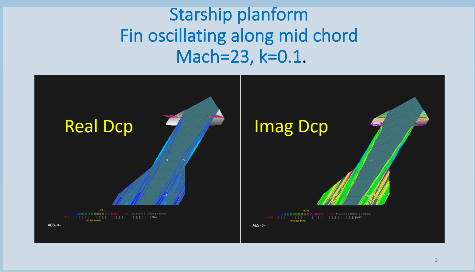
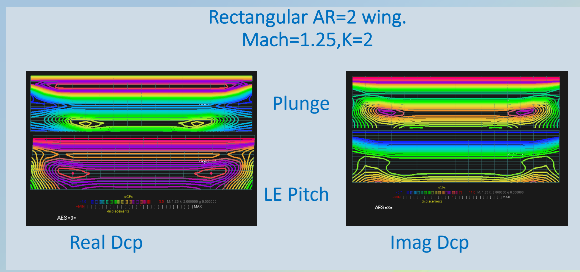
Installation and Compact Userguide AES=3=





Michael H.L. Hounjet

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1. Introduction

Applications of the general lifting surface **aes=3=** panel method (http://www.aes4ac.com/app3/apps3.html) have been described earlier in the report: Hounjet, M. H. L. (2017). *An application of AES=3=.* Berg en Terblijt: AES4AC B.V.
To support better the hypersonic Mach number range the method has taken into account a broad range of approaches (such as (Liu, 1997)) to account for wing thickness & wing camber to calculate efficiently unsteady aero loads on A/C due to oscillating vibrations.

This report describes details with respect to installation, format of files and the extension with hypersonic modelling.

1. Examples

We start with showing some examples of calculations made for supersonic/hypersonic flow.

Shown in figure 1 is a visualization by AES=3= of the real part and imaginary part of the pressure difference (delta Cp) calculated by AES=3= for a high reduced frequency(k=2) at a relatively low supersonic Mach number (Mach=1.25) for a plunging motion and a pitching motion of an AR=2 rectangular wing. Note the 3D effect at the tip region. Within the mach cones emanating from the leading edge of the wing tips the distributions are two dimensional.

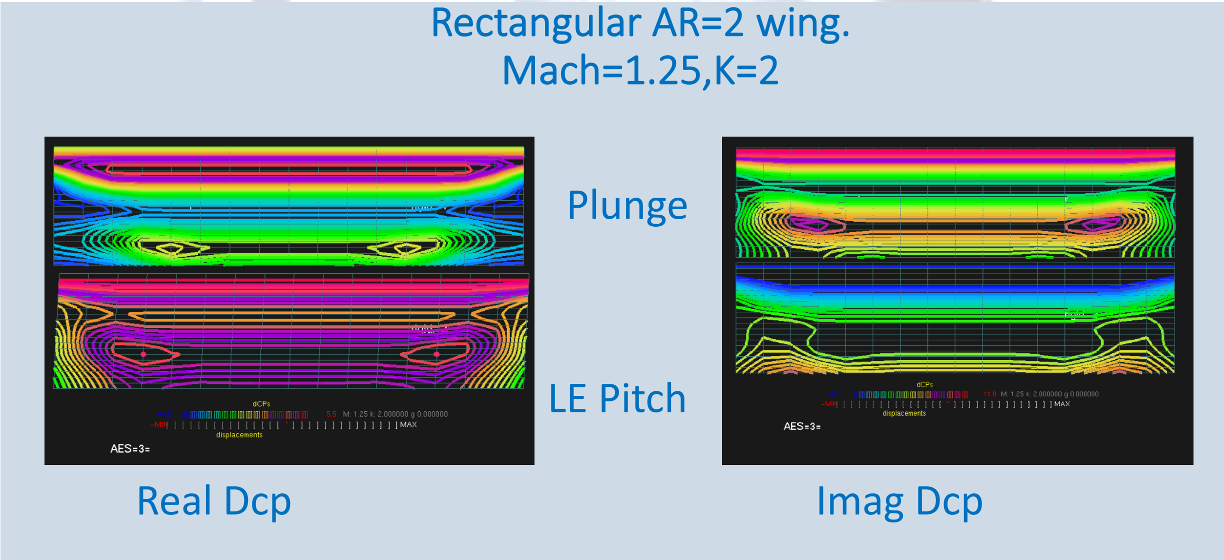

Figure 1 Unsteady pressure distributions on an oscillating rectangular wing

Shown In figure 2 is a visualization by AES=3= of the real part and imaginary part of the pressure difference (delta Cp) calculated by AES=3= for a low reduced frequency(k=0.1) at a high Hypersonic Mach number (Mach=23) for a pitching motion of the fin of a starship wing-fin-tail planform. Note the induced pressures of the fin on the tail which can be significant.

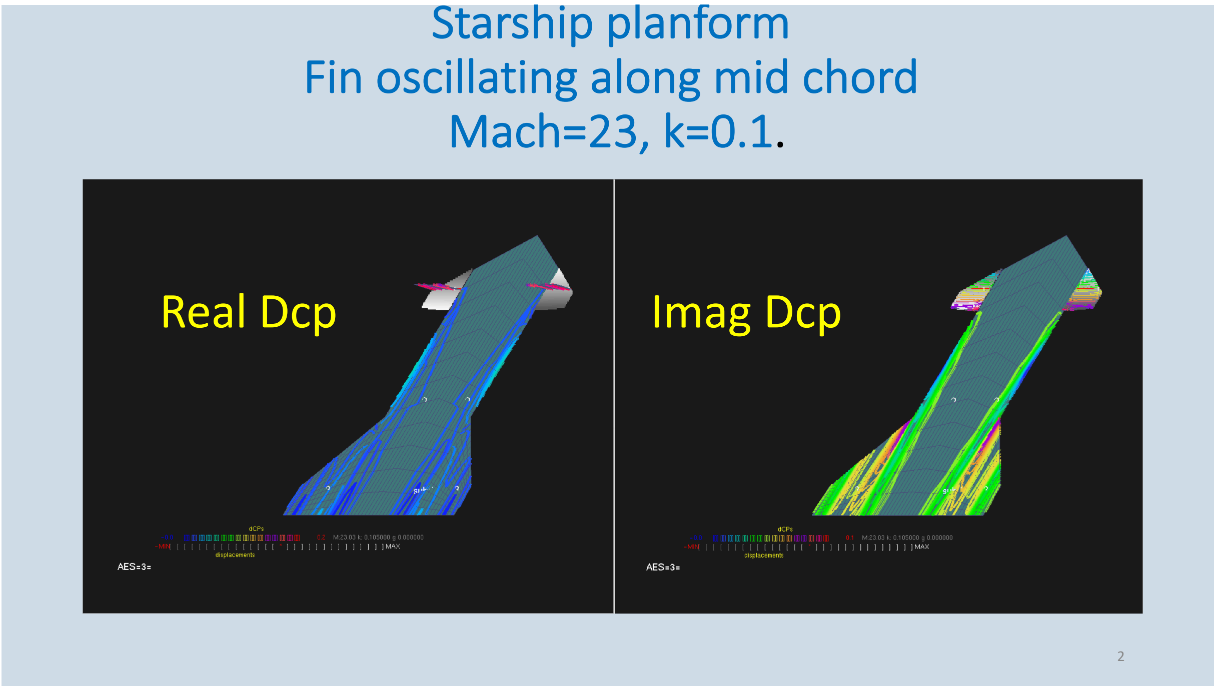

Figure 2 Unsteady pressure distribution on an oscillating starship planform

Finally, a comparison is presented in Figure 3 of some available AES=3= methods for a pitching motion about the quarter chord of a wing with a 10-degree semi-wedge aerofoil (<).
The methods are compared with calculated aero loads from an unsteady Euler CFD method (Prananta & Hounjet, 1998).

The aspect ratio of the wing is chosen such that the flow is two dimensional at the mid chord (AR=2). The figure illustrates the real and imaginary part of the calculated sectional CL_Alpha (CLA) & CM_Alpha(CMA) aero loads versus reduced frequency k up to 5.0 at Mach number 3.0. The imaginary parts (AI) are divided by the reduced frequency.

The figure compares calculations of five methods: a) panel method (PGM=Potential Gradient Method (*PG in figure 5*)); b) explicit third order piston theory (PISTON, (*P31 in figure 5*)); c) panel method implicitly fortified with third order piston theory (PGM+PISTON, (*IP3CP in figure 5*)); d) panel method based on the reduced local Mach number aft of the leading edge (PGM+MC)) and e) Euler CFD.

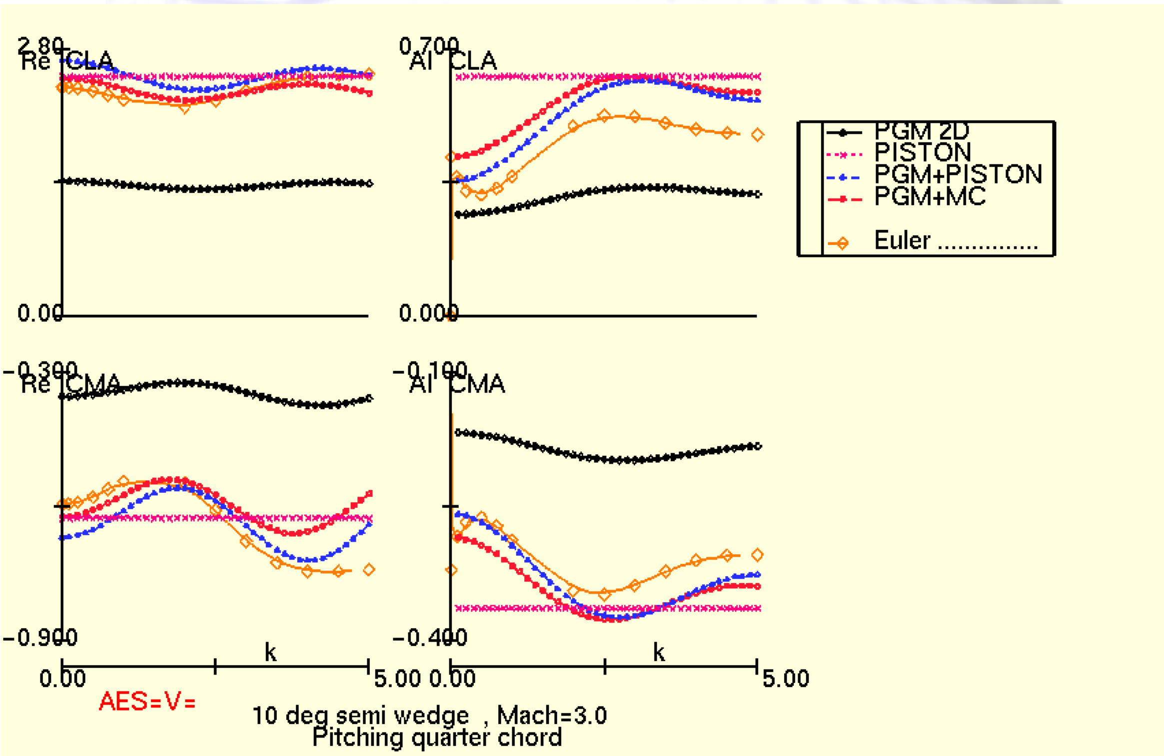

Figure 3 Comparison of unsteady forces

Compared to the unsteady Euler data the lifting surface method (PGM) shows the largest deviation. The real part of the Mach number corrected lifting surface method (PGM+MC) is the closest to the unsteady Euler data and the imaginary data of the (lifting surface implicitly fortified with third order piston theory (PGM+PISTON) is closest to the unsteady Euler data. The fortified hyperbolic methods are an improvement.

2. Installation

1. Installation should be performed for OSX 10.13.6 or OSX 10.14.6
2. Unzip the aes=3=.zip file
3. Move the files in the aes=3=/bin directory to your preferred bin location and/or set the path.
4. Move the file in the aes=3=/home directory to your HOME.
5. Move the files in the aes=3=/run directory to your preferred run location
6. Install a GLUT and an OPENGL framework when they are not installed
7. Install gfortran libraries when aes=3= complaints about missing libraries.

3. License validation

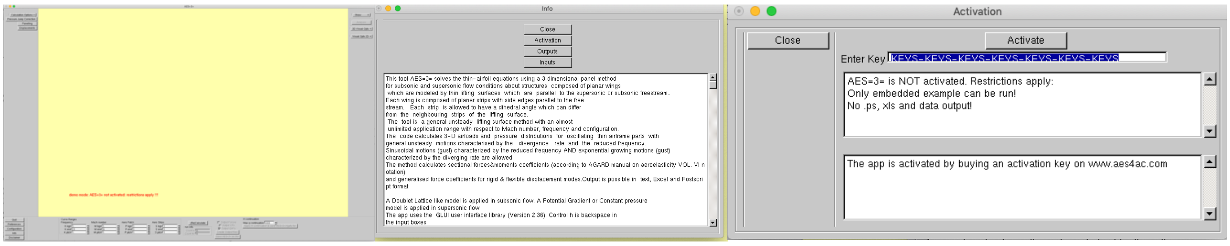

Figure 4 Activation

Activation is not needed for the evaluation version during the trial period.
The trial period is set to 30 days starting from first run.

1. Open a terminal.
2. Go to your run directory.
3. Run aes=3= (see figure 4)
4. Press info button. The info window opens.
5. Press activation in the info windows.
6. KEY in your validation license code.
7. Press activates.
8. Quit aes=3=.

4. Running

1. Open a terminal.
2. Go to your run directory.
3. Run aes=3=.

The main input file is AES=3=.cnf which together with .aes=3=.prfs controls the calculation. The .aes=3=.prfs data is also written to the AES=3=.cnf file.

The AES=3=.cnf file is created/updated upon saving in the configuration menu.
The save operation expands control, case and bulk information to the aes=3=.cnf file.

When one is satisfied with the aes=3=.cnf file and need to change only the bulky data it is sufficient by specifying the new bulky file names at the begin of the aes=3=.cnf. When these names are different from the names stored in the expansion area of aes=3=.cnf the new bulky file will be expanded and can be used to perform calculations without having to change control et cetera.

Note: AES=3=.cnf does not contain the AES=3=.slp file data. The latter file contains data used by the hypersonic methods.

Example of input files for the Rectangular Wing AR=2

The runs/recwing directory contains:

- the bulky file AES=3=.slp and
- the configuration file: aes=3=.cnf.

The AES=3=.slp file contains geometric and/or steady flow (CFD) data with respect to the hypersonic methods et cetera.
Initially all data is set to zero modelling of a lifting surface. By changing values in the third (-0.5 tan(semi-wedge angle)) and eight (0.5 tan(semi-wedge angle)) column on line 8 and line 15 one can run a diamond rectangular wing and by changing values in the third (-0.5 tan(semi-wedge angle)) and eight(0.5 tan(semi-wedge angle)) column on line 8 and line 15 and by changing values in the third(- tan(semi-wedge angle)) and eight (tan(semi-wedge angle)) column on line 10 and line 17 one can run a wedge rectangular wing. Simpler is to set the 3 on row 3 to 2 and delete the rows 7&8 and 14&15.

5. Control

Apart from the geometric and modes shape settings and many other aspects for which one should consult the document: Hounjet, M. H. L. (2017). *An application of AES=3=.* Berg en Terblijt: AES4AC B.V.) this section explains the main aerodynamic control settings.

After starting up you can open the rollouts at the left border which is depict in figure 5. It is advised to close rollouts after use to prevent their window growing beyond the screen bottom border resulting in losing control.

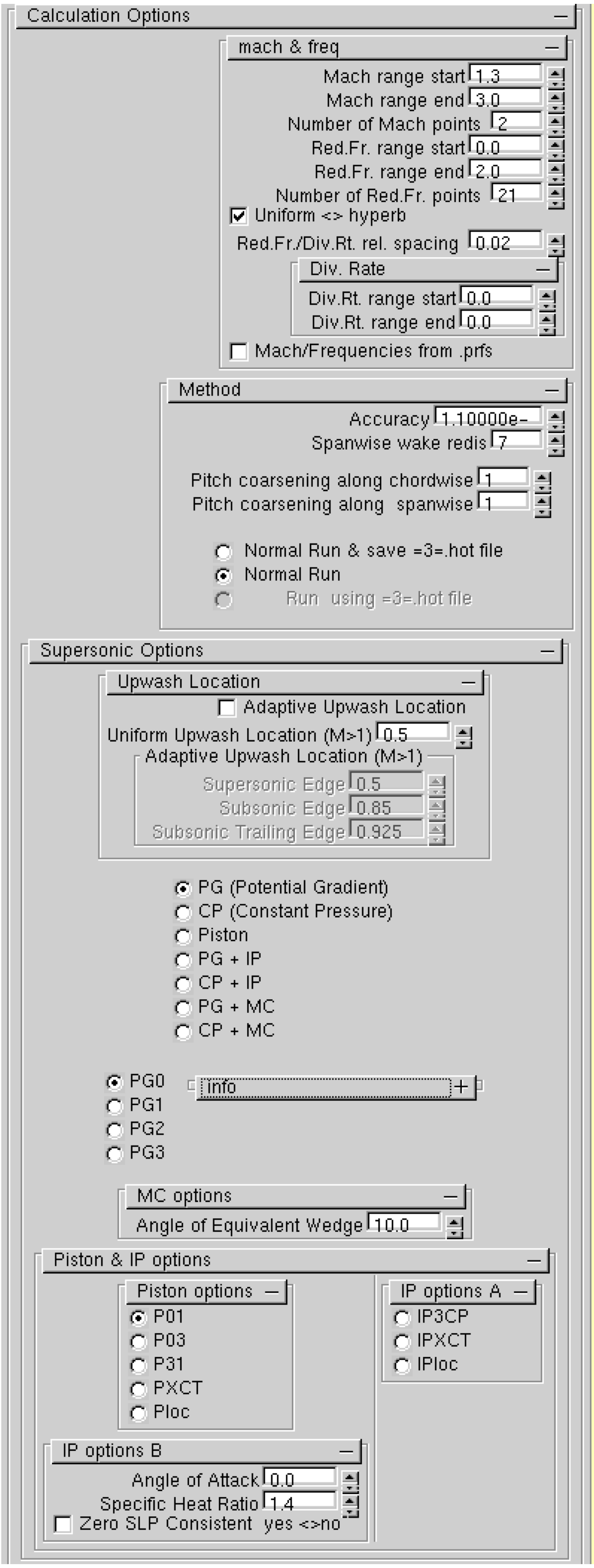

Figure 5 Calculation dashboard

Set your Mach number range
Set number of Mach runs
The distribution of the Mach numbers is uniform.
Set your reduced frequency range
Set number of frequency runs
The distribution of the frequencies can be uniform or hyperbolic with an initial step.
Set your reduced diverging rate range. Also H continuation is available to obtain diverging data from frequency data. (Hounjet, 2010)
Ranges can also be specified on the .aes=3=.prfs

Set accuracy
Set number of parabolic integrations for DL and CP
Set pitch if reducing number of panels in the calculation.
Start & restarts

Set the upwash location for supersonic/hypersonic flow
Adaptive to leading edge type or invariant.
DL applies the 75% location.

DL is default subsonic.
Set the supersonic/hypersonic method:
PG: low reduced frequencies & high supersonic Mach
CP: high reduced frequencies & low supersonic Mach
Piston: Explicit piston theory for high frequencies and moderate Mach
PG+IP: Implicit piston theory for High Mach
PG+MC/CP+MC: for High Mach, requires equivalent wedge angle.
Set numerics AIC calculation PG method
PG0/PG1: low reduced frequencies and moderate to high supersonic Mach. In between use PG2/PG3

Sets the equivalent wedge angle from which a corrected Mach number is employed.

Explicit Piston options when Piston is selected:
P01= 1 order Piston; **P03** is 3 order piston; **P31**= linearized 3 order piston. **PXCT**=linearized Exact piston. **Ploc** is linearized coefficient (from AES=3=.slp).
P31, **PXCT** and **Ploc** require AES=3=.slp data.

Implicit IP options when **PG+IP/CP+IP** is selected:
IP3CP= linearized 3 order Piston; **IPXCT**=linearized Exact piston. **IPloc** is linearized coefficient (from AES=3=.slp)
Zero SLP consistent makes sure that without thickness the **PG/CP** method is recovered. **IP3CP** and deactivating **Zero SLP consistency** is the method presented in (Liu, 1997)
IP3CP, **IPXCT** and **IPloc** requires AES=3=.slp data.

6. File outputs

AES=3= can create the following output files:

.aes=3=.prfs	contains preferences data
AES=3=.cnf	contains all input and control data
AES=3=.cps	A text file containing pressure data
AES=3=.frcs	A text file containing aero forces data
AES=3=.gafs	A text file containing the GAFs (generalized aero forces).
AES=3=.gafsV	A text file containing the GAFs in AES=V= format.
AES=3=.Hgafs	A text file containing GAFs extended to the diverging rate domain
AES=3=.HgafsV	A text file containing GAFs extended to the diverging rate domain GAFs in AES=V= format.
AES=3=.ppm	A graphics file
AES=3=.ps	A postscript file
AES=3=.cpsV	A text file containing pressure data in AES=V= format
AES=3=.xls	An excel file containing many data of aeroelasticity interest
=3=.hot	LU decompositions of influence matrices
=3=.wms	Warped regular modes on the aero paneling

The files are supposed to be self-explaining and are not further documented.

7. Geometric Input file

Besides interactive generation/change of the paneling one might specify the geometric data on the first file on AES=3=.cnf with format:

(int)	npatch	number of aerodynamic patches
	do p=1, npatch	
(char)	patchid(p)	name patch p
(int) (int) (int)	npi(p), npj(p), xoption(p)	number of vertices on patch p=1 along chord and span, respectively & input option
	if(xoption(p)=1) then	
	do j=1, npj(p)	
(float) (float)	ya(j,p), za(j,p)	y, z vertices of panels
	do i=1, npi(p)	
(float)	xa(i,j,p)	x vertices of panels
..	enddo i ..	..
	enddo j	
	else	
(float)(float)(float)	xa(1,1,p), ya(1,p), za(1,p)	x, y, z vertices of LE-PE patch corner
(float)	xa(npi(p),1,p)	x vertices of TE-PE patch corner
(float)(float)(float)	xa(1,npj(p),p), ya(npj(p),p), za(npj(p),p)	x, y, z vertices of LE-SE patch corner
(float)	xa(npi(p),npj(p),p)	x vertices of TE-SE patch corner
	endif	
	enddo p	
The first option allows to specify strips in a nonplanar plane (fuselage).		

8. Regular Vibration Input file

The second file on AES=3=.cnf containing regular vibration modes should be specified on a bulky input file with discrete format:

(int) (int) (int)	npart, nv, ndis	number of structural parts, vertices, modes, respectively
	do p=1, npart	
(char)	partid(p)	name part p
	enddo p	
	do p=1, npart	
(int)	nas(p)	number of vertices on part p
	enddo p	
	do p=1, npart	
	do i=1, nas(p)	
(float) (float) (float)	xs(i), ys(i), zs(i)	structural vertices
	enddo i	
	enddo p	
	Do m=1, ndis	
(char)	modeid(m)	name mode m
	do p=1, npart	
	do i=1, nas(p)	
(float) (float) (float)	dx(i,p), dy(i,p), dz(i,p)	displacement at vertices
	enddo i	
	enddo p	
	enddo m	
The subdivision in structural parts allows to restrict the warping to aerodynamic patches		

9. Polynomial displacements file

The third file on AES=3=.cnf contains structural displacements in the polynomial format:

(int)	mdis	number of polynomial displacements (modes)
	do m=1, mdis	
(char)	modeid	name mode m
(int)*8	(ipp(l,m), l=1,8)	patch ids of affected patches, npp is number of different entries)
((float)*36) *npp	(xpcs(i,j,l,m), i=1,6, j=1,6, l=1,npp)	(x-direction polynomial coefficients along chord, span
((float)*36) *npp	(ypcs(i,j,l,m), i=1,6, j=1,6, l=1,npp)	(y-direction polynomial coefficients along chord, span
((float)*36) *npp	(zpcs(i,j,l,m), i=1,6, j=1,6, l=1,npp)	(z-direction polynomial coefficients along chord, span
	enddo m	
Note the polynomials are defined along local patch coordinates (s,t): s=x-x_LP and t=arclength((y,z)-(y,z)_LP).		
Note: lines starting with % or # are treated as comments.		

10. Slope/Thickness file AES=3=.slp

The file AES=3=.slp containing data used by the Unified Hypersonic methods has the format:

(char)	info	Info
(float) (float)	Afac, Bfac	Afac is factor on the Delta coordinates, Bfac is reserved for future
	do p=1, npatch	
(int) (int) (int)	npi(p), npj(p)	number of vertices on patch p along chord and span, respectively
	do j=1, npj(p)	
(float) (float)	ya(j,p), za(j,p)	y, z vertices of panels
	Do i=1, npi(p)	
(float)	xa(i,j,p)	X vertices of panels
(float)*10	DXL(i,j,p), DYL(i,j,p), DZL(i,j,p), CL(i,j,p), DL(i,j,p) DXU(i,j,p), DYU(i,j,p), DZU(i,j,p), CU(i,j,p), DU(i,j,p),	Delta solid coordinates dx, dy, dz, at lower side and upper side; C is a coefficient used when Ploc or IPloc (Piston menus) is activated which might be chosen C=Two*Density/Mach(local) for obtaining a local piston theory model. C can be obtained from a CFD calculation. D is reserved for future extension.
..	enddo i	..
	enddo j	
	enddo p	
Note: The npi, npj and xa, ya, za do not need to be consistent with the geometric paneling data: eg a wedge can be described with npi=npj=2 (specifying LE and TE) and a diamond section with npi=3 and npj=2 (specifying LE, Mid chord and TE)		

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