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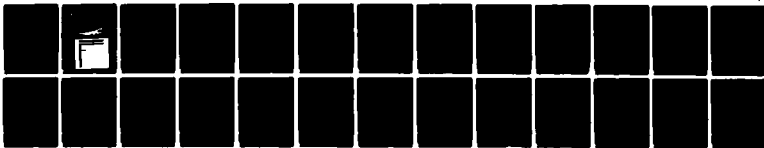
AREA EQUIVALENT METHOD VISICALC (TRADE NAME)(U) FEDERAL 1/1  
AVIATION ADMINISTRATION WASHINGTON DC OFFICE OF  
ENVIRONMENT AND ENERGY T L CONNOR ET AL. FEB 84

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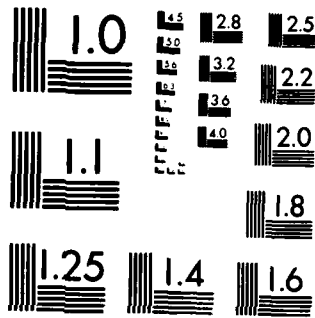
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MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

# AREA EQUIVALENT METHOD on VISICALC®

By: Thomas L. Connor  
David N. Fortescue

February 1984  
Report No. EE-84-8

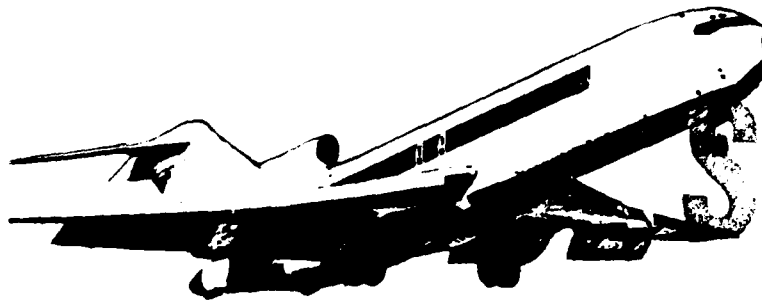
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1	DNLAEM			
2	Day Night Average Sound Level			
3	Area Equivalent Method			
4				
5	<<< Title (hit) to start			
6	<<< Level (1, 2, 3, or 4) to use			
7				
8				
9	Amount		LTO Cycle	
10		Day	Night	Weighted
11	11	11	11	11
12	11	11	11	11
13	11	11	11	11
14	11	11	11	11
15	11	11	11	11
16				
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Technical Report Documentation Page

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16. Abstract <p>This document contains instructions to execute the Area Equivalent Method (AEM). The AEM requires the VISICALC software package and an Apple IIe personal computer or a calculator.</p> <p>The Area Equivalent Method is a mathematical process to calculate Day Night Average Sound Level (DNL) contour area. The AEM is easy to use and is intended as a screening procedure to determine the need for an airport Environmental Impact Statement, (EIS).</p>			
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### ACKNOWLEDGEMENT

The Area Equivalent Method (AEM) was originally developed for the Environmental and Energy Programs Division, Office of Economic Analysis of the Civil Aeronautics Board (CAB). CAB wanted a quick way to determine airport Noise Exposure Forecast (NEF) contour area. The firm of J. Watson Noah Inc. created the original versions of AEM for computer, programmable calculator and pencil and paper (Reference 1). The AEM described within this report draws upon the techniques developed by J. Watson Noah Inc. with updated parameters to calculate Day Night Average Sound Level (DNL) contours.

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## 1.0 INTRODUCTION

The Area Equivalent Method is a mathematical procedure that provides the noise contour area of a specific airport given the types of aircraft and the number of operations for each aircraft. The noise contour area is a measure of the size of the land mass enclosed within a level of noise as produced by a given set of aircraft operations.

The noise contour metric is the Day Night Average Sound Level (DNL) which provides a single quantitative rating of a noise level over a 24-hour period. This rating involves a 10 decibel penalty to aircraft operations during nighttime (between 10pm and 7am) to account for the increased annoyance in the community.

The AEM produces contour areas (in square miles) for levels of 65 and 75  $L_{dn}$ . The AEM is used to develop insights as to the noise impact of an airport on its surrounding communities, as well as the potential increase or decrease of noise resulting from a change in aircraft operations.

The AEM is a useful screening tool in airport planning and development.

The following text will provide a more detailed explanation of the AEM as well as instructions for use of the AEM on the Apple® II plus or IIe using the VISICALC® software program. Instructions on the AEM calculator method are also included.

## 2.0 DESCRIPTION

According to FAA Order 1050.1C, "Policies and Procedures for Considering Environmental Impacts," an assessment must be made to determine the noise impact of a proposed airport action. This assessment compares the present noise impact on the environment with that of the proposed change. If the noise impact is significant then the FAA requires an Environmental Impact Statement (EIS). If the increase of noise impact on the community is not significant then the FAA prepares a Finding of No Significant Impact (FONSI), which briefly outlines the specifications of the change in airport operations for that particular airport.

An Environmental Impact Statement is a long and involved process which requires use of an airport noise computer model such as the Integrated Noise Model (INM). The INM is a complex and detailed procedure which determines the DNL noise contour area for a specific mix of aircraft, and plots the contour lines relative to runway configuration. The INM is a useful procedure for airport planners, airport operators and local governments in assessing the noise impact to the community around an airport. The INM offers the capability to analyze several operational controls beyond simply changing aircraft mix. The INM is the most appropriate tool for EIS, Airport Noise Control and Land Use Compatibility (ANCLUC), Part 150 and other federally funded airport environmental studies.

The FAA informally adopted the Noise Screening Methodology, developed by the Civil Aeronautics Board (CAB), to decide whether the noise impact due to a change is significant. CAB promulgated this noise screening procedure in 14 CFR 312 Appendix I. It is commonly called the "CAB Procedure." CAB established a decision criterion of 17% increase in cumulative noise contour area. If the percentage difference due to the change is less than 17%, no further study is necessary. A 17% increase in cumulative noise contour area translates into a one decibel increase in the airport noise. The Area Equivalent Method (AEM) is an outgrowth of the CAB Procedure. The FAA applies the same decision criterion to AEM as the CAB does with the Noise Screening Methodology.

The AEM is a screening procedure used to simplify the assessment step in determining the need for an EIS. The purpose of the AEM is to show change in airport DNL noise contour area relative to a change in aircraft mix and number of operations. The AEM determines the DNL noise contour area in square miles for a mix and number of aircraft types. The basis of AEM is the equation which determines the DNL noise contour area as a function of the number of daily operations. The AEM applies parameters derived from INM output to determine a contour area for each aircraft. The AEM then develops a single equation, representing the specific mix and number of aircraft to produce the contour area for an airport. The contour area produced by the AEM approximates the contour area produced by the INM for a particular airport case.

### 3.0 DEVELOPMENT

The AEM determines the Day Night Average Sound Level (DNL) noise contour area (in square miles) for a specific case of aircraft operations, given the mix of aircraft types and the number of landing-takeoff cycles (LTOs) per aircraft. In order to create the AEM, aircraft specific parameters relating DNL noise contour area to LTOs were derived from INM output for 65 and 75  $L_{dn}$ . These parameters, represented by the variables  $a$  and  $b$ , are constants which produce the 65 or 75  $L_{dn}$  contour area due specific number of operations of an aircraft from the following equation:

$$A = aN^b$$

The constant  $a$  is the noise contour area in square miles of a single LTO for an aircraft. The constant  $b$  is a scaling parameter which determines the change in contour area relative to a change in the number of effective LTOs for an aircraft. The noise contour area,  $A$ , is the result of applying the parameters  $a$  and  $b$  to  $N$ , the number of effective LTOs. The number of effective LTOs is the sum of the daytime LTOs and the nighttime LTOs of an aircraft. The nighttime LTOs are weighted by a multiple of 10 due to the added amount of annoyance to the community during the nighttime hours between 10pm and 7am.

The Integrated Noise Model (INM) Version 3.8 was used to produce aircraft noise contour areas for specific numbers of LTOs. INM was run for each of the 66 aircraft in the INM Version 3.8 data base. The parameters  $a$  and  $b$  are determined from the linear regression equation:

$$\log A = \log a + b \cdot \log N$$

Figure 3-1 illustrates the linear regression lines (solid lines) derived from this logarithmic equation for each DNL. The INM produced the contour areas as shown by the symbols  $\square$ ,  $\Delta$ ,  $\times$ ,  $\nabla$  and  $*$ . The graph is based on a log - log relationship between the contour area in square miles and the number of LTOs of an aircraft at different values of DNL. The AEM, however, uses only the 65 and 75  $L_{dn}$  equations. Below each regression line on the graph is the equation of that line and a value for  $r$ . The equation is the linear transformation of the logarithmic equation with the parameters  $a$  and  $b$  and  $N$ :

$$A = aN^b$$

The correlation coefficient,  $r$ , indicates how well the regression line represents the relationship of contour area to  $a$ ,  $b$  and  $N$ . An  $r$  value of 1.0000 indicates a perfect correlation between the equation and the calculated contour areas for that DNL. The parameters and correlation coefficients for all 66 aircraft in the INM Data Base #8 are given in Table 3-1.

The equation at the top of Figure 3-1 is the multiple regression equation for the aircraft. The dashed lines illustrate this multi-variate relationship. The equation involves a third parameter,  $c$ , which is a scaling parameter for a change in  $L_{dn}$  relative to a change in contour area:

$$A = aN^b \cdot L_{dn}^c$$

The multiple regression coefficient  $r$ , shown below the multiple regression equation, represents the correlation of the multilinear equation to the contour areas.

Ldn Area Equivalency Method  
 72709 STAGE 2  
 One Runway - One Direction

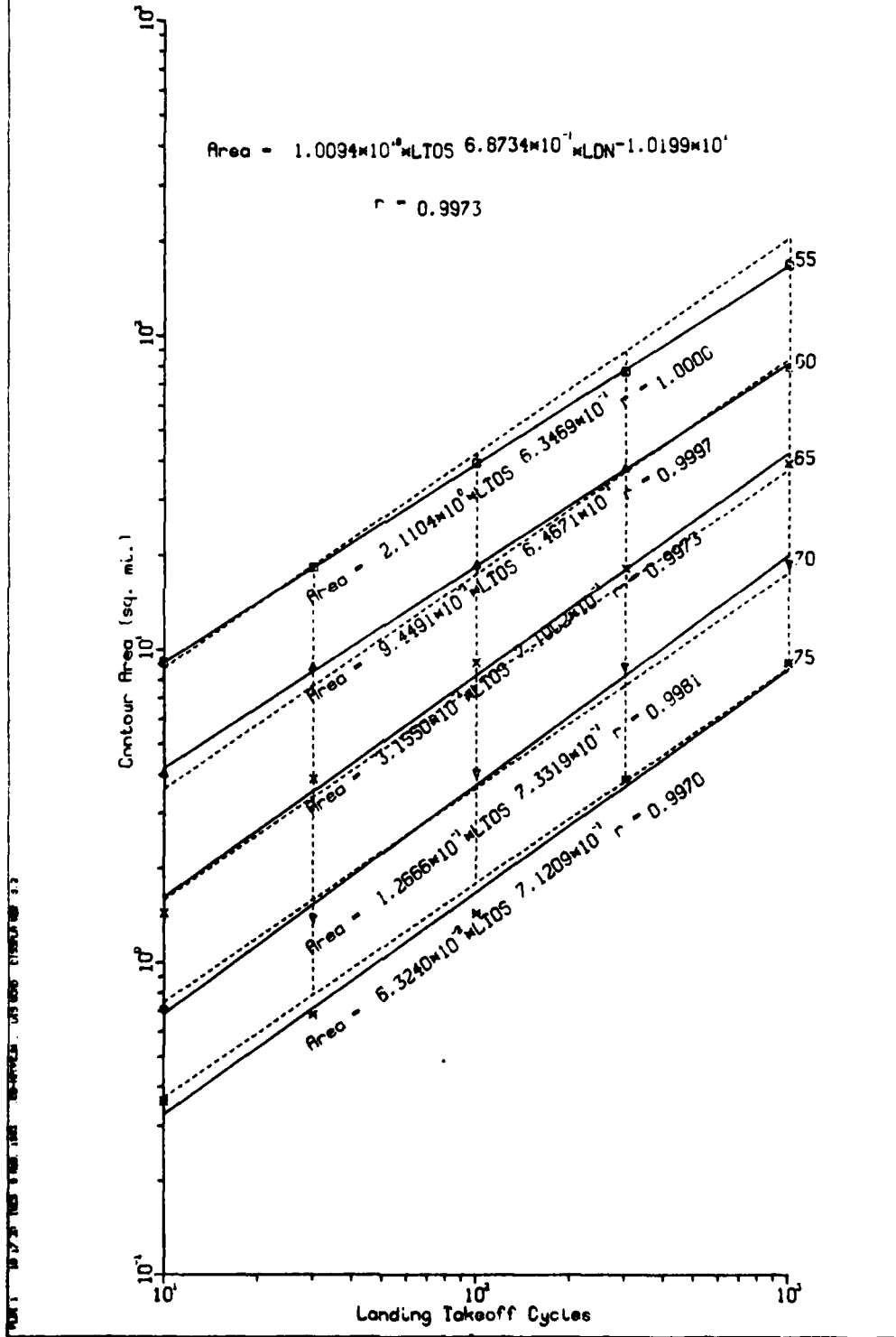


FIGURE 3-1. AEM LINEAR REGRESSION LINES FOR 727Q9 STAGE 2  
 3-3

TABLE 3-1

## AEM PARAMETERS AND CORRELATION COEFFICIENTS FOR INM AIRCRAFT

(part 1 of 2)

Aircraft Type	65 Ldn			75 Ldn		
	a	b	r	a	b	r
747100	.22594	.70658	.9999	.058717	.6568	.9982
747200	.094848	.71062	.9993	.056022	.52171	.9811
747100	.085753	.70686	.9994	.039767	.56111	.9922
747SP	.072382	.70726	.9987	.031276	.57653	.9889
DC820	.54677	.61749	.9995	.094781	.67403	.9994
707	.43092	.63363	.9997	.081632	.6692	.9999
720	.30018	.65145	.9997	.062408	.66438	.9997
707320	.46628	.63776	.9996	.086793	.67387	.9993
707120	.39068	.63666	.9994	.075951	.66588	.9976
720B	.33421	.64428	.9994	.057873	.68983	.9993
DC850	.45335	.6216	.9994	.085881	.66095	.9988
DC860	.50433	.63693	.9997	.093926	.67211	.9992
DC8CFM	.095168	.56752	.9995	.058978	.42531	.9901
707CFM	.090267	.56054	.9976	.075816	.36805	.9844
707DN	.39478	.61722	.9995	.070882	.66658	.9988
DC8DN	.46346	.60835	.9991	.074511	.68043	.9983
CONCRD	6.7267	.57708	.9809	.24387	.92165	.996
DC1010	.055833	.74586	.9981	.057591	.44377	.969
DC1030	.072532	.7207	.9992	.055537	.48144	.9765
DC1040	.069732	.72171	.9991	.055983	.47362	.9736
L1011	.061686	.74073	.9984	.059958	.45116	.9729
L10115	.070318	.73216	.9987	.061885	.46334	.9727
727200	.37045	.66575	.9994	.063094	.70508	.9984
727100	.31686	.66503	.999	.050802	.71719	.9988
727D15	.62462	.55075	.9906	.081524	.66068	.9902
72709	.39856	.64771	.9993	.063155	.70725	.9985
72707	.25431	.67698	.9987	.041575	.72221	.9987
727Q15	.63749	.59125	.9996	.088996	.69357	.9974
727D17	.77352	.58384	.9992	.13183	.65354	.9965
A300	.056243	.70843	.9973	.065947	.40001	.9676
767	.045582	.73509	.9994	.029423	.51749	.9843
A310	.049037	.70737	.9975	.033022	.4913	.9897
BAC111	.15806	.6387	.9998	.045305	.60061	.9996
F28	.11424	.67717	.9979	.061902	.51202	.9969
DC930	.255	.64224	.9992	.047022	.67878	.9992
DC910	.15256	.68445	.9994	.028217	.70457	.9974
737	.20892	.67236	.9977	.032167	.72995	.9991
DC909	.19709	.65771	.9971	.034592	.70398	.9957
DC907	.12141	.69248	.9992	.023937	.69715	.9941
737DN	.17448	.68081	.9973	.02582	.7414	.9974
DC950	.54058	.58632	.9992	.084585	.6713	.9977
737D17	.47652	.58646	.999	.058649	.7154	.9983
DC980	.057292	.7005	.9989	.029371	.53347	.985
757R8	.035748	.78426	.9998	.028126	.51577	.9737



TABLE 3-1

AEM PARAMETERS AND CORRELATION COEFFICIENTS FOR INM AIRCRAFT  
(part 2 of 2)

Aircraft Type	65 Ldn			75 Ldn		
	a	b	r	a	b	r
757JT	.035748	.78426	.9998	.028126	.51577	.9737
COMJET	.28504	.61027	.9993	.058735	.64206	.9995
GALTF	.044167	.62141	.9993	.030673	.4399	.9814
GALTJ	.38843	.60457	.9996	.061997	.68055	.999
GANTF	.052119	.63153	.9971	.037255	.43601	.9889
GALOTF	.022013	.52699	.9789	.015311	.3752	.9882
L188	.016869	.78133	.9863	.029594	.37025	.9639
L100	.033394	.79478	.9983	.026474	.51704	.9815
DHC7	.011101	.68707	.9794	.0073122	.47978	.9967
CV580	.020242	.632	.9712	.025308	.33308	.9961
HTETP	.026254	.69683	.9935	.030705	.39219	.9764
MTETP	.023894	.51311	.9644	.020488	.33031	.9881
DHC6	.015311	.4805	.9796	.0042779	.51577	.9779
4EP	.058605	.81526	.9993	.033666	.58784	.9876
TEP	.042943	.75885	.9969	.034507	.49549	.9898
COMTEP	.01671	.49302	.9749	.004013	.54427	.9773
COMSEP	.0096306	.54076	.9782	.0026634	.54335	.9829
KC135	2.7893	.63015	.998	.45159	.69334	.9995
C130	.033394	.79478	.9983	.026474	.51704	.9815
F4	1.0301	.66118	.9999	.23697	.65296	.9994
A7D	.47499	.6464	.9996	.11567	.63347	.9996
CL600	.049046	.5045	.9848	.039268	.33787	.9976

#### 4.0 VISICALC METHOD

The AEM doesn't require any programming experience. It does require VISICALC<sup>®</sup> and an Apple<sup>®</sup> II plus with 64K random access memory (RAM) or Apple IIe personal computer. VISICALC is a widely available electronic worksheet which combines the convenience of a calculator with the memory and screen control of a personal computer. In VISICALC parlance, AEM is a template called DNLAEM (Figure 4-1) which is stored on a 5-1/4 inch diskette. Appendix A provides instructions on how to obtain a copy of DNLAEM. When retrieved from the diskette the DNLAEM template becomes a worksheet to which you add aircraft identities and the associated landings and takeoffs (LTOs) in the appropriate columns (see Figure 4-2).

DNLAEM contains all the equations necessary to calculate an airport contour area from the list of aircraft types and LTOs. DNLAEM includes the a and b parameters for each of the 66 aircraft shown in Table 3-1. The following instructions should lead you to produce output reports similar to those examples in Figures 4-3 and 4-4. The keystrokes are given in **boldface** type. **RETURN** indicates the key labeled RETURN.

#### 4.1 INSTRUCTIONS

	<u>Instruction</u>	<u>Comment</u>
STEP 1.	Insert VISICALC diskette into disk drive #1 and close the door.	You must load VISICALC before each session.
STEP 2.	Turn on both the computer and the monitor. Wait for the standard VISICALC template to appear.	Turning on the computer "boots" the VISICALC diskette.
STEP 3.	Remove the VISICALC diskette and insert the AEM diskette into disk drive #1.	The VISICALC diskette is no longer needed for the duration of this session.

<u>Instruction</u>	<u>Comment</u>
STEP 4. Type /SL.	/ shifts you into the command mode. S selects STORAGE. L indicates the desire to load a template.
STEP 5. Hit the right arrow → until 'DNLAEM' appears on the edit line.	The right arrow "poles" through the diskette to find the AEM template.
STEP 6. Hit RETURN .	The AEM template is being loaded.
STEP 7. Wait for the cursor to appear in coordinate H5. If you are not in H5 type >H5 and RETURN.	> invokes the GOTO command and H5 indicates the destination coordinate.
STEP 8. Hit ' (quote mark), enter title (up to 9 characters) and hit RETURN.	The ' causes VISICALC to treat the entry as a label.
STEP 9. Hit → .	The cursor moves to H6.
STEP 10. Enter 1 or 2 and RETURN .	You are choosing between calculating 65 L <sub>dn</sub> ( 1 ) or 75 L <sub>dn</sub> ( 2 ) contour area.
STEP 11. Type >H11 and RETURN .	The cursor moves to the first coordinate under the column labeled 'Aircraft ID'.
STEP 12. For each aircraft type enter corresponding ID and hit →	The cursor moves down the column as you enter each aircraft. Up to 20 allowed.
STEP 13. Type >I11 and RETURN .	The cursor moves to the first coordinate under the column labeled 'DAY'.
STEP 14. For each aircraft type enter the corresponding LTOs during daytime and hit → .	Daytime includes the hours 7am to 10pm. The cursor moves down the column after each entry.
STEP 15. Type >J11 and RETURN .	The cursor moves to the first coordinate under the column labeled 'NIGHT'.

<u>Instruction</u>	<u>Comment</u>
STEP 16. For each aircraft type enter the LTOs which occur at night and hit → .	Night includes the hours 10pm to 7am. The cursor moves down the column after each entry.
STEP 17. Type ! (exclamation point).	The cursor disappears and the computations have begun. Return of cursor signals end of calculations.
STEP 18. Type >R35 and RETURN .	
STEP 19. If coordinate P34 contains 'NA' then type >H5 and RETURN . Go back to STEP 7 and check your entries.	Something is wrong with your input.
STEP 20. If coordinate R32 contains 'TRUE' then skip to STEP 29.	Your results are correct. You may now print them out.
STEP 21. Write down value in R31.	Validity test is FALSE.
STEP 22. Type >N32 and RETURN .	N32 contains reference area.
STEP 23. Enter a new reference contour area.	If value in R31 is greater than 1.02 then enter a number less than shown. Otherwise, enter a number greater than shown.
STEP 24. Hit RETURN then ! .	Recalculation starts. Await return of cursor.
STEP 25. Type >R35 and RETURN .	
STEP 26. If R32 contains 'FALSE' then repeat steps 21 through 25 until R32 contains 'TRUE'.	
STEP 27. Type >N32 and RETURN .	
STEP 28. Type +N31 and RETURN .	The coordinate N32 is now returned to its original value.
STEP 29. Write down contour area.	If you don't have a printer, you are done.
STEP 30. Type >H1 and RETURN .	
STEP 31. Make sure printer is turned on and ready. On Apple IIe, make sure CAPS LOCK key is down.	

<u>Instruction</u>	<u>Comment</u>
STEP 32. Type <b>/PP^AEQ</b> and <b>RETURN</b> .	/ shifts to command mode. P is PRINT command. P indicates printer. ^ invokes SETUP. ^EQ is a special command to compress print type. This last command works with only certain kinds of printers.
STEP 33. Type <b>-R35</b> and <b>RETURN</b> .	The completed worksheet is being printed. The output is single spaced with H1 upper left corner and R35 lower right corner.

The real utility of VISICALC comes from the fact that the worksheet is still available for you to change any of your entries and rerun. For example, let's say that you have just produced the 65 L<sub>dn</sub> contour area and you want to calculate the area within 75 L<sub>dn</sub>. Simply go to coordinate H6 and enter a 2 and RETURN. Skip to STEP 17 and proceed. You can do the same thing with aircraft types or LTOs.



DNLAEM  
Day Night Average Sound Level  
Area Equivalent Method

-----<<<Title (Hit " to start)  
-----<<<Level (1=65 or 2=75 LDN)

Aircraft ID	Day	LTO Cycles Night	Aircraft Type	Aircraft ID	Aircraft Type	Aircraft ID
I-----II-----II-----I			747100	1	F28	34
I-----II-----II-----I			747200	2	DC930	35
I-----II-----II-----I			74710Q	3	DC910	36
I-----II-----II-----I			747SP	4	737	37
I-----II-----II-----I			DC820	5	DC9Q9	38
I-----II-----II-----I			707	6	DC9Q7	39
I-----II-----II-----I			720	7	737QN	40
I-----II-----II-----I			707320	8	DC950	41
I-----II-----II-----I			707120	9	737D17	42
I-----II-----II-----I			720B	10	DC980	43
I-----II-----II-----I			DC850	11	757RB	44
I-----II-----II-----I			DC860	12	757JT	45
I-----II-----II-----I			DC8CFM	13	COMJET	46
I-----II-----II-----I			707CFM	14	GALTF	47
I-----II-----II-----I			707QN	15	GALTJ	48
I-----II-----II-----I			DC8QN	16	GAMTF	49
I-----II-----II-----I			CONCRD	17	GALQTF	50
I-----II-----II-----I			DC1010	18	L188	51
I-----II-----II-----I			DC1030	19	L100	52
I-----II-----II-----I			DC1040	20	DHC7	53
I-----II-----II-----I			L1011	21	CV580	54
Totals:	0	0	L10115	22	HTETP	55
			727200	23	MTETP	56
			727100	24	DHC6	57
			727D15	25	4EP	58
			727Q9	26	TEP	59
			727Q7	27	COMTEP	60
			727Q15	28	COMSEP	61
			727D17	29	KC135	62
			A300	30	C130	63
			767	31	F4	64
			A310	32	A70	65
			BAC111	33	CL600	66

FIGURE 4-2. DNLAEM FILLIN FORMAT

DNLAEM  
 Day Night Average Sound Level  
 Area Equivalent Method

LONG BCH<<<Title (Hit " to start)  
 1<<<Level (1=65 or 2=75 Ldn)

65 Ldn

Aircraft ID	LTO Cycles		Weighted	Constants		Aircraft			To Verify Area	
	Day	Night		a	b	Area	Energy	Wgtings	LTOs	Eff LTOs
26	31		3	.39856	.64771	.8119512	.5750402	.8878050	9.076823	.3305121
43	141		14	.057292	.7005	.3638787	.1906343	.2721404	122.5498	.1142392
46	101		10	.28504	.61027	1.161919		1	1.638619	17.99973
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
Totals:	27	0	27			1.161919	1.765674	2.798564		1.000315
						1.161919(Ref Area		Validity Test:		TRUE

Contour Area = 1.663248 sq. mi.

FIGURE 4-3. EXAMPLE OF AN AEM 65 LDN OUTPUT FROM VISICALC



DNL AEM  
 Day Night Average Sound Level  
 Area Equivalent Method

LONG BCH<<<Title (Hit " to start)  
 2<<<Level (1=65 or 2=75 Ldn)

75 Ldn

Aircraft ID	LTO Cycles		Weighted	Constants		Aircraft			To Verify Area	
	Day	Night		a	b	Area	Energy	Wgtings	LTOs	Eff LTOs
26	31	I	3	.063155	.70725	.1373573	.4110069	.5811338	11.46648	.2616323
43	141	I	14	.029371	.53347	.1200449	.2389925	.4479962	106.6107	.1313189
46	101	I	10	.058735	.64206	.2576066	1	1.557487	16.44653	.6080311
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
I	I	I	0	NA	NA	0	0	0	0	0
Totals:	27	0	27			.2576066	1.649999	2.586617		1.000982
						.2576066(Ref Area		Validity Test:		TRUE
						Contour Area =		0.35		sq. mi.

FIGURE 4-4. EXAMPLE OF AEM 75 LDN OUTPUT FROM VISICALC

## 5.0 CALCULATOR METHOD

In the event that an Apple II computer and VISICALC software are not available, your calculator and the worksheet in Figure 5-1 make good substitutes. With the following instructions, you perform the same tasks as accomplished by the AEM on VISICALC.

### 5.1 INSTRUCTIONS

- STEP 1. Enter aircraft types in column 1.
- STEP 2. Enter the daytime and nighttime LTOs for each aircraft type in columns 2 and 3.
- STEP 3. Compute the effective LTOs of each aircraft in column 4 by multiplying the nighttime LTOs from column 3 by 10 and adding the daytime LTOs from column 2.
- STEP 4. Enter in columns 5 and 6 the appropriate aircraft a and b parameters from Table 3-1.
- STEP 5. Compute the area of each aircraft by applying the equation in the development section  $A=an^b$ , where a is in column 5, b is in column 6, and N is the number of effective LTOs in column 4. Enter the area A, for each aircraft in column 7.
- STEP 6. Select the largest area in column 7 and refer to this as the "reference area,"  $A_R$ .
- STEP 7. Calculate the energy contribution E for each aircraft. This is done by dividing the area of each aircraft by the reference area and raise the quotient to the power of the reciprocal of the b parameter (1/b). Enter the result in column 8.
- STEP 8. Sum column 8 and enter the result in the box labeled  $\bar{E}$ .
- STEP 9. Calculate the weighting factor W for each aircraft with the equation  $W=E/b$ . Divide the energy contribution E of each aircraft by the b parameter and enter the quotient in column 9.
- STEP 10. Sum column 9 and enter the result in the box labeled  $\bar{W}$ .
- STEP 11. Calculate the scaling parameter  $\bar{b}$  for the aircraft mix by dividing  $\bar{E}$  by  $\bar{W}$ . Enter the quotient in the box labeled  $\bar{b}$ .

- STEP 12. Calculate the contour area of the aircraft mix by applying the energy contribution  $\bar{E}$ , the scaling parameter  $\bar{b}$ , and the reference area  $A_R$  to the equation  $\bar{A}=A_R(\bar{E}^{\bar{b}})$ . The result  $\bar{A}$  is the DNL noise contour area of the specific aircraft mix.
- STEP 13. Determine the number of LTOs that each aircraft must fly in order to have a noise contour area equal to that of the entire mix. Divide the DNL noise contour area of the entire mix  $\bar{A}$  by the parameter  $a$  in column 5 and raise the quotient to the power of the reciprocal of the  $b$  parameter. Enter the result  $\bar{N}$  in column 10.
- STEP 14. Calculate the ratio of LTOs of each aircraft by dividing the effective LTOs in column 4 by  $\bar{N}$  in column 10. Enter the result in column 11.
- STEP 15. Sum column 11 and enter the result in the box labeled 'Validity Check'.
- STEP 16. If the validity value is between 1.00 and 1.02 then the result is correct. You are done.
- STEP 17. If the validity value is not between 1.00 and 1.02, return to STEP 1 and check all your figures.
- STEP 18. If the validity check produces the same value, change the reference area according to the following:  
-If the validity value is greater than 1.02, enter a reference area less than already present.  
-If the validity value is less than 1.00, enter a reference area greater than already present.
- STEP 19. Repeat the steps starting at STEP 7.

Day Night Average Sound Level  
Area Equivalent Method

Calculator Method

1	2	3	4	5	6	7	8	9	10	11	
Aircraft Type	Daytime LTOs	Nighttime LTOs	Effective LTOs	Constants a                      b		Aircraft Area $A = aN^b$	Energy $E = \left( \frac{A}{AR} \right)^{\frac{1}{b}}$	Weighting Factor $W = E/b$	# of LTOs $\bar{N} = \frac{\sum A}{\sum W}$	Verification Eff. LTOs $\frac{\sum W}{\bar{N}}$	Eff. LTOs $\frac{\sum W}{\bar{N}}$
						Reference AR	Energy $\bar{E}$	Weighting $\bar{W}$	Validity Check		
						$\bar{b}$ :	$\bar{A}$ :	Contour Area:			

FIGURE 5-1. AEM CALCULATOR METHOD WORKSHEET

APPENDIX A

AVAILABILITY OF AEM ON VISICALC

The AEM is available on a single sided, single density 5-1/4 inch diskette. The information on the diskette is compatible with the 16 sector version of VISICALC® for Apple® II plus with 64K RAM and Apple IIe personal computers. The cost to you is \$10 for materials and services. To order AEM on VISICALC, fill out request form (p. A-2) and send with check or money order payable to the "United States Treasury" to:

Federal Aviation Administration  
AEE-120  
800 Independence Ave., S.W.  
Washington, DC 20591  
Attention: Thomas L. Connor

Appendix B contains a listing of the AEM template for VISICALC.

AEM ON VISICALC REQUEST

I request a 5-1/4 inch diskette of the AEM.

NAME: \_\_\_\_\_

TITLE: \_\_\_\_\_

COMPANY: \_\_\_\_\_

STREET ADDRESS: \_\_\_\_\_

CITY, STATE ZIP: \_\_\_\_\_

TELEPHONE NO.: \_\_\_\_\_

APPENDIX B

AEM TEMPLATE LISTING

This appendix contains the keystrokes to create the DNLAEM template on VISICALC. Please refer to the VISICALC user manual for an explanation of the commands. Entry at a particular coordinate (or cell) is shown as the coordinate identification followed by a colon and then the appropriate keystrokes. Keystrokes which are shown without a coordinate identification always refer to the previously specified coordinate, usually on the line above. Table B-1 contains the locations (row and column) of the specific aircraft a and b parameters on the AEM template. Table B-2 provides the locations of the aircraft names and identifications.

```

/X!/X>A1:>H5:
/GC9
/GRM
/W1
A8 : +H6
A11: +H11
      /R
      A12.A30
      R
B10: "a
B11: @IF(A8<>2,@LOOKUP(A11,B47.B112),@LOOKUP(A11,F47.F112))
      /R
      B12.B30
      NRNNRNN
C10: "b
C11: @IF(A8<>2,@LOOKUP(A11,D47.D112),@LOOKUP(A11,H47.H112))
      /R
      C12.C30
      NRNNRNN
H2 : "Day Night
H3 : "   Area E
H5 : "_____ (9 underline strokes)
H6 : "_____
H9 : /FL"Aircraft
H10: /FL"  ID
H11: "!_____! (7 underline strokes between two exclamation points)
      /R
      H12.H30
      /R.H30
      I11.J11
H32: /FR"Totals:

```

AEM TEMPLATE LISTING (continued)

I1 : /FG" DNLAEM  
 I2 : /FG" Average  
 I3 : "quivalent  
 I5 : /FG"<<<Title  
 I6 : /FG"<<<Level  
 I9 : " L  
 I10: /FL" Day  
 I32: @SUM(I11.I30)  
       /R  
       J32.K32  
       RR  
 J2 : /FG"Sound Lev  
 J3 : /FG" Method  
 J5 : "(Hit " to  
 J6 : /FG"(1=65 or  
 J9 : "TO Cycles  
 J10: /FL" Night  
 K2 : /FL"el  
 K5 : /FG" start)  
 K6 : /FG"2=75 Ldn)  
 K10: "Weighted  
 K11: +I11+(J11\*10)  
       /R  
       K12.K30  
       RR  
 L9 : /FR"Cons  
 L10: /FL" a  
 L11: @IF(@ISNA(B11),@NA,B11)  
       /R  
       L12.L30  
       RR  
 M7 : @CHOOSE(H6,65,75)  
 M9 : /FL"tants  
 M10: /FL" b  
 M11: @IF(@ISNA(C11),@NA,C11)  
       /R  
       M12.M30  
       RR  
 N7 : /FL" Ldn  
 N9 : /FL"Aircraft  
 N10: /FL" Area  
 N11: @IF(@ISNA(L11),0,+L11\*(K11 M11))  
       /R  
       N12.N30  
       RRRR  
 N31: @MAX(N11.N30)  
 N32: +N31  
 N34: /FR"Contou  
 O10: /FL"Energy



AEM TEMPLATE LISTING

O11: @IF(@OR(N32=0,@ISNA(M11)),0,(N11/N32) (1/M11))  
 /R  
 O12.O30  
 NRRNR  
 O32: /FR"<Ref Area  
 O34: /FL"r Area =  
 P10: /FL"Wgtings  
 P11: @IF(@ISNA(M11),0,O11/M11)  
 /R  
 P12.P30  
 RRR  
 O31: @SUM(O11.O30)  
 P31: @SUM(P11.P30)  
 P32: /FR"Valid  
 P34: /F\$@IF(P31=0,@NA,+(O31 (O31/P31))\*N31)  
 Q9 : /FR"To Veri  
 Q10: /FL" LTOs  
 Q11: @IF(@OR(@ISNA(L11),@ISNA(M11)),0,(P34/L11) (1/M11))  
 /R  
 Q12.Q30  
 RRRNR  
 Q32: /FL"ity Test:  
 Q34: /FG" sq. mi.  
 R9 : /FL"fy Area  
 R10: /FL"Eff LTOs  
 R11: @IF(Q11=0,0,+K11/Q11)  
 /R  
 R12.R30  
 RRR  
 R31: @SUM(R11.R30)  
 R32: @AND(R31>=1,R31<=1.02)

TABLE B-1

LOCATIONS OF A AND B PARAMETERS ON AEM TEMPLATE  
(part 1 of 2)

		COLUMN									
		A	B	C	D	E	F	G	H	I	
44	AIRCRAFT	AIRCRAFT	65	LDN	AIRCRAFT	65	LDN	AIRCRAFT	75	LDN	
45	TYPE	ID	A	ID	B	ID	A	ID	B		
46											
47	747100	1	.22594	1	.70658	1	.058717	1	.6568		
48	747200	2	.094848	2	.71062	2	.056022	2	.52171		
49	747100	3	.085753	3	.70686	3	.039767	3	.56111		
50	747SP	4	.072382	4	.70726	4	.031276	4	.57653		
51	DC820	5	.54677	5	.61749	5	.094781	5	.67403		
52	707	6	.43092	6	.63363	6	.081632	6	.6692		
53	720	7	.30018	7	.65145	7	.062408	7	.66438		
54	707320	8	.46628	8	.63776	8	.086793	8	.67387		
55	707120	9	.39068	9	.63666	9	.075951	9	.66588		
56	7208	10	.33421	10	.64428	10	.057873	10	.68983		
57	DC850	11	.45335	11	.6216	11	.085881	11	.66895		
58	DC860	12	.50433	12	.63693	12	.093926	12	.67211		
59	DC8CFM	13	.095168	13	.56752	13	.058978	13	.42531		
60	707CFM	14	.090267	14	.56054	14	.075816	14	.36805		
61	707DN	15	.39478	15	.61722	15	.070882	15	.66658		
62	DC8DN	16	.46346	16	.60835	16	.074511	16	.68043		
R	63	CONCRD	17	6.7267	17	.57708	17	.24387	17	.92165	
O	64	DC1010	18	.055833	18	.74586	18	.057591	18	.44377	
W	65	DC1030	19	.072532	19	.7207	19	.055537	19	.48144	
	66	DC1040	20	.069732	20	.72171	20	.055983	20	.47362	
	67	L1011	21	.061686	21	.74073	21	.059958	21	.45116	
	68	L10115	22	.070318	22	.73216	22	.061885	22	.46334	
	69	727200	23	.37045	23	.66575	23	.063094	23	.70588	
	70	727100	24	.31686	24	.66503	24	.050802	24	.71719	
	71	727015	25	.62462	25	.55075	25	.081524	25	.66868	
	72	72709	26	.39856	26	.64771	26	.063155	26	.70725	
	73	72707	27	.25431	27	.67698	27	.041575	27	.72221	
	74	727015	28	.63749	28	.59125	28	.088996	28	.69357	
	75	727017	29	.77352	29	.58384	29	.13183	29	.65354	
	76	A300	30	.056243	30	.70843	30	.065947	30	.40001	
	77	767	31	.045582	31	.73509	31	.029423	31	.51749	
	78	A310	32	.049037	32	.70737	32	.033022	32	.4913	
	79	BAC111	33	.15806	33	.6387	33	.045305	33	.68061	
	80	F28	34	.11424	34	.67717	34	.061902	34	.51202	
	81	DC930	35	.255	35	.64224	35	.047022	35	.67878	
	82	DC910	36	.15256	36	.68445	36	.028217	36	.70457	
	83	737	37	.20892	37	.67236	37	.032167	37	.72995	
	84	DC909	38	.19709	38	.65771	38	.034592	38	.70398	
	85	DC907	39	.12141	39	.69248	39	.023937	39	.69715	
	86	737DN	40	.17448	40	.68881	40	.02582	40	.7414	
	87	DC950	41	.54058	41	.58632	41	.084585	41	.6713	
	88	737D17	42	.47652	42	.58646	42	.058649	42	.7154	
	89	DC980	43	.057292	43	.7005	43	.029371	43	.53347	
	90	757RB	44	.035748	44	.78426	44	.028126	44	.51577	

TABLE B-1

## LOCATIONS OF A AND B PARAMETERS ON AEM TEMPLATE

(part 2 of 2)

		COLUMN							
	A	B	C	D	E	F	G	H	I
91	757JT	45	.035740	45	.78426	45	.028126	45	.51577
92	CONJET	46	.20504	46	.61027	46	.058735	46	.64206
93	ONLTF	47	.044147	47	.62141	47	.038673	47	.4399
94	ONLJ	48	.30043	48	.68457	48	.061997	48	.68055
95	ONMTF	49	.052119	49	.63153	49	.037255	49	.43601
96	ONLDTF	50	.022013	50	.52699	50	.015311	50	.3752
97	L100	51	.016849	51	.78133	51	.029594	51	.37025
98	L100	52	.033394	52	.79478	52	.026474	52	.51704
99	DNC7	53	.011101	53	.68707	53	.0073122	53	.47978
R 100	CV500	54	.020242	54	.632	54	.025388	54	.33308
O 101	MTETP	55	.026254	55	.69683	55	.030705	55	.39219
M 102	MTETP	56	.023894	56	.51311	56	.020488	56	.33031
103	DNC6	57	.015311	57	.4805	57	.0042779	57	.51577
104	4EP	58	.058605	58	.81526	58	.033666	58	.58784
105	TEP	59	.042943	59	.75885	59	.034507	59	.49549
106	CONTEP	60	.01671	60	.49302	60	.004013	60	.54427
107	CONSEP	61	.0096306	61	.54076	61	.0024634	61	.54335
108	KC135	62	2.7893	62	.63015	62	.45159	62	.69334
109	C130	63	.033394	63	.79478	63	.026474	63	.51704
110	F4	64	1.0301	64	.66118	64	.23697	64	.65296
111	A7D	65	.47499	65	.6464	65	.11567	65	.63347
112	CL600	66	.049046	66	.5045	66	.039268	66	.33787

TABLE B-2

LOCATIONS OF AIRCRAFT NAMES AND IDENTITIES ON AEM TEMPLATE

		COLUMN			
		S	T	U	V
9	Aircraft	Aircraft	Aircraft	Aircraft	Aircraft
10	Type	ID	Type	ID	
11	747100	1	F28	34	
12	747200	2	DC930	35	
13	747100	3	DC910	36	
14	747SP	4	737	37	
15	DC820	5	DC909	38	
16	707	6	DC907	39	
17	720	7	737DN	40	
18	707320	8	DC950	41	
19	707120	9	737D17	42	
20	720B	10	DC980	43	
21	DC850	11	757RB	44	
22	DC860	12	757JT	45	
23	DC8CFM	13	COMJET	46	
24	707CFM	14	GALTF	47	
R 25	707DN	15	GALTJ	48	
O 26	DC8DN	16	GAMTF	49	
W 27	CONCRD	17	GALQTF	50	
28	DC1010	18	L188	51	
29	DC1030	19	L100	52	
30	DC1040	20	DHC7	53	
31	L1011	21	CV580	54	
32	L10115	22	MTETP	55	
33	727200	23	MTETP	56	
34	727100	24	DHC6	57	
35	727D15	25	4EP	58	
36	727Q9	26	TEP	59	
37	727Q7	27	CONTEP	60	
38	727Q15	28	CONSEP	61	
39	727D17	29	KC135	62	
40	A300	30	C130	63	
41	767	31	F4	64	
42	A310	32	A7D	65	
43	BAC111	33	CL600	66	

## APPENDIX C

### REFERENCES

1. Civil Aeronautics Board, "Area Equivalent Method," February 1982.
2. Flythe, M. C., "INM Integrated Noise Model, Version 3 User's Guide," FAA-EE-81-17, October 1982.