Thermal & Fluids Analysis Workshop(TFAWS)
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Supersonic Hypersonic Arbitrary Body Program (S/HABP)

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What is S/HABP

S/HABP is a supersonic and hypersonic aerodynamic program that can compute the aerodynamic characteristics of complex arbitrary three-dimensional shapes utilizing engineering level methods

S/HABP has its origins in the Gentry code from Douglas Aircraft circa 1964

AFRL has maintained and sponsored development of several versions over the years and a new version that is PC based is under development

Current Code is contained in several routines

- VECC – Graphical User interface
- Mk5.exe – latest S/HABP executable
- Utilities routines – XY plotting and trim

What's new in current version of S/HABP

Latest version is S/HABP Mark 5 – contains

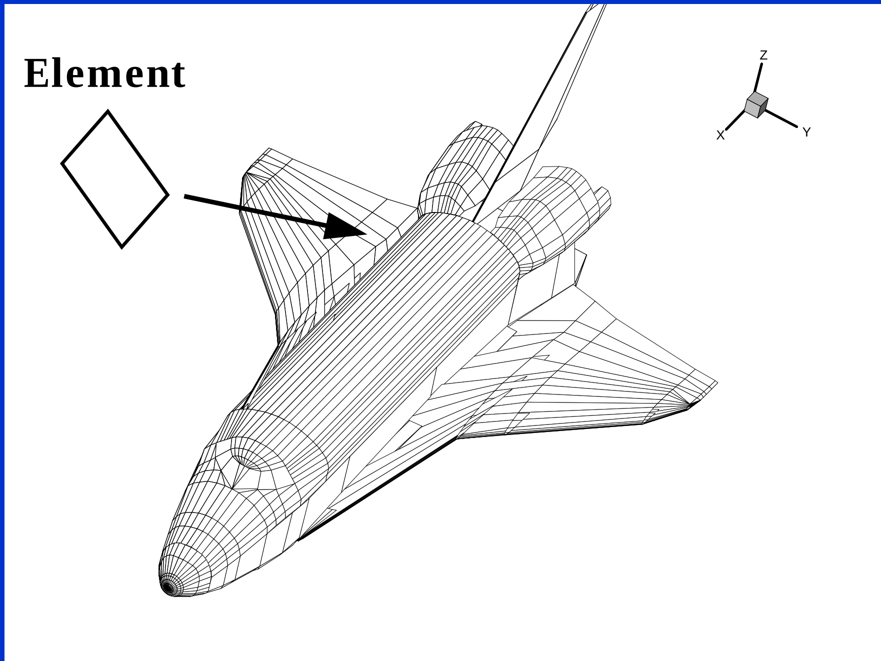
- **Upgraded viscous level 2 routines and aero-heating methods**
- **Unix GUI**
- **Multiple control deflections**
- **Trimmed aerodynamics**
- **Stability derivative methods**
- **Flowfield/Shock shape**

Geometry Inputs

S/HABP uses a x, y, z wire frame mesh for geometry input

Several other geometry generation routines exist in the code but are not widely used

Lowest level of geometry used in the analysis is a quadrilateral element

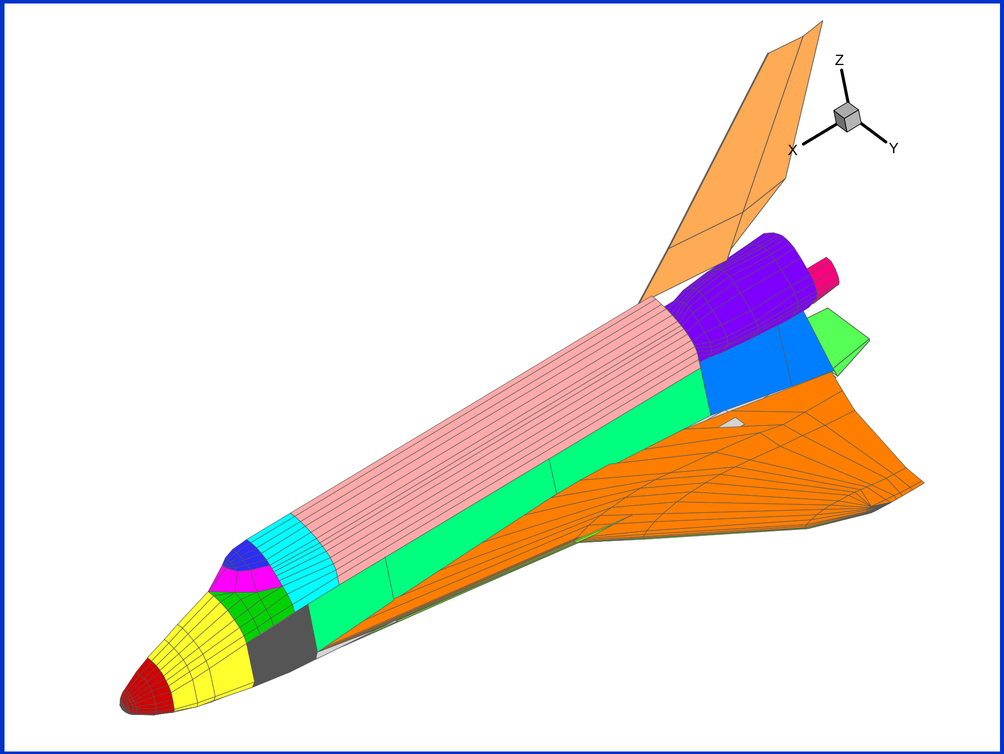


Geometry Inputs

Geometry is organized by panels and components for later analysis

Analysis methods are applied at a component level

Can deflect components to allow vehicle trim analysis



Aero Analysis

Aerodynamic analysis is broken down into runs

User can analyze multiple runs to form a case

Components Can later be summed to get total forces & moments or just component of interest

Can match Mach & Altitude points or wind tunnel test conditions

Air or Helium gases

Can run alpha & beta sweeps including dynamic pitch, yaw, roll rates

Can calculate

- Inviscid Surface pressures – windward & Leeward
- Viscous Forces
- Flow fields
- Component shielding
- Streamlines

Inviscid Analysis

Windward Inviscid surface pressures are calculated by impact methods (Newtonian flow) with many choices available

- **Modified Newtonian**
- **Modified Newtonian + Prandtl-Meyer**
- **Tangent-Wedge**
- **Tangent-Wedge Emppirical**
- **Tangent-Cone**
- **Inclined-cone**
- **Van dyke unified**
- **Shock Expansion**
- **Free Molecular Flow**
- **Input Presure Coefficient**
- **Dahlem-Buck empirical**

Inviscid Analysis

Leeward Inviscid surface pressures are calculated by shadow methods

- **Newtonian**
- **Modified Newtonian + Prandtl-Meyer**
- **Prandtl-Meyer expansion**
- **Inclined-cone**
- **Van dyke unified**
- **High Mach Base pressure**
- **Shock Expansion**
- **Free Molecular Flow**
- **Input Presure Coefficient**
- **Dahlem-Buck Mirror**
- **ACM Empirical**
- **Half Prandtl-Meyer**

Viscous Analysis

Viscous skin friction forces can be calculated with two methods

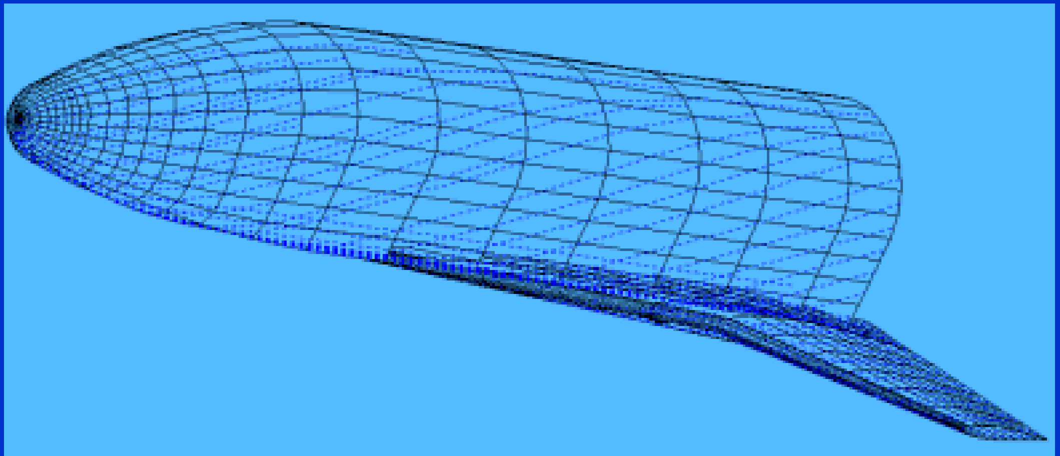
- Level I

  Skin friction based on local Reynolds number and <u>input</u> flow initial running length

- Level II

  Streamlines are generated on which the boundary layer properties are calculated

  Skin friction data from B.L. then interpolated to elements on geometry



Flowfield Analysis

Off body flow fields can be calculated or <u>input</u>

- **Shock expansion method**
- **Simple methods**

  *** Wedge flow * Prandtl-Meyer expansion * Cone flowfield**
  *** Newtonian Prandtl-Meyer Flowfield**

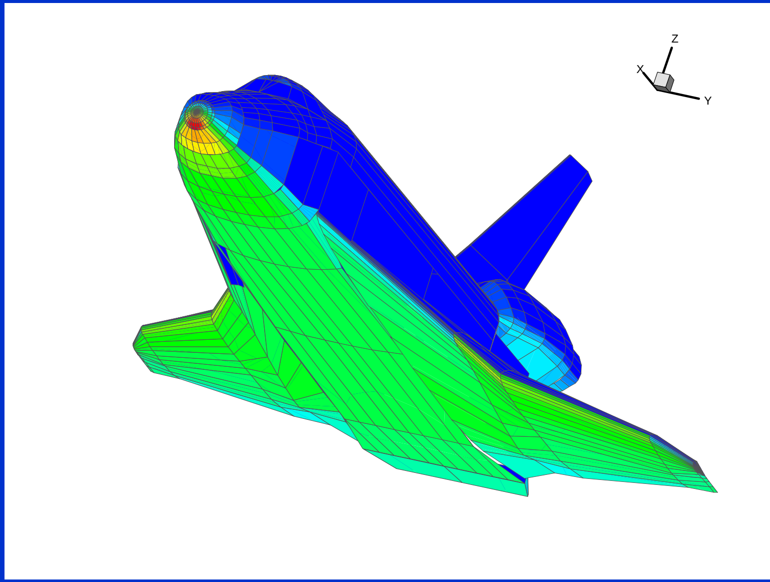
- **Input data can also be entered for flowfield and surface pressures.**

Shielding Analysis

Component shielding effects can also be accounted for

Accounts for effects of one part of the vehicle blocking the flow onto another at angle of attack

i.e. A vertical tail being hidden behind a body at high angle of attack and becoming ineffective



User Limitations

Newtonian flow model

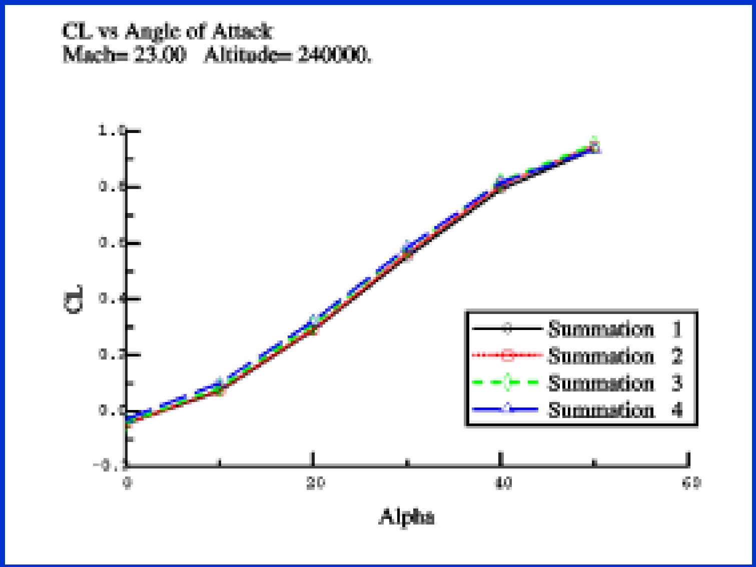
Useful over a wide range of Mach numbers - Mach 2 and up

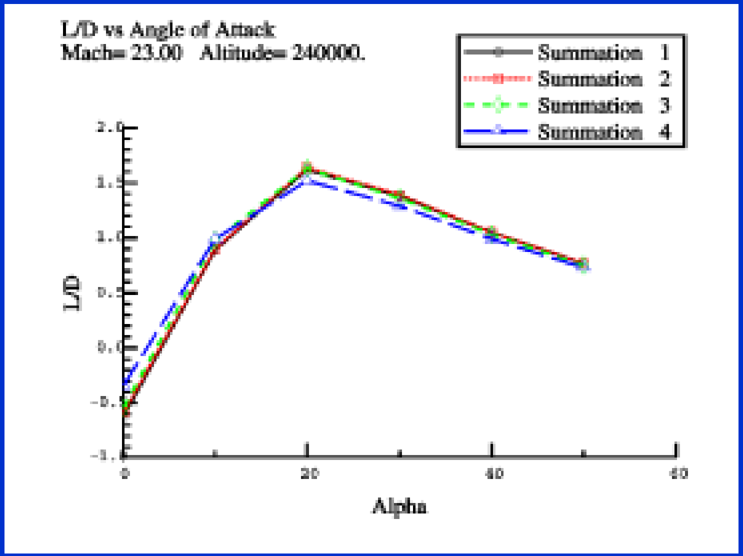
User must make correct choices for methods to get “good results”

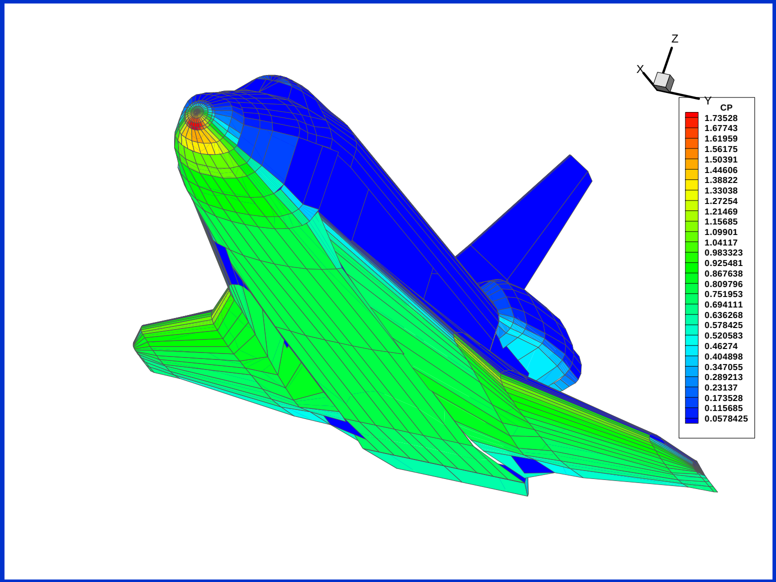
Level one viscous analysis is user dependent on input flow running lengths

Level 2 viscous analysis dependent on streamlines

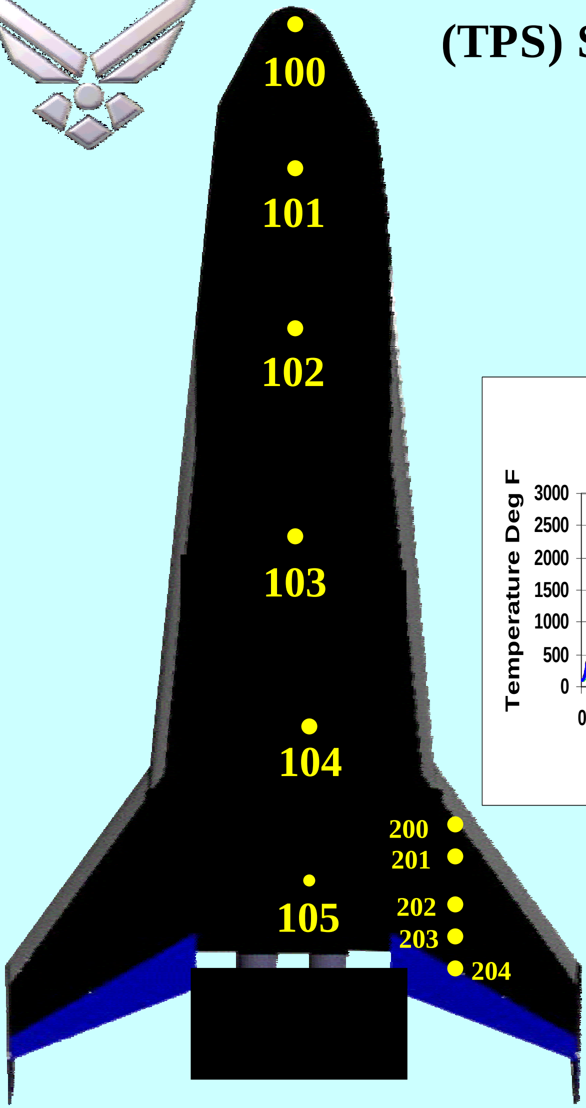
Output Sample Data

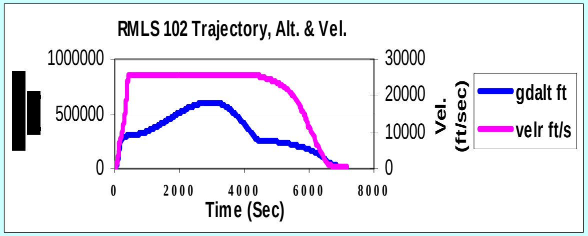


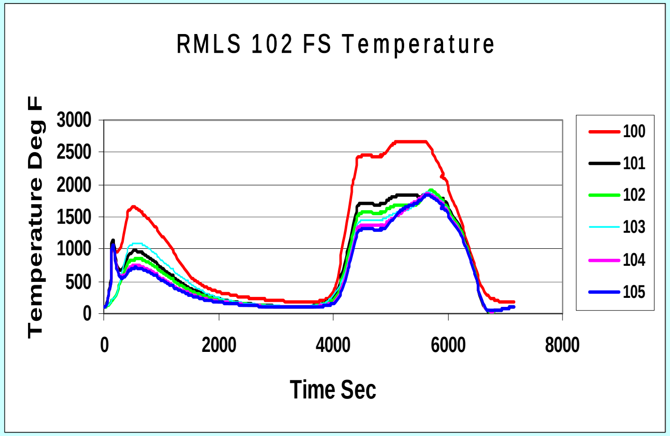


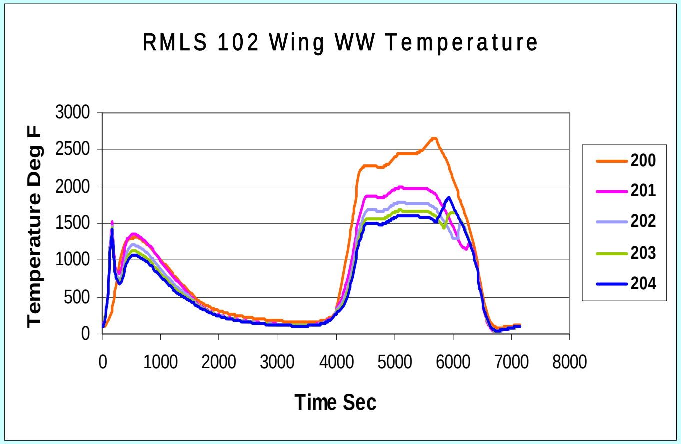


S/HABP Application to Thermal Protection System (TPS) Sizing and optimization for RMLS Vehicle



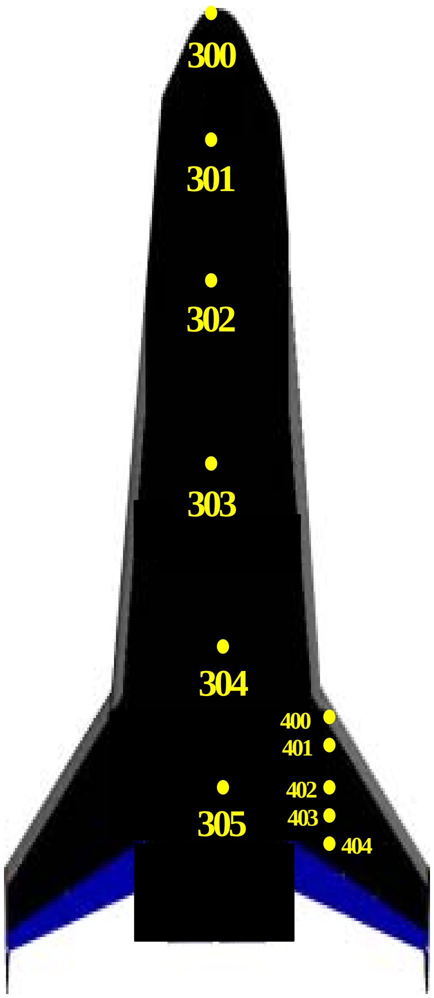


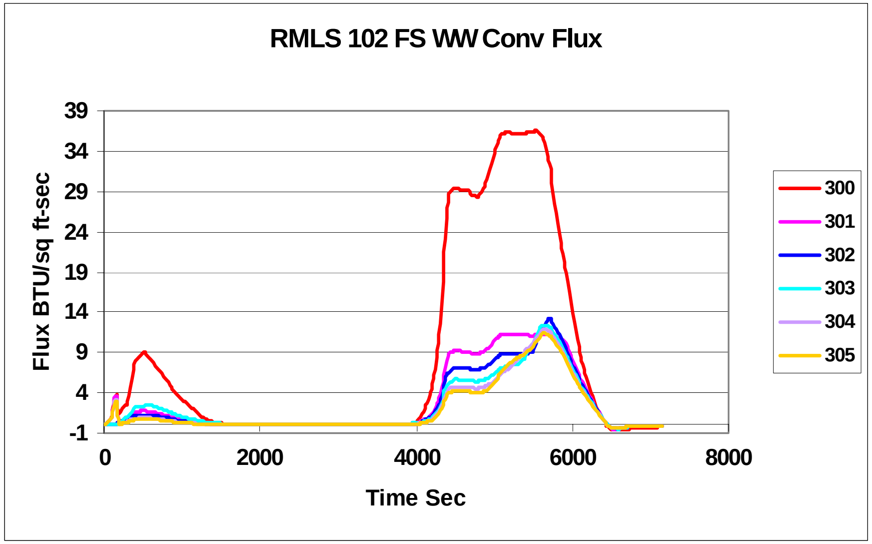


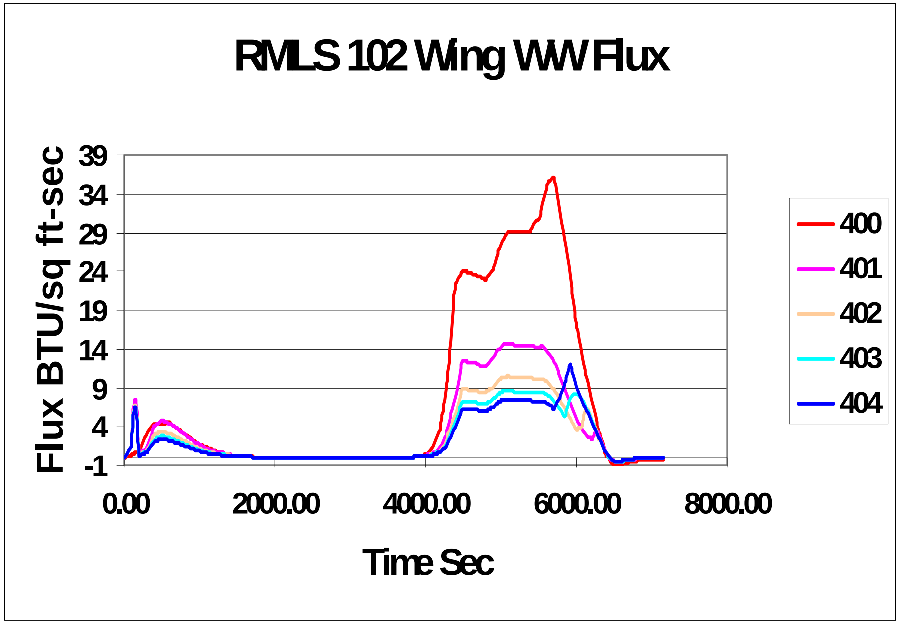


Fuselage		Interior Temp = 300 Deg F		
Point	Thickness (In)	Layup	Lbm/Sq Ft	X Ft
100	3.177	ACC(N), LI2200(N), 17LBSIP, AL2024-T4	8.19967	Stagnation
101	2.877	HRSI Coat, LI900(N), FRSI Nomax, AL2024T4	4.78792	11.42
102	2.777	HRSI Coat, LI900(N), FRSI Nomax, AL2024T4	4.71292	19.01
103	2.777	HRSI Coat, LI900(N), FRSI Nomax, AL2024T4	4.71292	30.68
104	2.677	HRSI Coat, LI900(N), FRSI Nomax, AL2024T4	4.63792	43.32
105	2.577	HRSI Coat, LI900(N), FRSI Nomax, AL2024T4	4.57012	56.03
Wing		Interior Temp = 300 Deg F		
Point	Thickness	Layup	Lbm/Sq Ft	X Ft
200	3.077	ACC(P), LI2200N, 17 LB SIP , Al 2024-T4	8.02	LE
201	3.177	HRSI Coat, LI900N, FRSI Nomex, Al 2024-T4	5.17	3.43
202	2.877	HRSI Coat, LI900N, FRSI Nomex, Al 2024-T4	4.95	6.81
203	2.877	HRSI Coat, LI900N, FRSI Nomex, Al 2024-T4	4.8	10.19
204	2.877	HRSI Coat, LI900N, FRSI Nomex, Al 2024-T4	4.8	13.57

TPS Heat Flux (RMLS) Vehicle







Summary

The Supersonic/Hypersonic Arbitrary Body Program (SHABP) calculates the aerodynamic coefficients arbitrary bodies for Mach numbers between 1.5 and 25, and for angles between 0-180 degrees. SHABP has been used to study the aerodynamic characteristics of reentry vehicles (RVs) for both Tactical Ballistic Missiles (TBMs) and Intercontinental Ballistic Missiles (ICBMs) as well as hyersonic cruise and launch vehicles. The SHABP engineering tool also computes rarefied aerodynamics of vehicles designed to operate in the transitional flow regime between completely continuum and free-molecular flows. SHABP contains a collection of gas/surface interaction models and an aerodynamic bridging procedure for use on calculating aerodynamic properties between the various regimes