Memorandum

U.S. Department
of Transportation

Subject:	Advanced Acoustic Model 2.4.x Supplemental Documentation *1/12 Octave Band and Pearls on Strings Implementation*	Date:	09 May 2019
From:	Juliet Page, Volpe V-324		*Project: VPK9A1*
To:	Rohit Goyal, David Josephson, Uber		

This Memorandum describes the Pearls on Strings implementation in the Advanced Acoustic Model (AAM) Version 2.4.0 as funded by Uber under Volpe Agreement VPK9A1. This feature allows for mixed fidelity time step analysis to facilitate periodic computation of Time Varying Loudness (TVL) for eVTOL vehicles using a 1/12 Octave Band (OB) analysis. The motivation behind the addition of the Pearls on Strings and full implementation of 1/12 OB capabilities in AAM is as follows:

- eVTOL acoustic analysis necessitates the use of the Narrow Band Capabilities with 1/12 OB center band frequencies to facilitate research into community acceptability and evaluation of suitable analysis parameters and audibility metrics including TVL. The 1/12 OBs are modeled as narrow bands in AAM, leveraging and extending the existing functionality of the tool.
- Continuous high frequency time sample rate propagation modeling is not needed for this construct, so the AAM Pearls on Strings analysis mode was conceived that includes hybrid micro and macro time based modeling in the AAM trajectory. This improves computational efficiency by reducing run time and memory requirements, and permits the calculation of full flight operations.

The AAM Supplement Section describes the specific keyword implementation and software details for the new features. This document is intended to complement the AAM User guide[1] that is distributed with the NASA public release version of the software. At this time, the new AAM 2.4.0 features (1/12 OB and PEARLS) are not compatible with multiple-operations analysis, Acoustic Repropagation Technique (ART), the DeDopplerizer tool, SPHERE or 3DVisualizer sound animations.

Section 2 includes examples of 1/12 OB analysis and PEARLS capabilities including the following test cases:

- Pearls on Strings analysis mode for an eVTOL as a Fixed Wing Aircraft at Points of Interest
- Pearls on Strings analysis mode for an eVTOL as a Rotary Wing Aircraft at Points of Interest
- Pearls on Strings analysis mode for an eVTOL as a Fixed Wing Aircraft at a Grid of Receptors

The sample input and output files illustated in this document are included with the AAM 2.4.0 supplemental software distribution. Chapter 5 in the AAM manual includes a series of tutorials intended to familiarize a new user to AAM. Since most of the programs included with the AAM distribution are run from the command line, all users are encouraged to start with the tutorial "Basic Setup of the Environment" (Section 5.1) in the AAM Manual.

[1] Wyle Report WR 16-08, "Advanced Acoustic Model Technical Reference and User Manual".

Advanced Acoustic Model Supplement

This supplement to the AAM Manual describes additional keywords and features for Version 2.4.0 and the new error and warning messages.

AAM Keywords

The AAM **Configuration File** may be used to avoid including the SET option in the execution batch file. The file must be called AAM.config and contain the path information as shown in Table 1. The AAM.config file should be located in the same directory with the AAM executable. Any or all of the configuration parameters (ROTOR_NOISE, FWING_NOISE or QUARRY_NOISE) may be entered into the file in any sequence.

Table 1. AAM.config File Format

Line	Position	Max Length	Description
1	1	A12	RWING_NOISE keyword for setup parameters
2	1	A256	Path to Helicopter Noise Spheres. C:\AAM\NCFiles\ or as needed
1	1	A12	FWING_NOISE keyword for setup parameters
2	1	A256	Path to Fixed Wing Noise Spheres. C:\AAM\NCFiles\ or as needed
1	1	A12	QUARRY_NOISE keyword for setup parameters
2	1	A256	Path to Quarry Acoustic Database. i.e. C:\AAM\NCFiles\Quarry\ or as needed

Note: The directory path needs to end with a backwards slash character,\

Keyword PEARLS

PEARLS intiates analysis using mixed fidelity trajectory time spacing and is described in Table 2. The "Pearls on Strings" concept is to define high resolution time sample periods (the pearls) within a lower fidelity time step trajectory (the string)[2]. This technique allows for computation of time varying loudness using high sample rates over a short burst of time. The implementation in AAM uses two different time steps: macro (lower fidelity time step over the whole trajectory string – legacy AAM technique) and micro (high fidelity time sampling over a shorter duration "pearl"). Common examples of AAM macro time steps are 0.2 to 1.0 seconds whereas the micro time steps are on the order of 10^{-2} to 10^{-4} seconds which last for a specified "pearl width" duration. At present PEARLS is not compatible with Quarry modes of analysis.

The PEARL rules specify that:

a) The Pearl Macro time spacing must be an integer multiplier of Pearl Micro time spacing,

b) The Pearl spacing (interval) must be an integer multiplier of the Pearl Macro time spacing (so that the pearls align on macro time steps) and

c) The Pearl width must be an integer multiplier of the Pearl Micro time spacing.

If one or more of these rules are violated, an error message will be generated and program execution will halt. The Error and Warning Messages section describes these in more detail.

[2] Strings, plural, was selected in anticipation of a multiple operations modeling (multiple strings) capability being implemented in AAM in the future.

Table 2. PEARLS Keyword Format

Line	Position	Max Length	Description
1	1	A5	PEARLS keyword for mixed fidelity time step analysis
2	1	F5	Macro time step (Pearl spacing interval between the start of pearls), seconds
	2	F5	Micro time step, seconds
	3	F5	Pearl width (duration over which micro times will be used), seconds

Notes: Current AAM 2.4.0 max dimension of the total number of trajectory points after applying PEARLS is 8,000.
Keyword TIMESPACING is incompatible with the PEARLS keyword. Use macro time step (line 2 position 1) instead.
PEARLS keyword is only compatible with FWING or RWING modes (not QUARRY mode)

Software Implementation Notes:

Within AAM the PEARLS subroutine orchestrates the creation of the multifidelity time trajectory using the existing INTRTIME and TRJresample algorithms. PEARLS is invoked near the top of the main program before the POI, Single or Multitrack loops. Before calling PEARLS, INTRTIME is called in the MAIN program, with the macro time (variable: *PearlMacroSec*, Line 2 position 1 in Table 2) to set up the AC trajectory arrays using the normal process. If the PEARLS keyword (flag(73)) is in use, then the PEARLS routine is invoked.

Inside PEARLS the AC trajectory arrays are copied into temporary storage. Then the pearl spacing (variable: *PearlMicroSec,* Line 2 Position 2 in Table 2) is used to determine the number of micro time steps across the macro interval (*nMicroPerStep*). Then *nMicroPerStep* is used in a call to TRJreample for each pearl sequentially and the micro sampling across the pearl is computed and inserted/dovetailed into the temporary arrays. Only the points across the pearl are kept. The rest are ignored. After the trajectories across each pearl have been computed, the counters for the number of points (iACpts, iACptsHold) and the arrays (AC, AC hold) are updated using the temp storage values, PEARLS returns to the main program where AAM program execution continues as usual.

Note that within INTRTIME the unit transformations happen as needed (meters to feet, knots to ft/sec etc.) The internal AC and AC hold arrays are in native AAM SI units so additional conversion is not needed.

Variable names for the four PEARLS input parameters in RNM_inc.F are: *PearlMacroSec*, *PearlMicroSec*, *PearlWidthSec*.

Keyword **NCTHIST**

NCTHIST signals AAM to output time history data for each point of calculation into a NetCDF .NC output file. This feature is recommended when the PEARLS keyword is enabled or when 1/12 Octave Band Source data is being used. The standard AAM output runstream does not support 1/12 OB detailed time history output and will only output the 1/3 OB results unless NCTHIST is enabled. No other inputs are required for this keyword and the keyword can appear in any sequence in the input file. This feature is currently only available in single operation analysis mode. When using this option the file naming convention is as follows:

- POI – NCTH*nnn*.nc where nnn is the POI 3-digit numbered sequentially based on the order presented in the POI keyword section in the input file.
- GRID – NCTH*iiiijjjj*.nc where *iiii* and *jjjj* are the x and y point indices respectively across the 2D grid as defined in the SETUP PARA keyword section in the input file.

Note that NCTH files will not be overwritten by AAM. If a file with this name already exists, program execution will halt and an error message will be reported as described in the Run Time Errors and Warning Section. It is recommended that for new cases AAM be run in a separate local directory, or the files be deleted prior to execution using the command line option: del NCTH_00*.NC .

The utility NCDUMP which is provided with AAM can be used to create an ASCII version of the output NetCDF files. An example ASCII fragment for a result at a POI is provided in Figure 1. Note that this .NC variable structure includes arrays (with the NUM_POI elements) that have been set up to accommodate future expansion to include multipe receiver points in a single file. The multiple points output for the NCTHIST keyword has not been established in AAM 2.4.0 and does not take advantage of this variable structure feature at this time.

```
netcdf NCTH_001 {
dimensions:
        NUM_POI = 1 ;
        XYZ = 3 ;
        FREQUENCY = 121 ;
        TIME = 2353 ;
variables:
        float NUM_POI(NUM_POI) ;
                NUM_POI:unit = "COUNT" ;
        float XYZ(XYZ) ;
                XYZ:unit = "FEET" ;
        float FREQUENCY(FREQUENCY) ;
                FREQUENCY:unit = "HERTZ" ;
        float TIME(TIME) ;
                TIME:unit = "SEC" ;
        float AMPLITUDE(FREQUENCY, TIME, NUM_POI) ;
                AMPLITUDE:unit = "DECIBEL" ;

data:

 NUM_POI = 1  ;

 XYZ = 2305500 , 1.2035e+007 , 5  ;

 FREQUENCY = 10 , 10.6 , 11.2 , 11.8 , 12.5 , 13.2 , 14 , 15 , 16 , 17 , 18 ,
    19 , 20 , 21.2 , 22.4 , 23.6 , 25 , 26.5 , 28 , 30 , 31.5 , 33.5 , 35.5 ,
    37.5 , 40 , 42.5 , 45 , 47.5 , 50 , 53 , 56 , 60 , 63 , 67 , 71 , 75 ,

<snip>

 TIME = 3.956753 , 4.006592 , 4.056432 , 4.106271 , 4.15611 , 4.205105 ,
    4.950013 , 4.999852 , 5.049691 , 5.099531 , 5.148526 , 5.198365 ,
    5.942355 , 5.992194 , 6.042033 , 6.090955 , 6.140794 , 6.190633 ,

<snip>

AMPLITUDE =
  73.18597 ,
  73.18597 ,
  73.18597 ,
  73.18597 ,
  73.18597 ,
  73.18781 ,
  73.19367 ,

<snip>
```

Figure 1. Example ASCII output from NCTHIST file NCTH_001.NC

Keyword **ABS1845**

ABS1845 signals AAM to use the SAE-AIR-1845 atmospheric absorption tables for 1/3 OB instead of the default ANSI/ISO standard [2004].[3] This keyword is not presently compatible with NB data. When using the ABS1845 keyword, the assumed atmosphere will be isothermal at 59°F and 70% Relative Humidity as specified in SAE-AIR-1845. Any other defined atmospheres in the input file will be ignored.

Table 3. ABS1845 Keyword Format

Line	Position	Max Length	Description
1	1	A7	ABS1845 keyword for SAE-AIR-1845 standard atmosphere

Error and Warning Messages

Error messages fall into three categories: Error, Warning and general information. Error messages are created when fatal situations are encountered that require cessation of program execution. These are preceded by ERROR: in the output. Warning messages are preceded by WARNING: and give critical information about analysis. Under warning conditions, execution is continued, however the user should be aware that non-standard program operation has occurred and some changes to their specified input parameters may have been made. AAM will indicate the changes made if any. All other messages and output fall into the informational category.

The ERROR and WARNING messages are itemized here in **BOLD** type along with an explanation and where appropriate, recommended changes to the input file. In some instances, values of particular variables are provided to the user. These are indicated in *italics* and explained with each error message. At the end of every message is the name of the subroutine that generated the message. While this is not likely to be of significant value to the user it should be reported when inquiring about AAM to Volpe.

Error messages are generated based on problems in two different areas: Input file errors and run time errors. Input file error message are generated after screening of the inputs and are standardized and conform to the general output listed in Table 3. Run time errors are generated later in program execution and may include a variety of output messages, all of which appear in alphabetical order in this document.

Table 4. Input File Error Message Standardized Output

ERROR: Read Error in the Advanced Acoustic Model.
Problem in the following file: Filename
Detailed Message
Problem detected at line number *line*#
Error located at or above this line:
Input file content

This is a generalized error reporting message, which is generated when problems are encountered in the input file, filename. The line number at which the error occurs is identified (line #), as well as a repeat of the Input file content. A Detailed Message is provided for the user's benefit and a summary of possible error messages are given in Table 4. The last word on the detailed message line contains the name of the

[3] American National Standards Institute (ANSI). 2004. "American National Standard Method for Calculation of the Absorption of Sound by the Atmosphere," ANSI S1.26 (R2004).

subroutine which reported the error. This additional diagnostic information is useful when contacting Volpe with questions.

Table 5. ERROR: Read Error Detailed Message Descriptions

Input keyword problem, COMPUTEPLT and COMPUTEPOI incompatible. INPUTTRK The COMPUTEPLT and COMPUTEPOI keywords were found in the same input file with the NCTHIST keyword. When using NCTHIST only POIs or only a PLT (grid) may be calculated. Use two separate input files for POIs and grids.
Input keyword problem, PEARLS and QUARRY incompatible. INPUTTRK The PEARLS and QUARRY keywords were found in the same input file. Remove one of them.
Input keyword problem, PEARLS and TIMESPACING incompatible. INPUTTRK The PEARLS and TIMESPACING keywords are incompatible. Remove one of them.

Run Time Errors and Warnings

ERROR: Pearls points exceeds Max. PEARLS *nTotPts*

The combination of inputs in the PEARLS keyword resulted in too many points for AAM to handle. The maximum allowable points is 8,000 and the inputs resulted in *nTotPts*. Reduce any or a combination of the input parameters to result in less than 8,000 trajectory points.

ERROR: Pearl Micro/Macro not even multiplier

The PEARL rules specify that the Pearl Macro time spacing must be an integer multiplier of Pearl Micro time spacing.

ERROR: Pearl Spacing/Macro not even multiplier

The PEARL rules specify that the Pearl spacing (interval) must be an integer multiplier of the Pearl Macro time spacing (so that the pearls align on macro time steps).

ERROR: Pearl Width/Micro not even multiplier

The PEARL rules specify that the Pearl width must be an integer multiplier of the Pearl Micro time spacing.

ERROR: All Pearl Parameters match. Use TIMESPACING

If the pearl spacing, width, micro and macro time steps are all the same there is no need to implement the pearls algorithms, so the user should instead use the TIMESPACING keyword with the desired time step.

AAM 2.4.0 Installation, Tutorials and Examples

Installation Instructions

The following files are included with the AAM 2.4.0 supplemental software package in a zip archive called AAM_2.4.0-InstallationFiles.zip. The AAM_2.4.0 executable should be put in the AAM bin directory as indicated, based on the default AAM installation directory structure as defined in the AAM software manual. If a custom AAM install step was used, put it in the same directory as the earlier AAM executable. The project files can be placed in a working directory at any desired location.

- AAM_2.4.0.exe – Computational executable for AAM. Put in C:/AAM/bin.
- F12NB100.nc, F12NB150.nc, R12NB100.nc – Noise data. Put in C:/AAM/NCfiles.

The remainder of the files are contained in the AAM-2.4.0-Supplement-SampleFiles.zip archive, and include sample input and output files for the Tutorial and Examples section that are described in further detail in the sections below.

Tutorials and Examples

Pearls on Strings analysis mode for an eVTOL as a Fixed Wing Aircraft at POIs

This example is a single operation of a 1/12 OB Fixed Wing vehicle named F12NB. Use of FW parameters allows the user to specify thrust as a source lookup parameter in AAM. The files included with this case include the following and should be put in a working directory.

- 1-AAM-F12NB.bat – batch file that runs the FW Pearls2 test case.
- Pearls2.inp – input file for this test case.
- Uber3.elv, Uber3_200.inp – sample elevation and impedance terrain files.
- Pearls2.zip – contains all the AAM output files for this run described below.

The test case was built using the Uber Summit 2018 Dallas flight trajectory with three points of interest as displayed in Figure 2. The flight operation is headed in the southward direction (down).

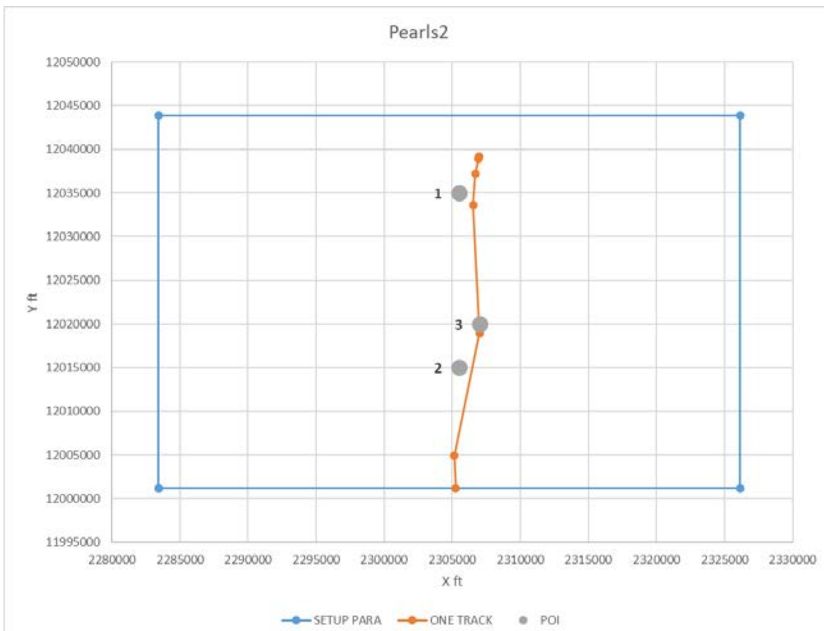

Figure 2. Example ground track trajectory, computational area and points of interest (from Pearls2.inp)

There are 2 source NetCDF files provided for this omnidirectional vehicle: F12NB100.nc and F12NB150.nc which contain the operating characteristics shown in Figure 3 as reported in the AAM primary output .txt file. Both of these source files represent a nominal speed of 100 knots in level flight. The run 100 source has a thrust of 1000 lbs; the run 150 source has a thrust of 1500 lbs.

```
NCFiles Environment Path FWING_NOISE
D:\Project_Docs\Uber-VPK9A1\04-2019-ProjectFiles\05-Pearls-Testing\




                         NETCDF FILES (UNSORTED)
      Number     Fixed-  Sequence  Thrust-     Power    Speed
                  Wing    Number   Vector-    Setting  (Knots)
                  Type              Angle
                                  (Degrees)
        1        f12nb     100        0.0      1000.0    100.
        2                  150        0.0      1500.0    100.


    NETCDF FILES (SORTED)     Path to .NC D:\Project_Docs\Uber-VPK9A1\04-2019-ProjectFiles\05-Pearls-Testing\
    Number  Fixed Run      Thrust      Power Speed  Climb   Broad Narr Pure Cent   Cent   Cent  Doppler     Vehicle    Interp.
            Wing  Number   Vector            Knots  Rate    Band  Band Tone X      Y      Z     State       Config.    State
            Type           Angle                    ft/min                  ft     ft     ft    F=Moving               0 = No Interp.
                           Deg.                                                                 T=Stat.                1 = Interpolate
      1    f12nb   100       0.0     1000.00  100.     0.0    0     1    0  0.0    0.0    0.0  F           01         1
      2            150     0.00     1500.00  100.     0.0    0     1    0  0.0    0.0    0.0  F           01         1
```

Figure 3. Fixed Wing 1/12 OB Source Characteristics

These two source files contain omnidirectional 1/12 OB data with sphere 100 at 100 dB in all bands and sphere 150 with 150 dB in all bands. One can use the NCDump utility provided with AAM to create ASCII versions of the source .NC files using the following from the command line:

```
C:\AAM\bin\NCDump.exe F12NB100.nc >F12NB100.nc.txt
```

Using NCDUMP results in a text file for the 1/12 OB test case (fragments provided in Figure 4 and Figure 5 for F12NB100 as indicated in the first line). Both sources are set up with a 1000 Ft radius and 5 degree spacing in phi and theta. Note that since Phi is defined from -90 to +90 degrees and Theta from 0 to 180 degrees, these two source files represent hemispheres with only the lower portion defined. Additional information about the NetCDF file structure for AAM noise sources may be found in the AAM manual.

A trajectory has been defined for this operation as outlined in the ONE TRACK keyword section of the AAM input deck (Figure 6). The keywords to note in this input file include the following (more information for each and the specific formats are in the AAM manual):

- COMPUTEPOI – signals the calculation of points of interest
- DIAGNOSTICS – signals supplemental output to the .txt file
- TERRAIN – computes terrain effects using the provided Uber3.elv and Uber3_200.imp files
- SETUP PARA – this mandatory section defines the computational parameters and identifies which vehicle is to be used for analysis (F12NB) and the spectral characteristics (BB, NB or PT).
- NCTHIST – this triggers output of a NetCDF output time history file which is suitable for PEARLS.
- PEARLS – indicates AAM should use PEARLS trajectory spacing and identifies parameters (see the AAM Supplement section of this document for PEARLS format and input parameter definitions).
- ONE TRACK – signifies user input of the trajectory. Note that the TIMETRAJ keyword is not used in this case, so AAM will determine the times for the trajectory points based on simple kinematics.
- POI – identifies 3 points of interest at which the acoustics are to be computed.
- ATMOS – this case uses an isothermal atmosphere at 59F and 70% RH.

To run AAM the FWING_NOISE parameter must be set up with a pointed to the directory where the .NC files are stored. An example batch script is provided that includes the following:

```
del NCTH_*.NC
set FWING_NOISE=C:\AAM\NCfiles\
C:\AAM\bin\AAM_2.4.0.exe Pearls2.inp
pause
exit
```

```
netcdf F12NB100 {
dimensions:
    BB = 1 ;
    NB = 1 ;
    PT = 1 ;
    DOPPLER_SHIFT_REMOVED = 1 ;
    RADIUS = 1 ;
    SPEED = 1 ;
    POWER = 1 ;
    AOA = 1 ;
    THRUSTANGLE = 1 ;
    ACCONFIG = 1 ;
    INTERPOLATIONSTATE = 1 ;
    XYZ = 3 ;
    PHI = 37 ;
    THETA = 37 ;
    FREQUENCY = 121 ;
variables:
    float BB ;
        BB:unit = "" ;
    float NB ;
        NB:unit = "" ;
    float PT ;
        PT:unit = "" ;
    float DOPPLER_SHIFT_REMOVED ;
        DOPPLER_SHIFT_REMOVED:unit = "" ;
    float RADIUS ;
        RADIUS:unit = "FEET                " ;
    float SPEED ;
        SPEED:unit = "KNOTS               " ;
    float POWER ;
        POWER:unit = "LBS                 " ;
    float AOA ;
        AOA:unit = "DEGREE              " ;
    float THRUSTANGLE ;
        THRUSTANGLE:unit = "DEGREE              " ;
    float ACCONFIG ;
        ACCONFIG:unit = ".                    " ;
    float INTERPOLATIONSTATE ;
        INTERPOLATIONSTATE:unit = ".                    " ;
    float XYZ(XYZ) ;
        XYZ:unit = "FEET" ;
    float PHI(PHI) ;
        PHI:unit = "DEGREE" ;
    float THETA(THETA) ;
        THETA:unit = "DEGREE" ;
    float FREQUENCY(FREQUENCY) ;
        FREQUENCY:unit = "HERTZ" ;
    float AMPLITUDE(PHI, THETA, FREQUENCY) ;
        AMPLITUDE:unit = "DECIBEL" ;

// global attributes:
        :title = "AIRPLANE 121 NB 100 dB Omni Sound Hemisphere        " ;

```

Figure 4. NetCDF ASCII fragment for F12NB100.nc – Part 1

```
data:

 BB = 0  ;

 NB = 1  ;

 PT = 0  ;

 DOPPLER_SHIFT_REMOVED = 0  ;

 RADIUS = 1000  ;

 SPEED = 100  ;

 POWER = 1000  ;

 AOA = 0  ;

 THRUSTANGLE = 0  ;

 ACCONFIG = 1  ;

 INTERPOLATIONSTATE = 1  ;

 XYZ = 0 , 0 , 0  ;

 PHI = -90 , -85 , -80 , -75 , -70 , -65 , -60 , -55 , -50 , -45 , -40 ,
    -35 , -30 , -25 , -20 , -15 , -10 , -5 , 0 , 5 , 10 , 15 , 20 , 25 , 30 ,
    35 , 40 , 45 , 50 , 55 , 60 , 65 , 70 , 75 , 80 , 85 , 90  ;

 THETA = 0 , 5 , 10 , 15 , 20 , 25 , 30 , 35 , 40 , 45 , 50 , 55 , 60 , 65 ,
    70 , 75 , 80 , 85 , 90 , 95 , 100 , 105 , 110 , 115 , 120 , 125 , 130 ,
    135 , 140 , 145 , 150 , 155 , 160 , 165 , 170 , 175 , 180  ;

 FREQUENCY = 10 , 10.6 , 11.2 , 11.8 , 12.5 , 13.2 , 14 , 15 , 16 , 17 , 18 ,
    19 , 20 , 21.2 , 22.4 , 23.6 , 25 , 26.5 , 28 , 30 , 31.5 , 33.5 , 35.5 ,
    37.5 , 40 , 42.5 , 45 , 47.5 , 50 , 53 , 56 , 60 , 63 , 67 , 71 , 75 ,
    80 , 85 , 90 , 95 , 100 , 106 , 112 , 118 , 125 , 132 , 140 , 150 , 160 ,
    170 , 180 , 190 , 200 , 212 , 224 , 236 , 250 , 265 , 280 , 300 , 315 ,
    335 , 355 , 375 , 400 , 425 , 450 , 475 , 500 , 530 , 560 , 600 , 630 ,
    670 , 710 , 750 , 800 , 850 , 900 , 950 , 1000 , 1060 , 1120 , 1180 ,
    1250 , 1320 , 1400 , 1500 , 1600 , 1700 , 1800 , 1900 , 2000 , 2120 ,
    2240 , 2360 , 2500 , 2650 , 2800 , 3000 , 3150 , 3350 , 3550 , 3750 ,
    4000 , 4250 , 4500 , 4750 , 5000 , 5300 , 5600 , 6000 , 6300 , 6700 ,
    7100 , 7500 , 8000 , 8500 , 9000 , 9500 , 10000  ;

 AMPLITUDE =
  100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
```

Figure 5. NetCDF ASCII fragment for F12NB100.nc – Part 2

```
REM AAM2 64-bit PEARLS2 test file
REM       ^         ^         ^         ^         ^         ^         ^         ^         ^
REM      11-20     21-30     31-40     41-50     51-60     61-70     71-80     81-90     91-100
COMPUTEPOI
DIAGNOSTICS
TERRAIN
Uber3.elv
Uber3_200.imp
SETUP PARA
     198.6     198.6         0
   2283437  12001166         5
   2326137  12043866
      1000    100000       200     .0004
F12NB
0
1
      0.00      0.00      0.00
0
FIXEDWINGAC
REM
NCTHIST
PEARLS
1.00                          !Macro Time Sec
.05                           !Micro Time Sec
.25                           !Pearl Width Sec
1.0                           !Pearl Spacing Sec
REM  X(ft)        Y(ft)      Z(ft)    Turn(deg)     Rad(ft)   Spd(kts)   Yaw(deg)   AOA(deg)  Roll(deg)    Power      T Vector  ACConfig
REM                                                                      +L turn               +L down                Angle
ONE TRACK
Connect the Dots input.  Treated as FixedWing AC
8
   2306966.7  12039174.0         0.0           0           0          2          0          0          0     1000.        0        1         0
   2306952.9  12039074.4         0.0           0           0         10          0          0          0     1000.        0        1         0
   2306932.4  12038925.0        20.0           0           0         20          0          0          0     1000.        0        1         0
   2306692.2  12037182.2       150.0           0           0         60          0          0          0     1000.        0        1         0
   2306550.0  12033649.6       400.0           0           0         60          0          0          0     1000.        0        1         0
   2307000.0  12018954.9       800.0           0           0         60          0          0          0     1000.        0        1         0
   2305145.9  12004926.2       800.0           0           0         60          0          0          0     1000.        0        1         0
   2305263.0  12001166.0       800.0           0           0         60          0          0          0     1000.        0        1         0
POI
3
1    2305500. 12035000.   5.0
2    2305500. 12015000.   5.0
3    2307000. 12020000.   5.0
ATMOS
2
FEET     F    KPA      %
0       59   101.325  70.00
50000   59   101.325  70.00
END
```

Figure 6. AAM input deck for FW mode: Pearls2.inp

The output files from AAM include the following:

- NCTH_001.nc, NCTH_002.nc, NCTH_003.nc – NetCDF output spectral time history at POIs
- Pearls2.txt – Primary ASCII output from AAM.
- Pearls2.POI – ASCII (tecplot format) time history in 1/3 Octave Bands at POIs
- Pearls2.Single.POI.csv – Resultant metrics at POIs for the single operation in ESRI ASCII format.

The Pearls2.txt file should be scanned to ensure there are no error messages and that any warnings are acceptable. This file contains a running diatribe of the AAM analysis run stream. It begins by echoing the input deck in an interpretative fashion. After the AAM Version identification (Figure 7) scan to ensure input formats (specifically those with fixed field requirements) are interpreted correctly. Summarized will be the input track parameters, the computational grid areas, the track specifications, the points of interest, the elevation and impedance information. That will be followed by information about the NetCDF source acoustic files (Figure 3).

```
***** ADVANCED ACOUSTIC MODEL *****
  Version 2.4.0   March 2019   Volpe
         SETUP PARAMETERS
```

Figure 7. AAM Version Identification

The output file will itemize the interpolated track for analysis. When PEARLS keyword is enabled this is a two step process. The first step will perform the legacy AAM interpolation using the Pearl Macro time spacing. The second step will add the Pearl micro time spacing at the user specified pearl width and spacing.

shows user input "waypoints", the first step spacing (393 points), and the final spaing with pearls (2353 points). Sample output from the Pearls2.txt file is provided in Figure 8.

Track Profile Name >CONNECT THE DOTS INP

T (sec)	X (feet)	Y (feet)	Z (ft MSL)	Speed (knots)	Yaw (degree)	Attack (degree)	Roll (degree)	Power	Thrust Angle (degree)	Cumulative Distance (feet)	Configuration
0.000	2306966.8	12039174.0	0.0	2.0	0.0	0.	0.	1000.	0.	0.	01
9.968	2306953.0	12039074.0	0.0	10.0	0.0	0.	0.	1000.	0.	101.	01
15.961	2306932.5	12038925.0	20.0	20.0	0.0	0.	0.	1000.	0.	251.	01
42.094	2306692.2	12037182.0	150.0	60.0	0.0	0.	0.	1000.	0.	2011.	01
77.088	2306550.0	12033650.0	400.0	60.0	0.0	0.	0.	1000.	0.	5546.	01
222.321	2307000.0	12018955.0	800.0	60.0	0.0	0.	0.	1000.	0.	20248.	01
362.061	2305146.0	12004926.0	800.0	60.0	0.0	0.	0.	1000.	0.	34399.	01
399.209	2305263.0	12001166.0	800.0	60.0	0.0	0.	0.	1000.	0.	38160.	01

Interpolated Track for analysis. 393 points

time	Xft	Yft	Z-MSL	ang	rad	spd	yaw	attack	roll	nacl
0.0000	2306966.750	12039174.000	0.000	0.000	0.000	2.000	0.000	0.000	0.000	90.000
0.9968	2306966.250	12039170.000	0.000	0.000	0.000	2.800	0.000	0.000	0.000	90.000
1.9936	2306965.500	12039165.000	0.000	0.000	0.000	3.600	0.000	0.000	0.000	90.000
2.9903	2306964.500	12039158.000	0.000	0.000	0.000	4.400	0.000	0.000	0.000	90.000
3.9871	2306963.500	12039150.000	0.000	0.000	0.000	5.200	0.000	0.000	0.000	90.000
4.9839	2306962.250	12039141.000	0.000	0.000	0.000	6.000	0.000	0.000	0.000	90.000
5.9807	2306960.750	12039130.000	0.000	0.000	0.000	6.800	0.000	0.000	0.000	90.000
6.9775	2306959.000	12039118.000	0.000	0.000	0.000	7.600	0.000	0.000	0.000	90.000
7.9743	2306957.250	12039105.000	0.000	0.000	0.000	8.400	0.000	0.000	0.000	90.000
9.9678	2306953.000	12039074.000	0.000	0.000	0.000	10.000	0.000	0.000	0.000	90.000
10.9667	2306950.500	12039056.000	2.407	0.000	0.000	11.667	0.000	0.000	0.000	90.000
11.9656	2306947.750	12039035.000	5.185	0.000	0.000	13.333	0.000	0.000	0.000	90.000
12.9644	2306944.500	12039012.000	8.333	0.000	0.000	15.000	0.000	0.000	0.000	90.000
13.9633	2306940.750	12038986.000	11.852	0.000	0.000	16.667	0.000	0.000	0.000	90.000
15.9610	2306932.500	12038925.000	20.000	0.000	0.000	20.000	0.000	0.000	0.000	90.000
16.9661	2306927.750	12038890.000	22.596	0.000	0.000	21.538	0.000	0.000	0.000	90.000
17.9713	2306922.500	12038853.000	25.385	0.000	0.000	23.077	0.000	0.000	0.000	90.000
18.9764	2306917.000	12038813.000	28.365	0.000	0.000	24.615	0.000	0.000	0.000	90.000

Interpolated Track for analysis. 2353 points

time	Xft	Yft	Z-MSL	ang	rad	spd	yaw	attack	roll	nacl
0.0000	2306966.750	12039174.000	0.000	0.000	0.000	2.000	0.000	0.000	0.000	90.000
0.0498	2306966.750	12039174.000	0.000	0.000	0.000	2.000	0.000	0.000	0.000	90.000
0.0997	2306966.750	12039174.000	0.000	0.000	0.000	2.002	0.000	0.000	0.000	90.000
0.1495	2306966.750	12039174.000	0.000	0.000	0.000	2.004	0.000	0.000	0.000	90.000
0.1994	2306966.750	12039174.000	0.000	0.000	0.000	2.008	0.000	0.000	0.000	90.000
0.2492	2306966.750	12039173.000	0.000	0.000	0.000	2.050	0.000	0.000	0.000	90.000
0.9968	2306966.250	12039170.000	0.000	0.000	0.000	2.800	0.000	0.000	0.000	90.000
1.0466	2306966.250	12039170.000	0.000	0.000	0.000	2.800	0.000	0.000	0.000	90.000
1.0965	2306966.250	12039170.000	0.000	0.000	0.000	2.802	0.000	0.000	0.000	90.000
1.1463	2306966.250	12039170.000	0.000	0.000	0.000	2.804	0.000	0.000	0.000	90.000
1.1961	2306966.250	12039169.000	0.000	0.000	0.000	2.808	0.000	0.000	0.000	90.000
1.2460	2306966.250	12039169.000	0.000	0.000	0.000	2.850	0.000	0.000	0.000	90.000
1.9936	2306965.500	12039165.000	0.000	0.000	0.000	3.600	0.000	0.000	0.000	90.000
2.0434	2306965.500	12039165.000	0.000	0.000	0.000	3.600	0.000	0.000	0.000	90.000
2.0932	2306965.500	12039165.000	0.000	0.000	0.000	3.602	0.000	0.000	0.000	90.000
2.1431	2306965.250	12039164.000	0.000	0.000	0.000	3.604	0.000	0.000	0.000	90.000
2.1929	2306965.250	12039164.000	0.000	0.000	0.000	3.608	0.000	0.000	0.000	90.000
2.2428	2306965.250	12039164.000	0.000	0.000	0.000	3.650	0.000	0.000	0.000	90.000
2.9903	2306964.500	12039158.000	0.000	0.000	0.000	4.400	0.000	0.000	0.000	90.000
3.0402	2306964.500	12039158.000	0.000	0.000	0.000	4.400	0.000	0.000	0.000	90.000
3.0900	2306964.500	12039158.000	0.000	0.000	0.000	4.402	0.000	0.000	0.000	90.000
3.1399	2306964.250	12039157.000	0.000	0.000	0.000	4.404	0.000	0.000	0.000	90.000
3.1897	2306964.250	12039157.000	0.000	0.000	0.000	4.408	0.000	0.000	0.000	90.000
3.2395	2306964.250	12039157.000	0.000	0.000	0.000	4.450	0.000	0.000	0.000	90.000
3.9871	2306963.500	12039150.000	0.000	0.000	0.000	5.200	0.000	0.000	0.000	90.000
4.0370	2306963.500	12039150.000	0.000	0.000	0.000	5.200	0.000	0.000	0.000	90.000
4.0868	2306963.250	12039149.000	0.000	0.000	0.000	5.202	0.000	0.000	0.000	90.000
4.1366	2306963.250	12039149.000	0.000	0.000	0.000	5.204	0.000	0.000	0.000	90.000
4.1865	2306963.250	12039149.000	0.000	0.000	0.000	5.208	0.000	0.000	0.000	90.000
4.2363	2306963.250	12039149.000	0.000	0.000	0.000	5.250	0.000	0.000	0.000	90.000
4.9839	2306962.250	12039141.000	0.000	0.000	0.000	6.000	0.000	0.000	0.000	90.000
5.0338	2306962.250	12039141.000	0.000	0.000	0.000	6.000	0.000	0.000	0.000	90.000
5.0836	2306962.250	12039140.000	0.000	0.000	0.000	6.002	0.000	0.000	0.000	90.000
5.1334	2306962.250	12039140.000	0.000	0.000	0.000	6.004	0.000	0.000	0.000	90.000

Figure 8. Interpolated Track for Analysis – First pass and Pearls pass from Pearls2.txt

After the flight trajectory has been processed and output, AAM provides information about the meteorological data in use and the atmospheric absorption by providing a table of absorption coefficients for the 1/12 OB in use (as dictated by the frequencies contained in the noise source .NC files).

At the very bottom of the file are the metric results at the points of interest, followed by a listing of the noise source files that were used in the analysis and the analysis run time (Figure 9). Within AAM the data calculations are "rolled up" from 1/12 OB (treated as narrow band with energy at the center band frequency) into the standard 1/3 OBs from which the typical noise metrics are computed.

```
                                   POINT OF INTEREST RESULTS
    NAME      X         Y         Z       LmaxA      LmaxC     Lmax      SEL       SEL      SEL        EPNL      PNLMX
           (feet)    (feet)    (feet)     (dBA)      (dBC)     (dB)     (dBA)     (dBC)   (Overall)    (dB)      (dB)
1         2305500. 12035000.      5.      113.7      119.0     121.4    127.5     133.8     136.4      16.3       0.0
2         2305500. 12015000.      5.      113.2      118.1     120.2    127.4     133.4     135.8      15.9       0.0
3         2307000. 12020000.      5.      119.0      122.9     124.5    131.1     136.0     138.1      16.0       0.0


    NETCDF FILES USED IN THE CALCULATIONS
    Number Filename     Thrust-       Power    Speed
                        Vector-       Setting  (Knots)
                        Angle
                       (Degrees)
    1       f12nb100      0.0        1000.00     100.


    Start Date 02-03-2019     Start Time 19:36:23.40
    Stop Date  02-03-2019     Stop Time  19:36:25.51
```

Figure 9. Point of Interest Results from file Pearls2.txt

Additional output generated by AAM for point of interest analyses include a POI file which contains ASCII spectral time history results at the POIs in TecPlot format (Figure 10) and plotted (Figure 11) for the 3 POIs in this test case. Each POI is a different zone in the POI file and they are sequenced as they appear in the input file.

```
TITLE = "Points of Interest Time History"
VARIABLES = "Time"  "SPL" "dBC"    "dBA"    "PNL"     "PNLT"   "f   10.0Hz" "f   12.5Hz" "f   16.0Hz" "f   20.0Hz" "f   25.0Hz"
ZONE I=2353 F=POINT
      3.96    108.66    105.04    79.85    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      4.01    108.66    105.04    79.85    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      4.06    108.66    105.04    79.85    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      4.11    108.66    105.04    79.85    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      4.16    108.66    105.04    79.85    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      4.21    108.66    105.04    79.85    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      4.95    108.67    105.04    79.86    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      5.00    108.67    105.04    79.86    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      5.05    108.67    105.04    79.86    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      5.10    108.67    105.04    79.86    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      5.15    108.67    105.05    79.86    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      5.20    108.67    105.05    79.86    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      5.94    108.68    105.06    79.88    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      5.99    108.68    105.06    79.88    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      6.04    108.68    105.06    79.88    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      6.09    108.68    105.06    79.88    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      6.14    108.68    105.06    79.88    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      6.19    108.68    105.06    79.88    0.00     0.00        96.2       100.2        98.0        99.2       100.2
      6.93    108.69    105.07    79.90    0.00     0.00        96.2       100.2        98.0        99.3       100.2
```

Figure 10. Tecplot ASCII .POI file contents – Pearls2.POI

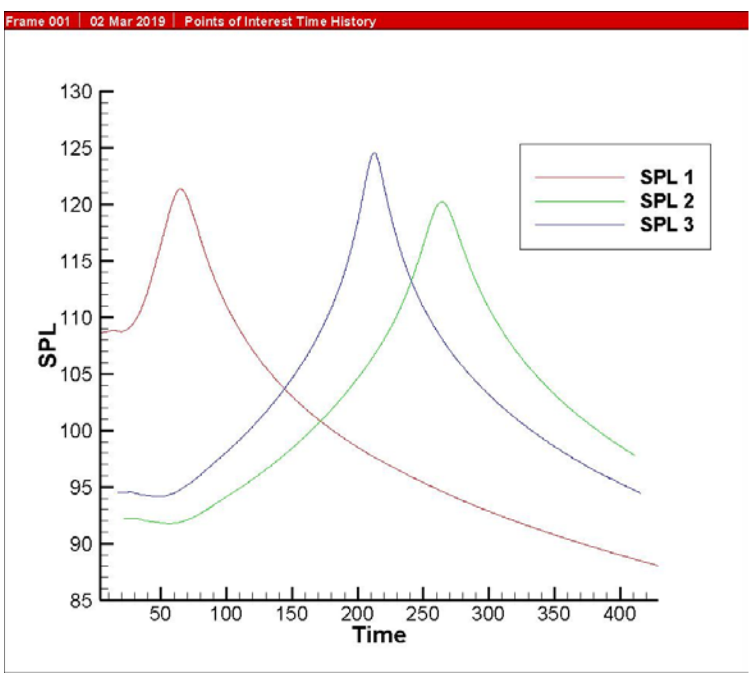

Figure 11. Plotted time history in the .POI file (overall SPL) – Pearls2.POI

The 1/12 OB time history data is contained in the NCTH_001.nc, NCTH_002.nc and NCTH_003.nc files and was triggered by the used of the NCTHIST keyword. The file naming convention is explained in the NCTHIST keyword section in this document. One can use the NCDump option to create an ASCII version of the .NC files as provided in the 2-NCTH-dump.bat file:

```
c:\AAM\bin\ncdump NCTH_001.nc >NCTH_001.nc.txt
c:\AAM\bin\ncdump NCTH_002.nc >NCTH_002.nc.txt
c:\AAM\bin\ncdump NCTH_003.nc >NCTH_003.nc.txt
pause
exit
```

A fragment of the ASCII content of the POI #1 1/12 OB time history files is provided in Figure 12.

```
netcdf NCTH_001 {
dimensions:
    NUM_POI = 1 ;
    XYZ = 3 ;
    FREQUENCY = 121 ;
    TIME = 2353 ;
variables:
    float NUM_POI(NUM_POI) ;
        NUM_POI:unit = "COUNT" ;
    float XYZ(XYZ) ;
        XYZ:unit = "FEET" ;
    float FREQUENCY(FREQUENCY) ;
        FREQUENCY:unit = "HERTZ" ;
    float TIME(TIME) ;
        TIME:unit = "SEC" ;
    float AMPLITUDE(FREQUENCY, TIME, NUM_POI) ;
        AMPLITUDE:unit = "DECIBEL" ;

data:

 NUM_POI = 1  ;

 XYZ = 2305500 , 1.2035e+007 , 5  ;

 FREQUENCY = 10 , 10.6 , 11.2 , 11.8 , 12.5 , 13.2 , 14 , 15 , 16 , 17 , 18 ,
    19 , 20 , 21.2 , 22.4 , 23.6 , 25 , 26.5 , 28 , 30 , 31.5 , 33.5 , 35.5 ,
    37.5 , 40 , 42.5 , 45 , 47.5 , 50 , 53 , 56 , 60 , 63 , 67 , 71 , 75 ,
    80 , 85 , 90 , 95 , 100 , 106 , 112 , 118 , 125 , 132 , 140 , 150 , 160 ,
    170 , 180 , 190 , 200 , 212 , 224 , 236 , 250 , 265 , 280 , 300 , 315 ,
    335 , 355 , 375 , 400 , 425 , 450 , 475 , 500 , 530 , 560 , 600 , 630 ,
    670 , 710 , 750 , 800 , 850 , 900 , 950 , 1000 , 1060 , 1120 , 1180 ,
    1250 , 1320 , 1400 , 1500 , 1600 , 1700 , 1800 , 1900 , 2000 , 2120 ,
    2240 , 2360 , 2500 , 2650 , 2800 , 3000 , 3150 , 3350 , 3550 , 3750 ,
    4000 , 4250 , 4500 , 4750 , 5000 , 5300 , 5600 , 6000 , 6300 , 6700 ,
    7100 , 7500 , 8000 , 8500 , 9000 , 9500 , 10000  ;

 TIME = 3.956753 , 4.006592 , 4.056432 , 4.106271 , 4.15611 , 4.205105 ,
    4.950013 , 4.999852 , 5.049691 , 5.099531 , 5.148526 , 5.198365 ,
    5.942355 , 5.992194 , 6.042033 , 6.090955 , 6.140794 , 6.190633 ,
    6.932936 , 6.982775 , 7.032615 , 7.081536 , 7.131375 , 7.181214 ,
    7.922674 , 7.972513 , 8.021434 , 8.071273 , 8.121112 , 8.170951 ,
    8.911494 , 8.961333 , 9.010329 , 9.060168 , 9.109933 , 9.158928 ,
```

```
    424.1088 , 424.1617 , 424.2146 , 424.2675 , 425.0982 , 425.1511 ,
    425.204 , 425.2569 , 425.3098 , 425.3627 , 426.1925 , 426.2454 ,
    426.2983 , 426.3512 , 426.4041 , 426.4569 , 427.2877 , 427.3935 ,
    427.4992 , 427.605 , 427.7108 , 427.8165 , 429.4771  ;

 AMPLITUDE =
  93.18597 ,
  93.18597 ,
  93.18597 ,
  93.18597 ,
  93.18597 ,
  93.18781 ,
  93.19367 ,
  93.19367 ,
  93.19367 ,
```

Figure 12. Example 1/12 OB Time History output – NCTH_001.nc.txt, case: Pearls2.inp

Pearls on Strings analysis mode for an eVTOL as a Rotary Wing Aircraft at POIs

This case is similar to the FW Pearls2 described in the previous section but instead has the vehicle defined using rotary wing characteristics. The input file is Pearls3RW.inp (Figure 13). The source acoustic file is R12NB100.nc and contains a 100dB omnidirectional source using 1/12 OB data. As described in the AAM manual the flight trajectory parameters used for source look up in AAM include flight path angle, speed and nacelle tilt angle as described in the ONE TRACK keyword section. The header information for the RW source data (R12NB100.nc.txt) is provided in Figure 14.

```
REM AAM2.4 64-bit PEARLS2 test file Rotorcraft Source
REM       ^         ^         ^         ^         ^         ^         ^         ^         ^
REM       11-20     21-30     31-40     41-50     51-60     61-70     71-80     81-90     91-100
COMPUTEPOI
DIAGNOSTICS
TERRAIN
Uber3.elv
Uber3_200.imp
SETUP PARA
     198.6     198.6         0
   2283437  12001166         5
   2326137  12043866
      1000    100000       200     .0004
R12NB
0
1
      0.00      0.00      0.00
0
REM
NCTHIST
PEARLS
1.00                           !Macro Time Sec
.05                            !Micro Time Sec
.25                            !Pearl Width Sec
1.0                            !Pearl Spacing Sec
REM
REM  X(UTM,ft) Y(UTM,ft)   Z(ft)   Turn(deg) Rad(ft) Spd(kts)  Yaw(deg)  AOA(deg) Roll(deg) Nacl(deg)      SphNum
REM
ONE TRACK                                                    +L turn            +L down
Connect the Dots input.  Uber Test Case
8
   2306966.7  12039174.0      0.0       0       0       2       0           0          0     90.
   2306952.9  12039074.4      0.0       0       0      10       0           0          0     90.
   2306932.4  12038925.0     20.0       0       0      20       0           0          0     90.
   2306692.2  12037182.2    150.0       0       0      60       0           0          0     90.
   2306550.0  12033649.6    400.0       0       0      60       0           0          0     90.
   2307000.0  12018954.9    800.0       0       0      60       0           0          0     90.
   2305145.9  12004926.2    800.0       0       0      60       0           0          0     90.
   2305263.0  12001166.0    800.0       0       0      60       0           0          0     90.
POI
3
1    2305500. 12035000.   5.0
2    2305500. 12015000.   5.0
3    2307000. 12020000.   5.0
ATMOS
2
FEET     F    KPA      %
0       59   101.325  70.00
50000   59   101.325  70.00
END
```

Figure 13. AAM Rotary Wing POI example input Pearls3RW.inp

```
netcdf R12NB100 {
dimensions:
    BB = 1 ;
    NB = 1 ;
    PT = 1 ;
    DOPPLER_SHIFT_REMOVED = 1 ;
    EMPTY_WEIGHT = 1 ;
    FUEL_WEIGHT = 1 ;
    LOAD_WEIGHT = 1 ;
    RADIUS = 1 ;
    FLIGHT_PATH_ANGLE = 1 ;
    PYLON_ANGLE = 1 ;
    SPEED = 1 ;
    XYZ = 3 ;
    PHI = 37 ;
    THETA = 37 ;
    FREQUENCY = 121 ;
variables:
    float BB ;
        BB:unit = "" ;
    float NB ;
        NB:unit = "" ;
    float PT ;
        PT:unit = "" ;
    float DOPPLER_SHIFT_REMOVED ;
        DOPPLER_SHIFT_REMOVED:unit = "" ;
    float EMPTY_WEIGHT ;
        EMPTY_WEIGHT:unit = "POUNDS" ;
    float FUEL_WEIGHT ;
        FUEL_WEIGHT:unit = "POUNDS" ;
    float LOAD_WEIGHT ;
        LOAD_WEIGHT:unit = "POUNDS" ;
    float RADIUS ;
        RADIUS:unit = "FEET" ;
    float FLIGHT_PATH_ANGLE ;
        FLIGHT_PATH_ANGLE:unit = "DEGREE" ;
    float PYLON_ANGLE ;
        PYLON_ANGLE:unit = "DEGREE" ;
    float SPEED ;
        SPEED:unit = "KNOTS" ;
    float XYZ(XYZ) ;
        XYZ:unit = "FEET" ;
    float PHI(PHI) ;
        PHI:unit = "DEGREE" ;
    float THETA(THETA) ;
        THETA:unit = "DEGREE" ;
    float FREQUENCY(FREQUENCY) ;
        FREQUENCY:unit = "HERTZ" ;
    float AMPLITUDE(PHI, THETA, FREQUENCY) ;
        AMPLITUDE:unit = "DECIBEL" ;

// global attributes:
        :title = "ROTORCRAFT 121 NB 100 dB Omni Sound Hemisphere        " ;
```

```
data:

 BB = 0  ;

 NB = 1  ;

 PT = 0  ;

 DOPPLER_SHIFT_REMOVED = 0  ;

 EMPTY_WEIGHT = 2460  ;

 FUEL_WEIGHT = 0  ;

 LOAD_WEIGHT = 0  ;

 RADIUS = 100  ;

 FLIGHT_PATH_ANGLE = -0.04677647  ;

 PYLON_ANGLE = 90  ;

 SPEED = 74.87335  ;

 XYZ = 0 , 0 , 0  ;

 PHI = -90 , -85 , -80 , -75 , -70 , -65 , -60 , -55 , -50 , -45 , -40 ,
    -35 , -30 , -25 , -20 , -15 , -10 , -5 , 0 , 5 , 10 , 15 , 20 , 25 , 30 ,
    35 , 40 , 45 , 50 , 55 , 60 , 65 , 70 , 75 , 80 , 85 , 90  ;

 THETA = 0 , 5 , 10 , 15 , 20 , 25 , 30 , 35 , 40 , 45 , 50 , 55 , 60 , 65 ,
    70 , 75 , 80 , 85 , 90 , 95 , 100 , 105 , 110 , 115 , 120 , 125 , 130 ,
    135 , 140 , 145 , 150 , 155 , 160 , 165 , 170 , 175 , 180  ;

 FREQUENCY = 10 , 10.6 , 11.2 , 11.8 , 12.5 , 13.2 , 14 , 15 , 16 , 17 , 18 ,
    19 , 20 , 21.2 , 22.4 , 23.6 , 25 , 26.5 , 28 , 30 , 31.5 , 33.5 , 35.5 ,
    37.5 , 40 , 42.5 , 45 , 47.5 , 50 , 53 , 56 , 60 , 63 , 67 , 71 , 75 ,
    80 , 85 , 90 , 95 , 100 , 106 , 112 , 118 , 125 , 132 , 140 , 150 , 160 ,
    170 , 180 , 190 , 200 , 212 , 224 , 236 , 250 , 265 , 280 , 300 , 315 ,
    335 , 355 , 375 , 400 , 425 , 450 , 475 , 500 , 530 , 560 , 600 , 630 ,
    670 , 710 , 750 , 800 , 850 , 900 , 950 , 1000 , 1060 , 1120 , 1180 ,
    1250 , 1320 , 1400 , 1500 , 1600 , 1700 , 1800 , 1900 , 2000 , 2120 ,
    2240 , 2360 , 2500 , 2650 , 2800 , 3000 , 3150 , 3350 , 3550 , 3750 ,
    4000 , 4250 , 4500 , 4750 , 5000 , 5300 , 5600 , 6000 , 6300 , 6700 ,
    7100 , 7500 , 8000 , 8500 , 9000 , 9500 , 10000  ;

 AMPLITUDE =
  100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
    100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 , 100 ,
```

Figure 14. ASCII NetCDF acoustic source data for 1/12 RW (R12NB100.nc)

Additional output from this case included the NCTH_001.nc, NCTH_002.nc and NCTH_003.nc files containing the 1/12 OB time history data at POIs 1, 2 and 3, respectively. These files are included with the software distribution but not displayed in this document. The 1/3 OB time history file Pearls3RW.POI and the main run stream output ASCII file Pearls3RW.POI are also included in the distribution.

Pearls on Strings analysis mode for an eVTOL as a FW Aircraft at a Grid of Receptors

This example (Area3FWPearls.inp) provides output on a grid for a FW Aircraft operation suitable for generating noise contours. The vehicle trajectory and study area are the same as the previous two cases and are provided in Figure 2. The input file now includes the COMPUTEPLT keyword which triggers creation of a NetCDF ASCII .PLT file with the standard metrics on the computational area. The SETUP PARA keyword section in the AAM manual describes the input structure, including how to define the study area (lower left and upper right corners) and the grid spacing across the area. In this case the corners are (2290000, 12002000) ft and (2320000, 12042000) ft with 5000 ft spacing in the X and Y directions. This results in a computational mesh of 7 x 9 points. AAM generates 63 1/12 OB time history output files which are named NCTH_00010001.nc to NCTH_00070009.nc – one for each grid point. Figure 15 shows a contour plot of the unweighted SEL (dB) results contained in the ASCII TecPlot Area3FWpearls.PLT file. Figure 16 shows a contour plot of Lmax(dBA) from this same file. Note that as described before, the 1/12 OB data has been rolled up into the 1/3 OBs for computation of these standard metrics. The capability to plot 1/12 OB results on a grid and for video rendering is under development.

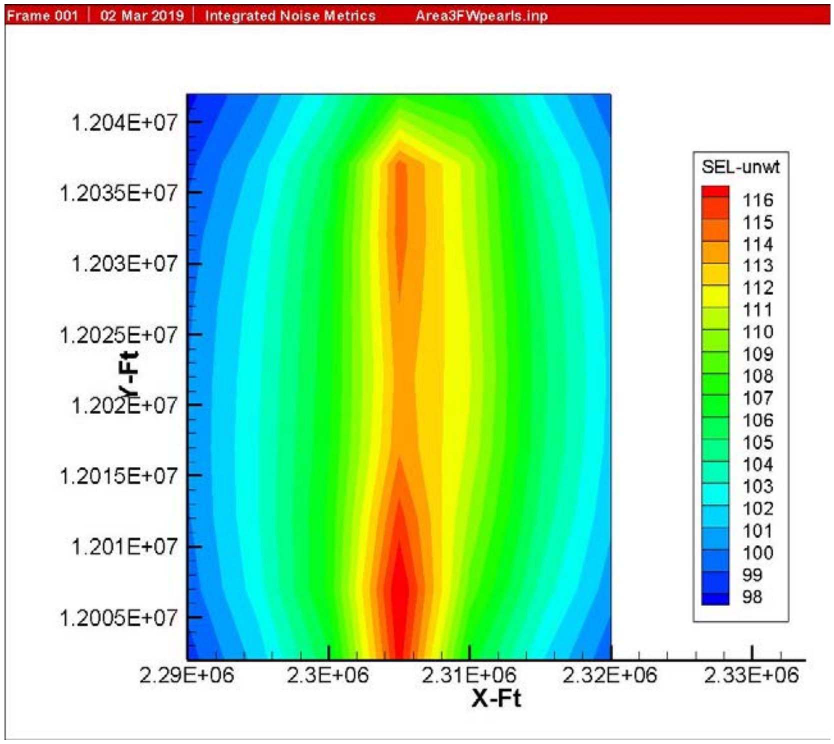

Figure 15. Unweighted SEL for Example FW Grid case - Area3FWpearls.PLT

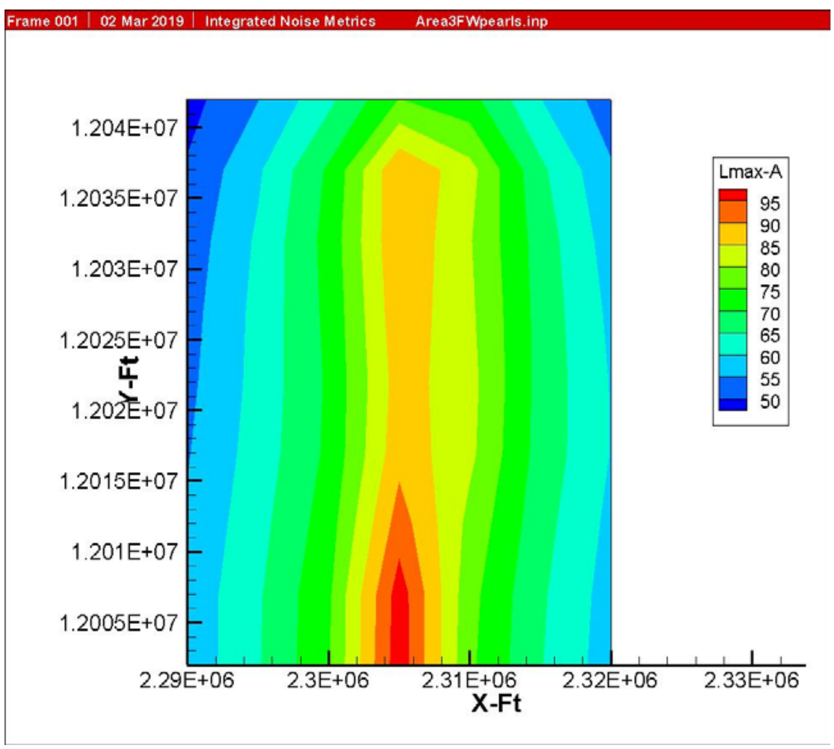

Figure 16. Lmax (dBA) for example FW Grid case – Area3FWpearls.PLT