AREA EQUIVALENT METHOD on VISICALC@

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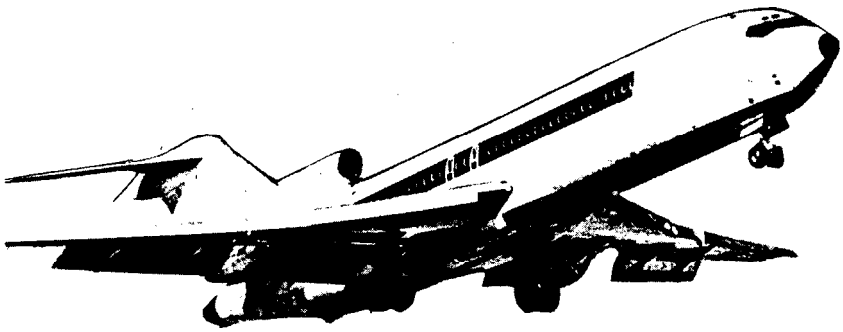

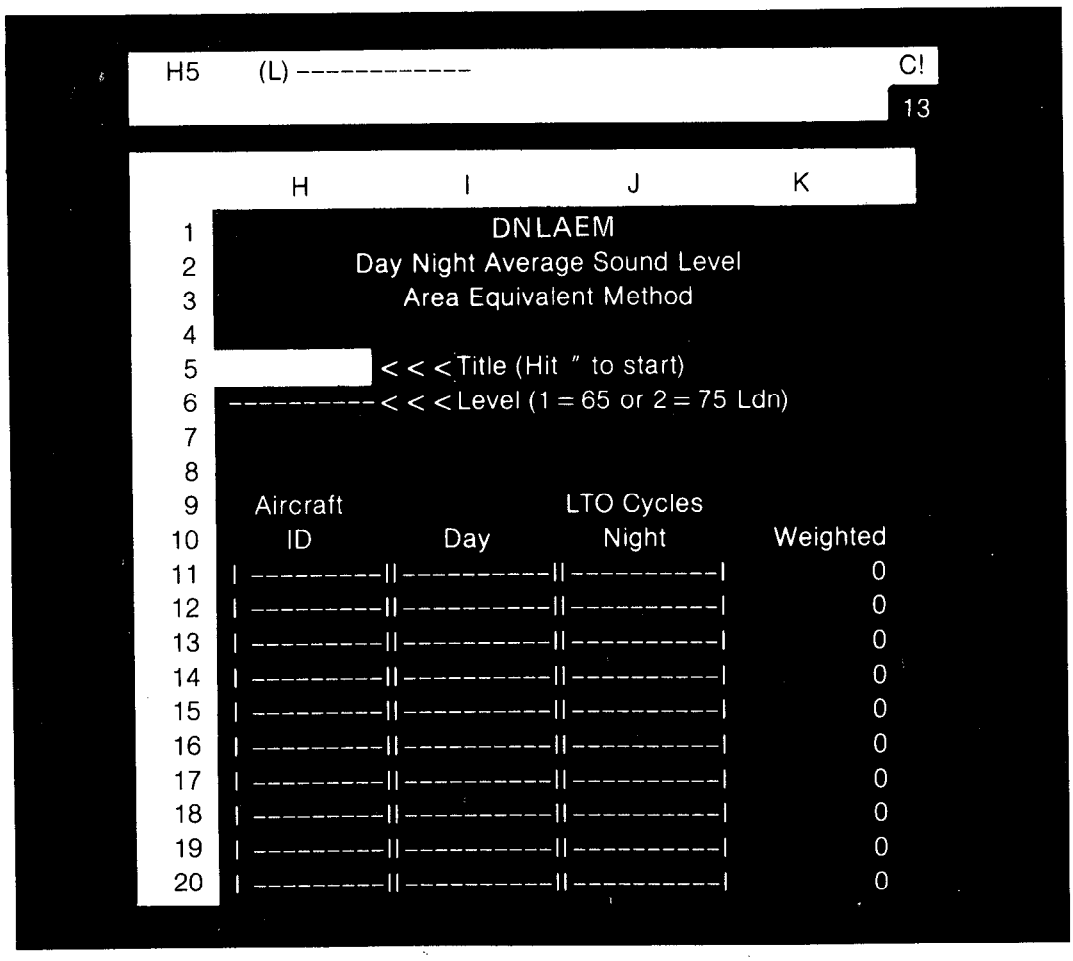

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nt contains instructions to execute the Area Equivalent . The AEM requires the VISICALC software package and personal computer or a calculator.

alent Method is a mathematical process to calculate ge Sound Level (DNL) contour area. The AEM is easy ntended as a screening procedure to determine airport Environmental Impact Statement (EIS).

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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 Ldn*. 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 ARM as well as instructions for use of the AEM on the Apple@ II plus or IIe using the VISICALC® software program. Instructions on the ARM 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 Compatability (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 to 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:

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

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 □, △, ×, ▽ 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.

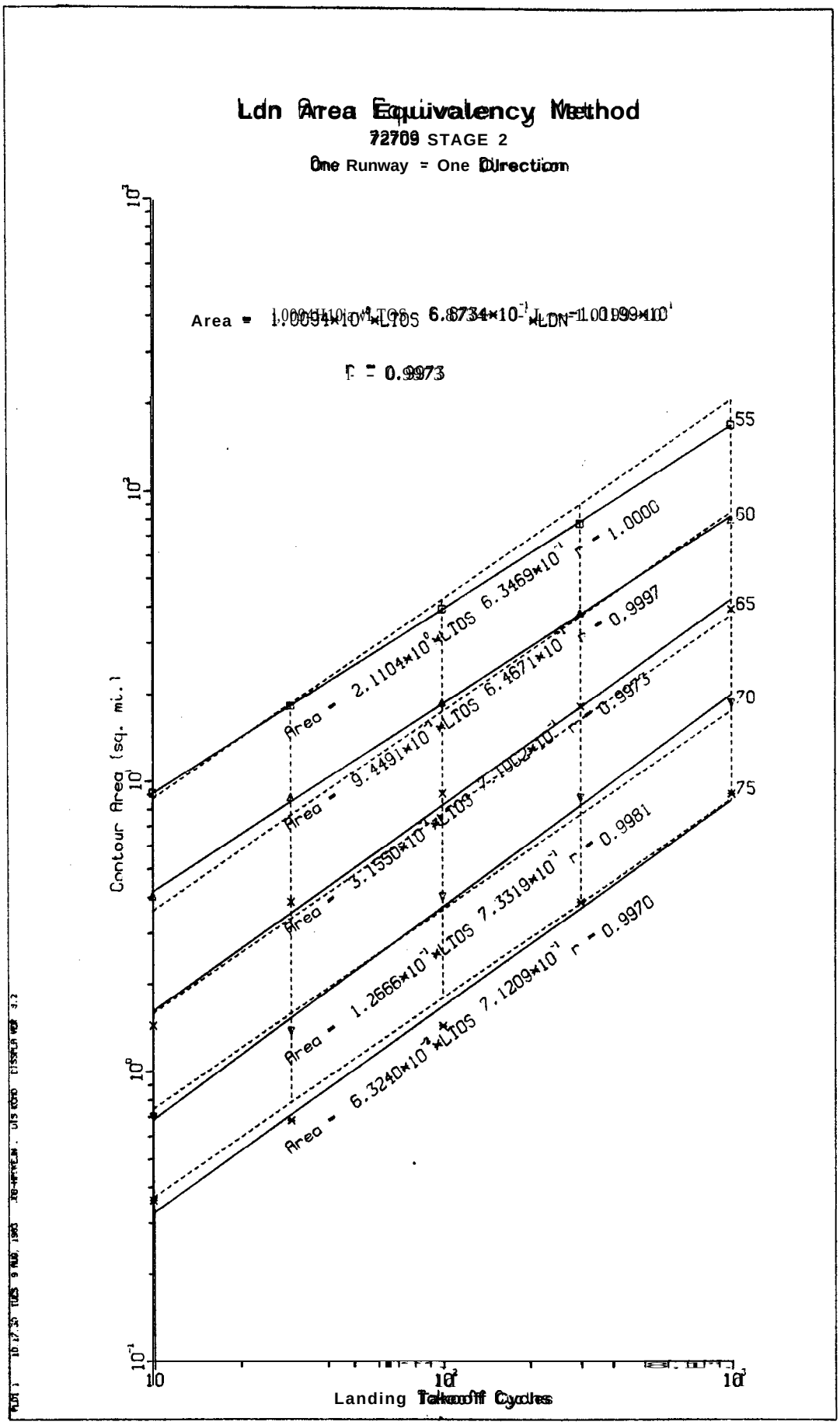


FIGURE 3-1. AEM LINEAR REGRESSION LINES FOR 72709 STAGE 2

TABLE 3-1

AEM PARAMETERS AND CORRELATION COEFFICIENTS FOR INM AIRCRAFT

(part 1 of 2)

Aircraft Type	65 Ldn a	65 Ldn b	65 Ldn r	75 Ldn a	75 Ldn b	75 Ldn r
747100	a22594	070658	.9999	a058717	a6568	.9982
747200	.094848	.710162	.9993	1056022	a52171	.9811
747100	0085753	.706886	.9994	1039767	a56111	a9922
747SP	1072382	170726	19987	.0312776	157653	a9889
DC820	854677	861749	19995	.094781	.67403	a9994
707	a43092	863363	.9997	8081632	a6692	89999
720	830018	a65145	.9997	a062408	166438	.9997
707320	.46628	863776	a9996	8086793	.67387	.9993
707120	839068	.636666	a9994	1075951	866588	19976
7208	a33421	164428	.9994	8057873	168983	.9993
DC850	1453335	86216	19994	a085881	a66095	a9988
DC860	a50433	163693	.9997	a093926	.67211	a9992
DC8CFM	8025168	.567752	09995	.0589778	.42531	.9901
707CFM	1090267	a56054	a9976	8075816	a36805	89844
707QN	.394478	.617222	.9995	.070882	.66658	a9988
DC8QN	146346	860835	.9991	s074511	168043	89983
CONCRD	6.772667	a57708	.9809	a24387	a92165	.996
DC1010	a055833	a74586	a9981	0057591	144377	.969
DC10B30	8072532	a7207	.9992	8055537	a48144	89765
DC1040	0069732	.72171	a9991	0055983	a47362	a9736
L1011	A0d1686	#74073	.9984	.059958	.45116	19729
L101B5	0070318	a73216	a9987	.061885	.46334	89727
727200	137045	a66575	19994	.063094	.70508	19984
727100	.316886	866503	.999	8050802	a71719	a9988
727D15	.62462	555075	a9906	.081524	866068	.9902
72789	.398856	a64771	19993	.063155	870725	89985
72707	.25431	a67698	19987	1041575	872221	19987
727015	.63749	559125	.9996	a088996	169357	.9974
727D17	.77352	a58384	19992	a13183	165354	89965
A300	.056243	.70843	a9973	8065947	.40001	a9676
767	.045582	.73509	.9994	a029423	.517749	89843
A310	.049037	.70737	.9975	8033022	.4913	09897
BAC111	a15806	16387	89998	a045305	.60061	.9996
F28	.114924	s67717	89979	a061902	a51202	.9969
DC930	.255	a64224	.9992	1047022	167878	89992
DC910	.155256	a68445	89994	.028217	.70457	19974
737	020892	a67236	19977	8032167	072995	.9991
DC909	819709	.65771	.9971	.034592	.70398	.9957
DC907	012141	169248	89992	8023937	869715	.9941
737QN	a17448	a68081	.9973	802582	.7414	.9974
DC950	a54058	.586632	a9992	8084585	a6713	.9977
737D17	.47652	858646	.999	.0158649	.71554	.9983
DC980	.0557292	.7005	a9989	.029371	153347	a985
757R8	.0357448	878426	.9998	a028126	.515577	.9737

TABLE 3-1

AEM PARAMETERS AND CORRELATION COEFFICIENTS FOR INM AIRCRAFT

(part 2 of 2)

Aircraft	65 Ldn			75 Ldn		
Type	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
GAMTF	.052119	.63153	.9971	.037255	.43601	.9889
GALQTF	.022013	.52699	.9789	.015311	.3752	.9882
L188	.016669	.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® and an Apple@ 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

	Instruction	Comment
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.

Instruction	Comment
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_{dn} (1) or 75 L_{dn} (2) contour area.
STEP 11. Type >H1 1 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 >I1 1 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 >J1 1 and RETURN.	The cursor moves to the first coordinate under the column labeled 'NIGHT'.

Instruction	Comment
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.	

Instruction	Comment
STEP 32. Type /PP"^EQ and RETURN.	/ 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 -R35 and RETURN.	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_{dn} contour area and you want to calculate the area within 75 L_{dn}. 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
Dar Night Average Sound Level
Area Equivalent Method

_____(((Title (Hit " to start)
_____{((Level (1=65 or 2=75 Ldn)

NA Ldn

Aircraft ID	LTO Cycles Day	Night	Weighted	Constants a	b	Aircraft Area	Energy	Wgtings	To Verify Area LTOs	Eff	LTOs
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
I -I	I -I	I -I	0	NA	NA	0	0	0	0	0	0
						0	0	0			0
Totals:	0	0	0				0	Reff Area	Validity Test:		FALSE

Contour Area = NA sq. mi.

FIGURE 4-1. DNLAEM, THE AEM VISICALC TEMPLATE

DNLAEM
Dar Night Average Sound Level
Area Equivalent Method

_____c<<(Ti tle (Hit " to start)
======a==<<<Level c1=65 o r 2=75 LDN)

Aircraft ID	LTO Cycles Day	LTO Cycles Night	Aircraft Type	Aircraft IQ	Aircraft Type	Aircraft ID
I------- I	I===,&,=II	==&===,I	747100	1	F28	34
I======L	II=======	II,====,,1I	747200	2	DC930	35
I===,===III	I=======	II-I-,,,L,LI	747108	3	DC910	36
I------- I	I=====,=III	==,==,=II	747SP	4	737	37
I=======1II	I,======1	1I-==~===II	DC820	5	DCPQP	38
I==,,===III	I,==,==,II	I,I_____,_II	707	6	DC9Q7	39
I=A,,=,=III	I,=======	II=======II	720	7	737QN	40
I=======1II	I-=1===1II	======LI	707320	8	DC950	41
I------- I	I-----,-II	--,--~-I	707120	9	737D17	42
I------- I	I-------I	I ======II	720%	10	DCYSO	43
I=i=,==iIII	I,=======	II-I====~=II	DC850	11	757HB	44
I=======II	I,------	II--,----I	DC860	12	757JT	45
I------- I	I,=======	II====,==II	DC%CFM	13	CQMJET	46
I======dIII	I===L=,=III	==,==,=II	707CFM	14	GALTF	47
I---,---I	I I,==i=,=III	==,===,II	707QN	15	GALTJ	48
I=====~III	I-~~~~~III	~-~~~~-II	DC8QN	16	GAMTF	49
I===,==~II	I,~~~~~~III	~_,,,=_II	CONCRQ	17	GALQTF	50
I==,,===II	I=,===,=II	I,=,,,,,1I	DC1010	18	L188	51
I==,,===III	I-,=====III	I-,,,=,1I	DC1030	19	L100	52
I------- I	I,--L---II	--,-&--I	DC1040	20	DHC7	53
			L1011	21	CV580	54
Total s:	0	0	L10115	22	HTETP	55
			727200	23	MTETP	56
			727100	24	DHC6	57
			727D15	25	4EP	58
			727QP	26	TEP	59
			72787	27	COMTEP	60
			727Q15	28	COMSEP	61
			727D17	29	KC135	62
			A300	30	Cl 30	63
			767	31	F4	64
			A310	32	A7D	65
			BAC111	33	CL600	66

FIGURE 4-2. DNLAEM FILLIN FORMAT

DNLAEM
Dar Night Average Sound Level
Area Equivalent Method

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

65 Ldn

Aircraft ID	LTO Cycles Day	Night	Weighted	Constants a	b	Aircraft Area	Energy		To Verify Area Wgt ings LTOs	Eff LTOs
26	31	[illegible]	3	.39856	.64771	.8119512	.5750402	.8878050	9.076823	.3305121
43	14	[illegible]	14	.057292	.07005	.3638787	.1906343	.8272404	122.5498	.1142392
46	10	[illegible]	10	.28504	.61027	1.161919	1	1.638619	17.99973	.5555638
I -II	[illegible]	[illegible]	0	NA	NA	0	0	0	0	0
I [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I -II	[illegible]	[illegible]	0	NA	NA	0	0	0	0	0
I [illegible]	[illegible]	[illegible]	0	NA	NA	0	0	0	0	0
I [illegible]	I I	- - -1	0	NA	NA	0	0	0	0	0
I [illegible]	[illegible]	[illegible]	0	NA	NA	0	0	0	0	0
I [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I -I	I -II'	[illegible]	0	NA	NA	0	0	0	0	0
I [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I -I	I -II	[illegible]	0	NA	NA	0	0	0	0	0
I [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I [illegible]	[illegible]	II [illegible]	0	NA	NA	0	0	0	0	0
1 [illegible]	I	I -I	0	NA	NA	0	0	0	0	0
I -II-	I	I -I	0	NA	NA	0	0	0	0	0
						1.161919	1.765674	2.798564		1.000315
Totals:	27	0	27			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

DNLAEM
Dar 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 Day	Night	Weighted	Constants a	b	Aircraft Area	Energy	Weightings	To Verify Area LTOs	Eff	LTOs
26	31	1	3	.0631155	.70225	.1373573	.4110069	.5811338	11.46648	.2816323	
43	141	1	14	.029371	.253347	.2800449	.2389925	.4479962	106.6107	.1313189	
46	1	1	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	Reff 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," AR.

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 (l/b). Enter the result in column 8.

STEP 8. Sum column 8 and enter the result in the box labeled $\overline{E}$.

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 $\overline{W}$.

STEP 11. Calculate the scaling parameter $\overline{b}$ for the aircraft mix by dividing $\overline{E}$ by $\overline{W}$. Enter the quotient in the box labeled $\overline{b}$.

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 AR to the equation $\bar{A} = A_R(\bar{E}^b)$. 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

Aircraft Type	Daytime LTOs	Nighttime LTOs	Effective LTOs	Constants a	Constants b	7 Aircraft Area $A=aN^b$	8 Energy $E=\left(\frac{A}{A_R}\right)^{\frac{1}{b}}$	9 Weighting Factor $W=E/b$	10 Verification # of LTOs $\bar{N}=\left(\frac{\bar{A}}{a}\right)^{\frac{1}{b}}$	11 Verification Eff. LTOs $\frac{\bar{N}}{\text{Eff. LTOs}}$
						Reference A_R	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-l 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 :   W_________   (9 underline strokes)
H6 :   W_________
H9 :   /FL"Aircraft
H10:   /FL"  ID
H11:   "!_______! (7 underline strokes between two exclamation points)
       /RR' - -
       H12.H30
       /R.H30
       I11.J11
H32:   /FR"Totals:
```

```
I1  :  /FG"  DNLAEM
I2 :   /FG" Average
I3 :   "quivalent
I5 :   /FG"<<<Title
I6 :   /FG"<<<Level
I9  :  "        L
I10:  /FL"    Day
I32:   @SUM(I11.I30)
       /R    'I
       532.K32
       R      R
52 :   /FG"Sound Lev
53 :   /FG"  Method
55 :   "(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 :   @HOSE(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
010:   /FL"Energy
```

```
011:  @IF(@OR(N32=Ø,@ISNA(M11)),Ø,(N11/N32) (1/M11))
      /R
      012.03Ø
      NRRNR
032:  /FR"<Ref Area
034:  /FL"r Area =
P10:  /FL"Wgtings
P11:  @IF(@ISNA(M11),Ø,Ø11/M11)
      /R
      P12.P3Ø
      RRR
031:  @SUM(010.030)
P31:  @SUM(P11.P3Ø)
P32:  /FR"Valid
P34:  /F$@IF(P31=Ø,@NA,+((031 (031/P31))*N31))
Q9 :  /FR"T6 Veri
Q10:  /FL"   LTOs
Q11:  @IF(@OR(@ISNA(L11),@ISNA(M11)),Ø,(P34/L11) (1/M11))
      /R
      Q12.Q30
      RRNRR
Q32:  /FL"ity Test:
Q34:  /FG" sq. mi.
R9 :  /FL"fy Area
R10:  /FL"Eff LTOs
R11:  @IF(Q11=Ø,Ø,+K11/Q11)
      /R
      R12.R30
      RRR
R31:  @SUM(R11.R30)
R32:  @AND(R31>=1,R31<=1.622)
```

TABLE B-1

LOCATIONS OF A AND B PARAMETERS ON AEM TEMPLATE

(part 1 of 2)

ROW	COLUMN A	B	C	D	E	F	8	H	I
44	AIRCRAFT	AIRCRAFT	65 LDN	AIRCRAFT	65 LDN	AIRCRAFT	75 LDN	AIRCRAFT	75 LDN
45	TYPE	ID	A	ID	B	ID	A'	ID	B
46									
47	747100	1	.122594	1	.70658	1	.058717	1	.65568
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	.043092	6	.63363	6	.081392	6	.6822
53	720	7	.30018	7	.65145	7	.062408	7	.66438
54	707320	8	.148628	8	.63776	8	.086793	8	.62387
55	707120	9	.39068	9	.63666	9	.075951	9	.66588
56	7208	10	.033421	10	.64428	10	.057873	10	.68983
57	DC850	11	.145335	11	.62116	11	.085881	11	.66085
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				14	.36805
61	707QN	15	.039478	15	.61722	15	.075816	15	.66658
62	DC8QN	16	.046346	16	.60835	16	.074511	16	.68043
63	CONCRD	17	.072267	17	.57708	17	.024387	17	.92165
64	DC1010	18	.055833	18	.74586	18	.057591	18	.44377
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	L1011-5	22	.070318	22	.73216	22	.061885	22	.46334
69	727200	23	.37045	23	.66575	23	.063094	23	.70508
70	727100	24	.316686	24	.66503	24	.050802	24	.70719
71	727D15	25	.062462	25	.55075	25	.081524	25	.66068
72	727-09	26	.139856	26	.64771	26	.063155	26	.70725
73	727-07	27	.25431	27	.67698	27	.041575	27	.72221
74	727-15	28	.637749	28	.59125	28	.088996	28	.69357
75	727D17	29	.773552	29	.58384	29	.131183	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	.015806	33	.6387	33	.045305	33	.60061
80	F28	34	.114424	34	.67717	34	.061902	34	.51202
81	DC930	35	.255	35	.642224	35	.047022	35	.67878
82	DC910	36	.152556	36	.68445	36	.028217	36	.70457
83	737	37	.20892	37	.67236	37	.032167	37	.72995
84	DC9-09	38	.197709	38	.65771	38	.034592	38	.70398
85	DC9-07	39	.12141	39	.69248	39	.023937	39	.69715
86	737QN	40	.117448	40	.68081	40	.02582	40	.7414
87	DC9-50	41	.054058	41	.58632	41	.084585	41	.6713
88	737D17	42	.147652	42	.58646	42	.058649	42	.7154
89	DC980	43	.057292	43	.7005	43	.029371	43	.53347
90	757R8	44	.035748	44	.78426	44	.028126	44	.55577

TABLE B-l

LOCATIONS OF A AND B PARAMETERS ON AEM TEMPLATE

(part 2 of 2)

ROW	A	B	C	D	E	F	G	H	I
					COLUMN				
91	757JT	45	a035748	45	a78426	45	,028126	45	,51577
92	COMJET	46	,28504	46	.61027	46	S058735	46	a64206
93	GALTF	47	n044167	47	.62141	47	S030673	47	.14399
94	GALTJ	48	138943	48	060457	48	.061997	48	.68055
95	GANTF	49	.052119	49	.63158	49	.037255	49	043601
96	GALOTF	50	.022013	50	a52699	50	.015311	50	a3752
97	L188	51	,016869	51	.78833	51	.029594	51	037025
98	L100	52	5033394	52	.79478	52	a026474	52	.51704
99	DHC7	53	1011101	53	a68707	53	a00731122	53	.47978
100	CV580	54	.020242	54	,632	54	n025308	54	,33308
101	HTETP	55	n026254	55	169683	55	.030705	55	a39219
102	NTEETP	56	a023894	56	.51311	56	S020488	56	,33031
103	DHC6	57	.015311	57	84805	57	.0042779	57	a51577
104	4EP	58	.058605	58	.81526	58	.033666	58	a58784
105	TEP	59	a042943	59	a75885	59	.034507	59	.49549
106	CONTEP	60	.016671	60	a49302	60	.004013	60	a54427
107	CONSEP	61	.00963306	61	a54076	61	:00266634	61	:54335
108	KC135	62	2.78893	62	a63015	62	,45159	62	a69334
109	C130	63	S033394	63	.79478	63	a026474	63	a51704
110	F4	64	1.01301	64	.66118	64	a23697	64	.65296
111	A7D	65	:47499	65	.6464	65	.11567	65	.63347
112	CL600	66	.049046	66	,5045	66	a039268	66	033787

TABLE B-2

LOCATIONS OF AIRCRAFT NAMES AND IDENTITIES ON AEM TEMPLATE

		COLUMN			
		S	T	U	V
	9	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	737QN	40
	19	707320	8	DC950	41
			9	737D17	42
	20	720B	10	DC980	43
	21	DC850	11	757RB	44
	22	DC860	12	757JT	45
	23	DCBCFM	13	COMJET	46
	24	707CFM	14	GALTF	47
R	25	707QN	is	GALTJ	48
O	26	DCBQN	16	GAMTF	49
W	27	CONCRD	17	GALQTF	50
	28	DC1010	18	LIB8	51
	29	DC1030	19	L100	52
	30	DC1040	20	DHC7	53
	31	L1011	21	CV580	54
	32	L10115	22	HTETP	55
	33	727200	23	MTETP	56
	34	727100	24	DHC6	57
	35	727D15	25	4EP	58
	36	72789	26	TEP	59
	37	727Q7	27	COMTEP	60
	38	727B15	28	COMSEP	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

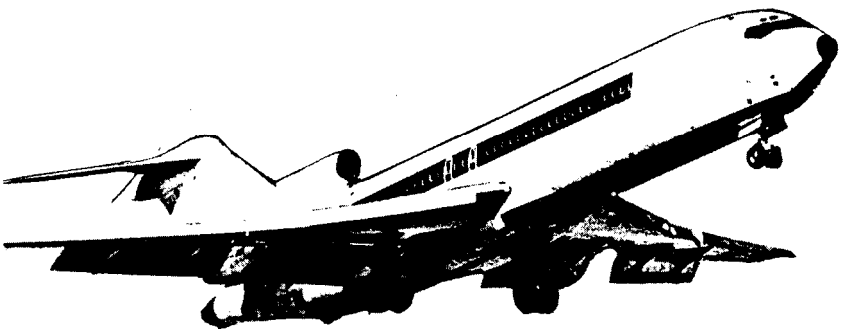
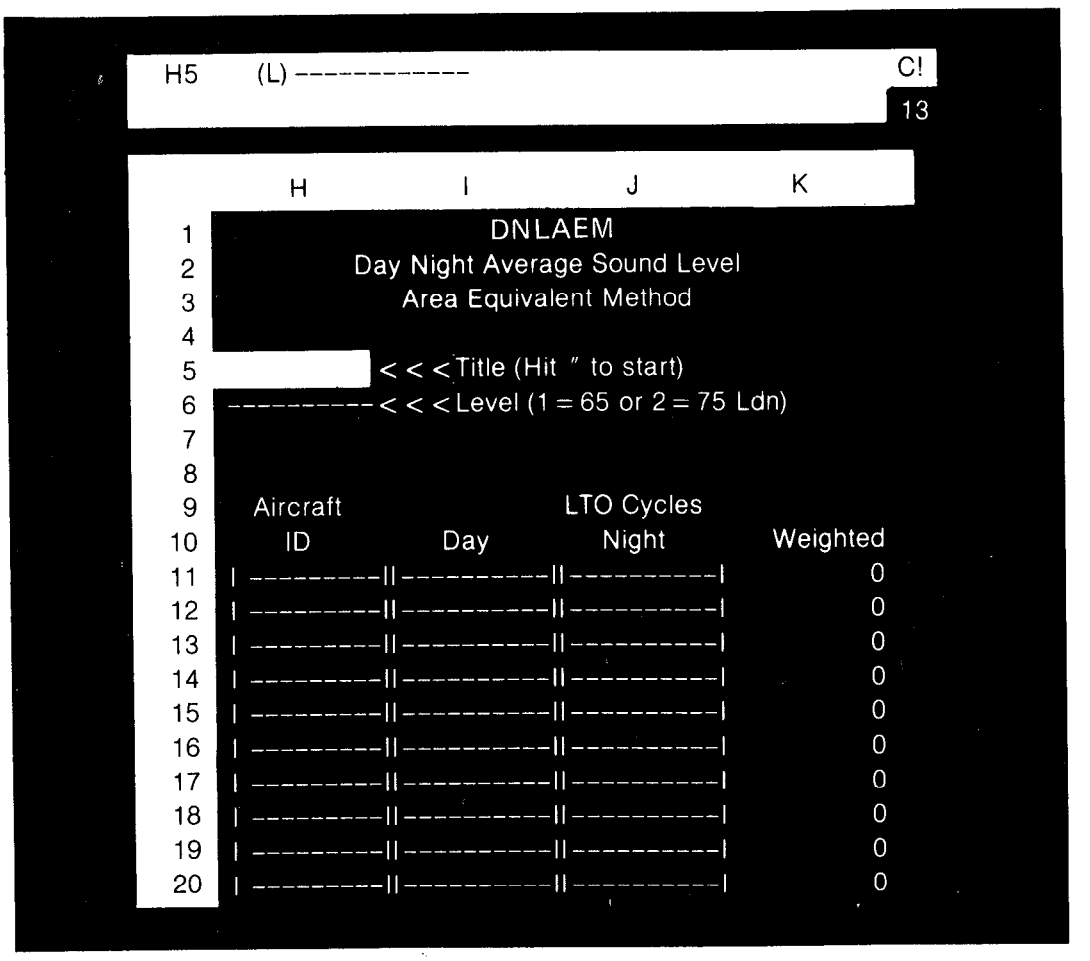
REFERENCES

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.

AREA EQUIVALENT METHOD on VISICALC@

By: Thomas L. Connor
David N. Fortescue

February 1984
Report No. EE-84-8

US. Department
of Transportation
Federal Aviation Administration