AAMRL-TR-78-109

NOISEMAP 5.1 COMPUTER PROGRAM UPDATE, OPERATOR'S MANUAL

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

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This report, an addendum to AMRL-TR-78-109, describes new capabilities for the NOISEMAP program that allows for the SAE AIR 1751 lateral attenuation algorithm to be substituted for the current NOISEMAP lateral attenuation algorithm for generating noise contours resulting from civil aircraft operations. When used in this mode for civil airport studies, the results normally agree within 0.5 dB with contours computed using the FAA Integrated Noise Model for the same civil aircraft operations. This version of NOISEMAP has been approved for Federal Aviation Regulation Part 150 studies when used with this option invoked. In addition, the NOISEMAP version number is now printed at the top of each output page.

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I. INTRODUCTION

NOISEMAP is a digital computer program which calculates the noise exposure from aircraft flight and ground run-up operations around civil and military airfields. This program was developed in 1974 under United States Air Force sponsorship to meet the need for a comprehensive land use planning tool relating to aircraft noise. The program operates in concert with a general purpose terrain contouring program to produce high quality noise contour maps. These contour maps define zones of noise exposure and are frequently used in land use compatibility analyses.

In addition to the computer program, a comprehensive military aircraft data base has also been developed by the Air Force. This data base provides the aircraft noise data needed by NOISEMAP. At this time, the most current release of this data base is NOISEFILE 5.1.

Since the original NOISEMAP development effort in 1974, the Air Force has provided continued support to maintain and refine the data base and to upgrade the computer program with additional capabilities. This report documents the latest NOISEMAP updates. This update adds the SAE AIR 1751 lateral attenuation algorithm as a user selectable option in lieu of the original NOISEMAP algorithm. The lateral attenuation algorithm is used in computing sound propagation at low angles of elevation between the aircraft and horizon.

Section II of this report provides a brief technical discussion of the lateral attenuation issue. Section III presents a NOISEMAP user's guide addendum describing how the SAE algorithm may be invoked. Appendix A discusses how the SAE algorithm was implemented. Appendix B describes additional modifications which resolve conditions known to produce abnormal program termination or (under extremely rare circumstances) minor computational discrepancies. Appendix C discusses test cases used to verify the functioning of the SAE algorithm.

II. TECHNICAL DISCUSSION

Since its inception NOISEMAP has consistently used a single algorithm to address the lateral attenuation issue. This algorithm finds its origin in an early Noise Exposure Forecast (NEF) computer program developed for the Federal Aviation Administration (FAA) in the late 1960s.

As it is commonly used today, the term "lateral attenuation" refers to attenuation in excess of that accounted for by spherical spreading and air absorption at ground positions to the side of runways and major flight corridors. At ground positions directly beneath flight corridors, it is assumed that spherical spreading and air absorption account for all sound attenuation.

Lateral attenuation embodies two basic concepts. One is the notion that when the sound source (i.e., the aircraft) is on the ground, the sound wave must propagate over the ground plane to reach the observer. This propagation regime is frequently referred to as ground-to-ground propagation. It is generally acknowledged that in this regime the sound level intensity is likely to be reduced over that which would be observed for sound traveling a comparable distance from an airborne source (air-to-ground propagation). The empirical evidence strongly supports this position.

The reasons for the additional attenuation are still a subject of discussion within the scientific community. Basically, they may be summarized as (1) the reflective effects of a finite impedance ground plane, (2) the effects of acoustic barriers such as houses, foliage, terrain irregularities, etc., (3) atmospheric effects such as wind, and temperature gradients, and (4) the sound source shielding effects of the airframe fuselage on sound propagation from far-side engines (relative to the observer).

The second notion is that there must be some transition region between the ground-to-ground and air-to-ground propagation regimes. Conventional wisdom suggests that this transition region is a function of the angle of elevation of the aircraft with respect to the ground plane, subtended by the observer.

The NOISEMAP algorithm treats these two concepts as independent phenomena. To address the former, the NOISEMAP data base contains two sound exposure level (SEL) versus slant distance profiles for each aircraft ... one is for air-to-ground propagation, the other for ground-to-ground propagation. The transition region between the two regimes is determined by angle of elevation. For angles up to 4.3 degrees only ground-to-ground propagation is assumed. Above 7.2 degrees only air-to-ground propagation is assumed. For 4.3 to 7.2 degrees a linear transition is assumed between the two regimes.

The SAE AIR 1751 algorithm uses a somewhat different approach. A single function, independent of aircraft type, is used to predict the difference between ground-to-ground and air-to-ground propagation. A second function describes the transition region. In contrast to the NOISEMAP algorithm the transition region covers a much broader range of angles of elevation (0 to 60 degrees).

Generally speaking, the SAE algorithm tends to predict greater attenuation (and, hence, smaller contours in the transition region) than does the NOISEMAP algorithm. Elsewhere the contours produced by the two algorithms are not substantially different.

III. USER'S GUIDE ADDENDUM

NOISEMAP 5.1 is fully upwardly compatible with all predecessor versions of the program. That is, an input file prepared for a lower version number will produce identical results with NOISEMAP 5.1. No input file modifications are required. The current version identifies itself in the Chronicle listing in two ways. First, the alignment pages carry the new version number. Second, "NOISEMAP 5.1" is printed in the banner at the top of each page of Chronicle output. An illustration is shown in Figure 1.

```
86/10/30.AMRL TEST (CIVILIAN & MILITARY)   MARCH 1986                        PAGE    18
 DNL     ------------------------  N O I S E M A P   5.1  -------------------------


                                     --------------------------
   +++                                   R U N W A Y    09
                                     --------------------------
        LENGTH 10000.0 FT, GL. SLOPE  3.00 DEG, HEADING  90.0 DEG
        START ( 150000.0,  250000.0),  END ( 160000.0,  250000.0)
        DISPLACEMENTS - TAKEOFF       0.0, LANDING       0.0


   +++  TAKE-OFFS     FLIGHT TRACK  09D1        DEPARTURE   09D1
                      PROCEED   300000. FT

                          FLIGHT OPERATIONS   -  TRACK 09D1
                        A/C NO  MISSION       -     0701-2200 2201-0700

   +++   F-4  ST          31       221                10.000     0.000
   +++   B52G ST          43       221                10.000     0.000
   +++   C-5A ST          22       221                10.000     0.000
   +++   C130 ST           6       221                10.000     0.000
   +++   2PP <           942         1                10.000     0.000  (SAE 1751)
   +++   4TFL  3         803      2303                10.000     0.000  (SAE 1751)
   +++   2PP ^           941         1                10.000     0.000  (SAE 1751)
   +++   2TFL  3         826       923                10.000     0.000  (SAE 1751)

   +++  RESET DATA BASE TO INITIALIZATION VALUES
```

FIGURE 1. NOISEMAP 5.1 Chronical Page Showing Revised Page Banner and SAE Annotations for Flight Listings

NOISEMAP 5.1 recognizes one new key word directive, SAELAT. This key word is used to select one of two lateral attenuation algorithms for sound propagation computations. The two algorithms are (1) the SAE AIR 1751 lateral attenuation algorithm and (2) the original NOISEMAP lateral attenuation algorithm. In the absence of the SAELAT directive, the program defaults to the original NOISEMAP algorithm.

The lateral attenuation algorithm specifies rules for calculating the amount of excess sound attenuation to be added to the air-to-ground SEL vs. distance curves in order to predict the ground-to-ground regime. It also provides an orderly means for transition between the two regimes.

The SAELAT key word (in columns 1-6) is used to toggle between the SAE lateral attenuation algorithm and the original NOISEMAP algorithm. It establishes the algorithm to be used until the next occurrence of the key word. The word ON in columns 71-74 enables the SAE algorithm. The word OFF in columns 71-74 restores the program to the original NOISEMAP algorithm. The SAELAT chronicle listing and input format are shown below.

```
+++  SAE AIR 1751 LATERAL ATTENUATION ALGORITHM ENABLED
                   AIRCRAFT NUMBERS INCLUDED
                   -------------------------
                        800 THROUGH     999
```

Columns	Contents
1 - 6	SAELAT
7 - 14	Lower A/C number bound, range 1
15 - 22	Upper A/C number bound, range 1
23 - 30	Lower A/C number bound, range 2
31 - 38	Upper A/C number bound, range 2
39 - 46	Lower A/C number bound, range 3
47 - 54	Upper A/C number bound, range 3
55 - 62	Lower A/C number bound, range 4
63 - 70	Upper A/C number bound, range 4
71 - 74	ON (anywhere in field)

The SAELAT card with the word "ON" in columns 71 to 74 invokes the use of the SAE lateral attenuation algorithm on a selective basis for only those flights whose aircraft identification numbers lie within a specified range. If columns 7 to 70 are left blank this range defaults to 800 through 999 (the currently used aircraft numbers for the civil fleet). The user may override the default range by supplying a range (or ranges) of his own (up to four) as shown above. Each of the four ranges consists of a pair of numbers. The first number is the numerically lowest aircraft identification number to be included in the range. The second is the numerically highest identification number to be included. Each range need not be mutually exclusive of any other -- overlapping or wholly contained ranges are legal. In this manner the SAE algorithm may be applied selectively to several different groups of aircraft. It may also be applied to all aircraft by placing a "1" in columns 7-14 and "99999999" in columns 15-22.

The word "OFF" in columns 71-74 disables the SAE algorithm and the program restores the original NOISEMAP algorithm for all aircraft. The chronicle echo and the input card image format are shown below.

+++ SAE AIR 1751 LATERAL ATTENUATION ALGORITHM DISABLED

Columns	Contents
1 - 6	SAELAT
7 - 70	- blank -
71 - 74	OFF (anywhere in field)

The SAE algorithm may be enabled and disabled any number of times throughout the input file. There are no restrictions as to where these key word directives may appear or how often. The presence of an AIRFLD key word does, however, restore the program to the default condition (SAELAT OFF).

For those portions of the input file where the SAE algorithm is enabled, the program prints "(SAE 1751)" in the chronicle listing to the right of the number of day/night operations of each flight utilizing the algorithm. For flights not utilizing the SAE algorithm (either because it has been disabled or because an aircraft identification number does not lie in the SAE inclusion range) no message is printed. An example is shown in Figure 1.

In addition, flights appearing on specific point summary pages are flagged if the SAE algorithm has been used. An asterisk printed to the right of the aircraft identification number along with a corresponding footnote at the bottom of the page identifies flights utilizing the SAE algorithm. An example is shown in Figure 2.

SUMMARY OF AIRCRAFT FLIGHT OPERATIONS AT SPECIFIC GROUND LOCATION 1

X = 170000.0 FT Y = 250000.0 FT
(20000.0 FT FROM START OF RUNWAY 09 ... 0.0 FT LEFT OF CENTERLINE)

RANK	1	2	3	4	5	6
AIRCRAFT	43	22	31	803*	826*	6
MISSION	221	221	221	2303	923	221
FLIGHT TRK	09D1	09D1	09D1	09D1	09D1	09D1
POWER	94 % RPM	4.92 EPR	100 % RPM	-- N/A --	-- N/A --	977 C TIT
AIRSPEED	170 KTS	250 KTS	300 KTS	-- N/A --	-- N/A --	130 KTS
ALTITUDE	991 FT	1023 FT	1528 FT	1168 FT	1940 FT	953 FT
SLANT DIST	995 FT	1024 FT	1536 FT	1168 FT	1947 FT	958 FT
ELEV ANGLE	84.86 DEG	89.21 DEG	84.00 DEG	87.89 DEG	84.87 DEG	84.17 DEG
EVENTS DAY	10.000	10.000	10.000	10.000	10.000	10.000
NIGHT	0.000	0.000	0.000	0.000	0.000	0.000
SEL	120.47 DB	113.90 DB	111.74 DB	100.11 DB	93.37 DB	91.97 DB
DNL	81.07 DB	74.50 DB	72.34 DB	60.71 DB	53.96 DB	52.57 DB
CUMUL DNL	81.07 DB	81.93 DB	82.38 DB	82.41 DB	82.42 DB	82.42 DB

RANK	7	8	9	10	11	12
AIRCRAFT	941*	942*	22	43	31	803*
MISSION	1	1	225	225	225	2225
FLIGHT TRK	09D1	09D1	09A1	09A1	09A1	09A1
POWER	-- N/A --	-- N/A --	3.00 EPR	86 % RPM	87 % RPM	-- N/A --
AIRSPEED	-- N/A --	-- N/A --	170 KTS	140 KTS	155 KTS	-- N/A --
ALTITUDE	1510 FT	2013 FT	50 FT	50 FT	50 FT	50 FT
SLANT DIST	1516 FT	2026 FT	20000 FT	20000 FT	20000 FT	20000 FT
ELEV ANGLE	84.98 DEG	83.49 DEG	.14 DEG	.14 DEG	.14 DEG	.14 DEG
EVENTS DAY	10.000	10.000	10.000	10.000	10.000	10.000
NIGHT	0.000	0.000	0.000	0.000	0.000	0.000
SEL	91.90 DB	80.18 DB	71.12 DB	70.36 DB	68.03 DB	65.54 DB
DNL	52.50 DB	40.78 DB	31.72 DB	30.96 DB	28.63 DB	26.14 DB
CUMUL DNL	82.43 DB	82.43 DB	82.43 DB	82.43 DB	82.43 DB	82.43 DB

RANK	13	14	15	16
AIRCRAFT	826*	6	941*	942*
MISSION	895	225	5	5
FLIGHT TRK	09A1	09A1	09A1	09A1
POWER	-- N/A --	932 C TIT	-- N/A --	-- N/A --
AIRSPEED	-- N/A --	143 KTS	-- N/A --	-- N/A --
ALTITUDE	50 FT	50 FT	50 FT	50 FT
SLANT DIST	20000 FT	20000 FT	20000 FT	20000 FT
ELEV ANGLE	.14 DEG	.14 DEG	.14 DEG	.14 DEG
EVENTS DAY	10.000	10.000	10.000	10.000
NIGHT	0.000	0.000	0.000	0.000
SEL	60.04 DB	53.55 DB	52.62 DB	45.63 DB
DNL	20.63 DB	14.15 DB	13.22 DB	6.23 DB
CUMUL DNL	82.43 DB	82.43 DB	82.43 DB	82.43 DB

FLIGHT DNL 82.43 DB
TOTAL DNL 82.43 DB

*SAE AIR 1751 LATERAL ATTENUATION ALGORITHM INVOKED

FIGURE 2. NOISEMAP 5.1 Chronicle Page Showing Specific Point Summary and SAE Footnoting.

APPENDIX A

IMPLEMENTATION

IMPLEMENTATION

Implementation of the SAE AIR 1751 algorithm consisted of modifying both the computational code as well as printed output. The NOISEMAP subroutine which contains the lateral attenuation code is function EPNLD. EPNLD has two calling parameters, aircraft altitude and slant distance to the observer at the closest point of approach. From these parameters both the angle of elevation and the lateral distance from the aircraft flight track can be determined. With this upgrade, EPNLD has two parallel computations paths. One is for the original NOISEMAP algorithm, and the other is for the SAE algorithm. Path selection is determined by a logical variable, FLTSAE. This variable is set or cleared for each aircraft flight depending upon (1) whether the SAE algorithm has been user enabled and (2) whether the aircraft number is within the user established range. If both conditions are met, then the SAE algorithm is selected; otherwise, the original NOISEMAP algorithm is used.

A new subroutine, XSAELA, has been added to service the SAELAT key word. This subroutine reads the variables on the SAELAT card and sets up various arrays and logical variables for subsequent processing.

A new common block, LATCOM, was also added to pass lateral attenuation parameters between subroutines. The existing common block, SUMMRY, was also modified.

Additional subroutines receiving modifications were: ALIGN, INTLZE, NEWPG, PROTECT, PSUMRY, SIMCHK, UPFLSP, XFLIGH. These modifications deal with parameter initialization key word directive recognition and chronicle output listings.

APPENDIX B

ADDITIONAL MODIFICATIONS

ADDITIONAL MODIFICATIONS

In addition to adding the lateral attenuation code, several long standing program deficiencies were also corrected. These may be enumerated as follows:

- code was eliminated in subroutine XFLIGH which circumvents portions of the flight initialization procedure when a second flight of identical aircraft and mission number appears immediately after a preceding one

- code was modified in subroutine PSUMMRY to avoid taking the logarithm of zero under certain conditions relating to specific point processing

- code was modified in subroutines UPFLSP and UPRUSP to ensure that the total sound exposure energy accumulated at each specific ground location includes all flights

- output formats were changed in subroutines XEPNDB and XPNLT so that large (erroneous) sound level values will be properly echoed from the input file without exceeding the output field widths.

APPENDIX C

TEST CASES

TEST CASES

Three input files were prepared by United States Air Force personnel to validate NOISEMAP 5.1. Each data file contained a scenario consisting of a single east/west runway with all operations flowing in an easterly direction on straight-in/out flight tracks. Both takeoffs and landings were included.

In addition, four specific ground locations were included. Each location was selected to be coincident with an x/y grid point location used for contour plotting. These positions were (1) directly beneath the departure path, (2) directly beneath the arrival path, (3) along the runway sideline, and (4) along the approach path sideline. Each file also included directives to print the x/y grid of noise exposure values and plot noise exposure contours using the Calcomp GPCP II contouring program.

The three test files differed in the aircraft mix contained within them. The mixes may be summarized as follows:

- Civil only (aircraft identification numbers in the range of 800 to 900)
- Military only (aircraft identification numbers outside the range of 800 to 900)
- Civil and military aircraft together

Seven test cases (using the above input files) were run at the United States Air Force Engineering Services Center (ESC), Tyndall AFB, Florida. These test cases are identified in Table C-1. The differences between the test cases involved the input file used, the presence or absence of the SAELAT directive, and the NOISEMAP version (4.4 or 5.1) used for computation.

TABLE C-1

NOISEMAP 5.1 Test Case Conditions

Case	Input File	"SAELAT" Directive	"SAELAT" A/C# Range	NOISEMAP Version
1	Civil	No	--	4.4
2	Civil	No	--	5.1
3	Civil	Yes	Default	5.1
4	Military	No	--	5.1
5	Military	Yes	Default	5.1
6	Civil & Military	Yes	Default	5.1
7	Civil & Military	Yes	4 Ranges 1 to 10,000 Inclusive	5.1

1) Upward Compatibility

The output from test cases 1 and 2 were compared to ensure that NOISEMAP 4.4 and NOISEMAP 5.1 would produce identical results with the same input file. The results of the comparison showed that all grid point values were identical between the two test cases and all specific point values for both cumulative DNL and individual aircraft SELs were identical. Contour plots, using the GPCP II software package also matched within the accuracy of the plotter pen-width.

2) SAE Algorithm Invocation -- Civil Aircraft

Test case 3 was prepared to demonstrate the proper invocation of the SAE lateral attenuation algorithm. Case 3 was identical to Case 2 (only civil aircraft) except for the inclusion of the new SAELAT directive placed at the beginning of the input file. An analysis of Case 3 output showed that the chronicle listing properly prints the "(SAE 1751)" caption to right of all flights, and also correctly footnotes the use of the algorithm on specific point summary pages.

Comparison of Cases 2 and 3 also confirms that comparable grid point DNL values directly beneath the flight tracks are near identical and that sideline levels are somewhat reduced using the SAE algorithm instead of the original NOISEMAP algorithm. The maximum observed reduction with the SAE algorithm was 5 decibels, along the runway sideline.

3) SAE Algorithm Invocation -- Military Aircraft

Cases 4 and 5 were prepared to demonstrate that the default invocation of the SAE algorithm has no effect on aircraft in the military fleet. The only difference between these two cases was the inclusion of the SAELAT directive in Case 5 and not in Case 4. A comparison of the output for these cases reveals that there are no differences in Chronicle listings, including specific point SEL and DNL summary values. In addition, grid point values were identical for the two cases.

4) Differentiation Between Civil and Military Aircraft

Case 6, consisting of both civil and military aircraft was prepared to demonstrate that the program properly distinguishes between civil and military aircraft. This case included the SAELAT card at the beginning of the file, with the default aircraft number range. An examination of the chronicle listing for this case shows that the caption "(SAE 1751)" is printed to the right of all civil flights and is not printed next to military flights. The specific point summary pages include the "*" footnote only on the civil flights.

5) Default Override of Aircraft Identification Number Range

Case 7 was prepared to demonstrate that the inclusion of a user specified aircraft number range with the SAELAT directive would override the default range (800 to 999). Four ranges (the maximum allowable) were specified. They included continuous groups of both civil and military aircraft. An examination of the chronicle listing and the specific point output pages confirmed that aircraft numbers within the specified ranges used the SAE algorithm and those outside the range did not.

6) SAE Algorithm -- Numerical Test

The SAE algorithm coded in function EPNLD was tested separately from the rest of the program to ensure that it performed properly. This test involved extracting the recoded EPNLD program module from the main program file and writing a short driver program to test the function at all combinations of angle (from 0 to 70 degrees in five-degree increments) and lateral distance (from 0 to 3,600 feet in 200-foot increments). The computed data points for two conditions were compared with the respective curves published with SAE AIR 1751. These conditions included (1) angles from 0 to 70 degrees with distance held constant at 3,600 feet and (2) distances from 0 to 3,600 feet with angle held constant at 0 degrees. Agreement with the published curves was within plotting accuracy of less than 0.5 decibels.

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