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## TECHNICAL MEMORANDUM

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**To:** Kenneth McMullen, Grand Canyon National Park  
**From:** Jason Ross, Christopher Menge, Nicholas Miller  
**Date:** June 23, 2004  
**Subject:** Percentage of Time Jet Aircraft are Audible in Grand Canyon National Park  
**Reference:** HMMH Job No. 295860.044

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### 1. INTRODUCTION AND SUMMARY

This report presents the percentage of time that jet aircraft were audible in the Grand Canyon during an extensive data collection program on September 10, 12 and 13, 1999. The audibility data used for this analysis were collected as part of the Aircraft Noise Model Validation Study (ANMV).<sup>1</sup> Although the audibility logging procedures were not set up specifically to distinguish between commercial and other jet aircraft in the logs, more than 99% of the jets logged are believed to be high-altitude commercial jet aircraft, based on comments logged by observers. The percentage of time that jet aircraft were audible from hour-to-hour across all sites ranged from 9.6% to 55.7%. The percentage of time that jet aircraft were audible on a daily basis across all sites ranged from 14.8% to 68.2%. The total percentage of time that jet aircraft were audible for all sites and all days was 34.4%. A total of 300 hours, 47 minutes and 37 seconds of active logging data was collected. Of the active logging data, fixed-wing propeller-driven aircraft and helicopters were logged for 99 hours, 38 minutes and 30 seconds and jet aircraft were logged for 69 hours, 8 minutes and 51 seconds.

### 2. SOURCE DATA

The ANMV included the collection of over 300 hours of “audibility logging” data at 43 sites. Audibility logging consists of an observer entering onto a palmtop computer the time and characteristic of sound sources heard while the observer is engaged in attentive listening at a site. A map showing all the locations where logging took place during the ANMV is given in Figure 1. Audibility logging data were collected between 8:00 am to 12:00 pm and 1:00 pm to 5:00 pm on September 10, 12 and 13, 1999. Detailed descriptions of the sites, protocols and reference data used for the analysis in this report can be found in the 267-page ANMV report. Much of the individual site data that formed the basis of this analysis are summarized in Table 1 in Section 4.1 below.

### 3. AUDIBILITY LOGGING PROTOCOL

An audibility logging protocol was used during the ANMV study that instructed all observers to log fixed-wing propeller-driven aircraft and helicopters as long as they were audible regardless of whether or not they were the dominant noise source heard.<sup>2</sup> Logging of fixed-wing propeller-driven aircraft and helicopters included both tour aircraft activity and other general aviation aircraft activity. This protocol means that other noise sources such as jet aircraft may or may not have been audible while the observers were logging propeller-driven aircraft or helicopters. Therefore, since no information about the audibility of jet aircraft exists for those periods, one cannot assume that jets were audible during all, part or none of

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<sup>1</sup> “Aircraft Noise Model Validation Study,” Harris Miller Miller & Hanson Inc. Report No. 295860.29, prepared for National Park Service, January 2003.

<sup>2</sup> Ibid, pp. 56-57

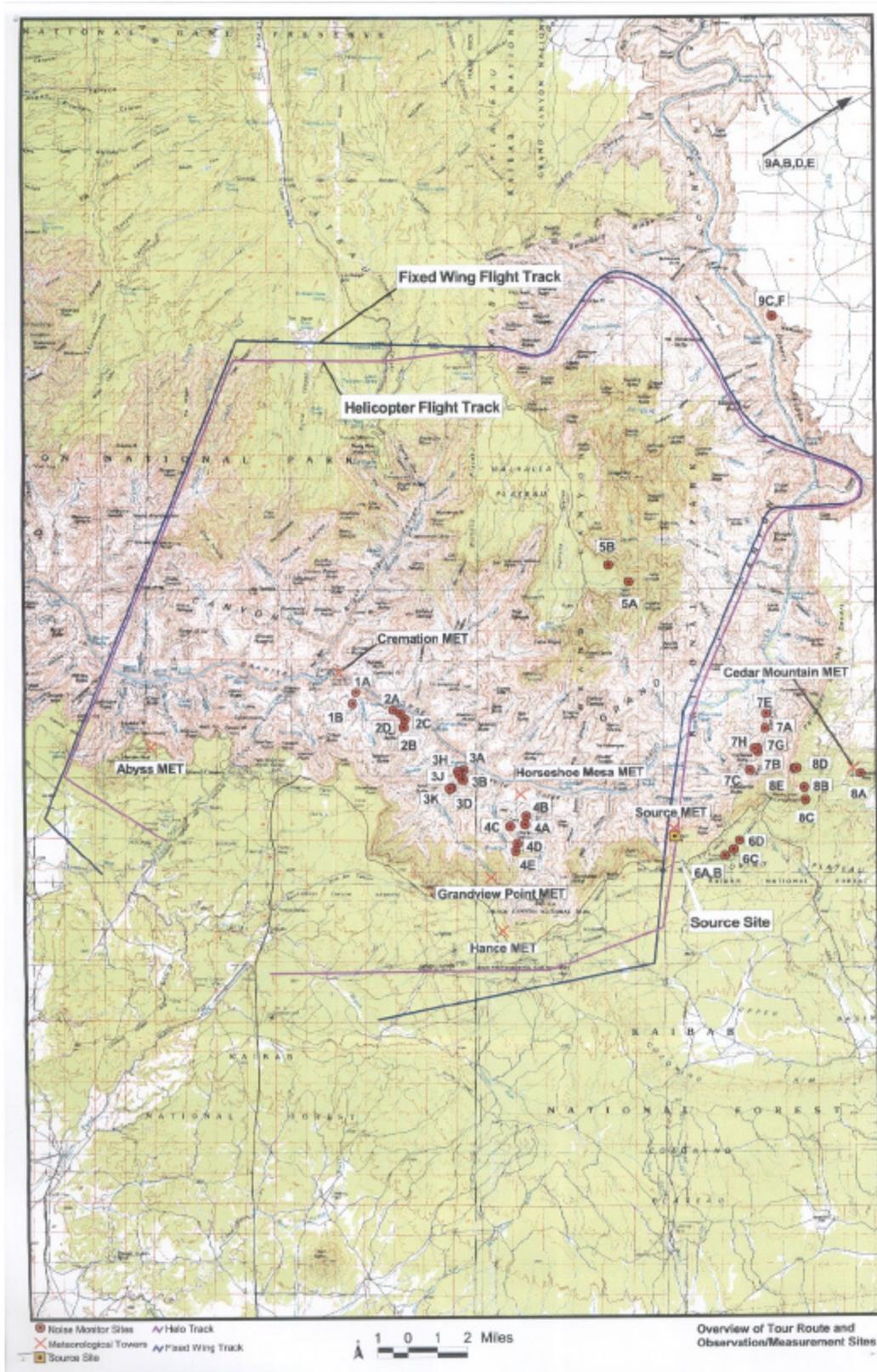


Figure 1. Aircraft Noise Model Validation Study Measurement Locations

the periods when propeller aircraft or helicopters were logged. Therefore, those periods must be and were excluded from the analysis of the percentage time jets were audible.

The logging protocol also instructed observers that if no fixed-wing propeller-driven aircraft or helicopters were audible and jet aircraft noise was audible, jet aircraft would be logged regardless of whether or not jet aircraft were the dominant noise source heard. This approach means that when jet aircraft were logged there may have been other noise sources such as birds or insects present, but jet aircraft were still audible. Therefore, all periods where jet aircraft were logged as audible were used to determine the “jet aircraft audible” periods in our analysis. Since “military” was noted in the comment field of fewer than 1% of the logged jet audibility, the results of this analysis are applicable to the only other type of jet aircraft observed, high-altitude commercial jets.

All remaining periods when no jet, fixed-wing propeller-driven aircraft or helicopters were logged, were used to determine the periods when jet aircraft were not audible.

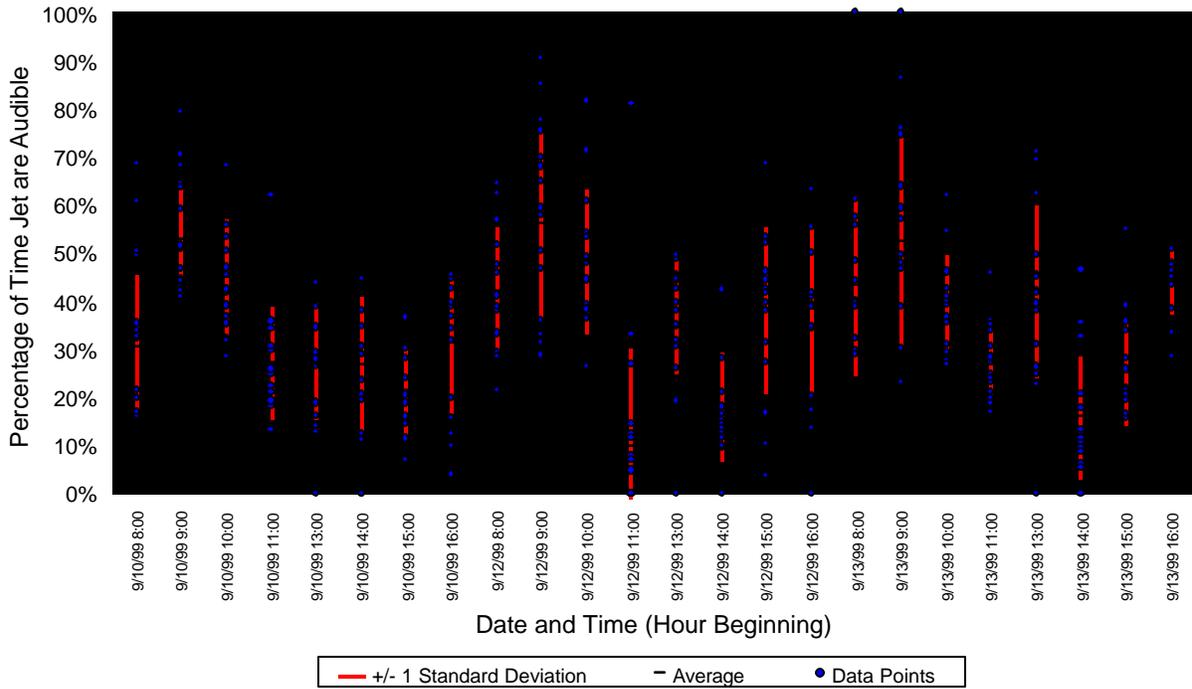
## 4. RESULTS

### 4.1 Results for All Sites

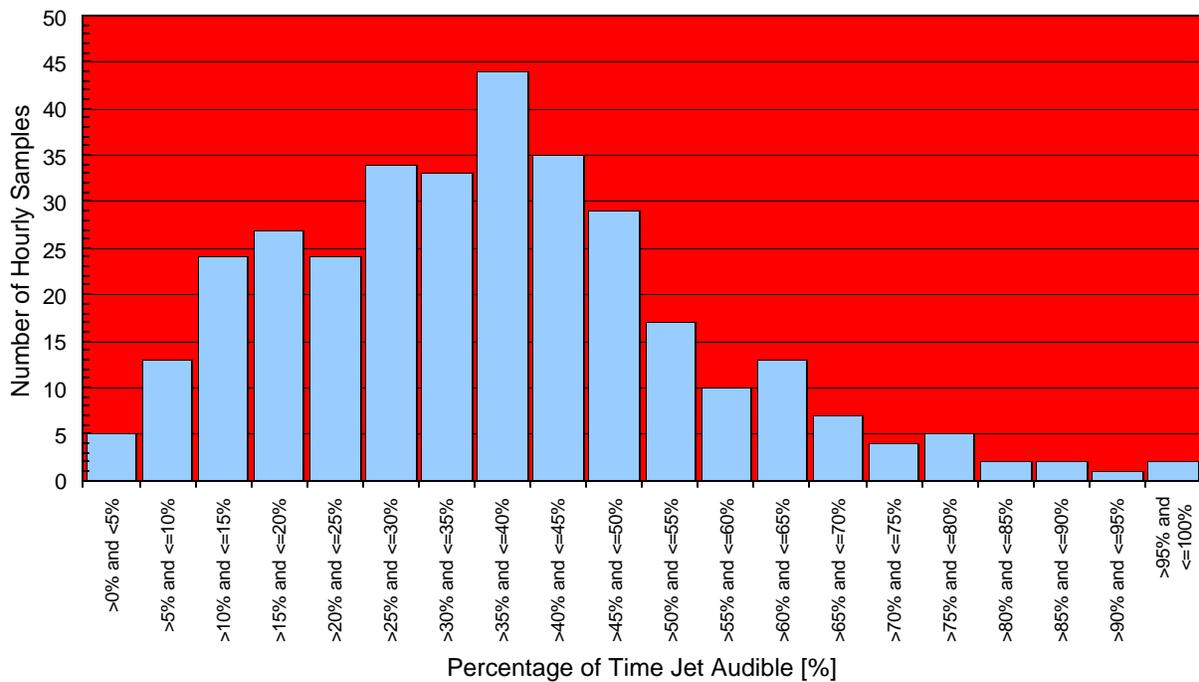
The percentage of time that jet aircraft were audible in the Grand Canyon was calculated for each site on an hourly basis. Results of the audibility logging were conducted by importing the data into a spreadsheet program and cumulating the periods of time that jet aircraft and non-aircraft acoustic states were logged. There are a total of 330 site-hours that contain audibility logging data. Figure 2 shows the percentages of time that jets were audible for each hour of the three-day measurement period for all sites combined. The blue circles represent the individual measurements conducted at each site, the black line represents the average percentage of time that jets were audible for that hour across all sites, and the red lines show the range of +/- one standard deviation about the average of the population of hourly data. There are many factors that can lead to differences in jet audibility among different sites during the same hour, such as distance to the jet flight path, acoustic shielding from the terrain, ambient sound levels, the amount of time propeller aircraft or helicopters were logged, and human observer hearing threshold. Figure 2 shows how the differences in jet aircraft audibility that were measured among all of the sites vary during the same hours, and for different hours in each day.

The average jet audibility across all sites for each hour of the day is a straightforward metric to examine trends throughout the day. The highest average jet audibility during the day typically occurred during the two morning hours of 8:00 am to 10:00 am, and averaged about 45% time audible across all sites and days. Jet audibility was lower during the mid-day hours between 11:00 am and 3:00 pm, averaging about 26% time audible. Jet audibility increased again toward the end of the afternoon between 3:00 pm and 5:00 pm to an average of 33% across all sites and days.

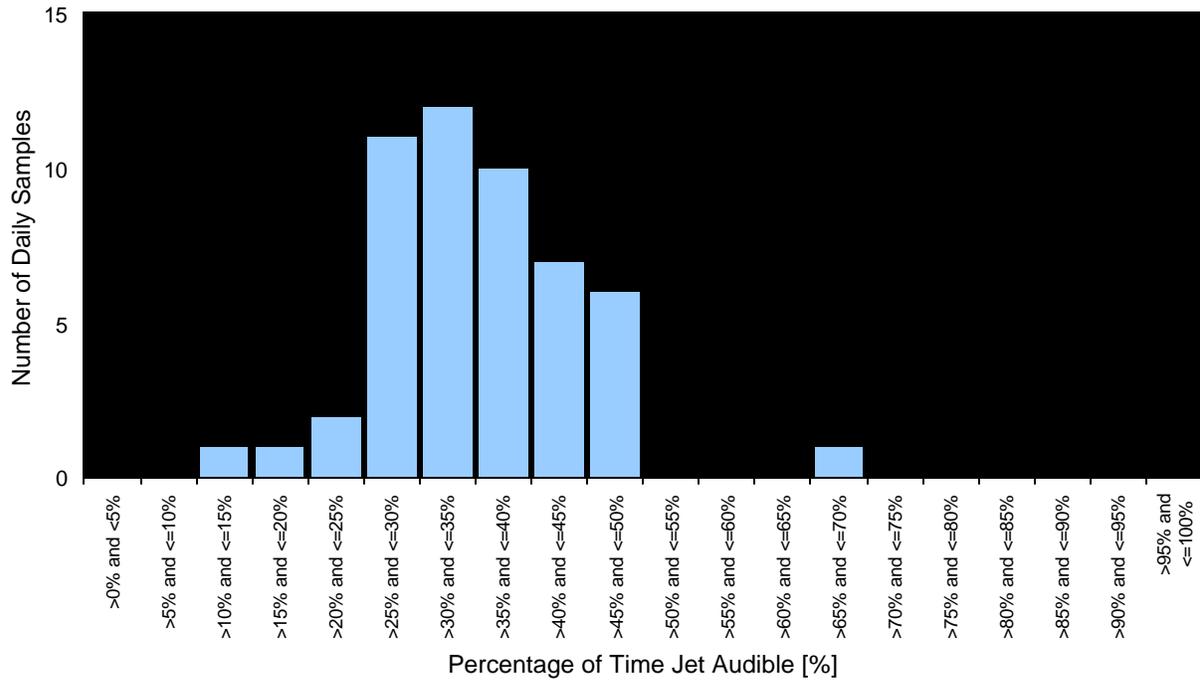
The same hourly data for all sites is presented differently, as a histogram of values, in Figure 3. This histogram shows that the hourly percentage of time jets were audible in the Grand Canyon ranged all the way from 0% to 100%, with the most common percentage of time that jets were audible in any given hour between 35% and 40%. Figure 4 shows a histogram of percentages of time jets were audible over the entire day at each site. The lowest daily percentage of time jets were audible was 14.8% at Site 9Fn and the highest daily percentage of time jet were audible was 68.2% at Site 2An. The percentage of time jets were audible for all sites and days individually is also presented in tabular form in Table 1 below.



**Figure 2. Percentages of Time Jets Were Audible Hour-by-hour for All Sites**



**Figure 3. Histogram of Hourly Percentages of Time Jets Were Audible at All Sites**



**Figure 4. Histogram of Daily Percentages of Time Jets Were Audible at All Sites**

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Percentage of Time Jets are Audible in Grand Canyon National Park

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**Table 1. Audibility Logging Results by Site and Date**

Site	Date	Total Logging Time [seconds] COL A	“Tour” Aircraft Audible [seconds] COL B	“Other” Aircraft Audible [seconds] COL C	Jet Aircraft Audible [seconds] COL D	Percentage of Time Jets are Audible [Col D / (Col A – Col B – Col C)]*100
1Ah	09/12/99	21,850	449	5,519	7,421	46.7%
1Bn	09/12/99	20,816	1,132	1,242	5,874	31.9%
2Ah	09/10/99	19,974	104	1,959	7,854	43.9%
2An	09/10/99	3,564	0	59	2,391	68.2%
2Bn	09/13/99	18,918	885	378	7,083	40.1%
2Cn	09/10/99	9,018	101	156	3,205	36.6%
2Dh	09/13/99	22,961	636	2,369	7,809	39.1%
3Av	09/10/99	22,307	2,228	1,260	6,692	35.6%
3Bv	09/12/99	27,415	4,671	2,443	6,843	33.7%
3Dv	09/13/99	27,683	1,262	1,319	8,084	32.2%
3Hn	09/10/99	14,996	1,439	1,680	2,978	25.1%
3Jn	09/12/99	15,278	4,827	992	2,980	31.5%
3Kn	09/13/99	23,841	647	1,623	5,855	27.1%
4Ah	09/10/99	26,089	5,027	2,154	6,647	35.2%
4Ah	09/12/99	27,786	8,236	4,767	5,176	35.0%
4Ah	09/13/99	28,394	6,445	4,598	7,976	46.0%
4Bn	09/10/99	19,192	6,441	622	5,497	45.3%
4Cn	09/12/99	21,178	6,809	1,356	4,535	34.8%
4Dn	09/13/99	9,863	758	532	2,452	28.6%
4En	09/13/99	10,933	911	173	2,662	27.0%
5An	09/12/99	28,408	15,649	0	3,014	23.6%
5An	09/13/99	28,279	13,500	14	3,879	26.3%
5Av	09/12/99	28,432	18,247	41	3,360	33.1%
5Av	09/13/99	27,980	14,026	167	5,578	40.5%
5Bn	09/10/99	27,249	3,508	0	7,342	30.9%
5Bv	09/10/99	27,414	3,626	766	6,802	29.5%
6Av	09/10/99	27,441	8,729	2,166	3,910	23.6%
6Av	09/12/99	27,848	8,876	2,550	5,410	32.9%
6Av	09/13/99	27,781	7,365	2,445	5,255	29.2%
6Bn	09/10/99	12,566	4,499	420	3,808	49.8%
6Cn	09/12/99	18,102	6,134	2,625	4,051	43.4%
6Dn	09/13/99	22,424	6,118	2,073	5,338	37.5%
7Ah	09/10/99	26,415	10,528	454	4,566	29.6%
7Bh	09/12/99	27,555	7,336	1,165	7,598	39.9%
7Ch	09/13/99	27,806	4,711	1,030	7,232	32.8%
7En	09/10/99	19,556	11,669	1,451	2,246	34.9%
7Gn	09/12/99	26,540	12,432	1,862	3,849	31.4%
7Hn	09/13/99	27,741	11,931	1,164	6,333	43.2%
8Ah	09/10/99	23,593	3,379	2,042	5,070	27.9%
8Ah	09/12/99	24,404	10,276	3,078	5,112	46.3%
8Bn	09/10/99	7,175	1,184	301	1,017	17.9%
8Cn	09/12/99	19,395	5,544	1,496	4,406	35.7%
8Dh	09/13/99	10,555	2,787	987	2,614	38.5%
8En	09/13/99	6,444	1,567	514	1,984	45.5%
9Av	09/10/99	26,291	175	1,094	6,338	25.3%
9Bn	09/12/99	24,837	4,476	3,668	6,414	38.4%
9Cv	09/12/99	25,455	16,139	2,174	2,013	28.2%

9Dv	09/13/99	19,372	628	1,067	5,362	30.3%
9En	09/10/99	10,610	1,466	1,034	3,590	44.3%
9Fn	09/10/99	8,980	2,427	233	933	14.8%
9Fn	09/13/99	24,153	12,051	1,437	4,493	42.1%

## 4.2 Results By Site

The following figures show the percentages of time jets were audible at each group of sites individually on an hour-by-hour basis. Displaying the data in this manner shows the variation in jet aircraft audibility as heard in different areas of the Grand Canyon, and permits site-to-site comparisons.

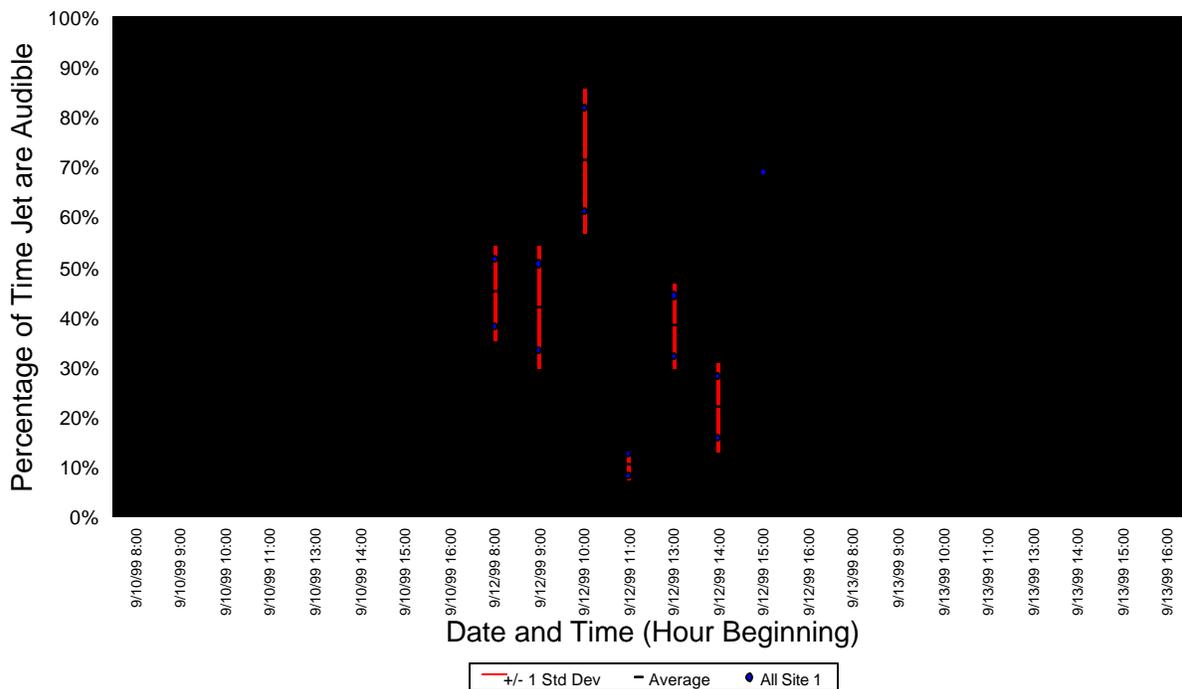


Figure 5. Percentage of Time Jets Were Audible at Sites 1Ah and 1Bn

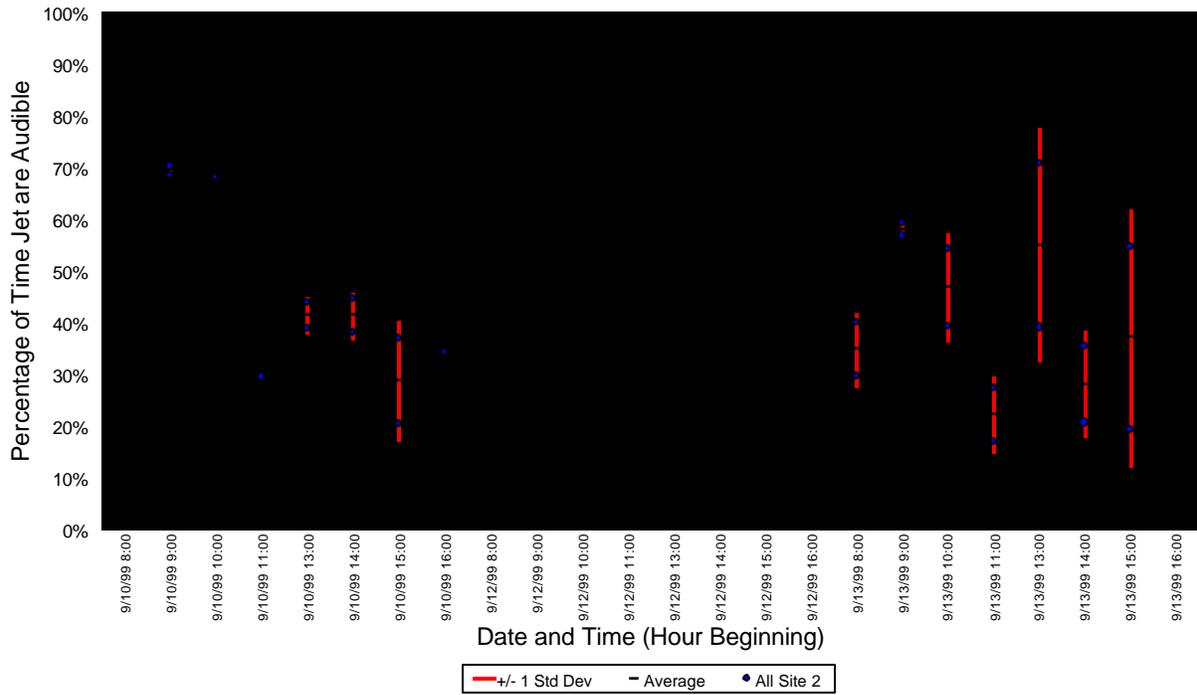


Figure 6. Percentage of Time Jets Were Audible at Sites 2Ah, 2An, 2Bn, 2Cn and 2Dh

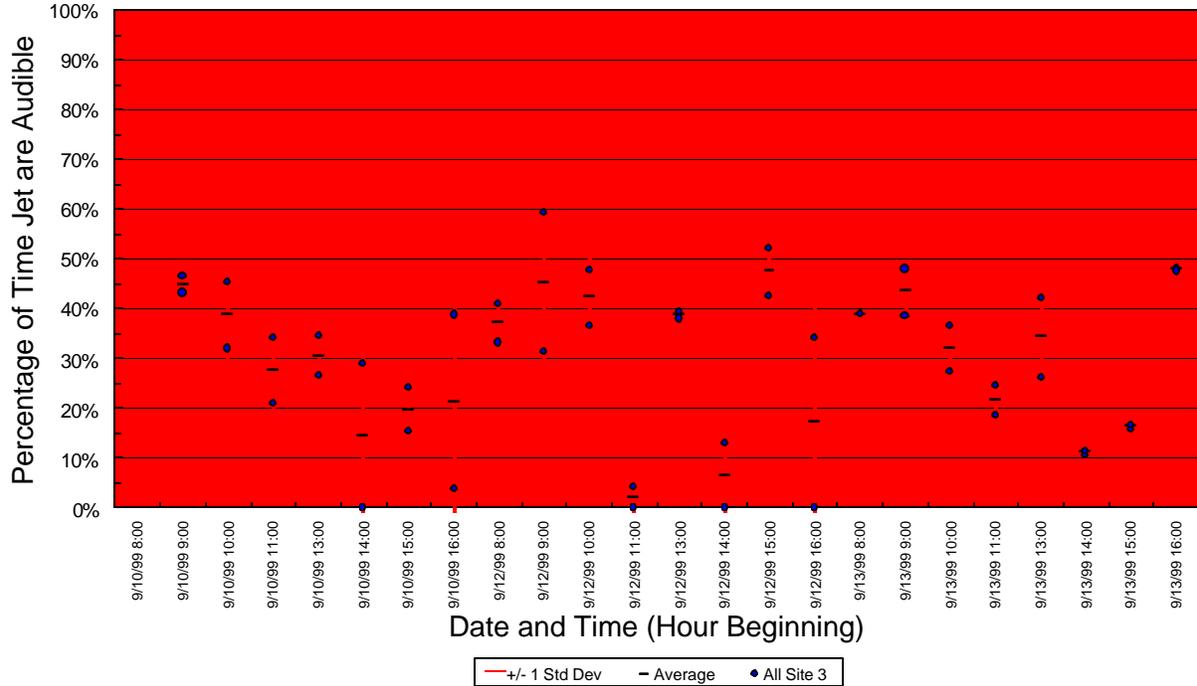
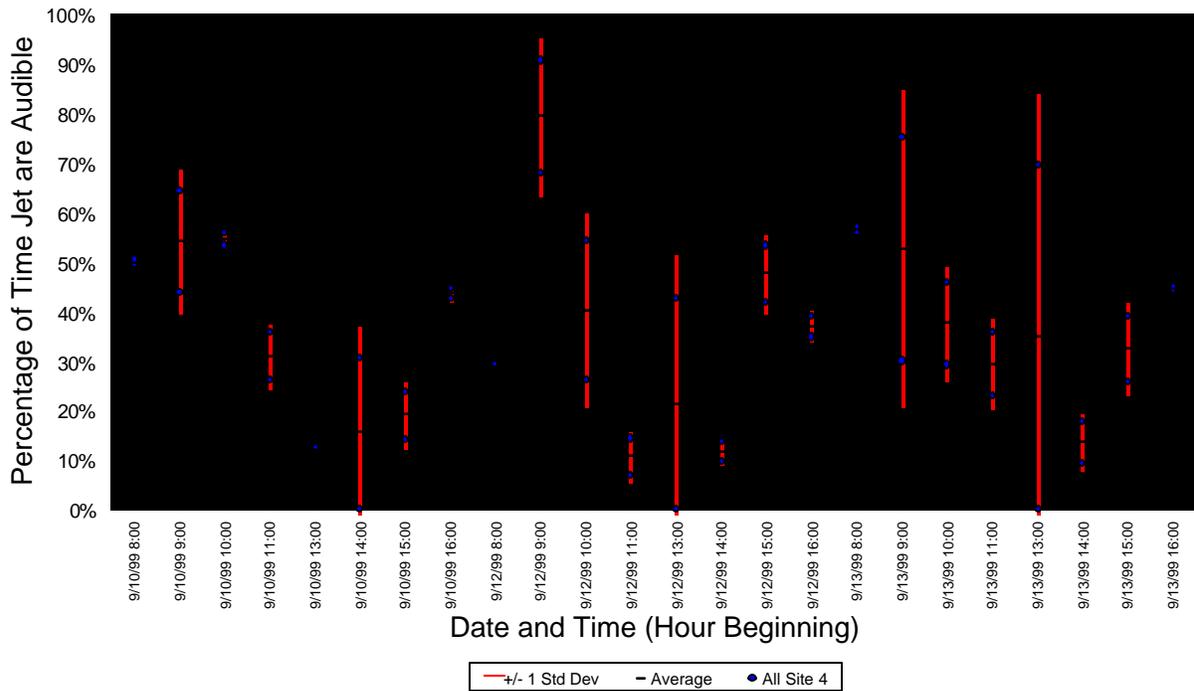
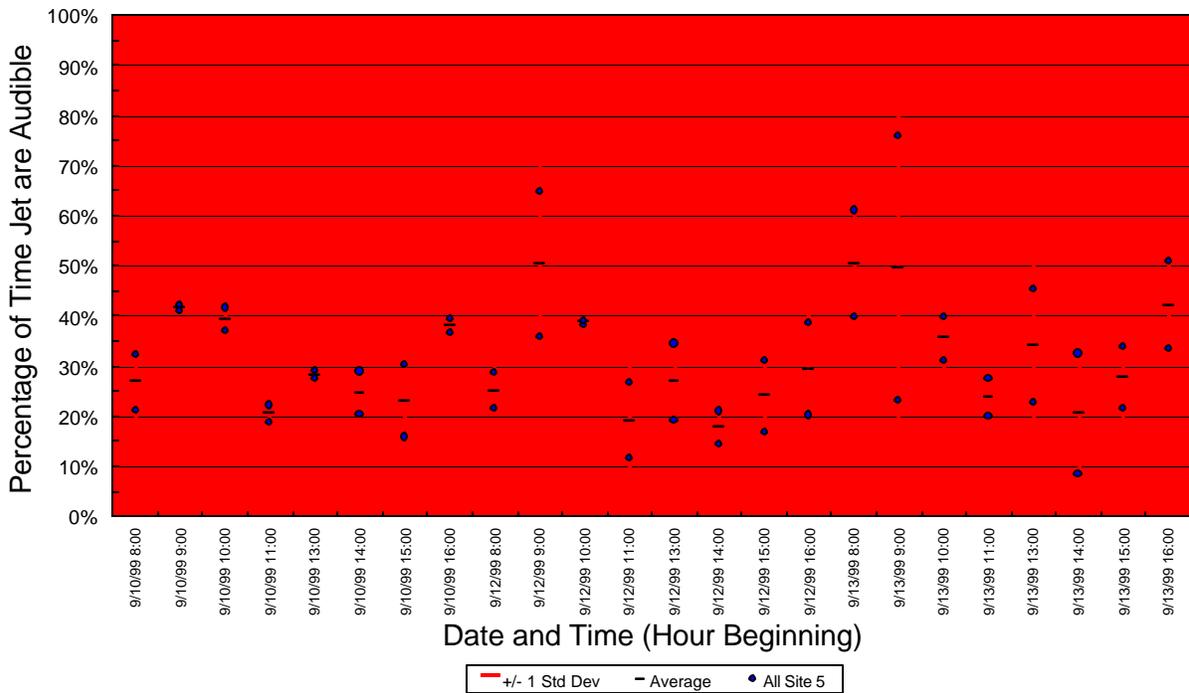


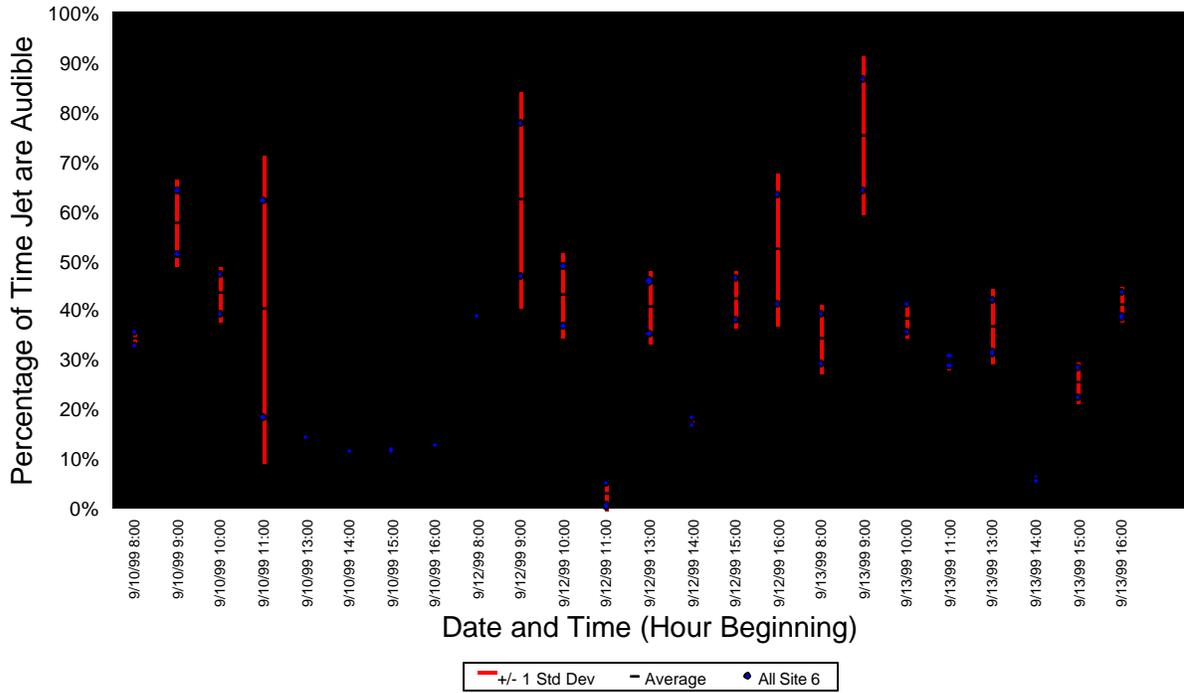
Figure 7. Percentage of Time Jets Were Audible at Sites 3Av, 3Bv, 3Dv, 3Hn, 3Jn and 3Kn



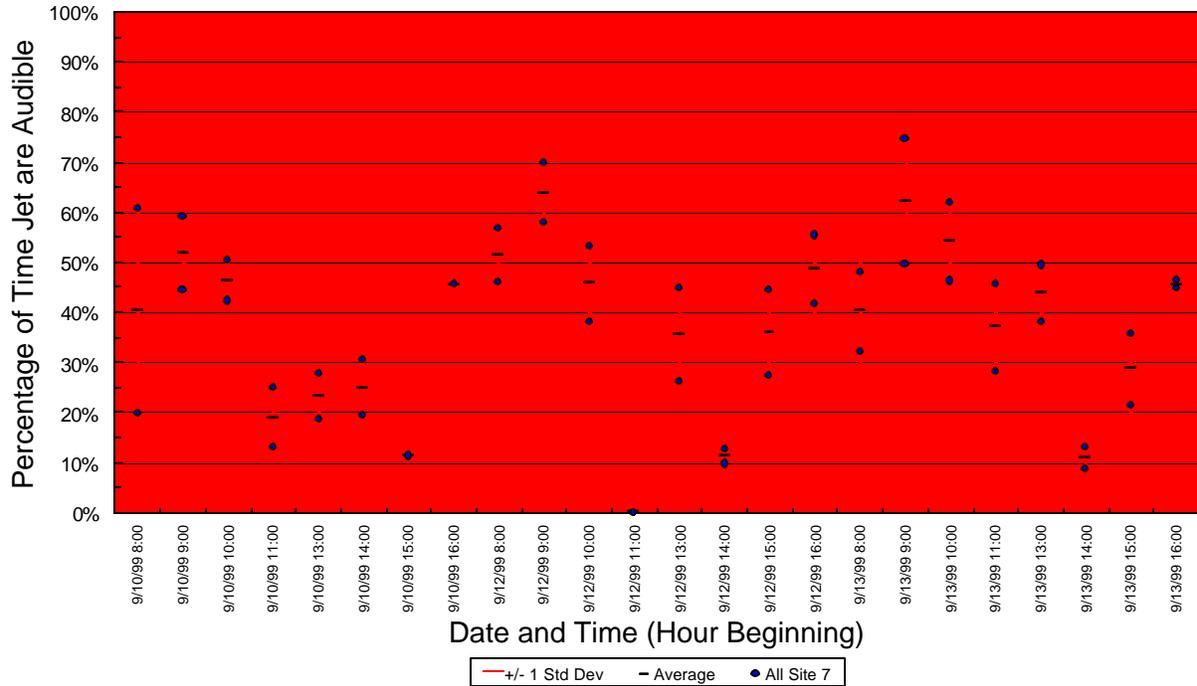
**Figure 8. Percentage of Time Jets Were Audible at Sites 4Ah, 4Bn, 4Cn, 4Dn, 4En**



**Figure 9. Percentage of Time Jets Were Audible at Sites 5An, 5Av, 5Bn and 5Bv**



**Figure 10. Percentage of Time Jets Were Audible at Sites 6Av, 6Bn, 6Cn and 6Dn**



**Figure 11. Percentage of Time Jets Were Audible at Sites 7Ah, 7Bh, 7Ch, 7En, 7Gn and 7Hn**

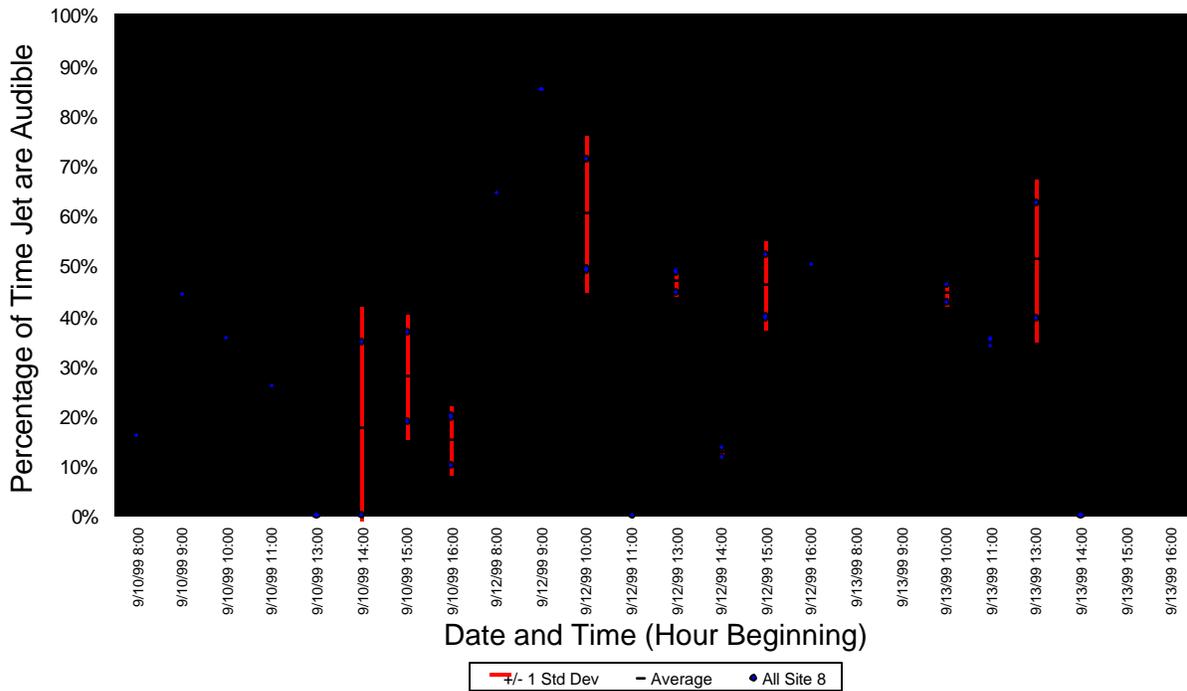


Figure 12. Percentage of Time Jets Were Audible at Sites 8Ah, 8Bn, 8Cn, 8Dh and 8En

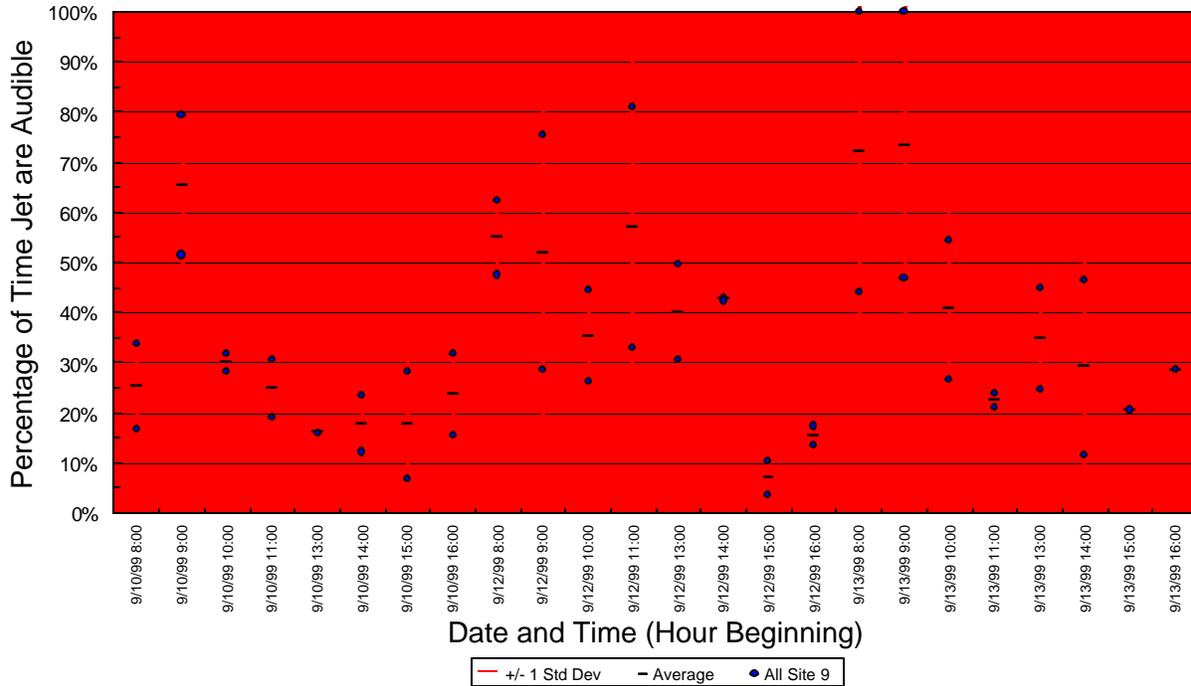


Figure 13. Percentage of Time Jets Were Audible at Sites 9Av, 9Bn, 9Cv, 9Dv, 9En and 9Fn