-dimensional characterizations, as well as orbits to collect hydrocarbon samples and sets of integrated filter samples during each flight.

Tables 2-3 through 2-8 identify the locations and altitudes of the hydrocarbon and tracer samples collected aboard the STI aircraft. The analytical results of these samples will be reported separately by the groups for whom the samples were collected. The samples are tabulated by sample identification number and date/sampling period.

Maps showing sampling locations identified in Tables 2-3 through 2-8 are located in Section 3 of this report.

Table 2-3 summarizes the information listed above for the hydrocarbon samples collected during summer sampling and referenced in Table 2-1. Table 2-4 displays the same information for samples collected during the fall study period and referenced in Table 2-2.

Airborne sampling during perfluorocarbon tracer release periods included the collection of bag samples for Tracer Technologies. Table 2-5 summarizes the bag samples collected during the two summer studies and, Table 2-6, the samples collected during the fall study.

Table 2-1. Summary of STI Aircraft Sampling Flights for SCAQS 1987 Summer Study Period

Date 1987	Julian Date	Sampling Period (PDT)	No. of Sampling: Spirals	No. of Sampling: Orbits	No. of Hydro-carbon Cans	No. of Filter Chemistry Sets	No. of Tracer Samples: Bags	No. of Tracer Samples: Syringes (SF_6)	Comments
6/19	170	0510-0723	7	-	-	-	-	-	Temperature data missing
		1010-1220	7	-	-	-	-	-	
		1459-1712	7	-	-	-	-	-	
6/24	175	0430-0703	7	-	-	-	-	-	NO/NO_X data missing
		1258-1548	7	-	-	-	-	-	Some data missing pass 1
		1630-1854	7	-	-	-	-	-	
6/25	176	0442-0728	7	-	4	-	7	-	
		0936-1230	7	-	1	-	6	-	
		1458-1724	7	-	-	-	7	-	
7/13	194	0457-0717	7	-	-	-	-	-	Loran data missing
		1011-1223	7	-	-	-	-	-	Loran data missing
		1507-1720	7	-	-	-	-	-	
7/14	195	0503-0713	7	-	-	-	-	-	
		1009-1239	7	-	-	-	-	-	
		1459-1725	7	-	-	-	-	-	
7/15	196	0525-0745	7	-	-	-	-	-	
8/27	239	0514-0627	2	1	1	1	-	-	Nephelometer missing passes 1-3
		1109-1324	7	-	-	-	-	-	
		1445-1840	7	2	2	2	-	-	Ozone missing passes 2-10
8/28	240	0503-0856	6	2	3	2	8	-	
9/2	245	0515-0848	7	2	3	2	-	-	
		1019-1253	7	-	-	-	-	-	
		1435-1830	7	2	3	2	-	-	SO_2 data missing passes 1-6 & 8
9/3	246	0501-0841	7	2	3	2	-	-	
		1035-1239	7	-	-	-	-	64	

Table 2-2. Summary of STI Aircraft Sampling Flights for SCAQS 1987 Fall Study Period

Date 1987	Julian Date	Sampling Period (PDT)	No. of Sampling: Spirals	No. of Sampling: Orbits	No. of Hydro-carbon Cans	No. of Filter Chemistry Sets	No. of Tracer Samples: Bags	No. of Tracer Samples: Syringes (SF_6)	Comments
11/11	315	0504-0859	6	2	4	2	-	-	
		1305-1718	6	2	4	2	4	4	
11/12	316	0451-0840	6	2	4	2	12	12	
		1312-1658	6	2	4	2	12	12	SO_2 data missing
11/13	317	0459-0921	6	2	4	2	10	10	
		1257-1701	6	2	4	2	10	10	
12/3	337	0507-0845	6	2	4	2	-	-	
		1300-1655	6	2	4	2	-	-	Time gaps in data
12/10	344	0934-1206	2	2	4	2	4	4	
		1304-1656	6	2	4	2	12	12	Some data missing pass 3
12/11	345	0449-0659	6	2	4	2	12	12	Ozone missing pass 3
		1254-1715	6	2	3	2	12	12	

Table 2-3. List of STI Aircraft Hydrocarbon Sample Locations and Altitudes for Samples Collected During the Summer Sampling Periods

Date Period* Location	6/25 AM Can Identification No. Altitude (msl)	6/25 MD	6/27 AM	8/27 PM	8/28 AM	9/2 AM	9/2 PM	9/3 AM
Cable Airport		VF807 762 m		VF997 610 m			VF808 610-442 m	
El Monte Airport	VF618 610 m							
Burbank Airport	VF631 610 m		VF805 762 m					
PADDR Intersection					VF874 671 m	VF810 ?????		VF884 ?????
Fullerton Airport	VF634 457 m							
Riverside Airport	VF635 549-396 m							
AMTRA Intersection					VF876 671 m	VF809 762 m	VF998 457 m	VF883 610 m
Riverside Orbit				VF806 762 m			VF999 457 m	
Goodyear Blimp Site					VF875 762 m	VF873 762 m		VF881 762 m

Period*: AM ~ 0500-0730 PDT, MD ~ 1000-1230 PDT, and PM ~ 1500-1730 PDT

Table 2-4. List of STI Aircraft Hydrocarbon Sample Locations and Altitudes for Samples Collected During the Fall Sampling Period

Date Period* Location	11/11 AM Can Identification No. Altitude (msl)	11/11 PM	11/12 AM	11/12 PM	11/13 AM	11/13 PM	12/3 AM	12/3 PM	12/10 AM	12/10 PM	12/11 AM	12/11 PM
El Monte Airport	VF766 114 m	SVF870 152-90 m	VF997 171 m	VF346 91 m	VF872 853 m	VF811 91 m	VF795 152 m			VF878 91 m	VF799 183 m	VF635 152 m
	VF769 549 m	SVF869 610 m	VF806 518 m	VF671 701 m	VF871 244 m	VF466 914 m	VF644 457 m			VF880 610 m	VF774 305 m	VF875 427 m
Hawthorne Airport	VF887 61 m	SVF888 610 m	VF807 61 m		VF869 27 m		VF790 61 m	VF873 61 m	VF495 46 m		VF818 152 m	
	SVF871 732 m	SVF872 30 m	VF634 427 m		VF870 335 m		VF192 274 m	VF641 366 m	VF882 274 m		NO # 274 m	
Fullerton Airport				VF341 61 m		VF467 46 m		VF642 61 m	VF885 91 m	VF879 46 m		VF618 518 m
				VF772 579 m		VF684 914 m		VF591 488 m	VF695 274 m	VF877 244 m		

Period*: AM ~ 0500-0900 PST and PM ~ 1300-1700 PST

Table 2-5. Location and Altitude of STI Aircraft Summer Tracer Gas Samples Taken for Tracer Technologies

Date Period* Location	6/25 AM Bag Identification No. Altitude (msl)	6/25 MD	6/25 PM	8/28 AM
Cable Airport	7060 762-459 m	7061 305 m	30430 762-457 m	13084 1036 m
El Monte Airport	29060 549 m		29053 396-122 m	13183 1128 m
Burbank Airport	29058 610 m	29056 305 m	29054 518-274 m	13037 1524-762 m
Hawthorne Airport	7062 366 m	29068 335 m	29069 305-30 m	
PADDR Intersection	7064 549-457 m	29055 305 m	30413 488-152 m	13119 671 m
Fullerton Airport	7063 457-244 m	29066 305 m	30441 305-61 m	13100 1524-1067 m
Riverside Airport	29070 549-396 m	30439 610 m	30412 610-305 m	
AMTRA Intersection				13156 671 m
Goodyear Blimp Site				13189 762 m
Torrance Airport				13141 1524-762 m

Period*: AM ~ 0500-0730 PDT, MD ~ 1000-1230 PDT, and PM ~ 1500-1730 PDT

Table 2-6. Location and Altitudes of STI Aircraft Fall Tracer Gas Samples taken for Tracer Technologies

Date Period* Location	11/11 PM Bag Identification No. Altitude (msl)	11/12 AM	11/12 PM	11/13 AM	11/13 PM	12/10 AM	12/10 PM	12/11 AM	12/11 PM
El Monte Airport		30423 122 m 30435 305 m	13152 91 m 13190 305 m	30417 427 m	13025 91 m 13071 355 m		80087 91 m 80091 335 m	80092 152 m 80068 305 m	15342 91 m 13488 335 m
Burbank Airport		30433 274 m 30438 427 m	13133 244 m 13186 488 m	13062 274 m 13114 457 m			80086 244 m 80085 488 m	80095 274 m 80098 396 m	80099 244 m 80127 488 m
Hawthorne Airport	30424 213 m 30415 305 m	30429 61 m 30420 244 m	13102 30 m 13122 244 m	13136 61 m 30440 274 m	13070 30 m 13137 274 m	80076 46 m 80080 274 m	80078 30 m 80075 274 m	80108 152 m 80090 213 m	80109 30 m 80139 274 m
PADDR Intersection		30422 61 m 30425 366 m	13092 61 m 13129 244 m	13082 914 m	13103 61 m 13116 274 m		80110 61 m 80097 305 m	80138 219 m 80073 366 m	80083 104 m 80079 305 m
Fullerton Airport	NO # 91-30 m 30428 152-244 m	30414 46 m 30421 274 m	30432 61 m 13076 244 m	13066 30 m 13158 152 m	29067 30 m 13083 274 m	80081 46 m 80066 244 m	80106 30 m 80064 274 m	80093 61 m 80084 244 m	80069 274 m 80089 300 m
Ontario Airport		30434 305 m 30427 427 m	13098 305 m 13170 610 m	30416 305 m 30419 457 m	30426 305 m 30418 549 m		80077 305 m 80088 549 m	80074 290 m 80112 396 m	15685 305 m 15651 549 m

Period*: AM ~ 0500-0900 PST and PM ~ 1300-1700 PST

Syringe samples were collected for CalTech during periods of SF_6 tracer release. During the second summer study period, a total of 64 samples were collected on the midday flight of September 3, 1987, and Table 2-7 summarizes the samples collected. The remainder of the SF_6 syringe samples were collected during the fall study period and are summarized in Table 2-8.

Table 2-7 List of STI Aircraft Tracer Gas Samples Collected on September 3, 1987 (1035-1239 PDT) for CalTech

Location / Altitude m msl	Cable Airport	El Monte Airport	Burbank Airport	Hawthorne Airport	PADDR Intersection	Fullerton Airport	Riverside Airport
1524	X	X	X	X	X	X	X
1372	X	X	X	X	X	X	X
1219	X	X	X	X	X	X	X
1067	X	X	X	X	X	X	X
914	X	X	X	X	X	X	X
762	X	X	X	X	X	X	X
610	X	X	X	X	X	X	X
457	X	X	X	X	X	X	X
305	-	X	X	X	X	X	X
152	-	X	-	X	-	X	-

Table 2-8. Location and Altitudes of STI Aircraft Fall Tracer Gas Samples Taken for CalTech

Date Period* Location	11/11 PM Syringe Identification No. Altitude (msl)	11/12 AM	11/12 PM	11/13 AM	11/13 PM	12/10 AM	12/10 PM	12/11 AM	12/11 PM
El Monte Airport		30423 122 m 30435 305 m	13152 91 m 13190 305 m	30417 427 m	13025 91 m 13071 355 m		80087 91 m 80091 335 m	80092 152 m 80068 305 m	15342 91 m 13488 335 m
Burbank Airport		30433 274 m 30438 427 m	13133 244 m 13186 488 m	13062 274 m 13114 457 m			80086 244 m 80085 488 m	80095 274 m 80098 396 m	80099 244 m 80127 488 m
Hawthorne Airport	30424 213 m 30415 305 m	30429 61 m 30420 244 m	13102 30 m 13122 244 m	13136 61 m 30440 274 m	13070 30 m 13137 274 m	80076 46 m 80080 274 m	80078 30 m 80075 274 m	80108 152 m 80090 213 m	80109 30 m 80139 274 m
PADDR Intersection		30422 61 m 30425 366 m	13092 61 m 13129 244 m	13082 914 m	13103 61 m 13116 274 m		80110 61 m 80097 305 m	80138 219 m 80073 366 m	80083 104 m 80079 305 m
Fullerton Airport	NO # 91-30 m 30428 152-244 m	30414 46 m 30421 274 m	30432 61 m 13076 244 m	13066 30 m 13158 152 m	29067 30 m 13083 274 m	80081 46 m 80066 244 m	80106 30 m 80064 274 m	80093 61 m 80084 244 m	80069 274 m 80089 300 m
Ontario Airport		30434 305 m 30427 427 m	13098 305 m 13170 610 m	30416 305 m 30419 457 m	30426 305 m 30418 549 m		80077 305 m 80088 549 m	80074 290 m 80112 396 m	15685 305 m 15651 549 m

Period*: AM ~ 0500-0900 PST and PM ~ 1300-1700 PST

3. FLIGHT PLANS

3.1 FLIGHT PLANS FOR THE FIRST SUMMER STUDY PERIOD

During this period (June 15 to July 24), the STI aircraft measured the spatial distribution of pollutants in the Basin, and the U. of W. plane was used to collect integrated filter samples and hydrocarbon samples for chemical analysis. Figure 3.1 shows the typical flight plan that the STI aircraft followed during the first study period of the summer. Sampling was performed during vertical spirals at the seven locations shown on the Figure. After take-off from the Ontario (ONT) airport, the aircraft climbed en route to the Cable (CCB) airport. At Cable, sampling would be performed while the aircraft was spiraling down from about 1500 m msl to within about 10 m of the surface. The aircraft then climbed while en route to the next sampling location at El Monte (EMT) airport. This procedure was repeated as the aircraft continued to the Burbank (BUR) and Hawthorne (HHR) airports. From Hawthorne, the aircraft proceeded to an off shore location called PADDR, spiraled, and then continued with spirals at the Fullerton (FUL) and Riverside (RAL) airports. After the last sampling spiral was completed at the Riverside airport, the aircraft returned to the Ontario airport where it was based. Normally, this pattern was flown three times on each study day starting at about 0500, 1000, and 1400 PDT.

3.2 FLIGHT PLANS FOR THE SECOND SUMMER STUDY PERIOD

The STI aircraft was the only plane used during the second summer study period (August 18 to September 4). Since only one aircraft was available, the STI aircraft was used both to measure the spatial pollutant distribution and to take integrated samples. The plane was scheduled to fly three flights on each study day (0500, 1000, and 1400 PDT).

During the early morning (0500 PDT) flights, integrated samples were collected during orbits flown in the El Monte and Long Beach areas and spirals were flown at seven locations. No chemical sampling was done during the second flight of the day, and thus the flight pattern of the previous study period was used. The afternoon (1400 PDT) flights also collected chemistry data by adding orbits near El Monte and Riverside to the midday (1000 PDT) flight pattern. The orbit was moved from Long Beach to Riverside on this flight to obtain at least one sample set per day in a downwind receptor location.

A typical early morning flight pattern is shown in Figure 3.2. The only difference between this pattern and earlier sampling was the addition of two orbits flown to collect integrated filter samples. After completing the spiral sounding at El Monte, the aircraft proceeded to an aerial location called the AMTRA Intersection which is about 8 km west of the El Monte airport. The plane orbited at this location while chemical sampling was being performed and then returned to the normal spiral sampling pattern as it proceeded to the Burbank airport. The second orbit was flown in the Long Beach area prior to the spiral at Fullerton airport. After the orbit, the

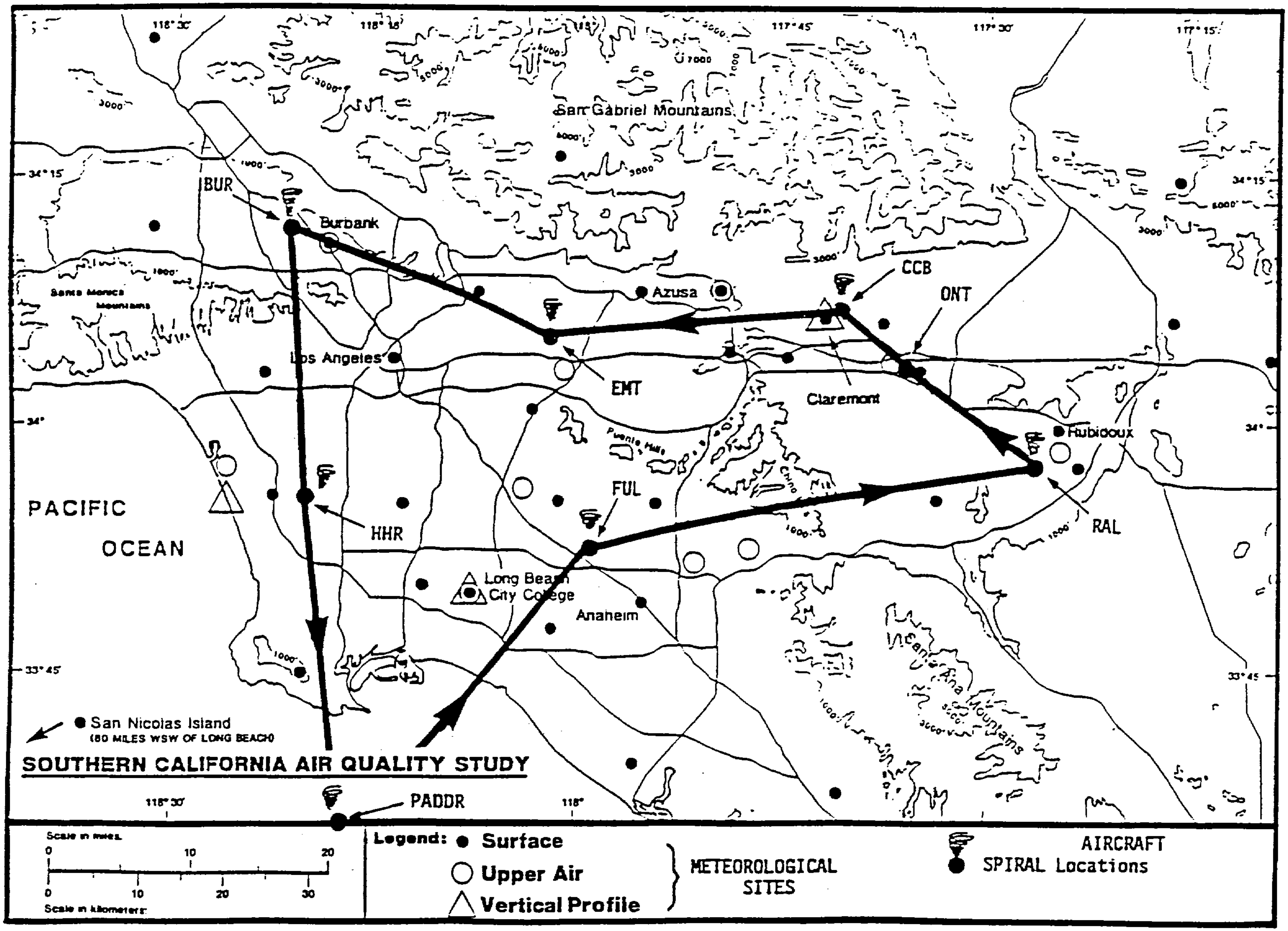

Figure 3.1 Typical STI Flight Plan for the First Summer Study Period

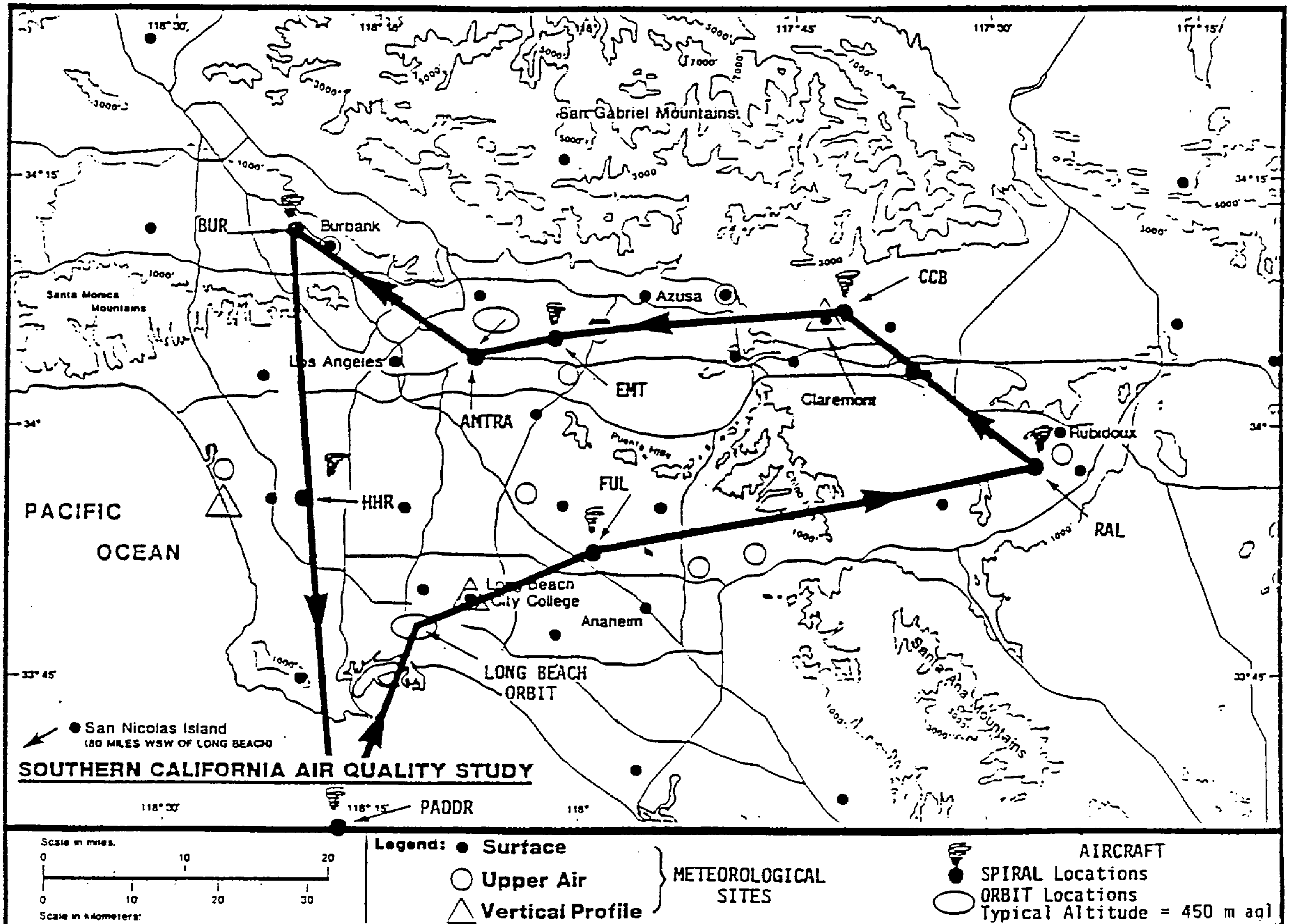

Figure 3.2 Typical STI Flight Plan for an Early Morning Sampling Flight During the Second Summer Study Period

aircraft continued with soundings at Fullerton and Riverside before returning to the Ontario airport.

Selection of altitudes for the orbits was based on maximum ozone concentrations that had been observed during soundings. Typically, during the early morning flight, ozone was depleted near the surface while aloft the concentrations were well mixed throughout the polluted layer. In this case, the orbit was flown at an altitude that was representative of the maximum ozone concentration (often about 450 m above the surface). If layering aloft was present, the altitude of the ozone maximum was selected for the orbit. Orbits were not flown lower than 300 m above the surface due to flight restrictions over populated areas.

The mid morning (1000 PDT) sampling flight did not require chemical sampling and thus used the flight plan shown in Figure 3.1 and discussed in Section 3.1.

A typical afternoon flight pattern is shown in Figure 3.3. Sampling proceeded as in the early morning flight but the orbit in the Long Beach area was replaced by an orbit in the Riverside area. During the afternoon, the atmosphere was normally well mixed and the orbits were typically flown about 450 m above the surface or at the altitude of the maximum ozone concentration.

3.3 FLIGHT PLANS FOR THE FALL STUDY PERIOD

During the fall study period (November 9 to December 12), the STI aircraft flew twice each intensive study day (approximate take-off times of 0500 and 1300 PST). Soundings at each airport were flown to ground level because of the shallow layers of pollution that existed. Chemical sampling was performed on each flight in addition to the vertical soundings. Figure 3.4 shows the sampling pattern that was used. Sampling began as the aircraft took-off from the Ontario airport and spiraled to about 1500 m msl. After completing the sounding, the aircraft ferried to El Monte and spiraled down to a "touch and go" before proceeding to the AMTRA Intersection for the chemistry orbit. Sampling continued after the orbit with spirals at Burbank, Hawthorne, and the PADDR Intersection. The aircraft then orbited in the Long Beach area and spiraled to a full stop landing at the Fullerton airport. The full stop landing was required at Fullerton since local noise abatement procedures prohibited twin engine "touch and go" operations. After landing, the aircraft took off and returned to the Ontario airport.

During the fall study period, sampling altitudes for orbits were chosen to be representative of maximum NO_x concentrations observed during soundings or the minumum altitude allowed by the FAA. Typically, orbits were flown about 300 m above the surface.

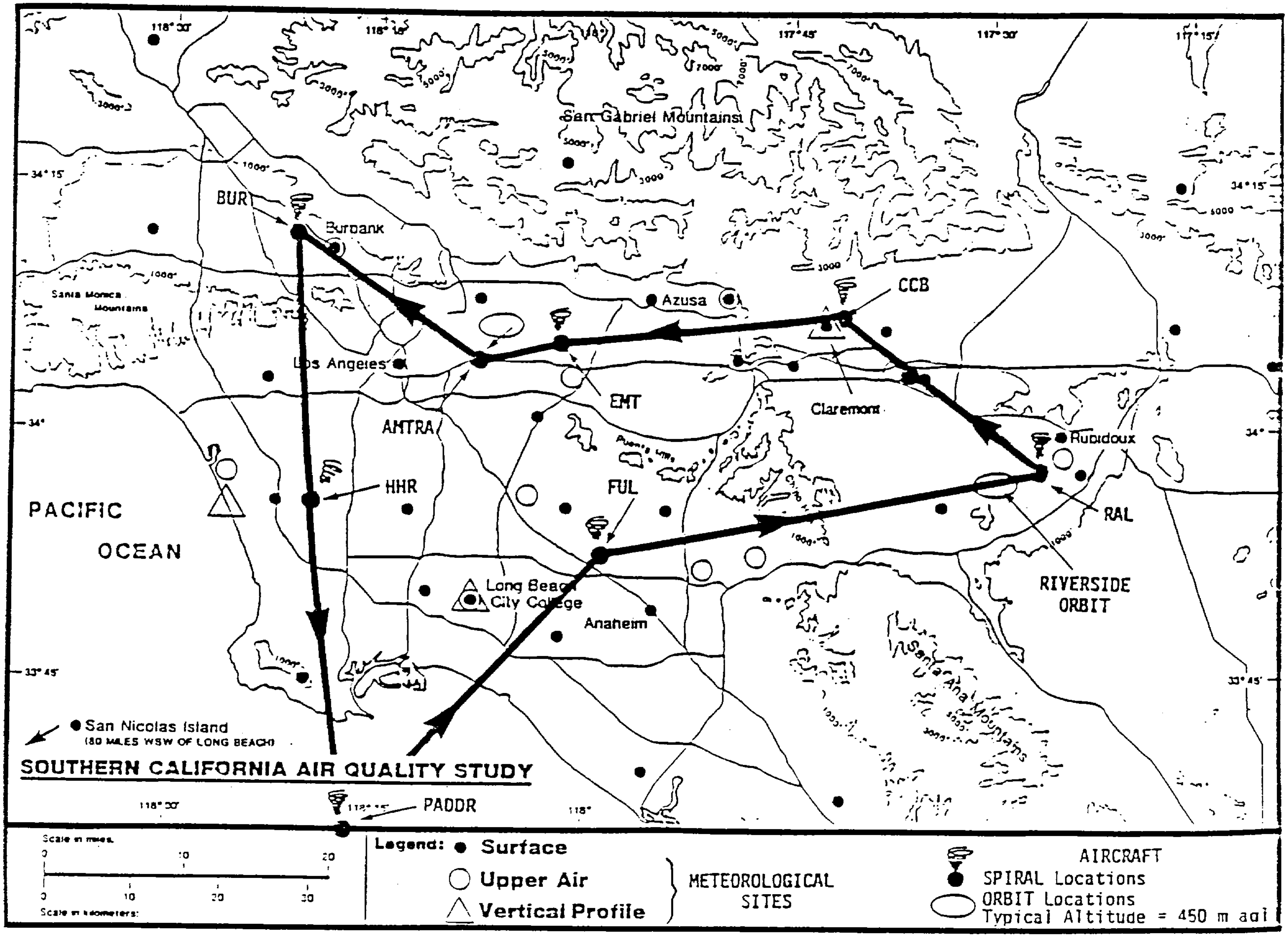

Figure 3.3 Typical STI Flight Plan for an Afternoon Sampling Flight During the Second Summer Study Period

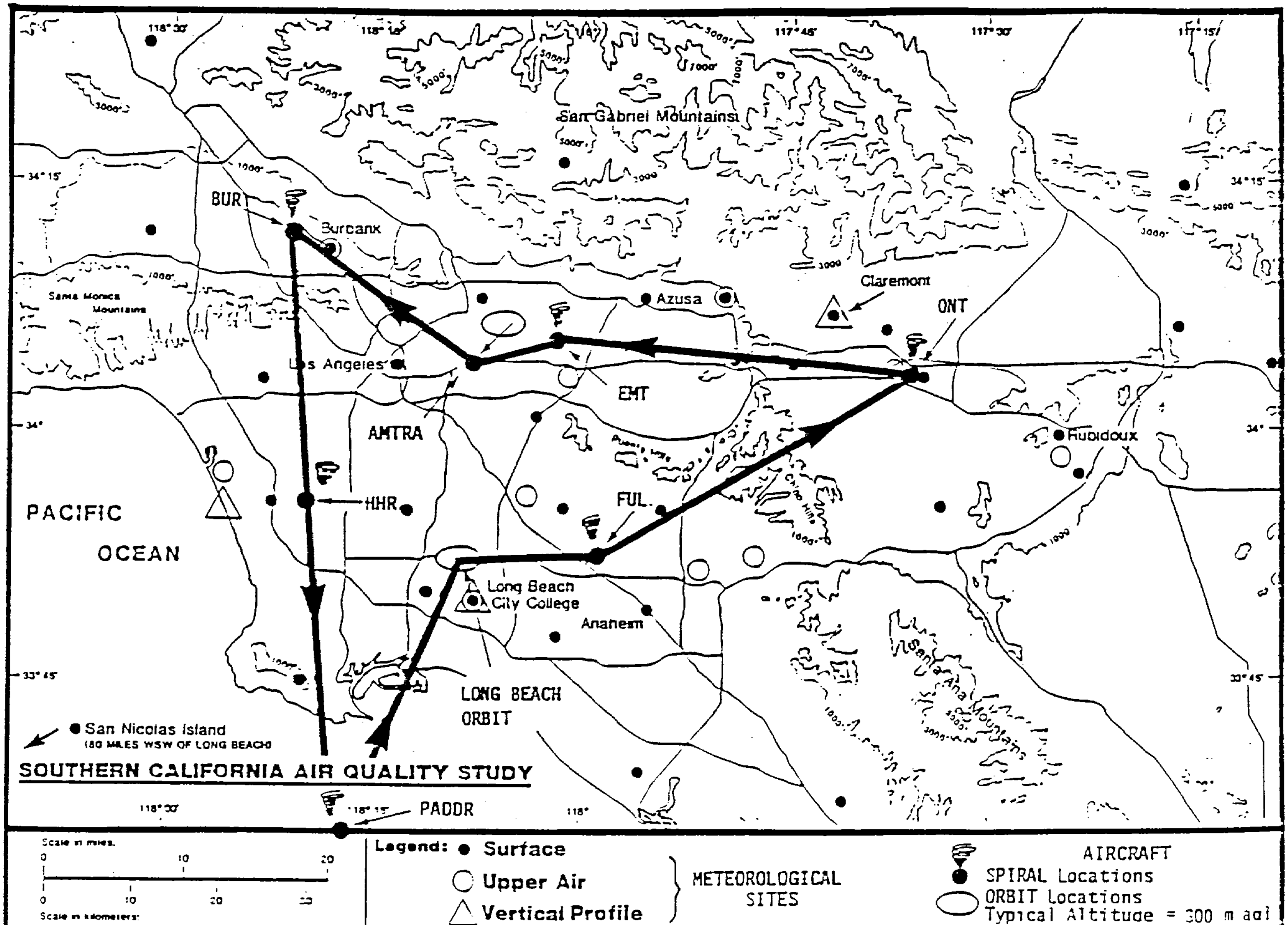

Figure 3.4 Typical STI Flight Plan for the Fall Study Period

4. SAMPLING PLATFORM, INSTRUMENTATION, AND SYSTEMS

4.1 SAMPLING AIRCRAFT AND CREW

4.1.1 Sampling Platform

The STI aircraft used during the sampling described in this report was a Piper Aztec. The Aztec is a twin engine, low-wing aircraft with retractable landing gear. The aircraft was chosen for its stable flight characteristics at the sampling speeds used during the program, its load carrying capabilities, and its capability to sample for periods of up to five hours. The aircraft was certified for instrument flight operations. This capability was used during some SCAQS sampling flights to continue soundings from above a layer of clouds to the airport below.

The aircraft's 28 volt DC electrical system provided power to two 1000 watt (115 volt AC, 60 Hz) inverters which were used to power the research instrumentation that required AC power. DC instrumentation was powered directly from the aircraft's 28 volt electrical system. Vacuum for filter sampling was provided by two engine-driven aircraft vacuum pumps mounted one on each engine. The research vacuum system was capable of providing about 175 liters per minute (lpm STP) of total flow during the filter sampling that was performed.

4.1.2 Crew

The flight crew consisted of a pilot, a safety observer, and an instrument operator. The safety observer (also a pilot) spotted traffic in the congested Basin area, helped handle radio communications, provided rest breaks for the pilot, and in one instance, assisted the instrument operator by taking syringe samples. The instrument operator monitored the sampling instrumentation, changed filters, collected grab samples as required, and documented the sampling events as each flight proceeded.

4.2 INSTRUMENTATION

4.2.1 Continuous Sampling Instrumentation

Table 4-1 lists the continuous sampling instruments that were used aboard the aircraft. Table 4-1 lists the manufacturer and model used, the analysis technique, instrument ranges available for use, the approximate time response to 90%, and the approximate resolution of the instrument.

4.2.2 Filter Samples and Grab Samples

During each orbit flown, eight individual filter packs were operated and called a filter set. Three of the filter packs contained two filters mounted in tandem in one filter holder. The remaining five filter packs contained only one filter. Table 4-2 lists the filter packs that made up each filter set. Table 4-2 lists whether each individual filter was run with or without a cyclone size separator, the typical sample flow rate, the diameter

Table 4-1. Continous Sampling Instruments for the SCAQS STI Aircraft

Parameter	Sampler Manufacturer and Model	Analysis Technique	Normal Measurement Ranges (full scale)	Time Response (to 90%)	Approximate Resolution
NO/NO_x	Monitor Labs 8440	Chemiluminescence	200, 500, 1000 ppb	5 to 10 secs.	< 10 ppb
O_3	Monitor Labs 8410	Chemiluminescence	500 ppb	5 secs.	5 ppb
SO_2	Meloy 285E	Flame Photometric	100, 500 ppb	30 secs.	1 ppb
b_{scat}	MRI 1560 series (modified by Waggoner)	Integrating Nephelometer	100,1000 x 10^{-6} m^{-1} Dual Range	1 sec.	1 x 10^{-6} m^{-1}
Aerosol Size	PMS ASASP-X	Laser Optical Particle Counter	0.09 - 3.0 μm	1 sec.	Size range divided into 32 channels
Dew Point	Cambridge Systems 137-C	Cooled Mirror	-50 to 50°C	5 sec.	0.5°C
Altitude	Validyne P24	Pressure Transducer	0 - 5000 m msl	< 1 sec.	5 m
Temperature	YSI/MRI	Bead Thermister/ Vortex Housing	-30 to 50 °C	5 secs	0.5°C
Turbulence	MRI 1120	Pressure Fluctuations	0 - 10 $cm^{2/3}$ s^{-1}	3 secs. (60%)	0.1 $cm^{2/3}$ s^{-1}
Indicated Airspeed	Validyne	Pressure Transducer	23 - 68 m s^{-1}	1 sec.	0.1 m s^{-1}
Broad Band Radiation	Epply	Pyranometer	0 - 1026 w m^{-2} Cosine Response	1 sec.	2 w m^{-2}
Ultraviolet Radiation	Epply	Barrier-Layer Photocell	295 - 385 μm 0 - 34.5 w m^{-2} Cosine Response	1 sec.	0.1 w m^{-2}
Position	II-Morrow Apollo I	LORAN-C	Lat.-Long.	< 1 sec.	16 m
Data Logger (includes time)	STI LSI-11 Acquisition System	Dual 8" Floppy Disk	± 9.99 VDC	Records data 1 s^{-1}	0.01 VDC
Stripchart Recorder	Linear Instruments	Dual Channel	0.01, 0.1, 1, 10 VDC	< 1 sec.	
Printer	Axiom Ex800			Prints out data every 10 secs. and at every event or data flag change.	

Table 4-2 Types of Integrated Aerosol and Gas Filter Samples Collected for Chemical Characterization by STI During Airborne Sampling for SCAQS.

Cyclone cutpoint size	Filter: Flow (lpm)	Filter: Diam. (mm)	Filter: Medium	Analytical method	Analytes	Detection limit for 30 minute sample[a] ($\mu g/^3$)	Analytical Lab which will report results
2.5 µm	25	47 (Tandem Filters)	Teflon (ZEFLOUR)	Not Analyzed			
			WHATMAN 41 Carbonate impregnated	IC	Sulfate (for SO_2)	0.6	EMSI
2.5 µm	70	47	Quartz	Staged pyrolysis	Organic, elemental, and total carbon[f]	3 5	ENSR
2.5 µm	15	25	Nuclepore (0.4 um)	Gravimetric	Aerosol mass	5[c]	EMSI
2.5 µm	20	47	Nylon (Behind a Denuder)	IC	Nitrate	Denuder Difference System	EMSI
2.5 µm	20	47	Nylon	IC	Nitrate + Nitric Acid	Denuder Difference System	EMSI
None	20	47 (Tandem Filters)	Teflon (Teflo)	IC Colorimetry	Sulfate[b] Nitrate[b] Cloride Ammonium[b]	0.6 0.6 0.6 0.6	EMSI
			Oxalic acid impregnated	Colorimetry	Ammonium (for NH_3)	2.5	EMSI
None	20	47 (Tandem Filters)	Teflon (ZEFLOUR)	Not Analyzed			
			Alkaline Impregnated	IC	Nitrate Acetate (for PAN)[d]	e	DGA
None	3	47	DNPH impregnated	HPLC	Aldehydes	e	ENSR

Abbreviations: IC = ion chromatography, HPLC = high performance liquid chromatography, EMSI = Environmental Monitoring and Services, Inc., ENSR = ENSR Consulting and Engineering, and DGA = Daniel Grosjean and Associates.

a. Detection limits are based on the uncertainty of the blank, which is typically larger than the analytical uncertainty.
b. Selected filters to be analyzed to provide replicate data.
c. If weighed immediately before and after flights.
d. Experimental method, but instrumental methods for aircraft are not yet reliably operational.
e. No data for the detection limits exist.

of the filter, the filter medium, the analytical method, analytes, and the approximate detection limit (if known) for a 30 minute sample. The analytical laboratory which performed the analysis is also listed in Table 4-2.

Table 4-3 lists the types of grab samples that were collected during the STI airborne sampling. Table 4-3 also indicates the collection media used and the analytical laboratory that will report the results.

4.3 SAMPLE INLETS

Air for the sampling instrumentation was obtained through three sample inlet tubes installed one above the other in a "dummy" window. The window was installed on the left side of the aircraft. The inlets were 4.5 cm (1 3/4") diameter aluminum tubes that extended about 15 cm (6") out past the skin of the aircraft and faced forward into the airstream. The exhaust from the aircraft engines exits the engine nacelles under the wing and well away from the sample inlets.

Six 9.5 mm (3/8") and one 6.5 mm (1/4") diameter Teflon sampling lines were inserted through the bottom sample inlet tube to provide sample air for the continuous gas analyzers, filter systems, and hydrocarbon canisters that were operated. Unused air through the sample inlet tube was dumped into the aircraft cabin. Two of the 9.5 mm lines were used for the continuous gas analyzers. Inside the aircraft, these analyzer lines terminated in glass manifolds. Each manifold was constructed in such a manner as to slow the inlet airflow provided by ram pressure. Teflon sampling lines from the gas monitors were attached to static ports in the manifolds. The balance of the unused air from each manifold was dumped into the aircraft cabin. The 6.5 mm line provided sample air for the hydrocarbon sampling system described in Section 4.5.1.

During chemical sampling, two of the 9.5 mm inlet lines provided sample air to the denuder difference sampling system (described in Section 4.5.2.1) that was used to collect nitrate and nitric acid samples. The remaining two 9.5 mm lines provided sample air for the substrates that collected total (non size-segregated) samples (see Section 4.5.2.3) for NH_3 and PAN analysis.

All other filters of a chemistry sample set were collected behind a cyclone separator and are discussed in Section 4.5.2.2. Sample air for these filters was delivered from the top inlet tube directly to the cyclone via a short flex-hose connection.

Preloaded DNPH cartridges were used to collect samples for aldehyde analysis. An inlet and exhaust tube was built into the case of each cartridge. Each was about 2.5 cm in length and 6.5 mm diameter. During sampling, a cartridge was attached with a clip just inside the bottom 4.5 cm sample inlet tube. The cartridge was mounted such that the inlet faced into the airstream coming through the large sample inlet tube.

Table 4-3. Types of Grab Samples Collected Aboard the STI Aircraft During SCAQS Sampling

Sample Type	Collection Media	Analytical Lab which will report the results
Hydrocarbon C1-C12	3.2 liter Stainless Steel Canisters	EPA & Biospherics Research, Corporation
Perfluorocarbon Tracers	"Aluminized" Mylar Bags with a 3.5 liter capacity	Tracer Technologies, Inc.
Sulfur Hexafloride (SF_6) Tracer	30 ml plastic Syringes*	CalTech

* During joint perfluorocarbon and SF_6 tracer releases, samples for both tracers were collected in the Mylar bags. After the flight, syringe samples were taken from each bag sample.

When only SF_6 was released, syringe samples were collected aboard the aircraft during flight.

Sampling for perfluorocarbon tracer gas was performed on several flights. A 9.5 mm tygon sample line was inserted through the bottom sample inlet tube and used to fill the bags that were used to collect sample air.

Sampling for SF_6 tracer gas was performed on a few flights. In most cases, syringe samples were taken from the perfluorocarbon bag samples after a flight had been completed. On one flight, the safety observer pulled syringe samples from an "eye ball" air vent that is a part of the aircraft ventilation system.

The nephelometer was connected to the middle inlet tube via a flex-hose connection. Sample air for the PMS ASASP-X particle probe was obtained from a sample port in the flex-hose leading to the nephelometer.

4.4 EXTERNAL SENSOR MOUNTING LOCATIONS

The dewpoint sensor head was mounted on the outside of the "dummy" window. The temperature probe was mounted under the right wing. The sensor for indicated air speed and turbulence was mounted under the left wing of the aircraft. Total and ultraviolet radiation sensors were mounted on the top of the fuselage. Antenna wires were located near the radiation sensors and their effects are discussed in Section 8.3.

The exhaust from the ozone monitor was vented overboard for safety reasons. The vent was located in the aft end of the "dummy" window and well behind the sample inlet tubes to avoid contamination.

4.5 SAMPLING SYSTEMS FOR INTEGRATED AND GRAB SAMPLES

4.5.1 Hydrocarbon Sampling System

Hydrocarbon sampling was performed aboard the aircraft during some flights. The sampling was performed using a system provided by Biospherics. The system consisted of a 2.4 m (8′) length of 6.5 mm diameter Teflon sample inlet tubing, a Metal Bellows (Model MB-158) pump, a 1.8 m (6′) length of 6.5 mm Teflon sample delivery tubing, a two way toggle valve and pressure gauge assembly (called a "purge tee"), and 3.2 liter stainless steel canisters for sample collection. A Nupro valve assembly on the inlet of each canister was used to seal the canister. A stainless steel Swagelok cap protected the threaded portion of the canister inlet that connected to the "purge tee" assembly.

The sample inlet and delivery tubing were connected to the inlet and exhaust ports of the Metal Bellows pump using stainless steel Swagelok fittings. The sample delivery tubing was also connected to the "purge tee" with a stainless steel Swagelok fitting. When sampling was anticipated, a canister was connected to one of the exhaust ports of the "purge tee." Then, depending on the position of the toggle valve and the valve on the canister, the output of the pump would either vent into the aircraft or be used to pressurize the canister.

4.5.2 Sampling Systems Using Cyclone Size Separators

During each chemical sampling orbit, filters in eight different filter holders were operated as a sample set. As shown in Table 4-2, five of the measurements were performed behind cyclone size separators. Details of which filters were operated behind cyclones are also included with the chemical data reported in the data volume. The following sections describe measurement systems that used cyclones.

4.5.2.1 Nitric Acid Sampling System

A denuder difference sampling method, to collect a pair of filter samples to be analyzed for nitric acid, was used during each chemical sampling orbit. One filter of the pair collected both nitrate and nitric acid and the second filter collected only particulate nitrate. Nitric acid was determined by the difference between the two measurements.

The equipment was provided by Mr. Jack Horrocks of the Air Resources Board (El Monte office) and consisted of inlet tubing, two Teflon cyclones, filter holders, a denuder assembly, and two mass flow controllers. The parts were assembled into two filter sampling systems that were operated in parallel.

In the first system, a 47 mm nylon filter sample was collected directly behind a Teflon cyclone separator. The cyclone was custom built by Mr. Horrocks and had a cutpoint of about 2.5 μm. This filter collected both nitrate and nitric acid. The 9.5 mm Teflon sample inlet tubing used for this system was approximately 60 cm (2′) in length from the inlet to the cyclone. The filter assembly was mounted directly on top of the cyclone. All tubing lengths for this system were as short as possible to maximize the collection of nitric acid vapors by the nylon filter.

In the second system, a 47 mm nylon filter sample was collected behind the second Teflon cyclone (similar cutpoint of about 2.5 μm) and a multiple tube denuder. The denuder contained 36 tubes that were coated with magnesium oxide. The length of coating on each tube was 29.69 cm and the tubes were connected in series. Thus, the effective length of the denuder was greater than 10 m. The denuder removed nitric acid vapors, and the filter collected only particulate nitrate. The 9.5 mm sample inlet tubing for the denuder system was also Teflon and was approximately 185 cm (6′) in length from the inlet to the cyclone. The exhaust of the cyclone was connected directly to the denuder assembly. The filter assembly for this system was mounted directly on the outlet of the denuder assembly.

The vacuum for both filters was provided by the aircraft research vacuum system. The flows for both systems were controlled by mass flow controllers mounted downstream of the filters. The flow controllers were set to sample at 20 lpm STP.

4.5.2.2 Other Filter Sampling Using a Cyclone

Table 4-2 details the filter packs that were used to collect samples for SO_2, carbon, and mass. Each of these filter packs was connected downstream of a Bendix 240 cyclone. The cutpoint of the cyclone was about

2.5 μm. Sample air from the cyclone went directly to a filter manifold. Individual filter cassettes were connected to the manifold using Swagelok connectors. The downstream side of each filter holder was fitted with a quick disconnect fitting that mated with plumbing to a rotameter. An aircraft vacuum pump pulled the sample air through the cyclone, filter, and rotameter combination. The system vacuum was monitored using a gauge mounted downstream of the rotameters.

4.5.2.3 Other Filter Sampling

Filter packs used to collect samples for NH_3 and PAN analysis did not require collection behind a cyclone. These samples were collected in the same manner as other filter samples but were not size segregated by the cyclone separator. For each measurement, sample air went directly to the filter holder using a 9.5 mm sample inlet line, from the filter holder through a rotameter, and to the vacuum system.

Preloaded DNPH filter cartridges (holders) to collect samples to be analysed for aldehydes were used during chemical sampling. They also did not require air from a cyclone and sampled directly from the airstream coming through the bottom sample inlet in the "dummy" window. After passing through the cartridge (holder), the air passed through a rotameter and into the vacuum system.

4.5.3 Tracer Sampling Systems

The sampling system for the collection of perfluorocarbon tracer samples was provided by Tracer Tech and consisted of a 9.5 mm tygon inlet tube (about 1.8 m long) and bags in which to collect sample air. "Aluminized" mylar bags with a 3.5 liter capacity were used. The inlet to each bag was a short length (about 45 cm) of tygon tubing that was sealed with a plastic pinch clamp. Sample air was provided by ram air through the 1.8 m sample inlet tube. A short piece of Teflon tubing was used to connect the sample inlet tube to the bag inlet tube.

When dual tracer releases were performed by Tracer Tech and CalTech, syringe samples for CalTech would be pulled from the tracer bags after the flight had been completed. On one occasion, only CalTech was releasing a tracer, and syringe samples were collected during flight by filling syringes from an "eye ball" outlet in the aircraft. The syringes were provided by CalTech and had a 30 cc capacity.

5. SAMPLING METHODOLOGY

5.1 SELECTION OF SAMPLING DAYS

During each study period, SCAQS management, in conjunction with meteorological inputs from various sources and ARB program management review, made daily decisions concerning upcoming sampling activities. Each group that was involved in the sampling called the SCAQS headquarters each day to learn the status of sampling for the next day(s). In general, most intensive studies were chosen to run for two consecutive days of favorable meteorological and air pollution episodes.

5.2 AIRCRAFT SAMPLING METHODOLOGY

5.2.1 Ground Procedures

At the start of each study period, power was applied to the gas monitors aboard the aircraft. Those instruments which required a warmup period were operated continuously throughout the study period. This was accomplished by transferring power from the ground source to internal aircraft power just before the aircraft was ready to taxi for take-off. The transfer was instantaneous and was repeated in the reverse order after the aircraft landed. This procedure maintained internal operating temperatures of the sampling instruments.

The hydrocarbon sampling line was plugged as soon as the aircraft landed and the plug was not removed until the aircraft was ready to taxi for the next flight. This protected the sample line from organic vapors and other contaminants that could be encountered at an airport.

In a similar fashion, the inlets to the nephelometer and filter sampling system were also capped while on the ground.

5.2.2 In-Flight Sampling Procedures

During vertical spirals, the aircraft would normally climb or descend at a rate of about 150 m/min. In a few instances, different rates were used to comply with FAA requests to schedule the aircraft into or out of a given airport traffic pattern. The rates used were fast enough to avoid inadvertent sampling of the aircraft exhaust but at the same time did not exceed the response time of the various monitors. During orbits, sampling speeds of about 55 m/sec were maintained. Based on expected concentrations and flow rates that were used during chemical sampling, it was necessary to orbit for about 30 minutes to obtain an adequate sample for analysis.

During each flight, the instrumentation and the data acquisition system were run continuously. The real time instrument data were recorded once per second and stored on eight inch diskettes. A printer recorded instantaneous values every ten seconds and served as the primary recording backup. Two channels of data (normally O_3 and b_{scat}) were recorded on a strip chart for use by the instrument operator.

To document the altitude response of the SO_2, NO-NO_X, and O_3 monitors aboard the aircraft, one extra spiral was flown during most flights. This spiral was typically flown in the vicinity of the PADDR sampling location or as the aircraft was proceeding back toward the coast after performing the sampling spiral at PADDR. Each of the gas monitors were placed in the "zero" mode of operation, and their zero response (as a function of altitude) was recorded during the extra spiral. This sampling was called a "zero spiral", and correction factors derived from the data were applied to the respective instrument's indicated response during data processing.

In addition to recording the start and end time of each sampling event (spiral, "zero spiral", or orbit) in written flight notes, the instrument operator activated an event switch to indicate each valid sampling period. The event switch (flag) was recorded by the aircraft data acquisition system.

5.3 SAMPLE HANDLING PROCEDURES

5.3.1 Filter Handling Procedures

Prior to the first intensive study period, all 47 mm filter holders that were used during STI sampling were disassembled and cleaned by STI. The 47 mm filter holders were not cleaned again during the SCAQS program. Prior to the first intensive study period, 25 mm Nuclepore filter holders were purchased and delivered to Environmental Monitoring and Services, Inc. (EMSI). These holders were cleaned by EMSI, and the Nuclepore filters were weighed and loaded as required. Details of the loading schedule of Nuclepore filters are available from EMSI.

During the preparation phase of the program, filter holders were separated into groups. Each group of holders would be used to load only one type of filter (e.g. quartz filters were always mounted in holders that had been selected for quartz filters). Each group of holders was color coded by adding a strip of colored tape to the holder. Thus for example, all filter holders that would be used for mounting quartz filters had a strip of green tape attached to the holder. Inside the aircraft, similar strips of the same color tape were attached to the inlet and exhaust mountings for each filter holder and to the rotameter used to measure the flow through the filter.

ENSR Consulting and Engineering (ENSR) provided the 47 mm quartz filters and the DNPH filter cartridges that were used. Daniel Grosjean and Associates (DGA) provided the 47 mm alkaline impregnated filters for PAN sampling, and they also provided glass vials used for the storage of PAN samples after sampling. The vials contained a stabilizing solution of water and biocide. All other 47 mm and the 25 mm filter substrates were provided by EMSI.

Preloaded Nuclepore filter holders, filter substrates, cartridges, and stabilizing solutions were delivered in ice chests to the flight crew at the aircraft operations base at the Ontario airport. When received by the flight crew, all 47 mm filter substrates were individually stored in petri dishes. All petri dishes had been prelabeled except those containing the quartz filters. Each petri dish had been sealed using Parafilm. Petri dishes containing similar types of filters (e.g. oxalic acid impregnated filters) had been grouped together and were sealed in Ziploc bags. Each preloaded 25 mm filter holder and DNPH cartridge was also prelabeled. The 25 mm filter holders were also sealed in Ziploc bags. The DNPH cartridges were capped on each end and stored in glass vials when delivered. The 47 mm quartz filters were not labeled when received.

Between sampling flights, all filter sampling substrates (petri dishes) and preloaded holders were refrigerated and stored at the motel where the flight crew lived. Filter holders that were not being used were sealed in Ziploc bags.

Several times during the three intensive study periods and at the end of each intensive study period, exposed sample sets were delivered to EMSI in ice chests. EMSI was responsible for delivering the appropriate exposed samples to their own laboratory or to the ENSR and DGA laboratories for analysis. Unexposed filters and cartridges were stored at EMSI between intensive study periods.

Assembly of non-preloaded filter holders used aboard the STI aircraft was performed at the motel where the flight crew lived. When a chemical sampling flight was anticipated, four sets of 47 mm filter holders were loaded by a member of the flight crew. As each filter holder was being assembled, filter substrates were removed from the petri dish in which they had been stored and transferred to the filter holder. The petri dish identification sticker, for each substrate used, was transferred to the filter holder. Empty petri dishes were returned to the Ziploc bag from which they had been removed. In the case of quartz filters (not prelabeled), filter identification numbers that were consistent with the other numbers of an individual sample set, were assigned.

Six separate 47 mm holders (two for the denuder difference measurement and one each for SO_2, NH_3, carbon, and PAN) were prepared for each of the four sets. A preloaded 25 mm Nuclepore filter holder and a DNPH cartridge were added to the set. Thus, one complete sample set consisted one 25 mm filter holder, six 47 mm filter holders, and one DNPH cartridge (holder).

Each of the sample sets was grouped together and sealed in a Ziploc bag. When delivered, the DNPH cartridges were capped and stored in glass vials. None of the other filter holders were capped before being transferred to the Ziploc bags. The four filter sample sets (four bags) were then placed in an ice chest and transported to the aircraft. Although only two sample sets were expected to be exposed during a flight (two orbits), the two extra sets provided backup and allowed for the selection of a set of flight blanks after a flight was completed.

The sample sets remained in the ice chest until sampling was about to begin. Then, one sample set (bag) was removed, the DNPH cartridge removed from its glass vial and the caps removed, and all holders connected to the filter sampling system. Filter holders were mounted such that the colored tape on each holder matched the colored tape on the inlet and exhaust lines for the holder. During sampling, the instrument operator recorded in written flight notes the sample identification number(s) for each filter holder or cartridge of the sample set, as well as the pertinent sampling data (vacuum, flow, and exposure time). At the completion of sampling, the filter holders and cartridge were removed from the sampling system, the DNPH cartridge capped and returned to its vial, and everything returned to the Ziploc bag. After sealing, the bag was returned to the ice chest.

One set of filters and a DNPH cartridge were exposed during each sampling orbit flown by the aircraft. Normally two orbits were flown during each flight in which integrated sampling was performed. The duration of each orbit was typically 30-35 minutes. Typical flow rates (at STP) for each of the samples collected are shown in Table 4-2.

After a flight was completed, the ice chest was removed from the aircraft and transported back to the crew's motel. One of the unexposed filter sets was designated a "flight blank" and was unloaded as if it were a sample. The 47 mm filter holders were disassembled and each filter substrate was returned to a petri dish. Although filters were returned to empty petri dishes of their own type (e.g. empty oxalic acid impregnated filters to oxalic acid petri dishes), it is likely that they were not returned to the exact petri dish in which they had previously been stored. The labels were transferred from the filter holders to the petri dish in which the sample was being stored. Each petri dish was sealed using Parafilm. The alkaline impregnated filters for PAN were placed in the vials containing the water-biocide stabilizing solution and identification labels transferred to the vials. All samples were segregated by filter type, each type sealed in its own Ziploc bags, and refrigerated. Exposed samples were kept separate from unexposed media.

5.3.2 Hydrocarbon Sampling Procedures

Hydrocarbon samples were collected in stainless steel canisters that were provided by Biospherics. The canisters were prepared for sampling in the Biospherics laboratory prior to being sent to the Ontario airport where the sampling aircraft was based. During the preparation phase, each canister was cleaned, baked under vacuum, and sealed under vacuum. After receipt of the canisters by STI, they were stored at the airport base of operations until sampling was performed.

When a sampling flight was anticipated, a set of canisters (normally six canisters) was loaded aboard the aircraft. Normally a maximum of four canister samples per flight would be collected and the remaining cans were carried for backup.

Prior to connecting a canister for sampling, the Metal Bellows pump was turned on and run for at least five minutes to purge the inlet system. The sample delivery system from the pump ended in a "purge tee" assembly that consisted of a pressure gauge, a toggle valve, and two exhaust ports. The first port exhausted directly into the aircraft cabin. The second port contained Swagelok fittings that mated with the sample canisters. The toggle valve directed air through both ports or only to the port that was used to connect to the canister.

The inlet assembly for each canister consisted of a Nupro valve between the inside volume of the canister and its inlet, and a Swagelok cap that protected the threaded portion of the inlet that mounted to the "purge tee" assembly.

To connect a canister to the "purge tee" assembly, the toggle valve was set to exhaust through both ports. The cap was removed from the canister and air flow from the "purge tee" was used to flush the dead air space inside the inlet assembly of the canister. After about 15 seconds of flushing, the Swagelok fittings between the "purge tee" assembly and the canister were secured. Air from the pump would exhaust through the other port of the "purge tee" into the aircraft cabin.

To sample, the toggle valve was switched to the sample position (air to the canister only) and the Nupro valve on the canister was fully opened. The canister was pressurized to as close to 25 psi as possible (normally this took about two minutes). To end sampling, the Nupro valve on the canister was closed, the "purge tee" assembly removed, and the Swagelok cap reinstalled on the canister. The toggle valve was not repositioned until the canister had been sealed with the Nupro valve, removed from the "purge tee" assembly, and capped. This ensured that the contents of the canister would not be lost after it had been collected.

Log sheets that were delivered with each canister were filled out during sampling. The log sheet data included canister identification number, time, temperature, and altitude of sample collection, final canister pressure, and notes that often included raw concentrations of O_3 or other parameters. Log sheet observations were duplicated in the operator's flight notes.

After landing, the canisters were stored at the aircraft operations base pending delivery to either Biospherics or the EPA for analysis. If canisters were to be analyzed by Biospherics first (normal operation for the summer intensive study periods), they were sent via UPS to Biospherics who performed the analysis. Biospherics in turn sent the canisters to the EPA operation at the Claremont SCAQS site. During the fall study period, the samples were to be analyzed first by EPA and then by Biospherics. Thus, the aircraft crew delivered the samples to the EPA operation which at that time was located at the Long Beach SCAQS site. The EPA analyzed the samples and forwarded them to Biospherics for analysis.

5.3.3 Tracer Sampling Procedures

5.3.3.1 Perfluorocarbon Tracer Sampling Procedures

Tracer Tech delivered and picked up the bags that were used during perfluorocarbon tracer sampling. Prior to a tracer release episode, the bags were stored at the aircraft operations base. Tracer Tech personnel collected the exposed sample bags a day or two after completion of each tracer release episode.

"Aluminized" mylar bags were used. Prior to delivery, the bags were evacuated and prelabeled stickers attached. The label on each bag had a unique identification number and space to fill out details of sampling. Each bag had a 3.5 liter capacity and a short length of tygon tubing for an inlet. A pinch clamp about 5 cm from the inlet end of the tube closed the bag to the atmosphere.

The sample delivery line in the aircraft was a 9.5 mm tygon tube that was approximately 1.8 m long. Ram air pressure provided continuous flow though the sample delivery line. Connection between the sample delivery tubing and the bag inlet was accomplish using a short piece of 9.5 mm ID Teflon tubing as a sleeve.

To prepare for sampling, air from the 1.8 m sample delivery line was used to flush the 5 cm dead space of the bag inlet line (to the pinch clamp). To sample, the two tygon lines were connected using the Teflon sleeve, the pinch clamp was opened, and the bag filled. Using ram air pressure, the bag was filled to roughly 75% of its volume capacity in about 15-20 seconds. To end sampling, the pinch clamp was closed and the tygon lines disconnected. Labels on the bag were filled out with pertinent sampling information, and the information was duplicated in the observer's flight notes.

5.3.3.2 SF_6 Tracer Sampling Procedures

Samples for SF_6 were collected using 30 cc plastic syringes that were provided by CalTech. Each syringe when delivered was empty and capped. Syringes that were collected in flight (September 3, 1987 only) were identified by date, location, and altitude. During this flight, syringes were taken every 150 m (500 ft) at each of the seven spiral locations. A syringe was uncapped, sample air drawn from air coming through the "eye ball" air outlet, and the syringe capped. Identification labels were taped on each syringe and recorded in the flight notes. Syringes taken during flight were filled to about 20 cc's and required only one to two seconds to fill.

The remaining SF_6 releases occurred during perfluorocarbon tracer release periods. Thus, syringe samples could be drawn from bag samples collected for perfluorocarbon sampling. The syringe samples were taken from the bags after a sampling flight had been completed. Normally, the sample transfer was done on the day of the flight, but in one instance it was done on the following day. The bag number was used as sample identification. To collect the syringe sample, the syringe was uncapped, a hypodermic needle installed on the syringe, the needle inserted into the tygon tubing inlet of the bag (near the mouth of the bag), about 25 cc's of sample air withdrawn from the bag system, and the needle removed. The tygon tubing would self-seal when the needle was removed. The hypodermic needle was removed and the syringe capped. Labels were prepared that included the sample identification number (bag number) and other pertinent details of where the sample was collected. Each label was then taped to the appropriate syringe. Exposed syringe samples were picked up a day or two after each release episode by personnel from CalTech.

5.3.4 Data Diskette and Flight Note Handling Procedures

After the completion of each flight, the data diskettes from the flight were duplicated and the flight notes were copied. The copies were returned to STI so that data processing could begin. The original diskettes and flight notes were maintained in the field until it was verified that the copies had been received at STI and that the diskette copies had been read by the STI computer.

6. QUALITY ASSURANCE AND CALIBRATION

6.1 GENERAL QUALITY ASSURANCE PROCEDURES

General steps used during the SCAQS intensive study periods to assure the quality of the aircraft data are outlined below:

- Standardized procedures were used for all measurements. Extensive checklists and log sheets were used throughout the program to standardize operational procedures and to document all activities relating to the measurements.

- Using checklists, operational checks were performed on each instrument prior to each sampling flight.

- Redundancy in recording data was achieved using standardized log sheets, stripcharts, inflight data printouts, and the aircraft data acquisition system.

- The on-board printouts were reviewed daily to detect instrument problems.

- The project manager for the STI aircraft operations debriefed flight crews daily to ascertain any operational problems.

- Data disks and flight notes were copied after each flight and returned to STI's home office. After receipt, the data disks were "dumped" and the data reviewed for instrument problems. Any problems that were noted were discussed with the project manager.

- Multi-point calibrations of the gaseous monitors were performed throughout each intensive study period.

- A system audit of the aircraft instrumentation and crew was performed by personnel from ENSR.

- Twice during the program, performance audits were performed by an audit team from the CARB.

- Blank and redundant samples were collected for chemical analysis to determine blank levels and sampling precision.

- Chemical sampling supplies (filters, cartridges, and preloaded filter holders) were refrigerated at all times (including during transport) except while they were being exposed during sampling.

6.2 AIRCRAFT SYSTEM QUALITY CONTROL AND CALIBRATION

Prior to the start of the sampling, the aircraft was equipped with the sampling instrumentation and test flights were flown. Data recorded during these flight were processed and reviewed to ensure that the instruments were operational. The gas monitors were checked and calibrated. In addition, the temperature and dew point sensors were cross checked using wet bulb-dry bulb measurements from an aspirated psychrometer. The airspeed and altitude sensors were calibrated by a certified aircraft instrument repair facility.

During the studies, checks on all sensors were made each flight day to ensure the sensors were operational. Throughout the study periods, multipoint calibrations of the gas monitors were performed routinely. The nephelometer was calibrated before the first study period and periodically during all three study periods using Freon 12. The results of these calibrations were applied during data processing. Although the nephelometer was not audited during either ARB audit discussed below, the most recent audit of the instrument was performed by ENSR during January of 1987, and they reported no differences between the instrument and the audit value.

During the study periods, the gas monitors were calibrated using a Columbia Scientific Instruments (CSI) Model 1700 gas phase calibrator. The NO/NO_x and SO_2 monitors aboard the aircraft were calibrated using the CSI gas phase calibrator to dilute low concentration source gases (from bottles) with "Ultra Pure" zero air. The NO gas bottle concentration was 100.8 ppm and the SO_2 concentration was 25.8 ppm. Both bottles were supplied by Scott-Marrin, Inc. of Riverside, California and were certified by Scott prior to the first study period. The zero air bottles that were used as dilution sources were also provided and certified by Scott.

During the preparation phase of the program, the flows of the calibrator were checked using bubble flow meters. The CSI calibrator was taken to the ARB laboratory at El Monte prior to the first study period. Flows were again checked and verified and the unit was calibrated against an absolute photometer (Dasibi Model 1003-PC). The O_3 monitor aboard the aircraft was then calibrated using the CSI unit. During the fall intensive study period, the CSI calibrator was returned to the ARB El Monte laboratory and its operation was verified. Also during the fall study, AeroVironment (AV) calibrated the NO/NO_x monitor using their audit system. The purpose of the independent calibration was to again verify the operation of the CSI system.

Twice during the first study period the PMS ASASP-X particle probe was calibrated. The first calibration was performed by AV while performing a calibration of a similar unit that was used at one of the ground monitoring sites. AV measured the instrument response to polystyrene latex (PSL) spheres. They reported that all parameters were within specifications.

The second calibration was an ambient particle calibration that was performed by Dr. Peter McMurry of the University of Minnesota and Dr. Susanne Hering of STI. They determined the instrument response to monodisperse atmospheric aerosols obtained using an electrostatic classifier to select particles of a uniform geometric diameter. They compared the instrument response for atmospheric aerosols to responses for PSL and oleic acid particles. The comparison was performed for five sizes in the 0.3 to 0.82 μm diameter range. They reported that the atmospheric aerosols were found to scatter about the same amount of light as oleic acid spheres but less than PSL particles of the same size. They concluded that in the 0.4 to 0.8 μm size range the instrument response to atmospheric aerosols would be between 65-80% of the value reported for a PSL equivalent optical size.

On June 20, 1987, ENSR performed a system audit of the aircraft, personnel, and data handling procedures that were being used. No discrepancies were reported.

On June 22 and on November 18, 1987, the ARB auditors audited the NO/NO_x and O_3 monitors aboard the aircraft. The SO_2 monitor was audited only in June. Table 6-1 summarizes the preliminary results of these audits.

Table 6-1 COMPARISON OF STI AIRCRAFT INSTRUMENT RESPONSE TO AUDIT VALUES

	AVERAGE % DIFFERENCE	
MEASUREMENT	6/22/87	11/18/87
03	-3.5	+12.7
NO_2	-13.5	+10.0
SO_2	+0.0	NOT AUDITED

Differences between the NO_2 results for the two audits are misleading since a different monitor was used during the November period than the one reported during the June audit. The cause of the O_3 shift between the audits was not obvious and when the CSI calibration system was rechecked (December 3, 1987) at the ARB El Monte laboratory, the calibration of the unit had shifted by only a few percent.

7. DATA PROCESSING PROCEDURES

7.1 AIRCRAFT AND FIELD PROCEDURES

During each flight, the instrumentation and the data system were run continuously. During portions of a flight, the data being recorded were invalid because instruments were being "zeroed" (at times other than a "zero spiral") or the aircraft was being positioned to start another sampling event. The only data processed by STI were those recorded during valid sampling events (spirals, "zero spirals", or orbits). These sampling events were called "passes" and were numbered sequentially from the beginning of each flight, starting at one.

Aboard the aircraft, the instrument operator controlled an event switch that was used to flag these sampling events (passes). The data flag was recorded by the aircraft data acquisition system and used in later data processing steps to identify sections of data to be processed. The operator also filled out sampling forms that summarized each sampling event. Information written on the form included the start and stop time of each event, sampling altitudes used, instrument ranges, and special samples (filters, canisters, bag samples, and/or syringes) that were collected. The form also contained space for comments concerning the sampling.

Immediately after each sampling flight, data diskettes were copied, printer tapes archived, filter and grab samples verified, and flight notes reviewed and duplicated. The duplicate diskettes and copies of the flight notes were returned to STI. The diskettes were "dumped" at STI and reviewed by data processing personnel. Any problems or questions that were noted were discussed with the field personnel.

After the completion of each field study period, all original data and supporting documentation were returned to STI and inventoried, cataloged and stored.

7.2 DATA PROCESSING STEPS

7.2.1 Processing Data From the Real Time Instrumentation

"Dumping" the aircraft data diskettes was the first step in data processing. This procedure converted all data recorded during a flight into raw voltages and produced a summary of sampling periods as indicated by the data flag. The summary was checked against the flight notes, and any discrepancies were corrected.

The one-second raw voltage output data for a complete flight were then plotted in a strip chart format and reviewed by the program manager or instrument operator who collected the data. This overview of the data identified missing or questionable data. Invalid or questionable data were identified for later processing steps. Using the summary, flight notes, and the review of the data in raw voltage form, a flight summary and flight map were produced for each flight.

The "dumped" data (raw voltages) from the entire flight were next segmented into passes and processed by a program which converted raw voltages into engineering unit data for each instrument. Previously, calibration data had been reviewed and calibration factors determined for each instrument for each flight. These calibration factors, instrument range, zero and offset values, and altitude correction factors (when applicable) were applied during this processing step. Only data recorded during a "pass" were processed. Data after this step of processing were considered preliminary. These data were then replotted in a strip chart format and again reviewed.

Editing of the preliminary data was the next step in the processing sequence. Invalid or missing data that had been identified were assigned an integer value of 32767 to flag the processed data. Editing programs were run to replace invalid data with this integer value.

After editing was completed, the data were plotted in final form and reviewed. After review and acceptance by the program manager, these calibrated, edited data were considered final. The format of the final data plots and the associated tape format are discussed in the next section.

7.2.2 Calculation of Sample Volumes for Chemical Sampling Data

During each orbit, integrated filter sampling was performed. With the exception of the denuder difference measurements which were controlled by mass flow controllers, the flow through each filter holder was measured downstream (on the vacuum side) of the filter holder by a rotameter. During each sampling orbit, the instrument operator recorded the flow rates of each rotameter and its units of measurement, the system vacuum, and the duration of sampling.

During data processing, the orbit sampling periods were identified both from the operator's flight notes and the event flag that was recorded by the data acquisition system to mark the sampling. Average ambient temperature and pressure values were then determined from the data collected during each orbit period.

Combining these measurements, sample flow rates at both ambient and standard (STP) conditions were calculated. The calculated rates all were converted to units of liters per minute (lpm). Total volume flows were then calculated for each filter that was exposed. These volume flows were calculated for both ambient and standard conditions. Standard conditions were defined as 25 ^{o}C and 760 torr (29.92 "Hg). The chemical data reported includes the concentrations at both ambient and standard conditions.

8. DATA REPORTING FORMATS AND COMMENTS ON THE DATA

8.1 FORMAT OF DATA TAPES

A set of magnetic tapes containing all of the "final engineering unit data" from all the real time instruments operated aboard the STI aircraft has been delivered to the SCAQS data manager for inclusion in the SCAQS data archive. The tapes contain final processed and edited engineering unit data for all real time instruments except the ASASP-X optical particle counter and the radiations sensors.

During sampling, data from the ASASP-X optical particle counter were recorded continuously, but funding to reduce or analyze these data was not included in the current contract. Data from this instrument were included on the data tapes delivered to the SCAQS archive. The data were included "as recorded" and have not had calibration factors applied to them.

The total and ultraviolet radiation sensors were not required by the contract, but since they were installed aboard the aircraft, they were operated and their data recorded. Calibration factors have been applied to the data, but editing was not performed. As discussed in Section 8.3, these sensors are located near aircraft radio antennas and radio transmissions affect their data. Because of the numerous radio transmissions during each flight in the LA Basin, it was not practical to edit these data. These calibrated (but unedited) data were also included on the data tapes that were delivered to the SCAQS data archive.

The format of the data tapes that were delivered the SCAQS data manager was:

- 9 track
- 800 BPI
- odd parity
- unlabeled
- binary
- fixed block length (2100 words or 4200 bytes)
- 30 records/block.

Data from one flight consisted of a series of data files corresponding to each pass numbered sequentially. Each data file consisted of a series of fixed length, 2100 word blocks. As indicated in Figure 8.1, the first block in a file was a tape header whose format is given in Table 8-1. The second block was a pass header whose format is given in Table 8-2. The third and subsequent blocks in the file were the sampling data from the pass recorded in the format specified in Table 8-3.

The engineering unit data obtained from the aircraft measurements were reported in the data blocks which followed the pass header block. For every second of a pass, 70 channels of engineering unit data were included in a "data record." Thirty seconds of data (30 data records) were contained in one tape block. The last block in a data file was typically only partially filled with data records and the remainder of that block was filled with

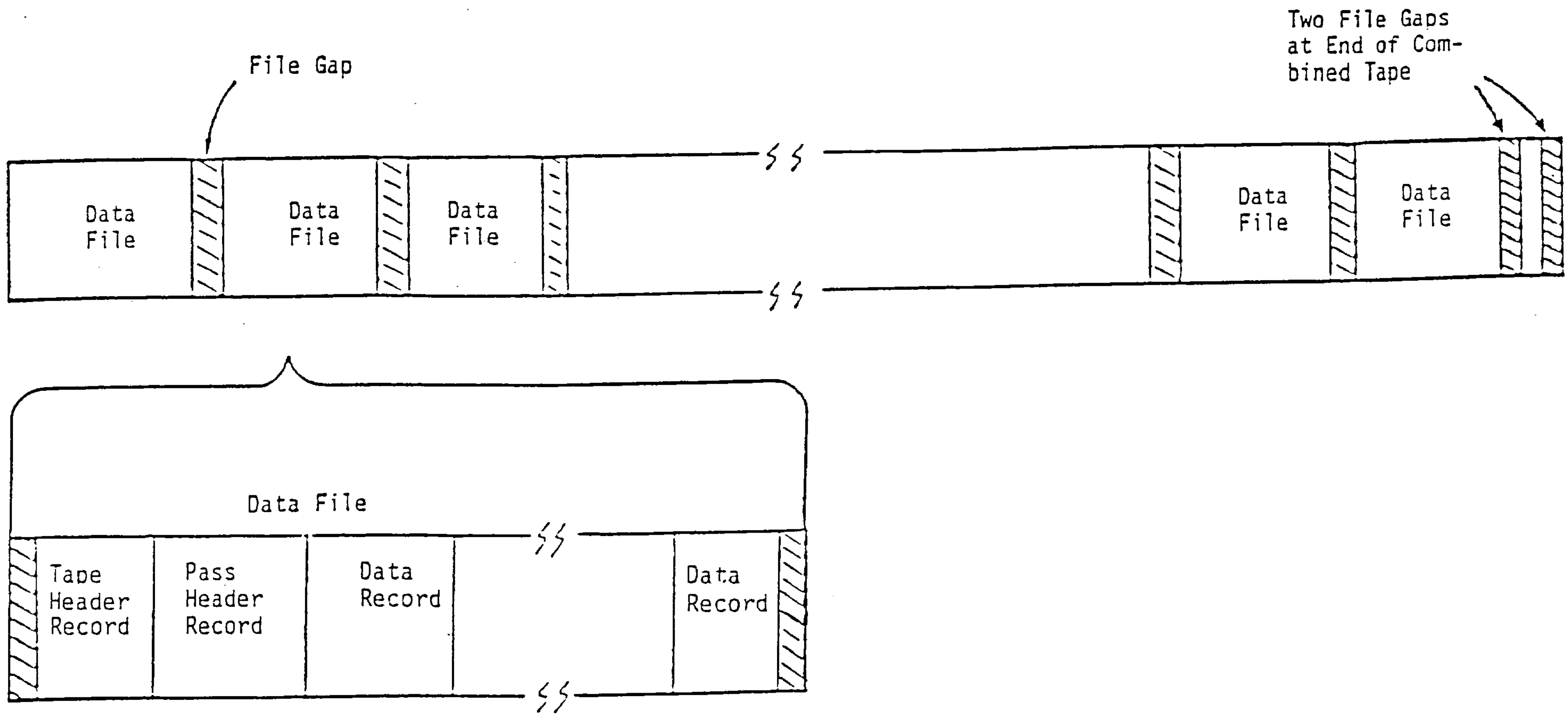

Figure 8.1. STI Aircraft Data Tape Format

Table 8-1. Tape Header Block Format

Word	Parameter
1	Tape number
2	Month
3	Day Sampling date
4	Year
5	1 = Raw data 2 = Engineering unit data
6-2100	Filled with zeros

Table 8-2. Pass Header Block Format

Word	Parameter
1	999 Code to identify pass header
2	999 Code to identify pass header
3	Pass number
4	Type of pass 1 = Spiral 2 = Traverse or Orbit
5	Number of data scans in the pass
6	Maximum sampling altitude in meters
7	Minimum sampling altitude in meters
8	Minimum ground elevation in meters (optional)
9	Traverse length in 0.01 km or orbit duration in 0.01 min
11	Pass start point number
18	Pass end point number
10,12-17,19-2100	Numbers generated during data processing for internal use.

Table 8-3. STI Data Tape Engineer Unit Format

WORD #	PARAMETER	UNITS	OUTPUT RANGE
1	TIME	HOUR	0 TO 24
2	TIME	MINUTE	0 TO 60
3	TIME	SECOND	0 TO 60
4	ALTITUDE	M-MSL	0 TO 3048
5	TEMPERATURE	.1 DEG. C	-300 TO +500 (-30.0 TO +50.0 DEG. C)
6	INDICATED AIRSPEED	MPH	50 TO 150
7	PRESSURE	Mb	1013 TO 697
8			
9	TURBULENCE	.1 CM2/3 S-1	0 TO 100 (0-10.0 CM2/3 S-1)
10	NEPHELOMETER	1 X 10-6 M-1	RAYLEIGH TO 100
11	NEPHELOMETER	10 X 10-6 M-1	RAYLEIGH TO 1000
12			
13			
14	DEW POINT	.1 DEG. C	-500 TO +500 (-50.0 TO +50.0 DEG. C)
15	OZONE	PPB	0 TO 5000
16	NO	PPB	0 TO 5000
17	NOX	PPB	0 TO 5000
18			
19	SO2	PPB	0 TO 1000
20	DISTANCE OR TIME	USED FOR PLOTTING	0 TO XXXXX
21	ULTRAVIOLET RADIATION	.01 WATTS / M2	0 TO 5850 (0 TO 58.50 WATTS /M2)
22	TOTAL RADIATION	WATTS / M2	0 TO 1100
23	SO2 RANGE	RANGE	0,1,2,3,4 VOLTS
24	SO2 SAMPLING STATUS	MODE	0,1,2,3,4 VOLTS
25			
26			
27			
28			
29			
30	LORAN	DDMM LAT.	
31	LORAN	.MMDD LAT. AND LONG.	
32	LORAN	DMM.M	
33	LORAN	MXYZ (SIGNAL STATUS INDICATORS)	
34			0 TO 10 VOLTS
35	X-PROBE ACTIVITY	PERCENT	0 TO 100 %
36	X-PROBE CHANNEL # 1	COUNTS (0.090-0.101)	0 TO XXXXX
37	X-PROBE CHANNEL # 2	COUNTS (0.101-0.113)	0 TO XXXXX
38	X-PROBE CHANNEL # 3	COUNTS (0.113-0.126)	0 TO XXXXX
39	X-PROBE CHANNEL # 4	COUNTS (0.126-0.141)	0 TO XXXXX
40	X-PROBE CHANNEL # 5	COUNTS (0.141-0.158)	0 TO XXXXX
41	X-PROBE CHANNEL # 6	COUNTS (0.158-0.177)	0 TO XXXXX
42	X-PROBE CHANNEL # 7	COUNTS (0.177-0.198)	0 TO XXXXX
43	X-PROBE CHANNEL # 8	COUNTS (0.198-0.222)	0 TO XXXXX
44	X-PROBE CHANNEL # 9	COUNTS (0.222-0.249)	0 TO XXXXX
45	X-PROBE CHANNEL # 10	COUNTS (0.249-0.278)	0 TO XXXXX
46	X-PROBE CHANNEL # 11	COUNTS (0.278-0.312)	0 TO XXXXX
47	X-PROBE CHANNEL # 12	COUNTS (0.312-0.349)	0 TO XXXXX
48	X-PROBE CHANNEL # 13	COUNTS (0.349-0.391)	0 TO XXXXX
49	X-PROBE CHANNEL # 14	COUNTS (0.391-0.437)	0 TO XXXXX
50	X-PROBE CHANNEL # 15	COUNTS (0.437-0.490)	0 TO XXXXX
51	X-PROBE CHANNEL # 16	COUNTS (0.490-0.548)	0 TO XXXXX
52	X-PROBE CHANNEL # 17	COUNTS (0.548-0.614)	0 TO XXXXX
53	X-PROBE CHANNEL # 18	COUNTS (0.614-0.687)	0 TO XXXXX
54	X-PROBE CHANNEL # 19	COUNTS (0.687-0.770)	0 TO XXXXX
55	X-PROBE CHANNEL # 20	COUNTS (0.770-0.862)	0 TO XXXXX
56	X-PROBE CHANNEL # 21	COUNTS (0.862-0.965)	0 TO XXXXX
57	X-PROBE CHANNEL # 22	COUNTS (0.965-1.080)	0 TO XXXXX
58	X-PROBE CHANNEL # 23	COUNTS (1.080-1.210)	0 TO XXXXX
59	X-PROBE CHANNEL # 24	COUNTS (1.210-1.354)	0 TO XXXXX
60	X-PROBE CHANNEL # 25	COUNTS (1.354-1.516)	0 TO XXXXX
61	X-PROBE CHANNEL # 26	COUNTS (1.516-1.696)	0 TO XXXXX
62	X-PROBE CHANNEL # 27	COUNTS (1.696-1.900)	0 TO XXXXX
63	X-PROBE CHANNEL # 28	COUNTS (1.900-2.127)	0 TO XXXXX
64	X-PROBE CHANNEL # 29	COUNTS (2.127-2.382)	0 TO XXXXX
65	X-PROBE CHANNEL # 30	COUNTS (2.382-2.667)	0 TO XXXXX
66	X-PROBE CHANNEL # 31	COUNTS (2.667-3.000)	0 TO XXXXX
67	X-PROBE CHANNEL # 0	COUNTS (>3)	0 TO XXXXX
68	N.A.		
69	RECORD NUMBER	COUNTS	0 TO XXXXX
70	RECORD NUMBER	COUNTS	0 TO XXXXX

zeros. The parameters recorded in the 70 channels are specified in Table 8-3 and are coded as signed integers. Table 8-3 gives the engineering unit equivalent of one integer unit for each channel. Many of the channels were not used.

Missing or invalid data were assigned the integer value of $2^{15}-1 = 32767$, which is the largest integer the STI computer can store. Unused channels were filled with 32767 or zeroes.

For orbits, channel 20 contained the time from the start of the pass in units of 0.01 minutes. During spirals, this channel was filled with 32767.

The numbers in channels 69 and 70 can be combined by a formula of (1000 X channel 69) + channel 70 to give an integer which is the number of data records since the data set began recording for the flight.

8.2 DATA REPORT FORMAT

The real time data from most of the instruments that were operated during the aircraft sampling (described in this report) are presented in the data report entitled "A Report of STI Airborne Data Collected During the SCAQS Sampling Program." Not all of the analytical results from the filter analyses have been received yet. When they are complete and have been reviewed, the results will be included as Appendix A (entitled "STI Filter Sampling Data") of the data report. Copies of the data report will be delivered to the SCAQS data manager and the CARB project officer.

In addition to the filter chemistry results, the data report presents the data from each flight. Each flight is reported in its own section. Each section begins with a flight summary, is followed by a map showing the sampling locations and flight path, and concludes with plots of the real time data. For each pass, the header block on the data plots contains the same identifying information as the flight summary. Flight summaries contain the data tape identification, sampling times, locations, altitudes, tracer sample bag identification, hydrocarbon can identification, filter chemistry identification, and pertinent comments.

8.2.1 Formats of Plots Included in the Data Report

Data from each spiral were plotted as a function of altitude (m msl). To keep plots legible, the data from each spiral was separated into three pages of plots. The first page contains plots of the temperature, dew point, turbulence, and b_{scat} data. The second page plots temperature, SO_2, and O_3 data, and the final page plots the temperature, NO, NO_x, and O_3 data. Although the nephelometer recorded two ranges of information, only the $1000X10^{-6}$ range was plotted.

Orbit data have been plotted as a function of sampling time (in tenths of minutes). Again, three pages of plots were produced for each orbit, and they contain plots of the same parameters as were plotted for spirals.

In reporting the data collected during spirals and orbits, indicated airspeed, the $100X10^{-6}$ range of the nephelometer, ultraviolet and total radiation, recorded Loran position, and the ASASP-X probe data were not plotted. These data were included on the final data tapes that were delivered to the SCAQS data archive.

Figures 8.2 and 8.3 are examples of the types of plots contained in the data report. Figure 8.2 shows an example of the three pages of plots that can be expected for each spiral that was flown. Figure 8.3 is an example of the plots that are reported for each orbit that was flown.

On plots that contain nephelometer data, the units reported were actually 10^{-6} m^{-1}. The plots that were produced might appear to have units of 10^{-5} m^{-1} but close inspection will reveal that the 10^{-6} m^{-1} units were used. This artifact is a function of how the machine (used to produce the plots) writes a superscript.

8.3 COMMENTS ON THE DATA

During data processing, the data were carefully reviewed by the personnel who ran the sampling instrumentation aboard the aircraft. Every effort was made to remove "bad" data or to identify questionable data. Users of the data are encouraged to report any comments they have concerning the data to the authors. These comments will be forwarded to the SCAQS data archive and may be of assistance to other users of the data.

The sampling instruments were run continuously throughout each flight even though only "pass" portions of the data were processed (see discussion in Section 7.1. All flight data that were recorded, but not processed, exist in raw voltage format on tapes at STI. These portions of data typically occurred as the aircraft was moving from one sampling location to the next. The instruments were operated and the Loran position was recorded during the events. Additional processing would be required to recover these data and portions of the data are invalid due to instrument zeroing or other reasons. But, during analysis of the data, additional information might be contained in the sections of data that were recorded, but not processed. Processing of these data was beyond the scope of the current work.

The ultraviolet and total radiation sensors are extremely sensitive to variations from their vertical alignment. During spirals and orbits, changes in aircraft heading caused a sinusoidal oscillation in the data. In addition, excursions in these data occurred as antenna wire shadows crossed the sensor. The sensors were also sensitive to aircraft radio transmissions of which there were many. These transmissions resulted in spikes in the data. Users of these data are cautioned that no editing was performed for any of these excursions, but sections of the data are valid and can be used with discretion.

During the program, several instrument problems arose, and the specific problems are outlined in the flight summaries. The predominant problem was noisy NO/NO_x monitors that were operated during the two summer study periods. The monitor that was used to start the sampling was quite stable but failed early in the study and was replaced. The replacement unit was relatively noisy and was later replaced by another unit. This unit was

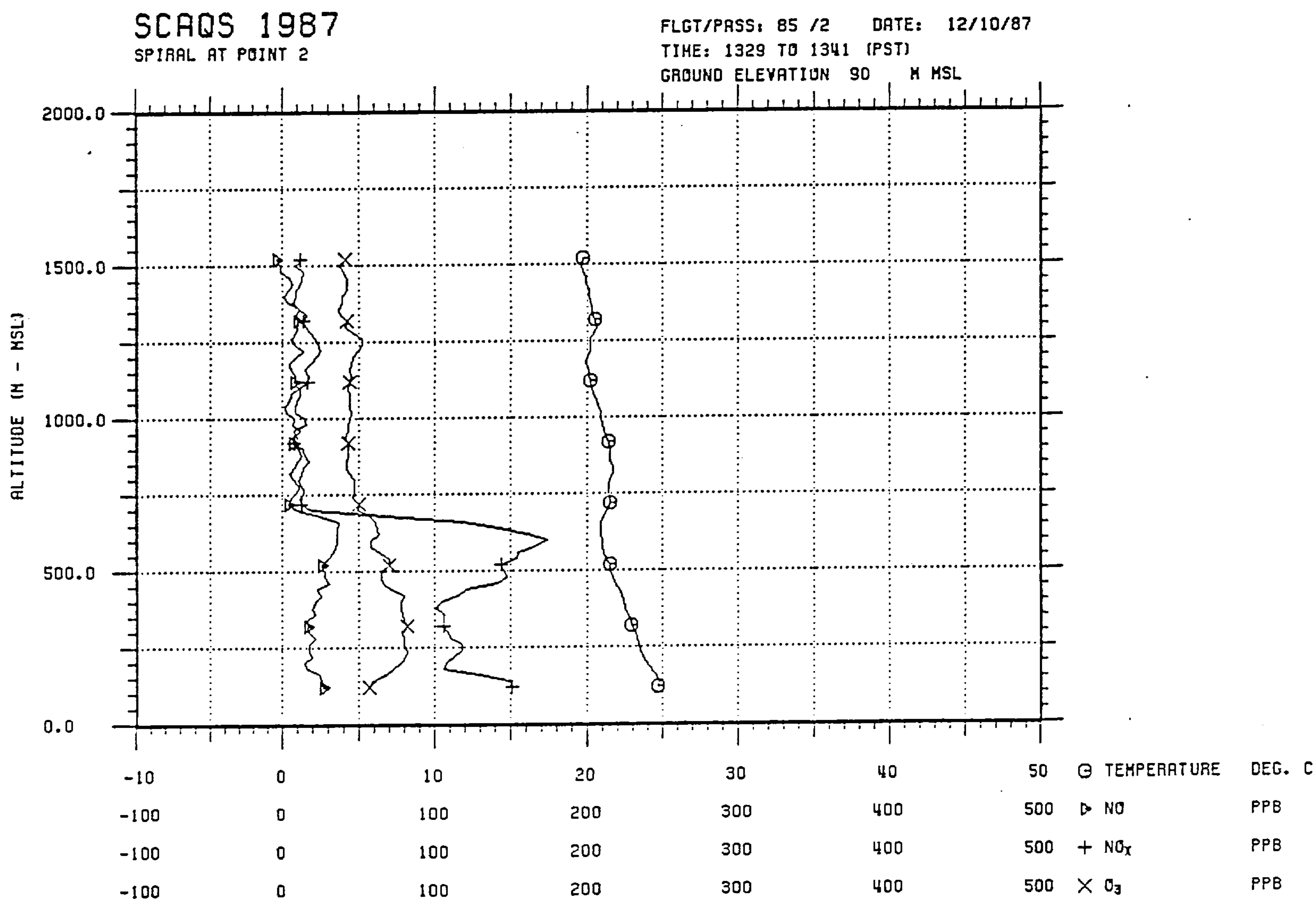

Figure 8.2. An Example of the Type of Spiral Plots Contained in the Data Report. This Spiral was Flown at the El Monte Airport 1329-1341 PST 12/10/87. (Page 1 of 3)

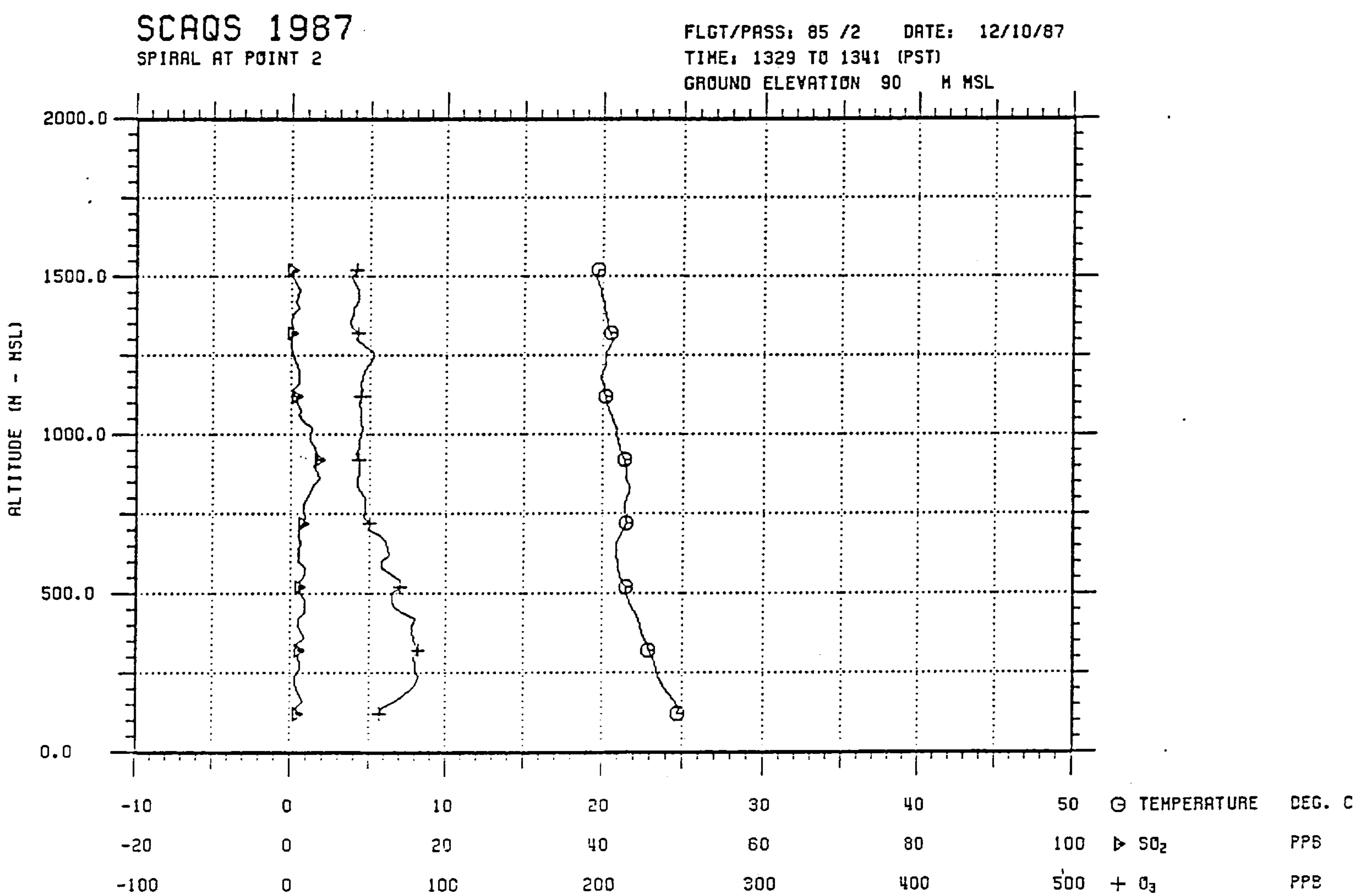

Figure 8.2 (Continued) Page 2 of 3

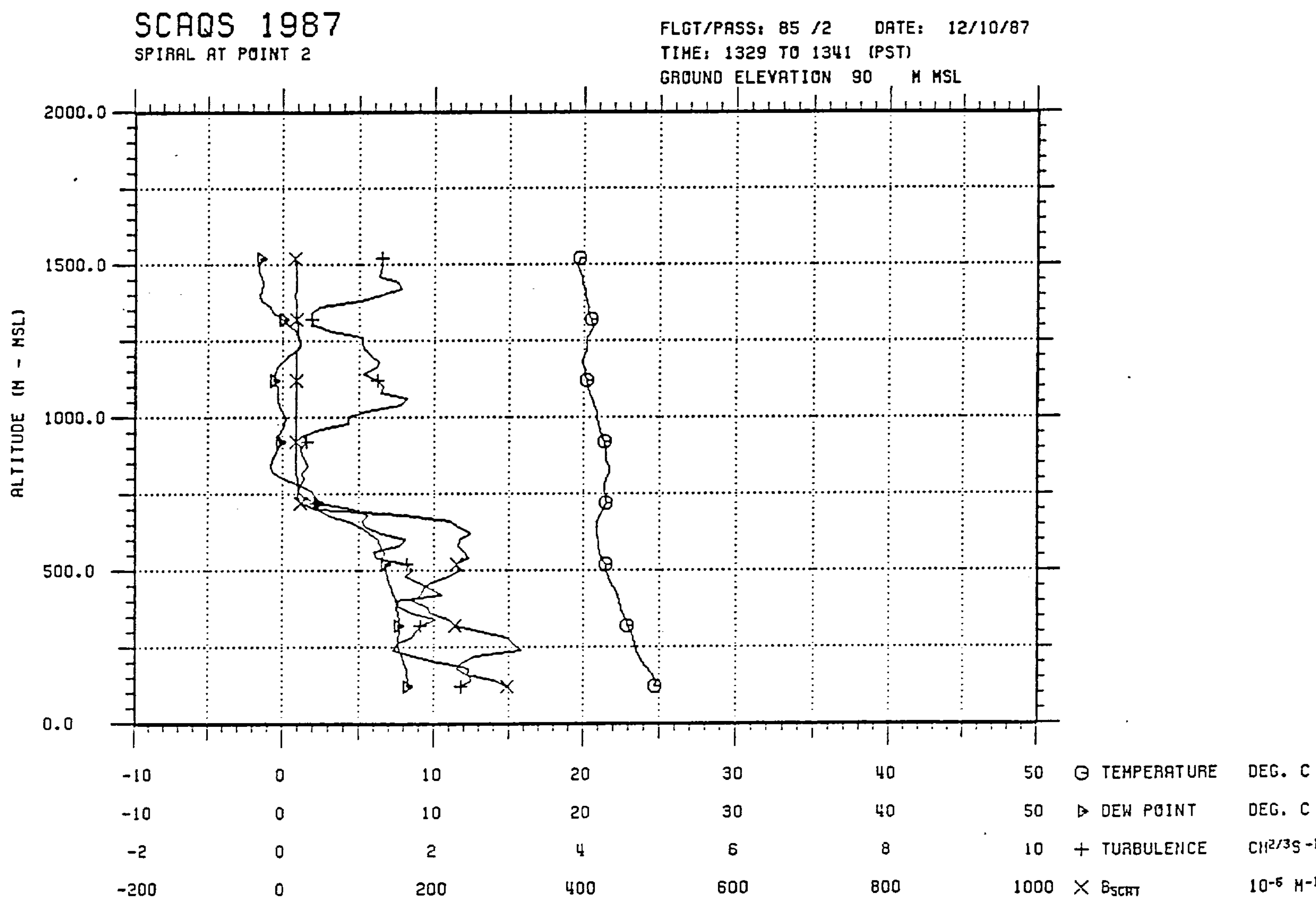

Figure 8.2 (Continued) Page 3 of 3

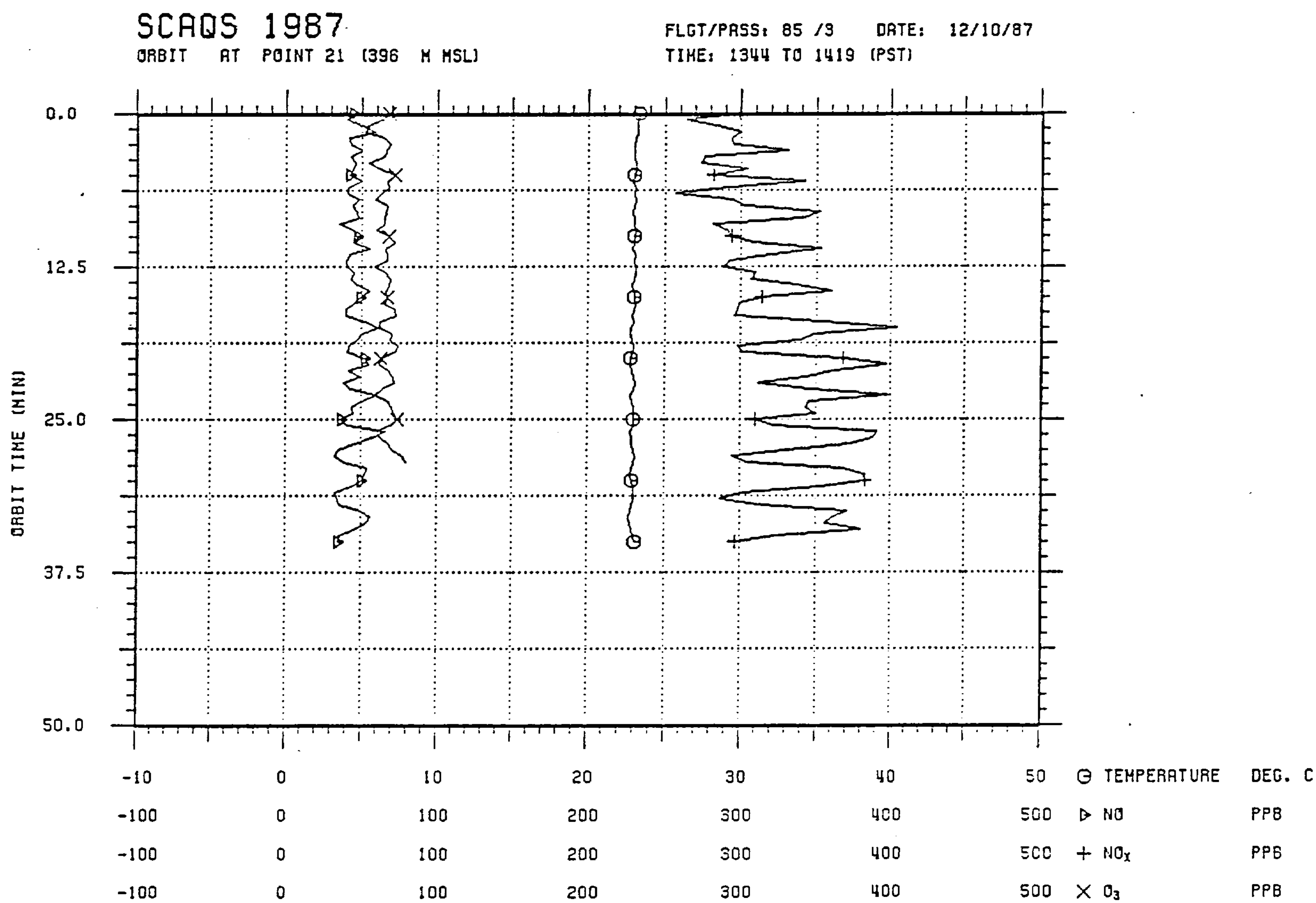

Figure 8.3 An Example of the Type of Orbit Plots Contained in the Data Report. This Orbit was Flown at the AMTRA Location 1344-1419 PST 12/10/87. (Page 1 of 3)

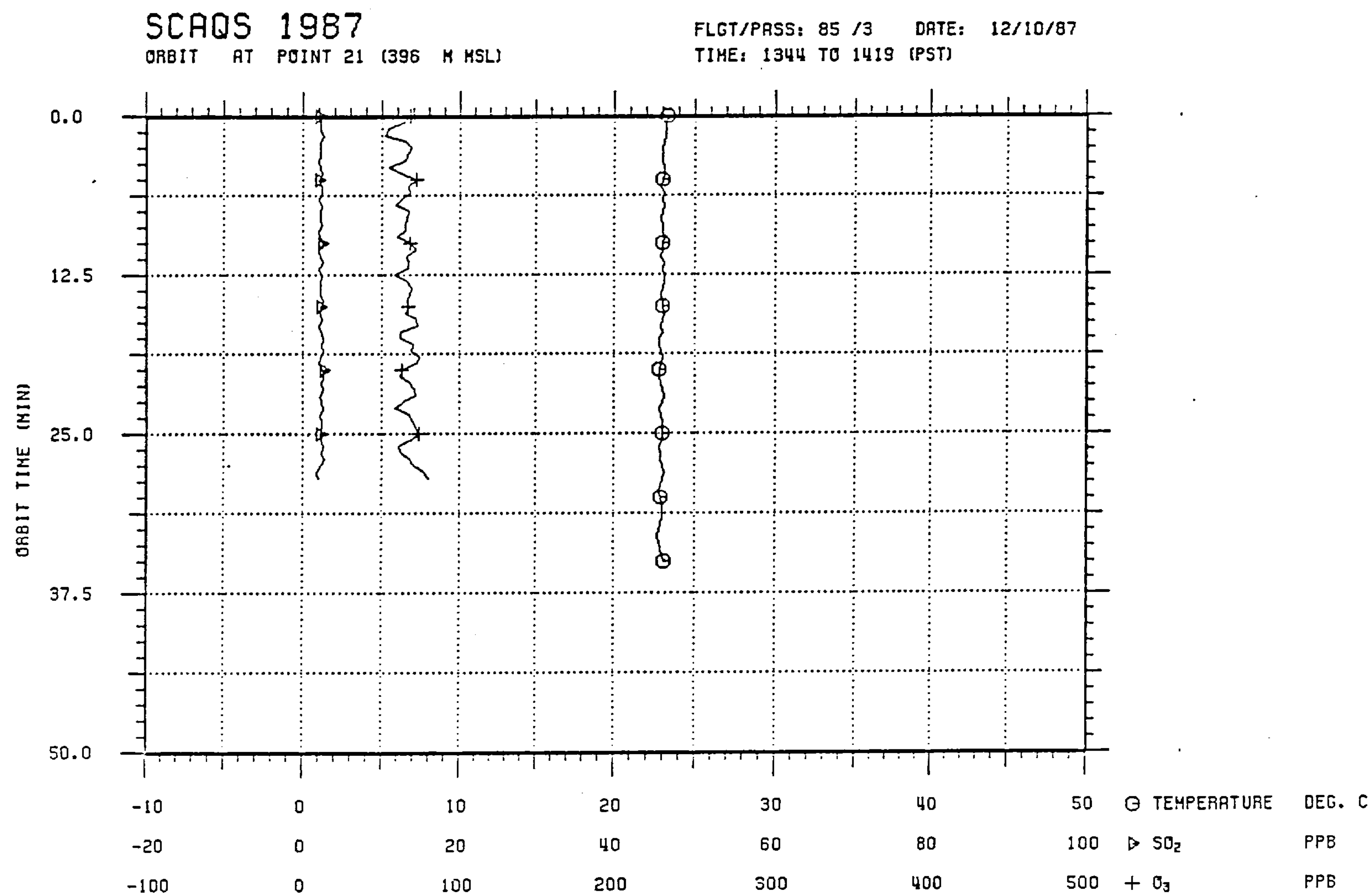

Figure 8.3 (Continued) Page 2 of 3

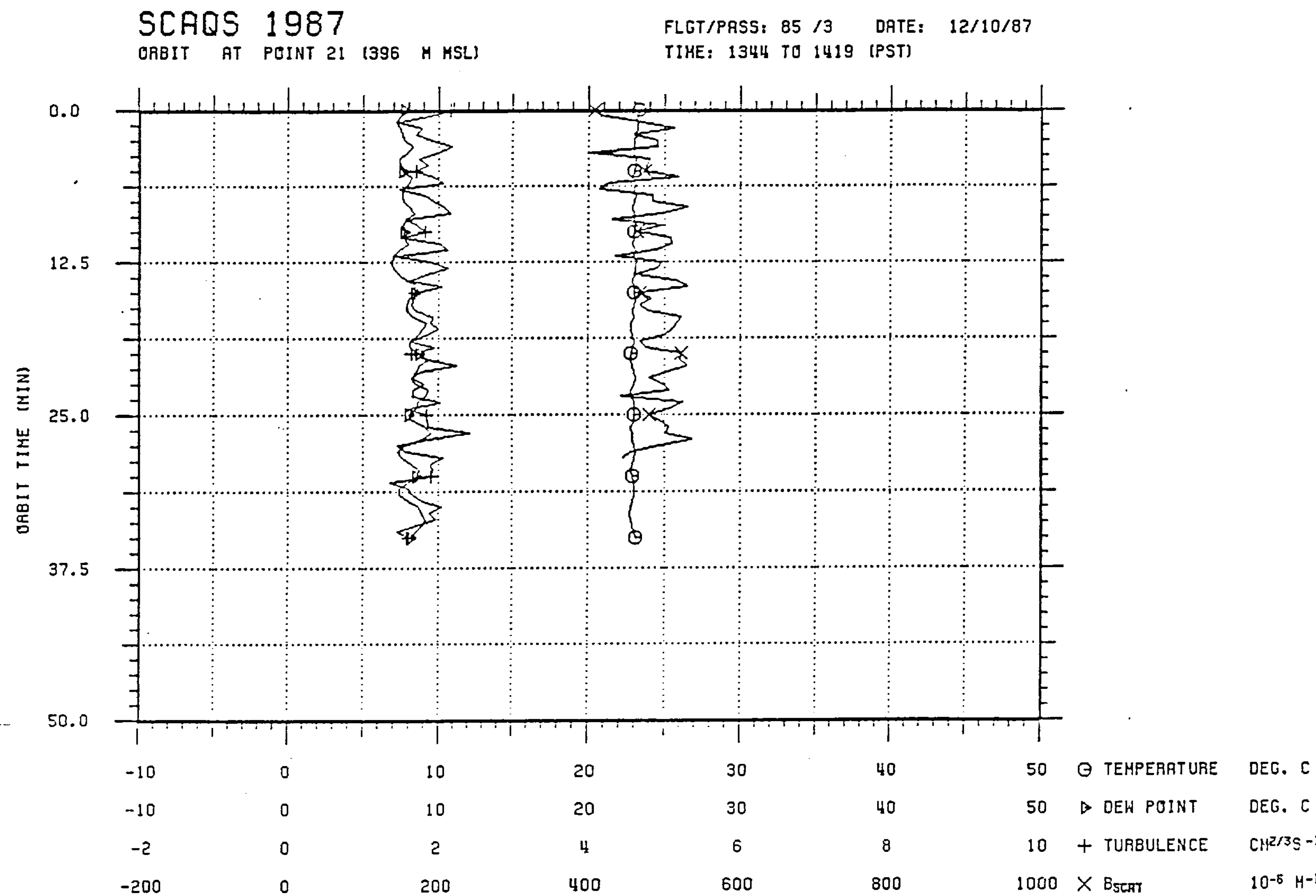

Figure 8.3 (Continued) Page 3 of 3

also noisy. It was not until the fall study period that a stable unit was located and installed in the aircraft. The monitors were operated on a one second time constant. The data, if analyzed on a second by second basis, were quite noisy for the second and third monitors that were used. To plot the data, seven-second averaging was performed to smooth the data without removing any structural details.

During the early morning flight of June 25, 1987, a data acquisition system failure occurred, and the 10 second printer data were used to process the data from this flight. ASASP-X optical particle probe data are not printed out, and thus the probe data for this flight are missing. During the early morning flight of December 12, 1987, a disc recording error occurred during passes 6, 7, and 8. Again, the data reported were processed from the printer tape, and the probe data are missing.

During the first day of sampling (June 19, 1987), the temperature probe failed just after take-off. All temperature data for this flight are missing. During the remaining two flights of the day, temperatures were manually recorded from the aircraft outside air temperature (OAT) sensor, and edited into the data set at the appropriate altitudes.