SHABP Use at LaRC

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TFAWS

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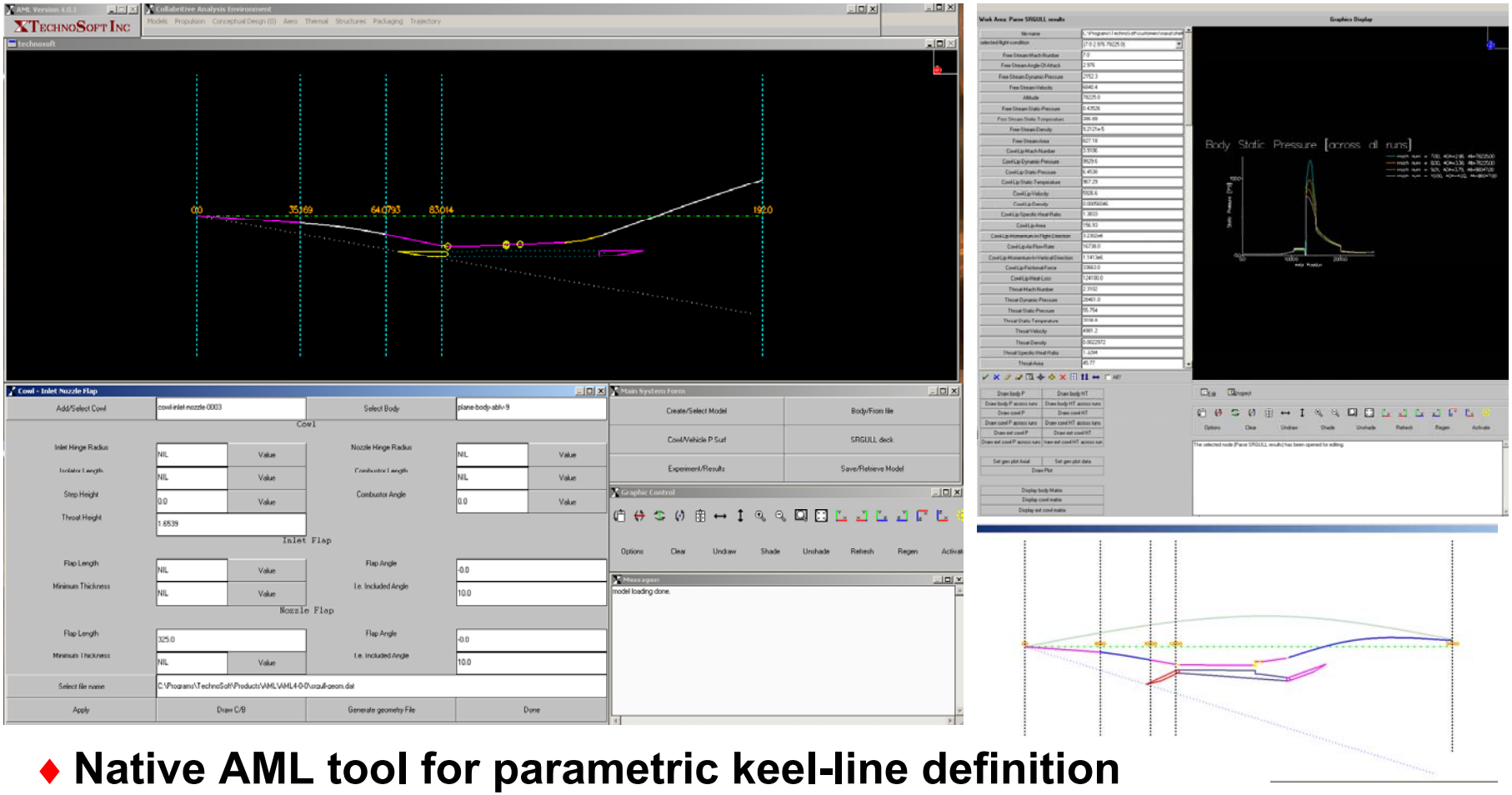
SHABP at LaRC

- **Focus on use in Vehicle Analysis Branch**
  - AML environment
  - Hyper-X
- **In-house modified version of code**
  - NASP boundary layer transition criteria
  - Link to GRAM-95 atmosphere
  - Link to trajectory file
  - Based on Mark IV version

Modeling Environment

- SHABP is incorporated into a modeling environment created using AML (Adaptive Modeling Language) provided by Technosoft and developed under an SBIR
- AML provides geometry preprocessing, file setup, and data visualization for SHABP
- AML can provide geometry creation within tool as well as facilitate geometry import
- SHABP is linked with AML, not rewritten
- Other hypersonic airbreathing tools used at NASA LaRC either linked with AML or have native AML modules – allows use of a common model
- Information sharing and concurrent work at AFRL to link both rocket and airbreathing methodologies

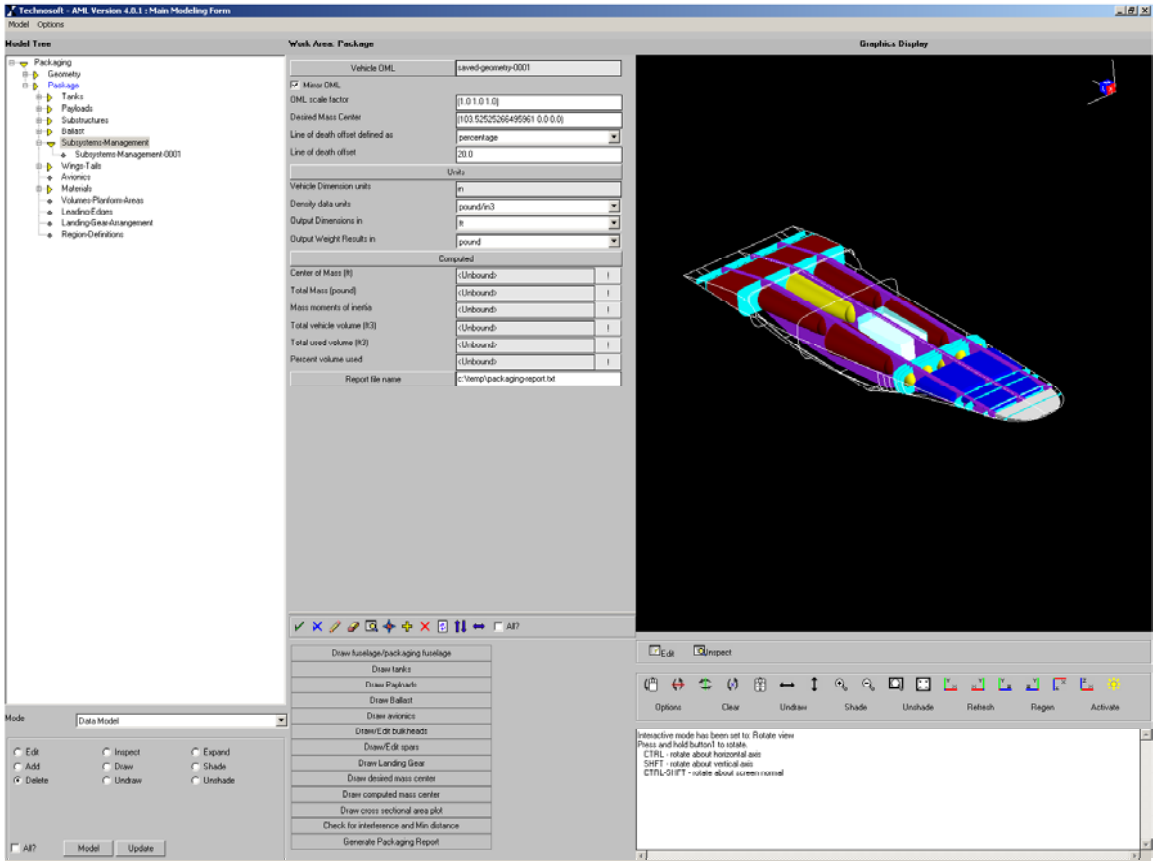
Propulsion Keel-line Development



- Native AML tool for parametric keel-line definition following user-defined rules
- Prepares Design-of-Experiments files
- Output to SRGULL

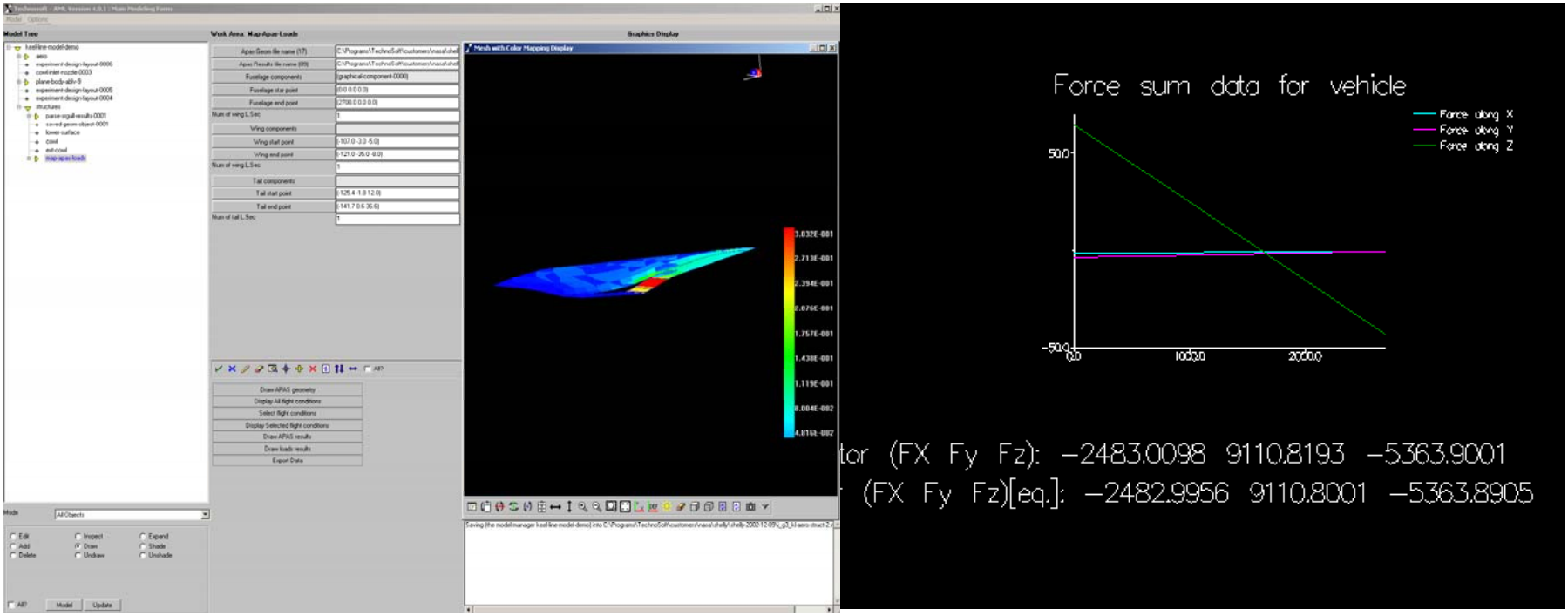
Parametric Packaging/Sizing

- Packaging and sizing can be defined in absolute or parametric terms
- Pre-defined library of parts
- Mass properties defined allowing calculation of moments of inertia and c.g.



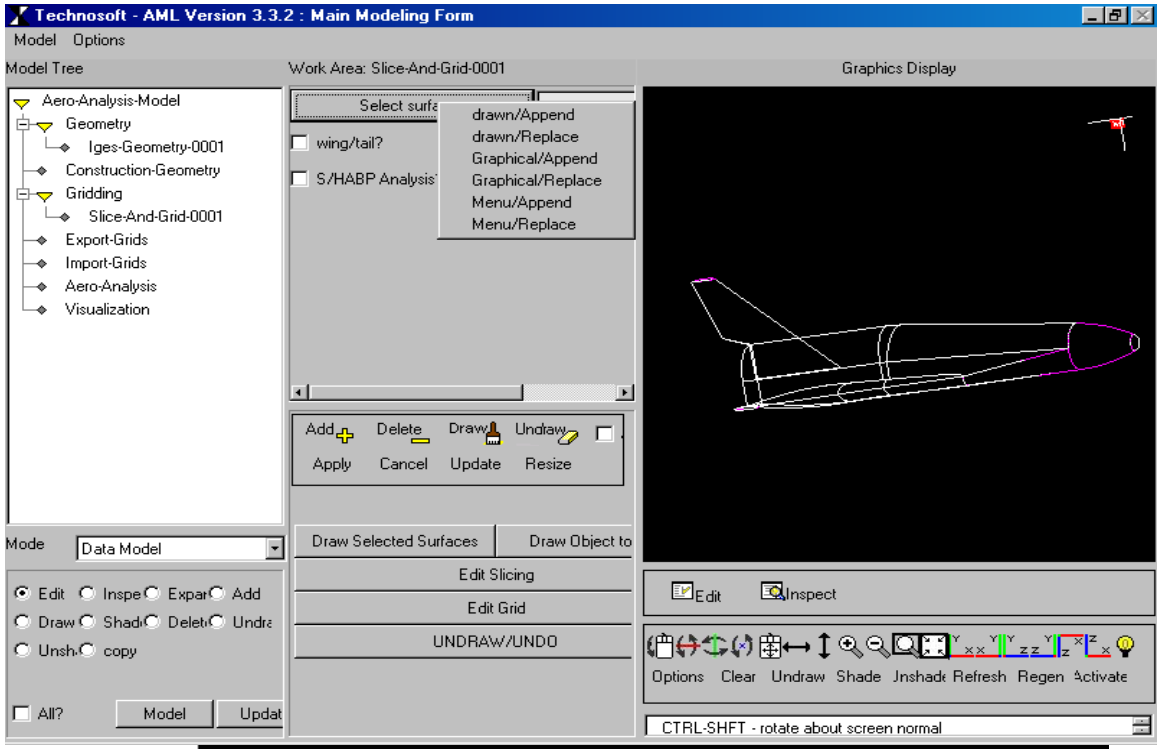
Structures

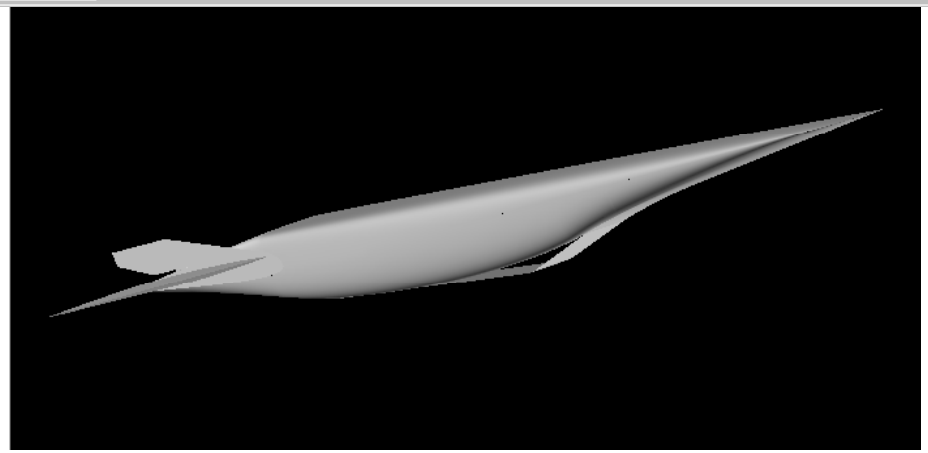
- Map pressure and heat loads from aero and propulsion onto structural line model
- Component based decomposition for structural sizing



Import CAD Model

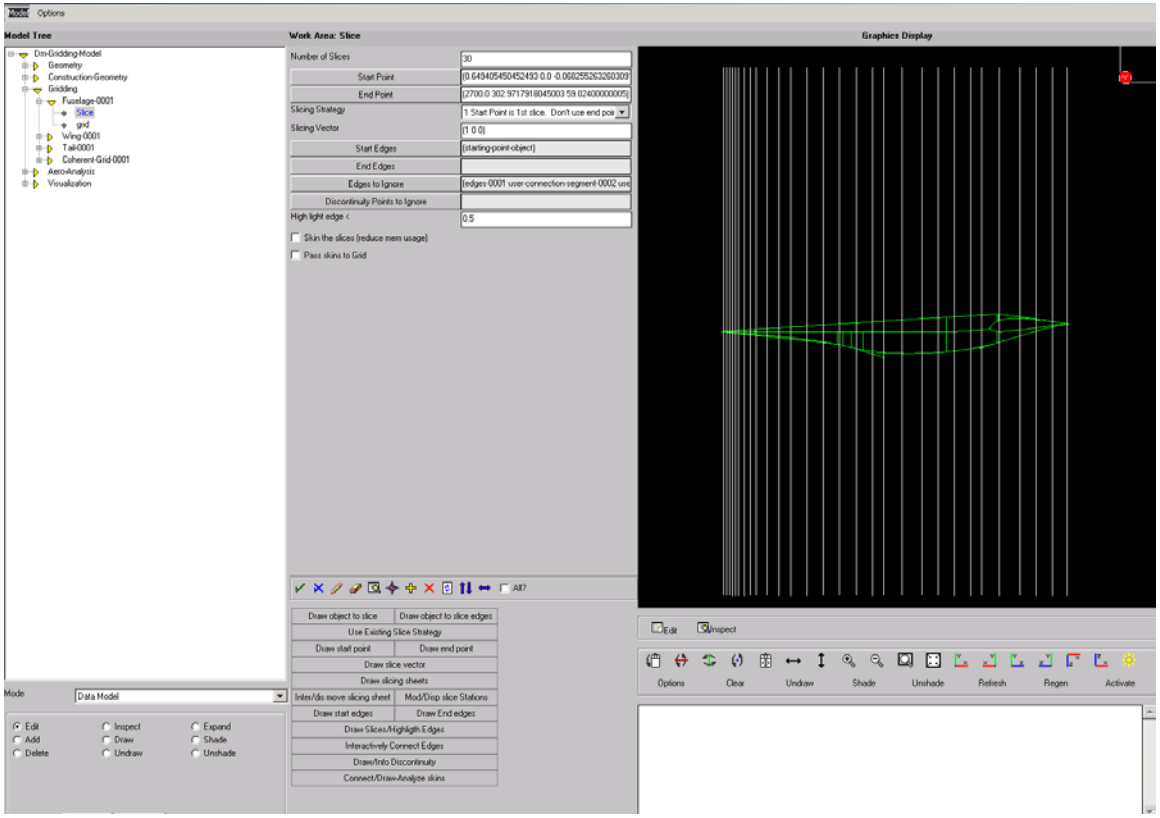
- Outer mold line imported into AML
- IGES is the typical import format but higher order geometries allowed
- Can be viewed as wireframe or solid
- Surfaces can be grouped and selected/deselected for ease of use
- Multiple models can be loaded together





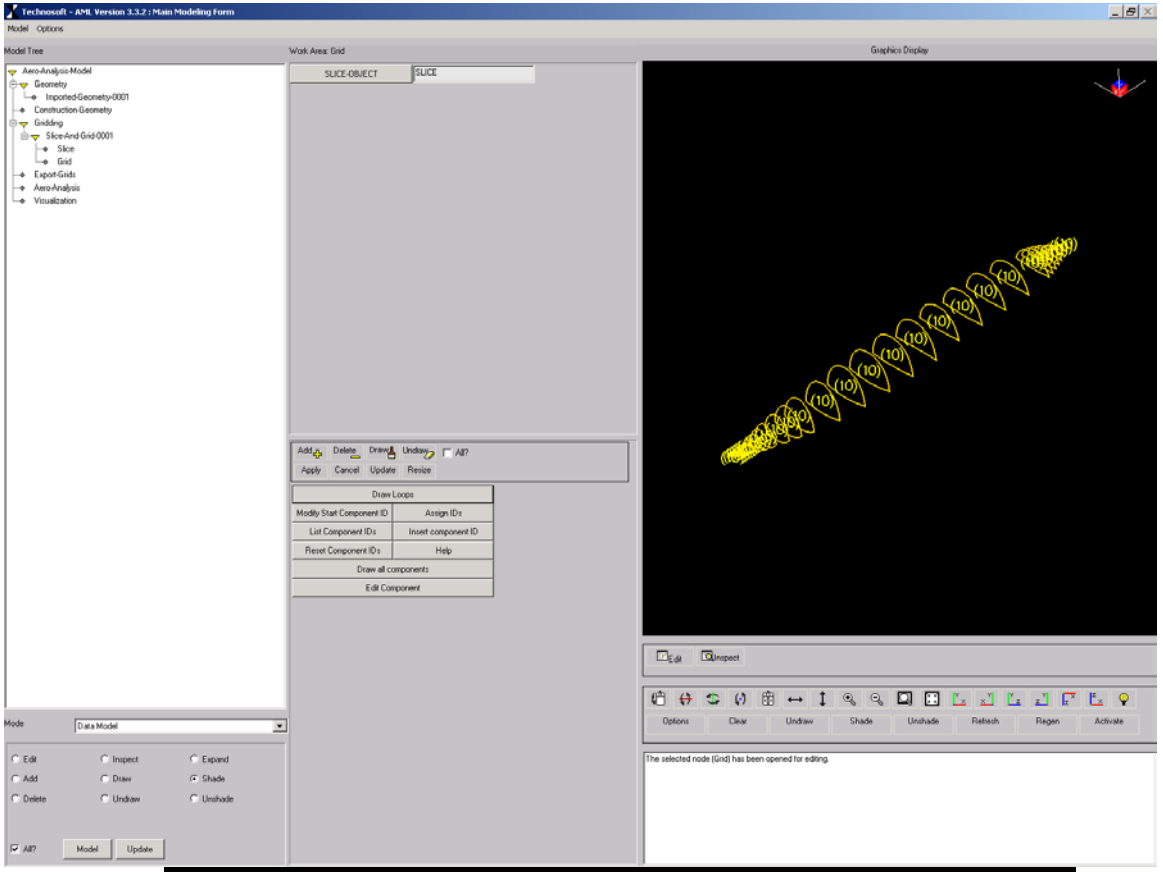
Slicing Sheets

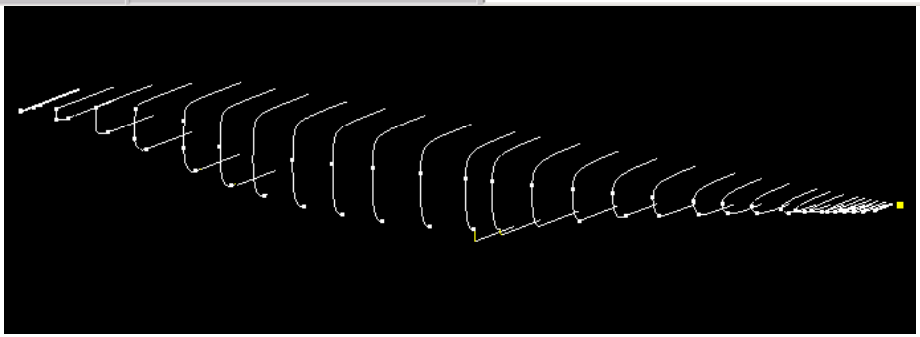
- User selects the number of slicing sheets desired
- The sheets are positioned to capture important geometric features
- Sheets can be given arbitrary orientations



Slices

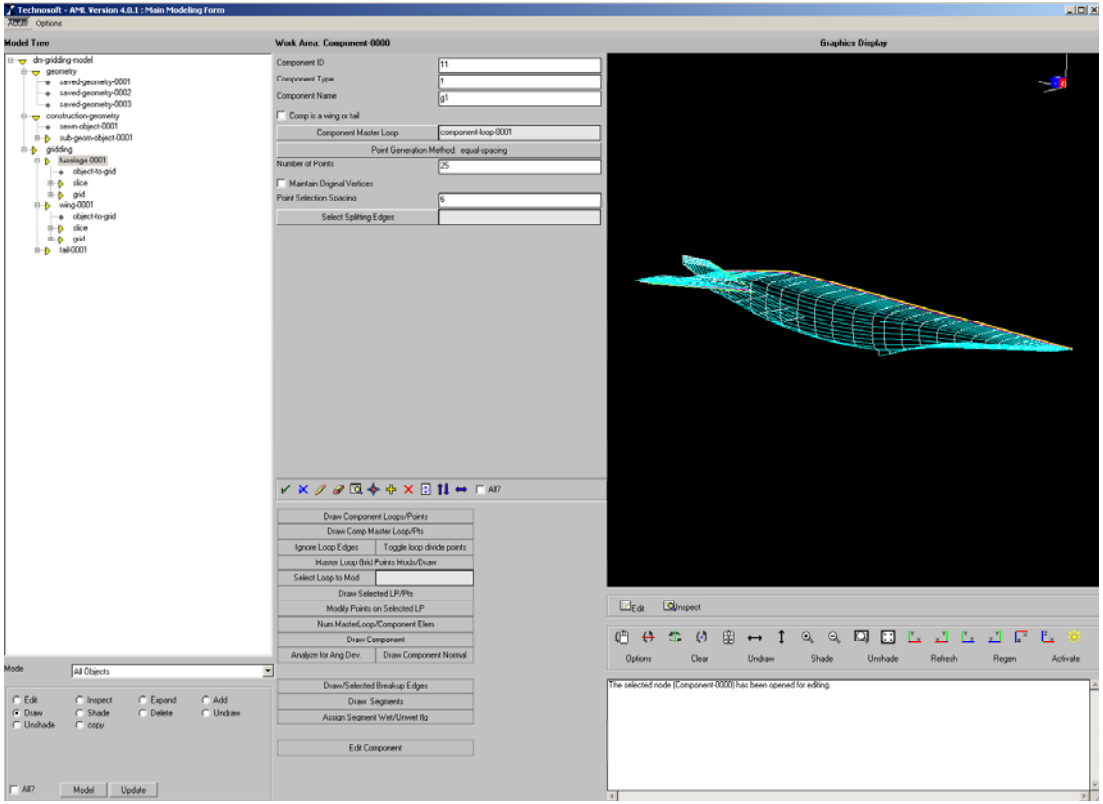
- A series of cross-sections (loops) are produced by the slicing sheets
- User specified tolerance determines what gaps are auto-closed
- Individual components are designated from loops





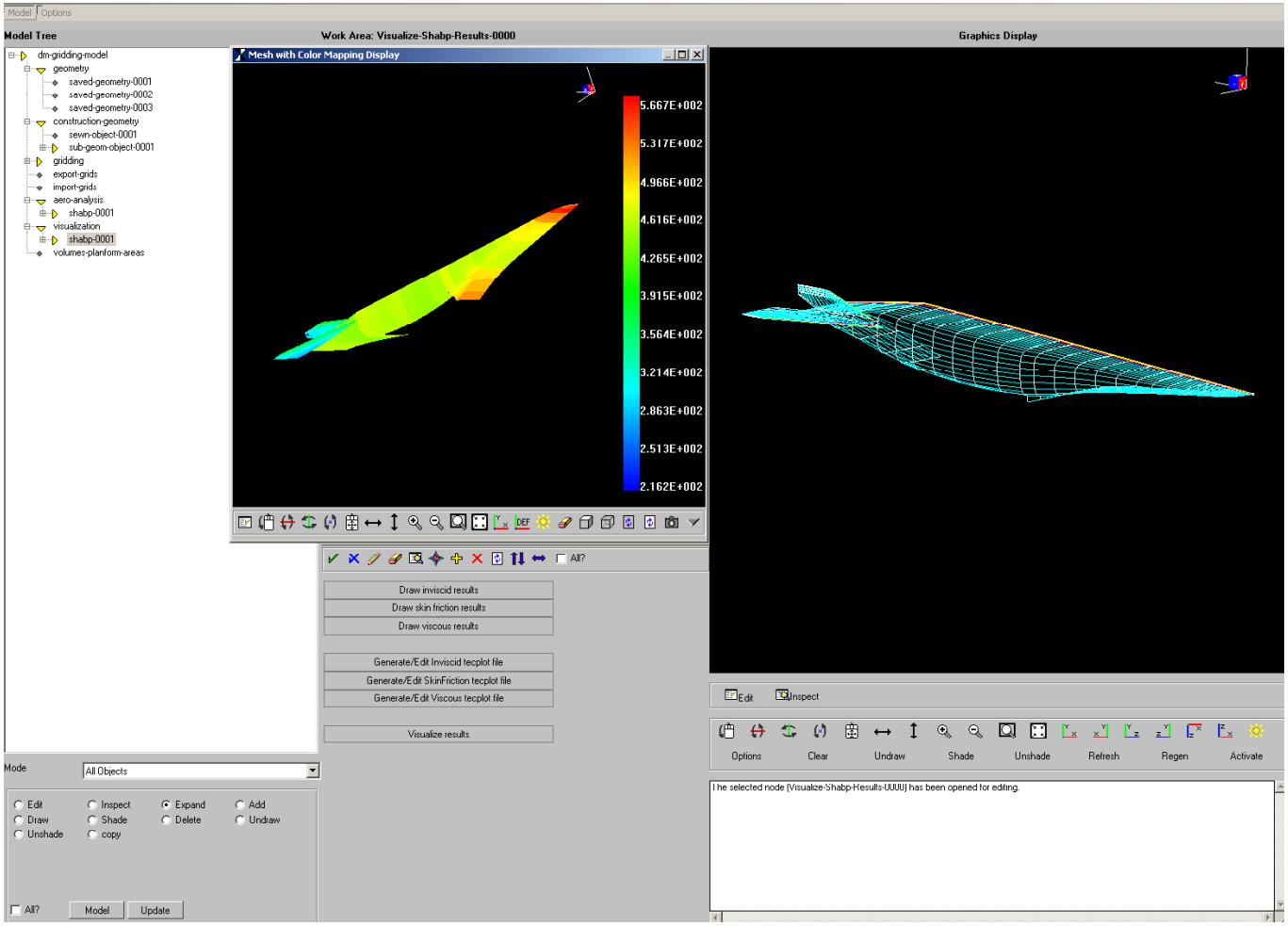
Aero/Aerothermal Model Export

- Loops are concatenated to produce surface mesh based on user specified point distribution
- Analysis methods selected for each component
- Same interface can used for APAS or SHABP



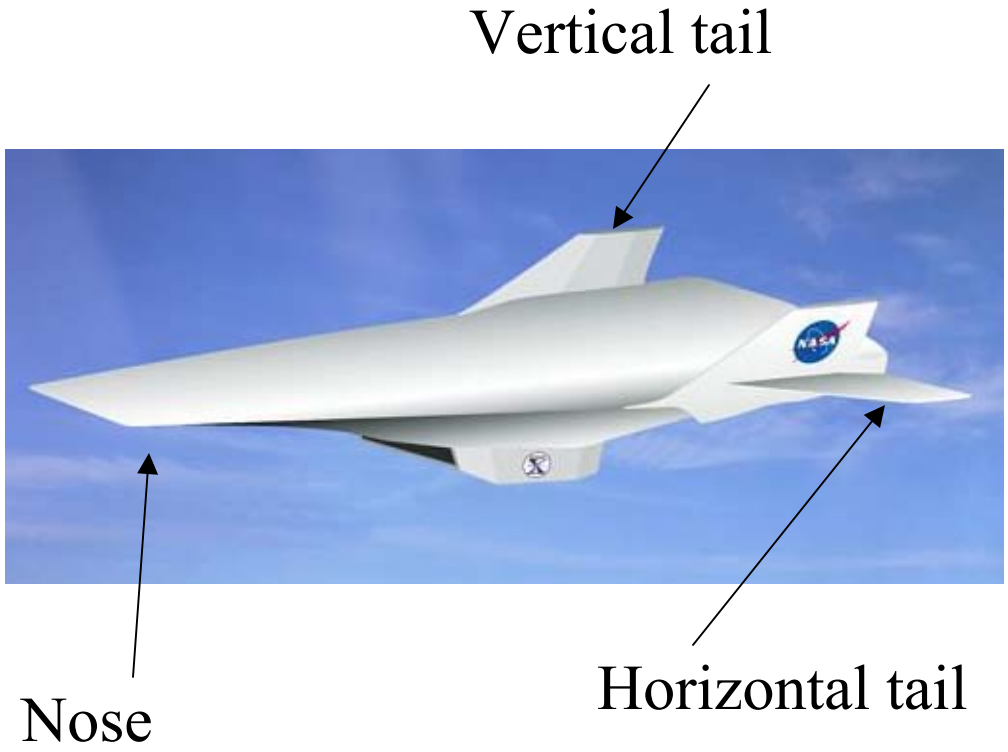
Results

- Results can be visualized within AML
- AML module also can export to other data visualization tools (e.g. Tecplot)
- Results exported for use in other analyses (SINDA, structural sizing, trajectory)

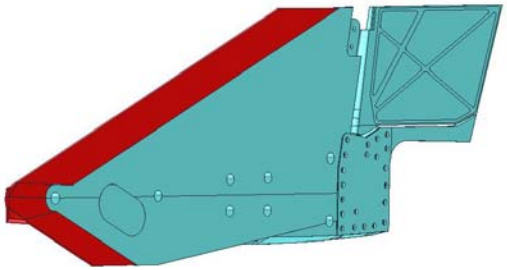


Use in the Hyper-X Program

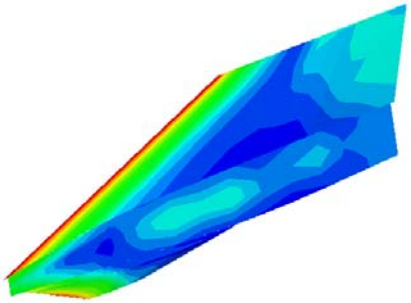
- SHABP used to develop heat loads for X-43A hot structure (specified Twall)
- Used to check required TPS thickness (radiation equilibrium)
- Part of a process including thermal analysis and structural analysis on 3D geometries



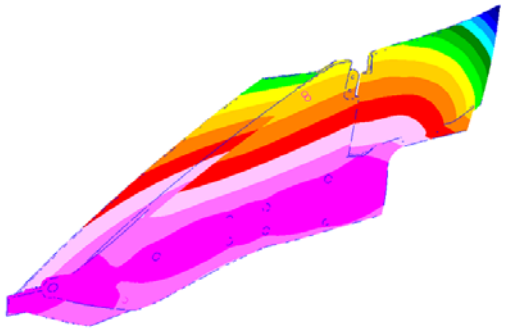
Hyper-X Thermal Analysis Process



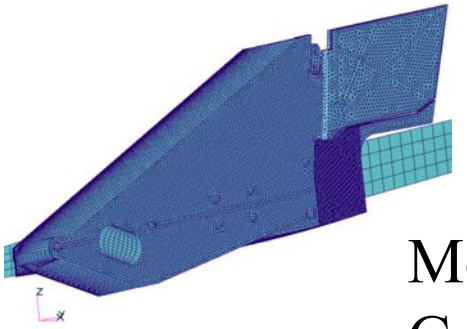
CAD Design



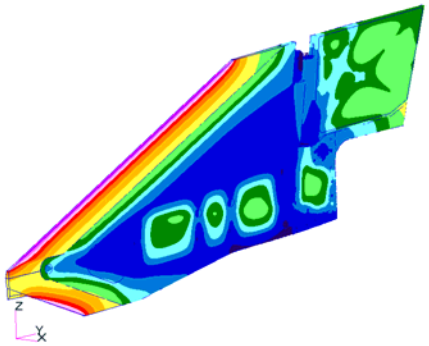
SHABP
Aeroheating



Structural
Analysis



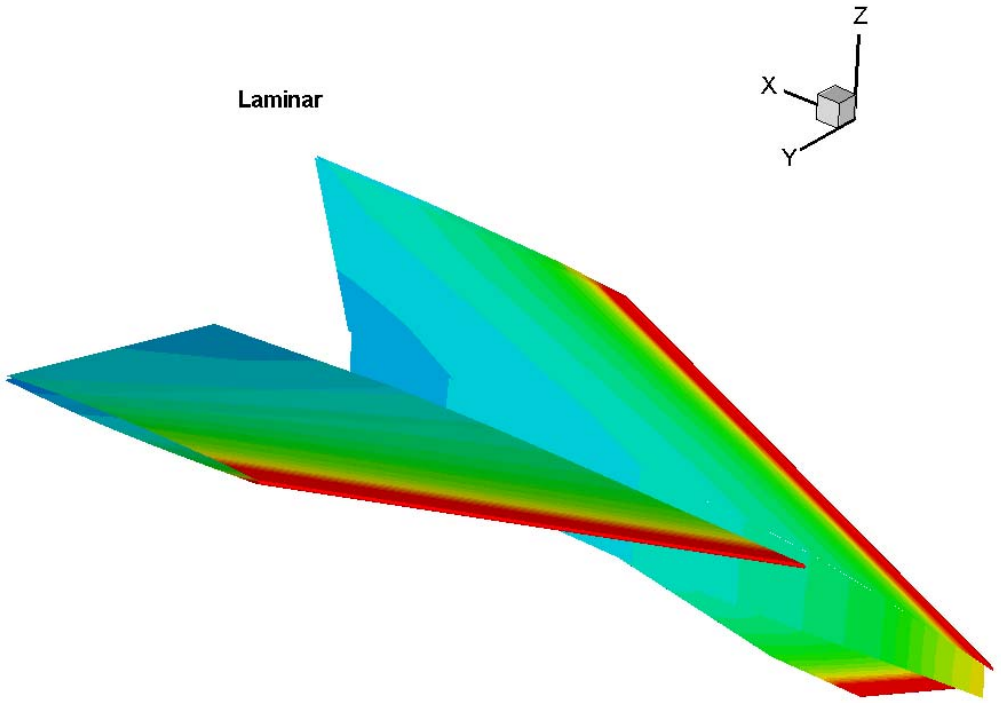
Mesh
Generation



Thermal
Analysis

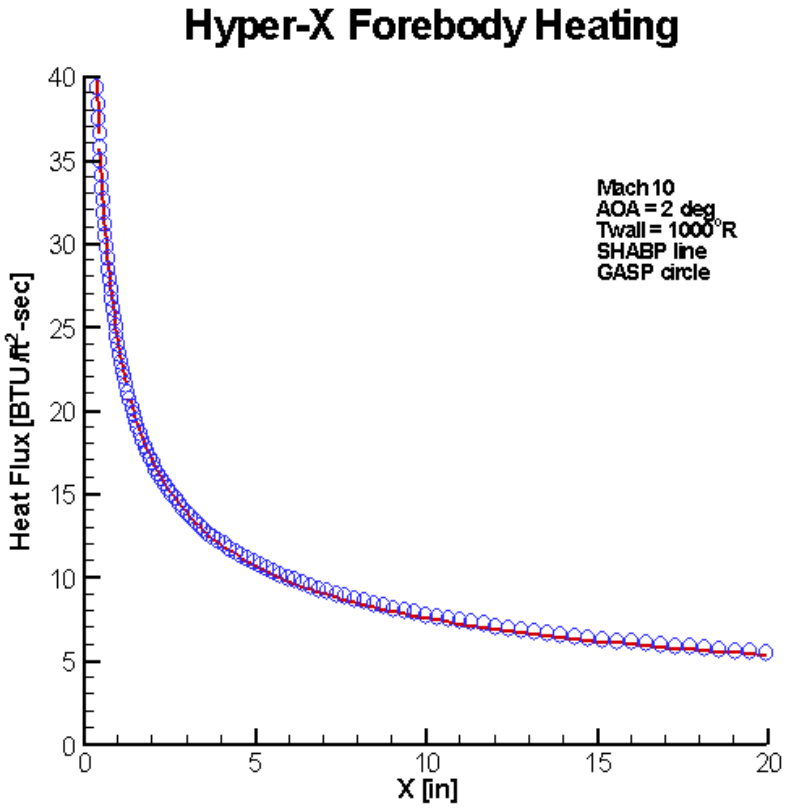
SHABP

- Fairly coarse grid (refined near leading edge) allowed for conceptual design
- Solves heat flux for a 3D temperature distribution or uniform Twall
- Rapid turnaround allows consideration of multiple architectures quickly
- Over 400 runs on multiple architectures
- Allow approximately 30% uncertainty to account for methodology and trajectory uncertainty



Validation

Heat flux calculations validated for multiple geometries for varying wall temperatures, angles of attack, Mach numbers, and boundary layer states



Limitations

- **Vertical/horizontal tail junction and vertical tail/fuselage junction**
  - Shock impingement of horizontal sweeping across vertical solved with results from literature
  - Corner flow: literature derived factors
  - Gap heating: literature derived factors
- **Bow shock**
  - Use CFD or wind tunnel data to characterize
  - Use shock relations for heating augmentation
- **Stagnation heating**
  - In-house code StagHeat
  - Results are faired in with SHABP

Summary

- SHABP has been incorporated into a practical environment for modeling hypersonic vehicles
- Allows for rapid and accurate analysis of multiple configurations
- Effective tool for conceptual aerothermal design by itself
- Coupled with targeted higher fidelity solutions can be used in final design