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Integration of ATAC within Thermal Desktop

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Background

- ATAC
 - ↙ Developed by ITT Industries (Huntsville, AL)
 - ↙ Non-axisymmetric
 - ↙ 3D Configurations
 - ↙ Aerothermal and aerodynamic analysis
 - ↙ Charring Material Ablation (CMA) capabilities
 - ↙ Also developed and continued enhancement by ITT (continued team, but as different company)

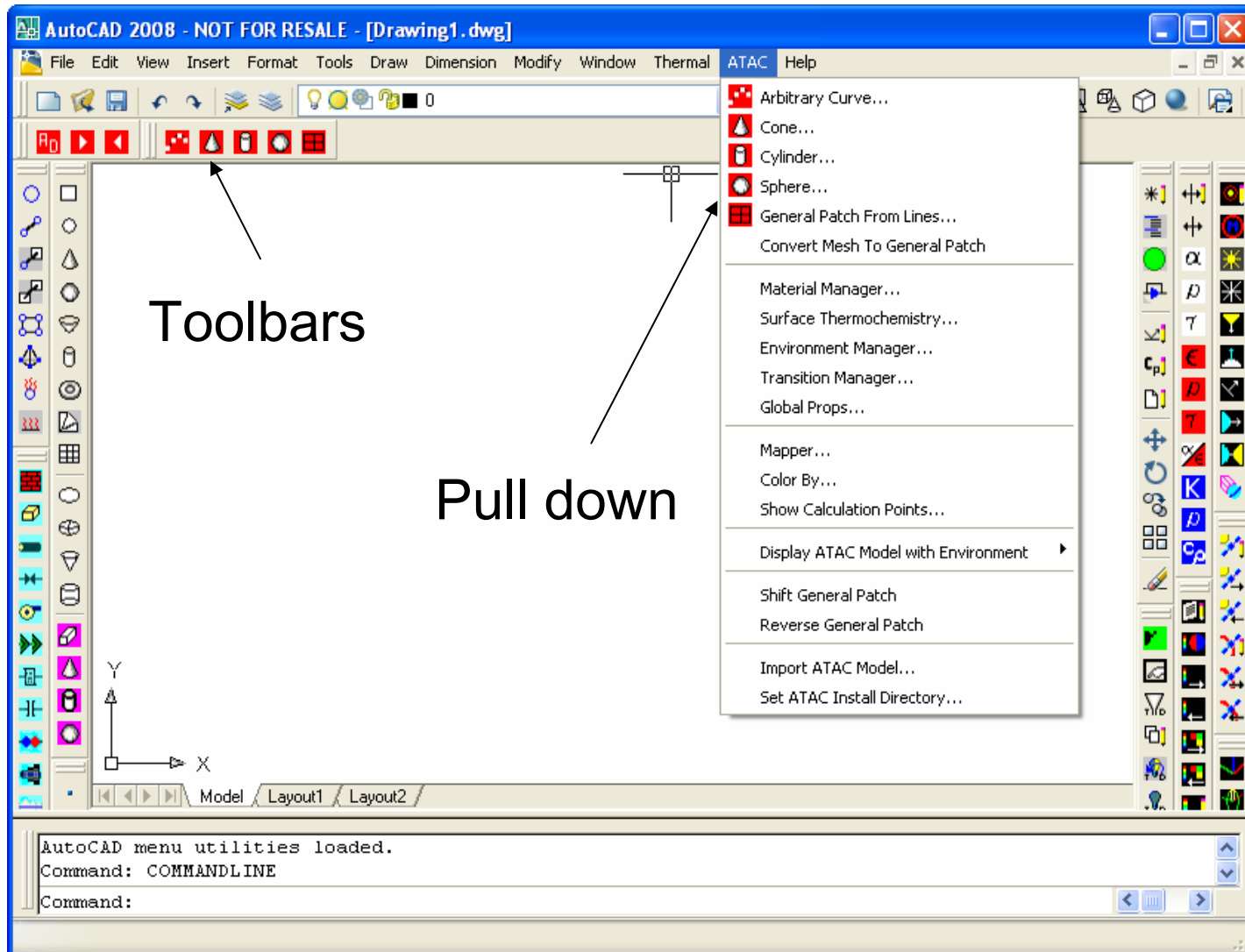


Background

- This work is being funded under Air Force SBIR funds (Contract Number FA940106P0129). Phase II work began in June 2006
 - ↙ Contract Monitor Keith Bowman
- Beta to be released soon
 - ↙ Contact Mark Welch



ATAC Interface





ATAC Interface

- Geometric Entities
 - ↳ 4 Point Arbitrary Curve
 - ↳ Cone
 - ↳ Cylinder
 - ↳ Sphere
 - ↳ General Patch





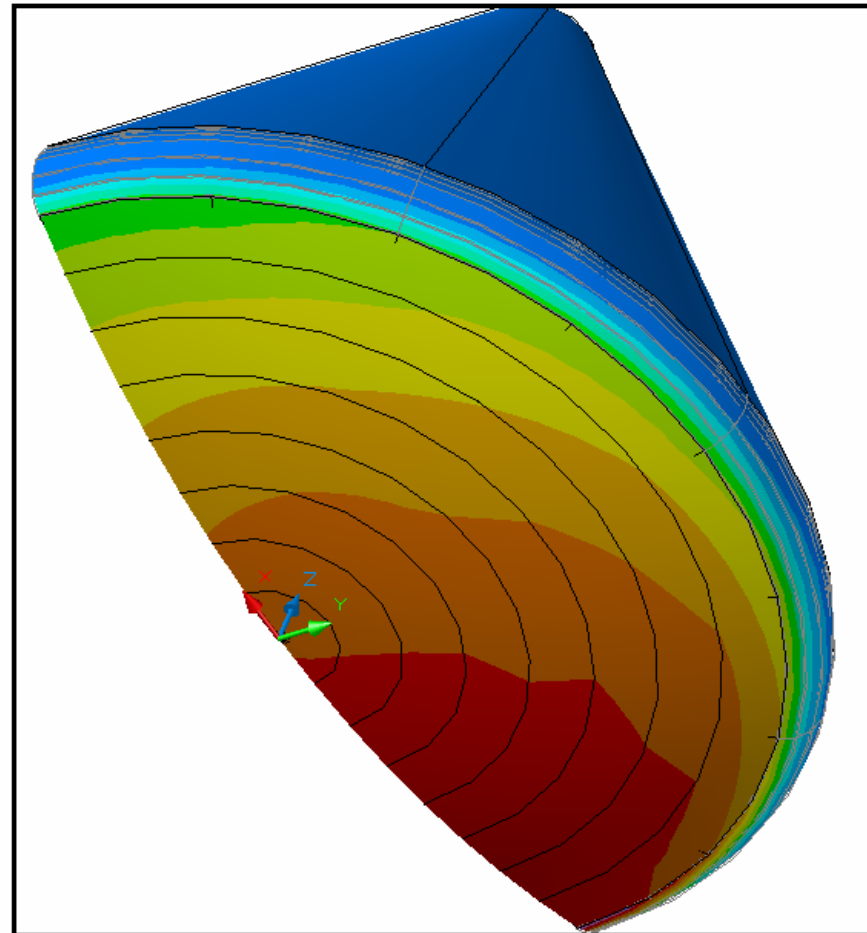
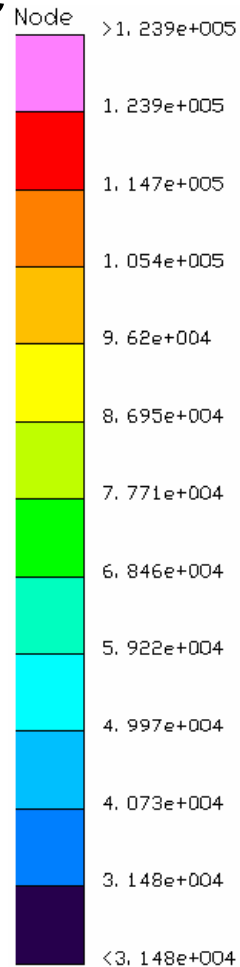
ATAC Interface

- Apollo Module

- ↳ Sphere

- ↳ Cone

- ↳ 4 pt curve

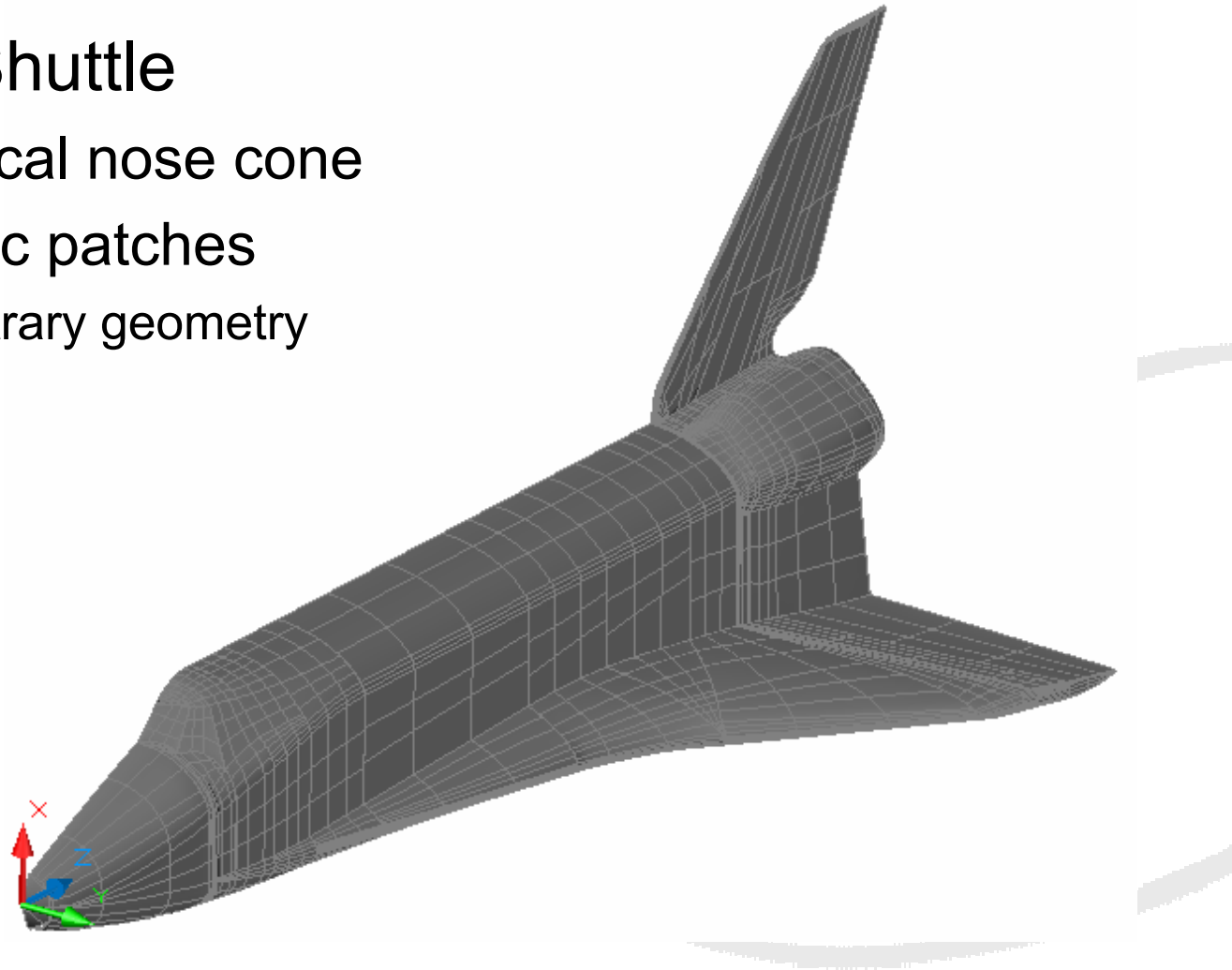


Pressure[Pa], Time = 5200. sec



ATAC Interface

- Space Shuttle
 - ↳ Spherical nose cone
 - ↳ Bi cubic patches
 - ↳ Arbitrary geometry





ATAC Interface

The screenshot shows the ATAC Data window with the Material tab selected. The Property List contains the following data:

Property	Value
siph	0.500000
carbonfiberflake	0.250000
titanium	0.250000

The Atac Material Input dialog box is open, showing the following fields:

- Material: carbonfiberflake
- Total Thickness: 0.25 in
- Number of Nodes: 10
- Initial Temperature: 530 R
- First Node Thickness: 0.01 in
- Contact Conductance: 0 BTU/sec/in²/f

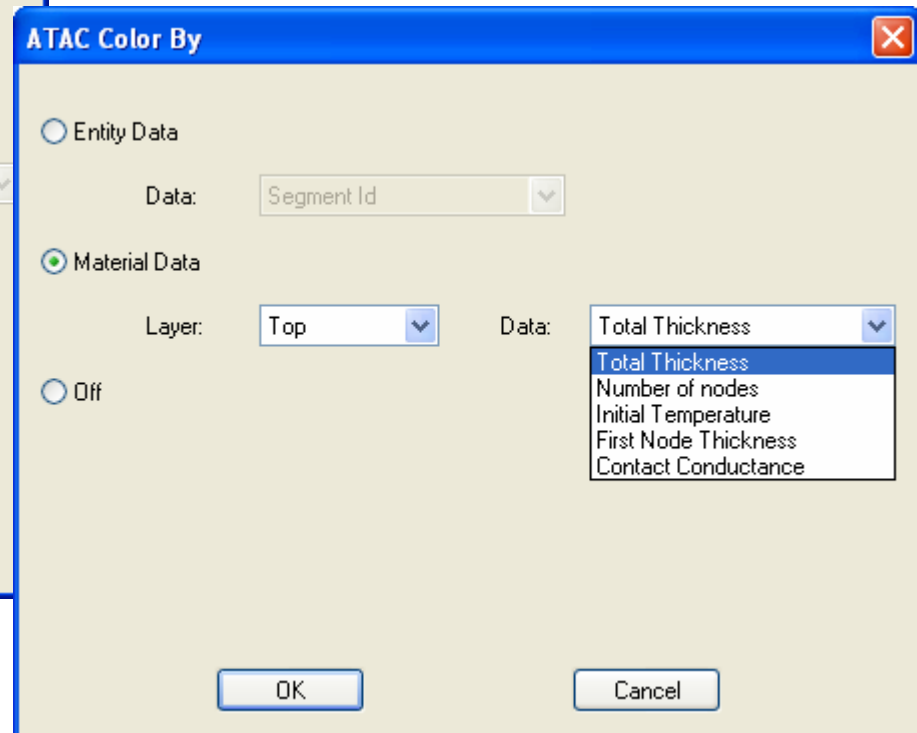
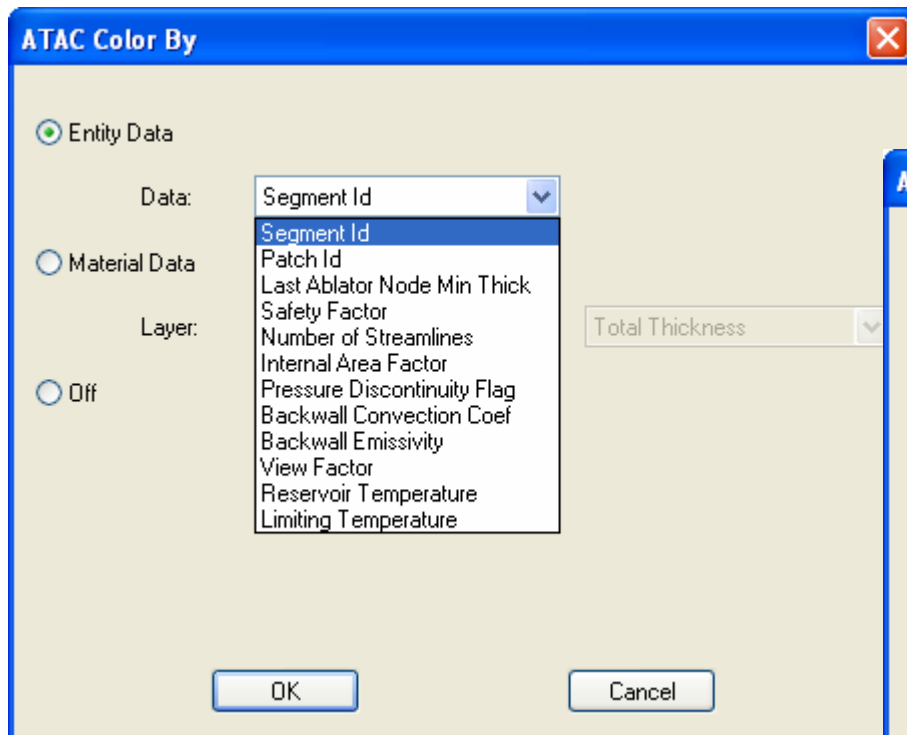
The Thermocouple Input section contains a text area with the value 1. The dialog box has OK and Cancel buttons.

ATAC entity properties



ATAC Interface

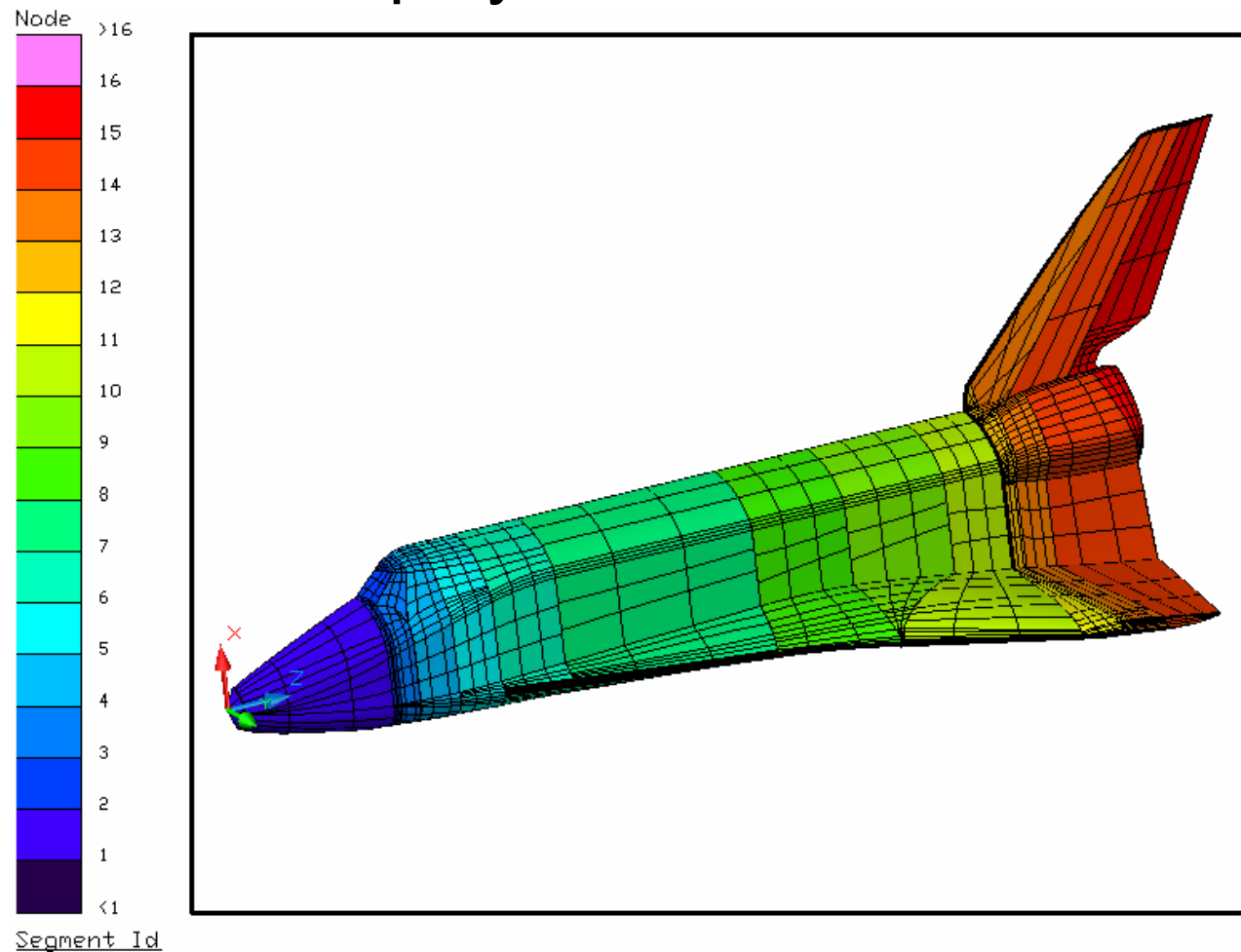
- Color by properties allow model input verification





ATAC Interface

- Segment IDs displayed on model





ATAC Interface

- ATAC Managers
 - ↳ Material Manager
 - ↳ Property Files
 - ↳ Roughness algorithms
 - ↳ Blowing correction factors
 - ↳ Surface Thermo-chemistry
 - ↳ Environment
 - ↳ Detailed Next Slide
 - ↳ Flow Transition Regimes/Algorithms



ATAC Interface

- Environment Manager
 - ↙ Allow multiple environments to be defined in the same model
 - ↙ In conjunction with the Case Set Manager, this allows the user to setup multiple runs in a single model



ATAC Interface

The image displays two overlapping dialog boxes from the ATAC software interface. The 'Create Atac Environment' dialog is in the background, showing a text field for 'Name' containing 'Environment 1' and a 'Type' section with radio buttons for 'Arc Heater' (selected), 'Ballistic Range', 'Flight', 'General', 'Internal Trajectory', 'QSC Trajectory', and 'Wind Tunnel'. The 'Flight Environment' dialog is in the foreground, showing a table of flight parameters and a dropdown menu for the atmospheric model.

Create Atac Environment

Name: Environment 1

Type

- Arc Heater
- Ballistic Range
- Flight
- General
- Internal Trajectory
- QSC Trajectory
- Wind Tunnel

OK Cancel

Flight Environment

Flight Parameters:

Time [sec]	Altitude [km]	Velocity [m/sec]	Angle of Attack [deg]	Yaw Angle [deg]	Roll Rate [rps]	Mollier Table
0	5	1000	15	0	0	1
1000	4	1500	15	0	0	2

Plot Altitude
Plot Velocity
Plot AoA
Plot Yaw
Plot Roll Rate

Atmospheric Model: U.S. Standard Atmosphere

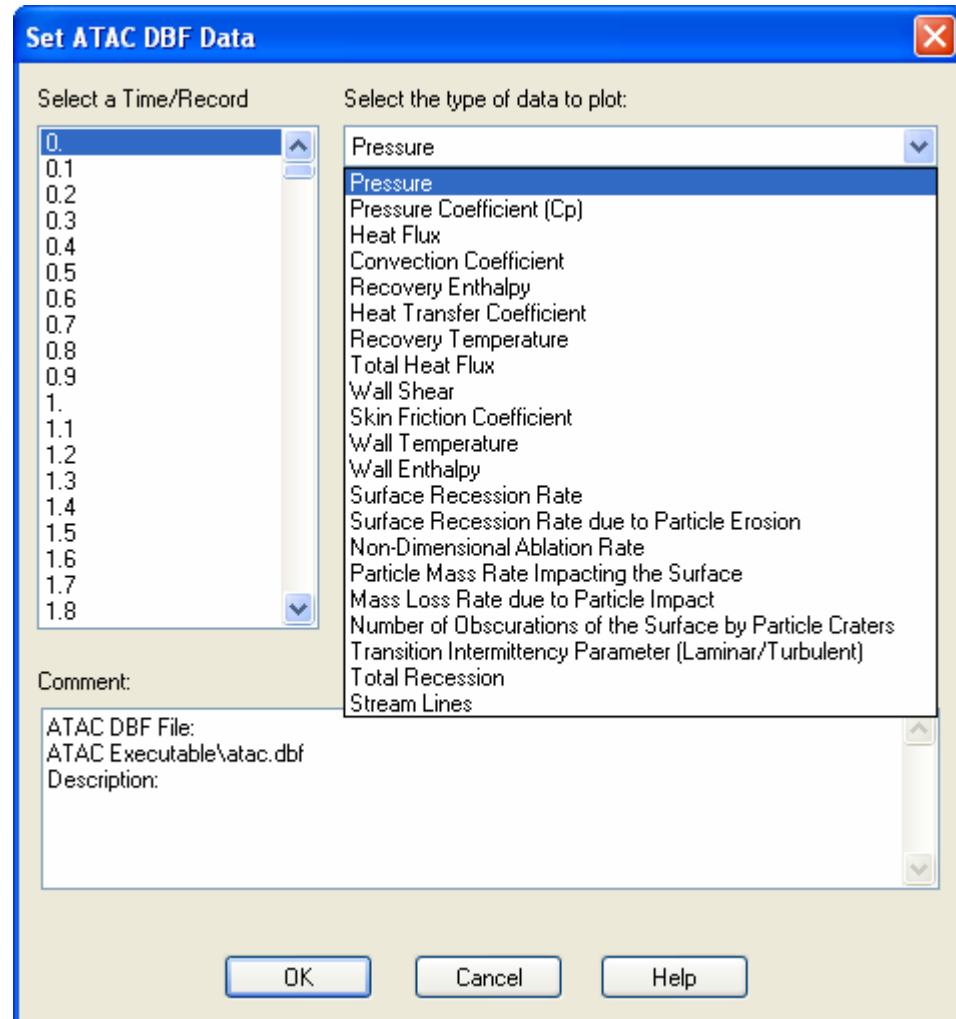
- U.S. Standard Atmosphere
- Standard Kwajalein Atmosphere
- 15 deg north annual
- 30 deg north January
- 30 deg north July
- 45 deg north January
- 45 deg north July
- 45 deg north Spring/Fall
- 60 deg north January

ATAC environment input forms



ATAC Interface

- Post Processing



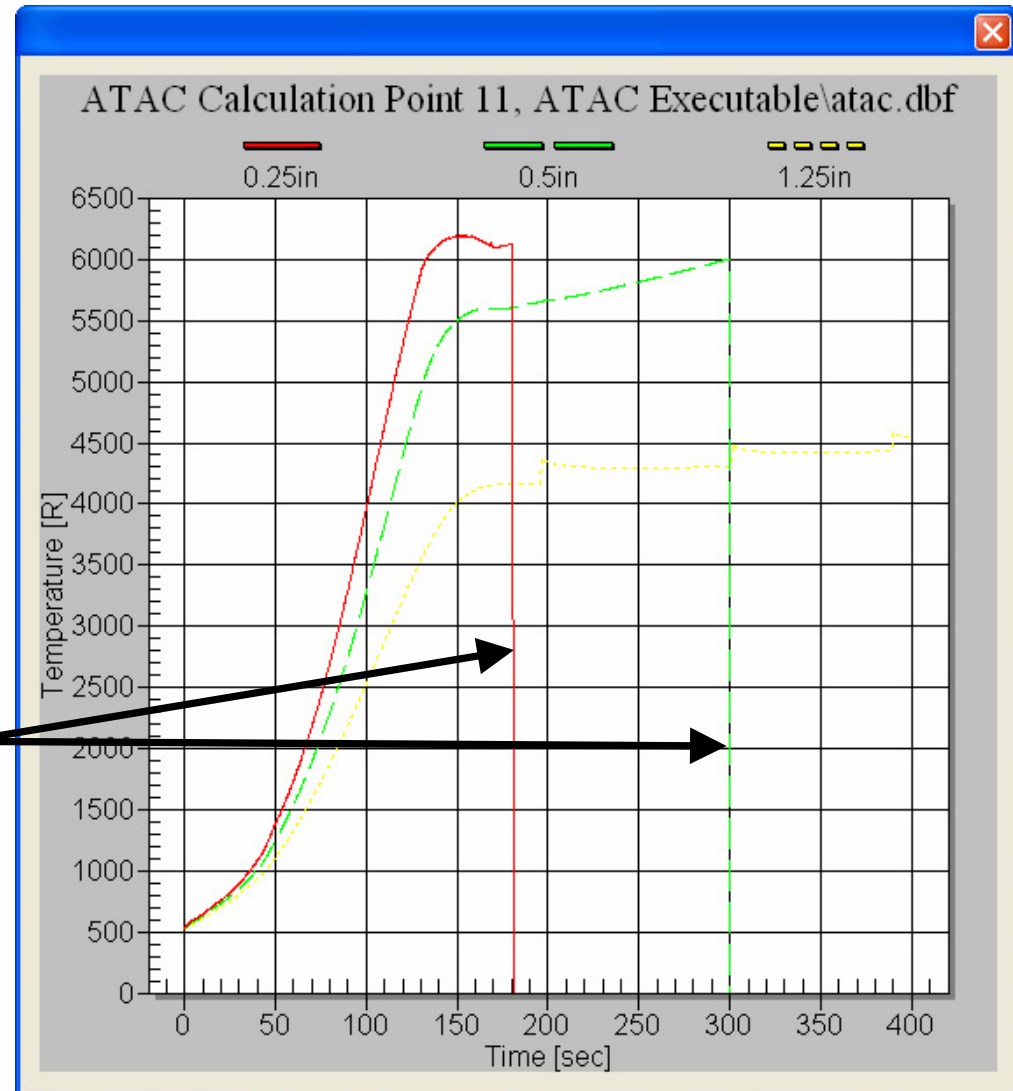


ATAC Interface

- XY Plotting

- ↳ ATAC calc data
- ↳ Thermocouples

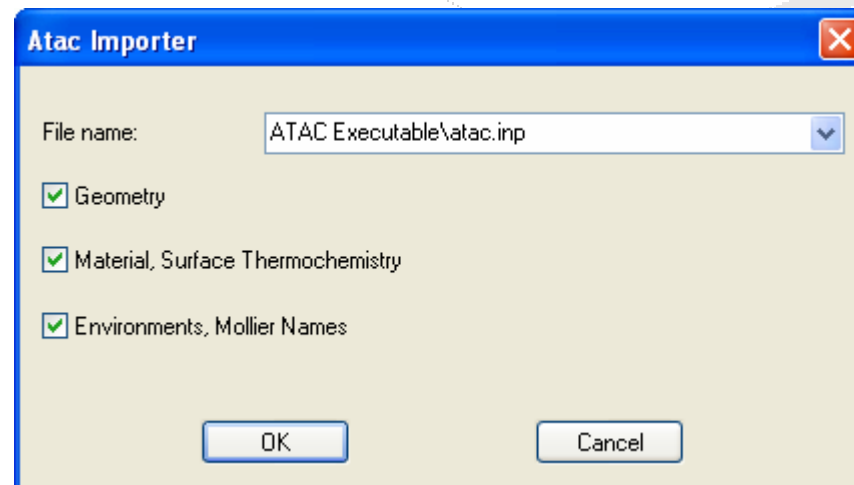
↳ Drop off indicates burn through of that TC





ATAC Interface

- Importer
 - ↳ Control of importing Geometry, Materials, and Environments





ATAC Interface

- Case Sets

Case Set Information - ATAC Executable

ATAC Setup | ATAC Calc | Advanced | Symbols | Comments

Calculation Mode: Run ATAC Only

File name prefix: atac

Environment: Flight

Transition: Transition-0

Initial Time: 0 sec

Final Time: 400 sec

Safety Factor: 0

Initial Wall Temperature: 530 R

Max energy change/interval [BTU/in²]: 1.22299e-006

Max co-solve time step [sec]: 0.01

Output Print: Boundary layer streamline points

Plot Output: TECPLOT

Set Time Steps... Set Print Times... Set Debug Output...

OK Cancel Help



ATAC Interface

- Case Set (cont...)

Case Set Information - ATAC Executable

ATAC Setup | **ATAC Calc** | Advanced | Symbols | Comments

Shape Change Calc Mode:	Surface Energy Bal - Transient Conduct (CMA)	Thermal grid global thickness optimization iterations:	0
Leeward Pressure:	Cp = 0	Char Zone Criteria Percent:	0
Windward Pressure:	Modified Newtonian	Pyrolysis Zone Criteria Percent:	0
High Altitude Boundary Layer Model:	Continuum Boundary Layer	Char Swell Proportionality Constant:	0
Shock Layer Radiation Model:	None	Critical Density[lbm/in ³]:	0
		Number of Nodelets:	0

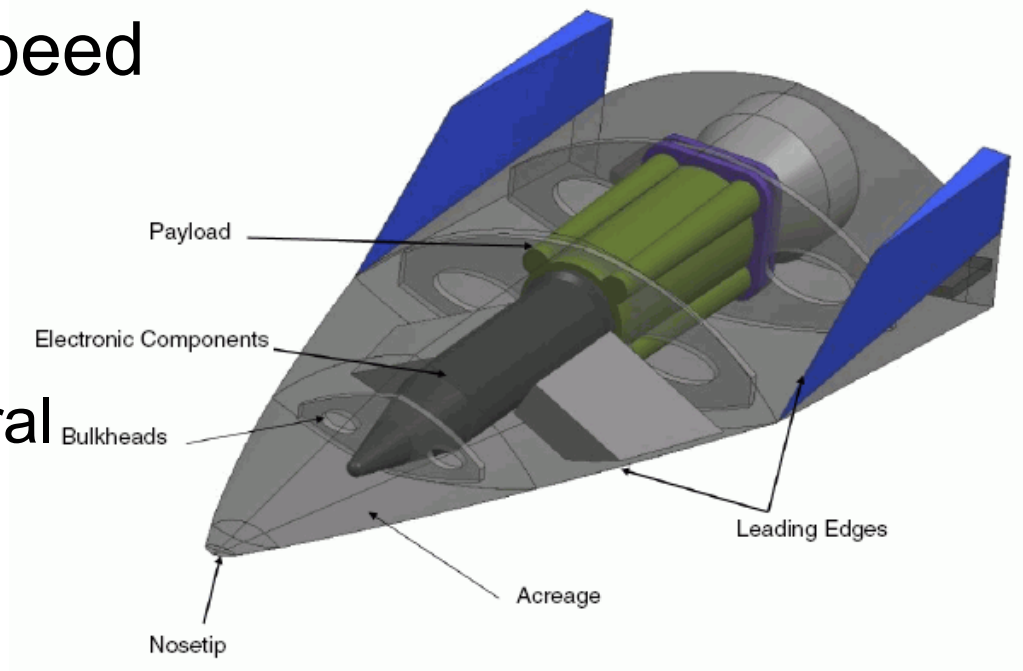
Set Aero Coeff Calcs...
Set Surface Data...
Set Particle Environment...
Set Boundary Condition Output...
Set zPod Data...

OK Cancel Help



Background

- Complex physics of analyzing high speed vehicles
 - ↙ Aerothermal
 - ↙ TPS
 - ↙ Thermal/Structural Response





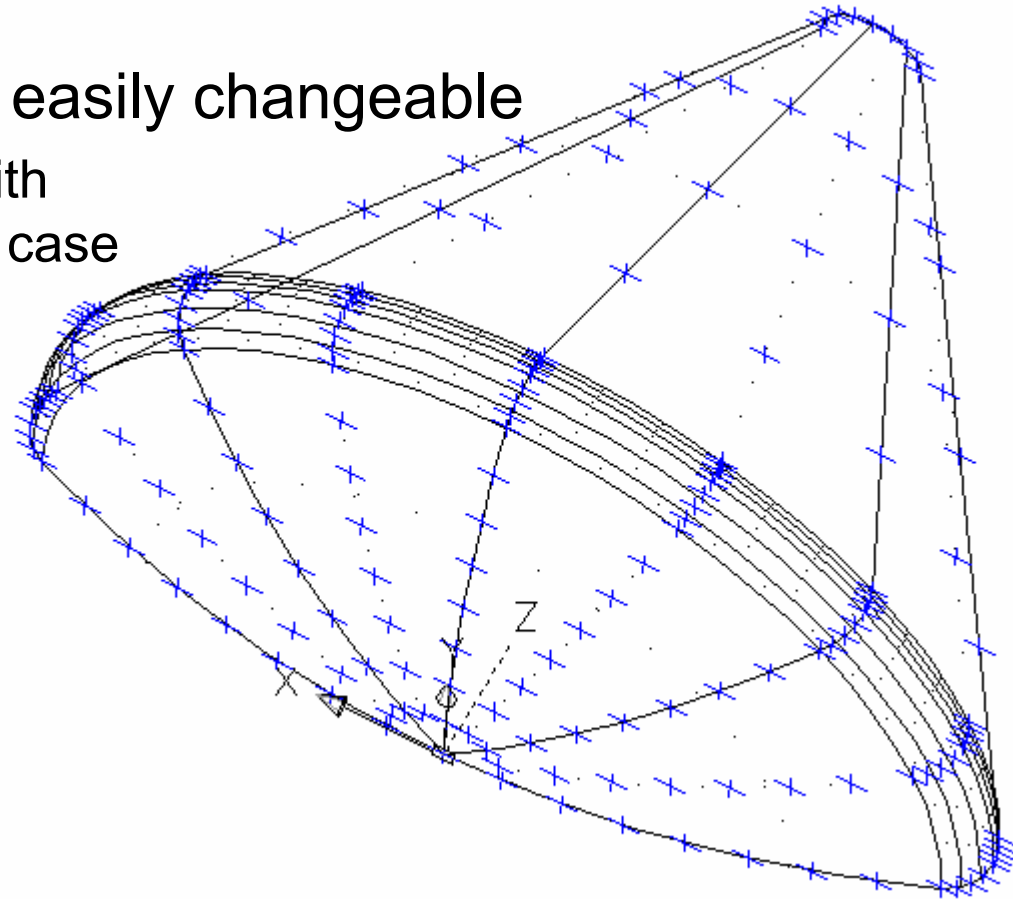
Background

- 3 Disciplines Involved
 - ↙ CFD for external flow
 - ↙ Teamed with Zona Technologies and their product zPod
 - ↙ ATAC allows for input of CFD Cp and shock locations to calculate external heating
 - ↙ ATAC also has engineering methods to calculate streamlines and external flow (breaks down for complex vehicles)
 - ↙ This topic is very complex, but not the focus of this presentation
 - ↙ TPS
 - ↙ Solved by ATAC with CMA
 - ↙ Thermal/Structural
 - ↙ Thermal Desktop
 - ↙ Mapping nodal temperature to structural programs



Calculations

- ATAC performs 1D calculations at points on the vehicle
 - ↳ Number of points easily changeable
 - ↳ Programmable with symbols for each case

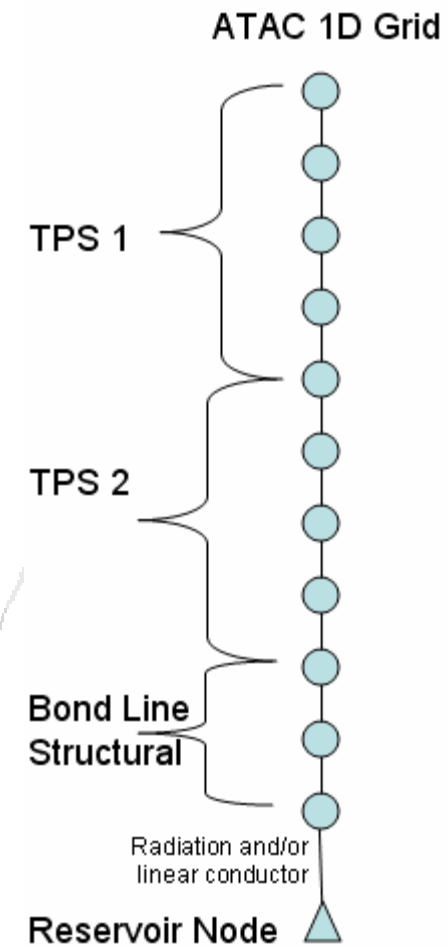




Calculations

- 1D Limitations

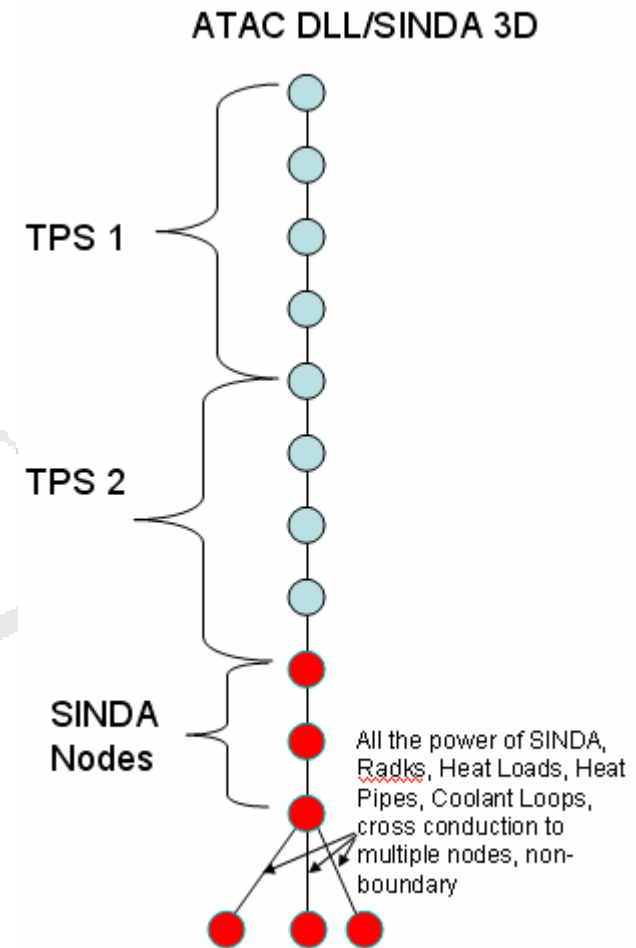
- ✘ Constant reservoir
- ✘ Constant conductance to reservoir
- ✘ Difficult to model structural ribs
- ✘ Lack of user logic disallows time dependent events in the vehicle
- ✘ Challenging to make ATAC calculation point locations line up with thermal-structural node locations





Calculations

- Desire 3D solution
 - ✦ Model bond line in SINDA
 - ✦ Co-solve ATAC and SINDA at the same time, exchanging fluxes and temperatures.
 - ✦ Conserve Energy
 - ✦ Allows for all SINDA/FLUINT modeling from the bond line in
 - ✦ Finite Difference or Finite Element
 - ✦ Heaters, Heatloads
 - ✦ Coolant Loops
 - ✦ Radks
 - ✦ Time dependent events





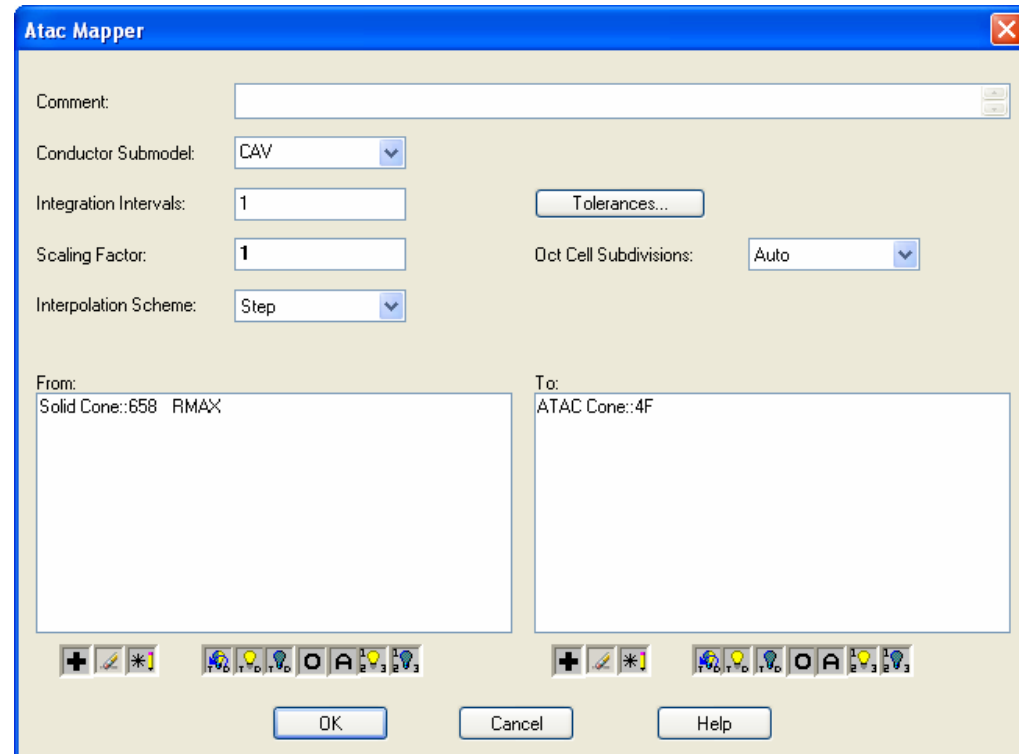
Co-solve Calculations

- Co-Solve Steps
 - ↳ SINDA to ATAC
 - ↳ Bond line temperatures (reservoir/boundary node for ATAC)
 - ↳ Amount of time to march (user controlled)
 - ↳ ATAC solves
 - ↳ Time met or a user input max energy has entered the bond line node
 - ↳ Returns to SINDA
 - ↳ Time Solved
 - ↳ Flux into each node at the bond line
 - ↳ SINDA solves to “catch-up” to the ATAC time
 - ↳ Repeat until the end time



Calculations

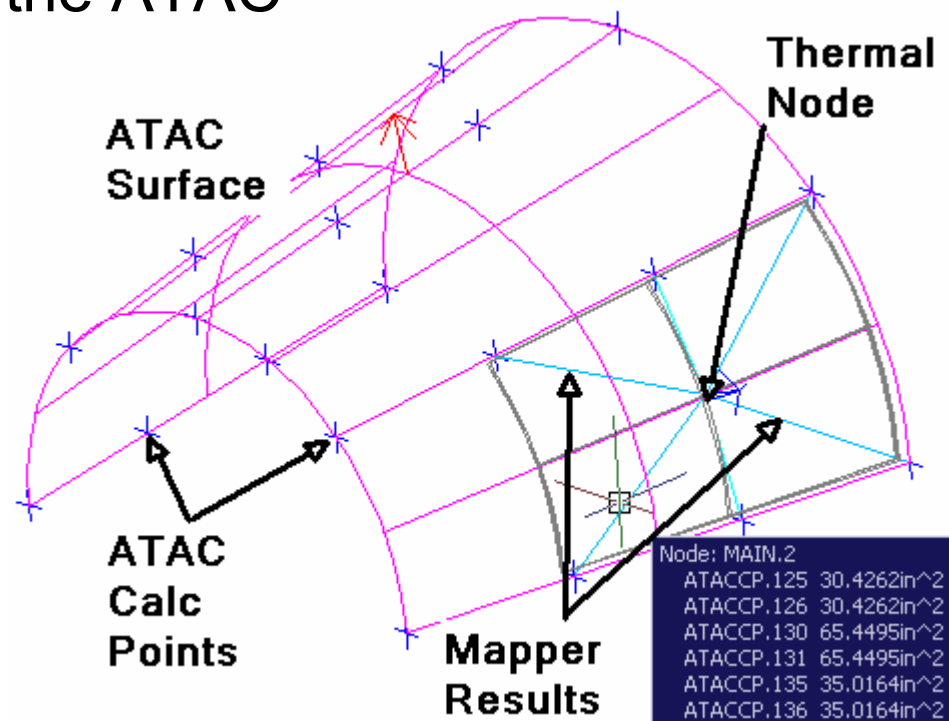
- Interface ATAC calc point to thermal nodes
- ATAC Mapper
 - ↳ Maps points from thermal model to ATAC calc points
 - ↳ User controls fidelity of the points mapped





Calculations ATAC Mapper

- ATAC Mapper Calculations
 - ↙ 100 points sampled (10 integration intervals)
 - ↙ Areas distributed to the ATAC calculation points





Co-Solve Interface

- Turn on SINDA ATAC Co-Solve
 - ↳ SINDA Tabs appear when selected

Case Set Information - CoSolve ATAC and SINDA

ATAC Setup | ATAC Calc | Radiation Tasks | S/F Calculations | S/F Output | SINDA | Dynamic | Advanced | Props | Symbols | Comments

Calculation Mode: Co-solve ATAC and SINDA

File name prefix: atac

Environment: Flight

Transition: Transition-0

Initial Time: 0 sec

Final Time: 400 sec

Safety Factor: 0

Initial Wall Temperature: 530 R

Max energy change/interval [BTU/in²]: 1e+010

Max co-solve time step [sec]: 5000

Output Print: Boundary layer streamline points

Plot Output: TECPLOT

Set Time Steps... Set Print Times... Set Debug Output...

OK Cancel Help



Calculations

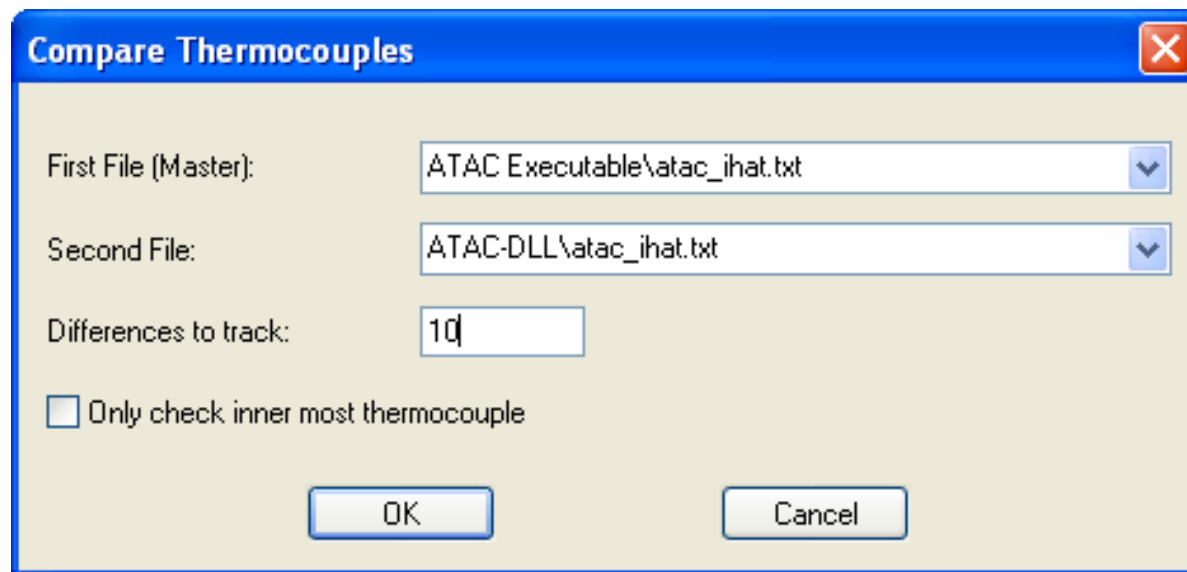
- Verification of the co-solve
- Build the SINDA model to be the same as the 1D ATAC model
- Perform the co-solve
- Compare thermocouple results
 - ↳ Find largest differences





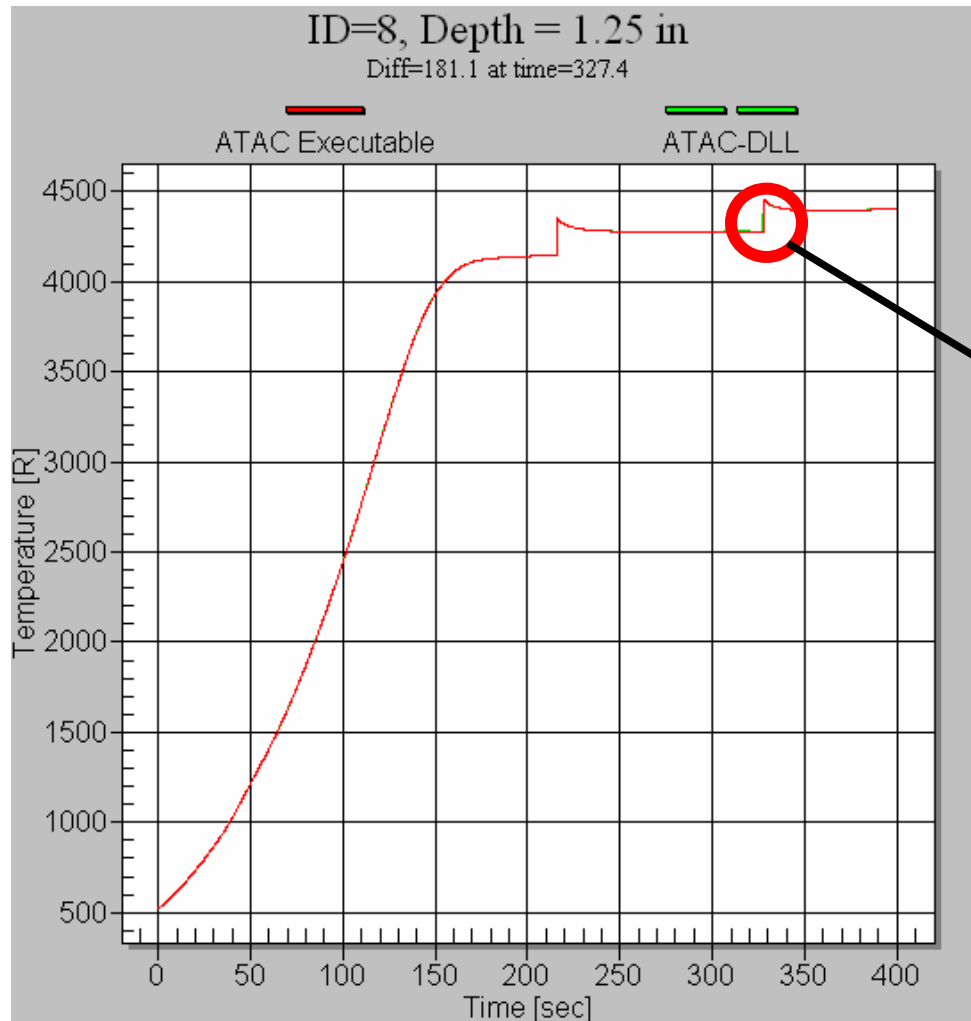
Calculations

- Comparison utility added

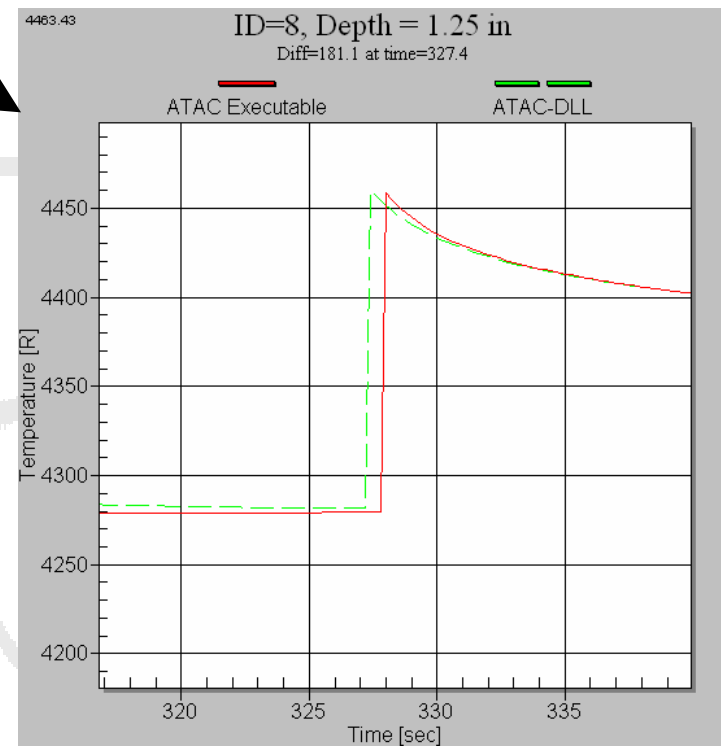




Calculations



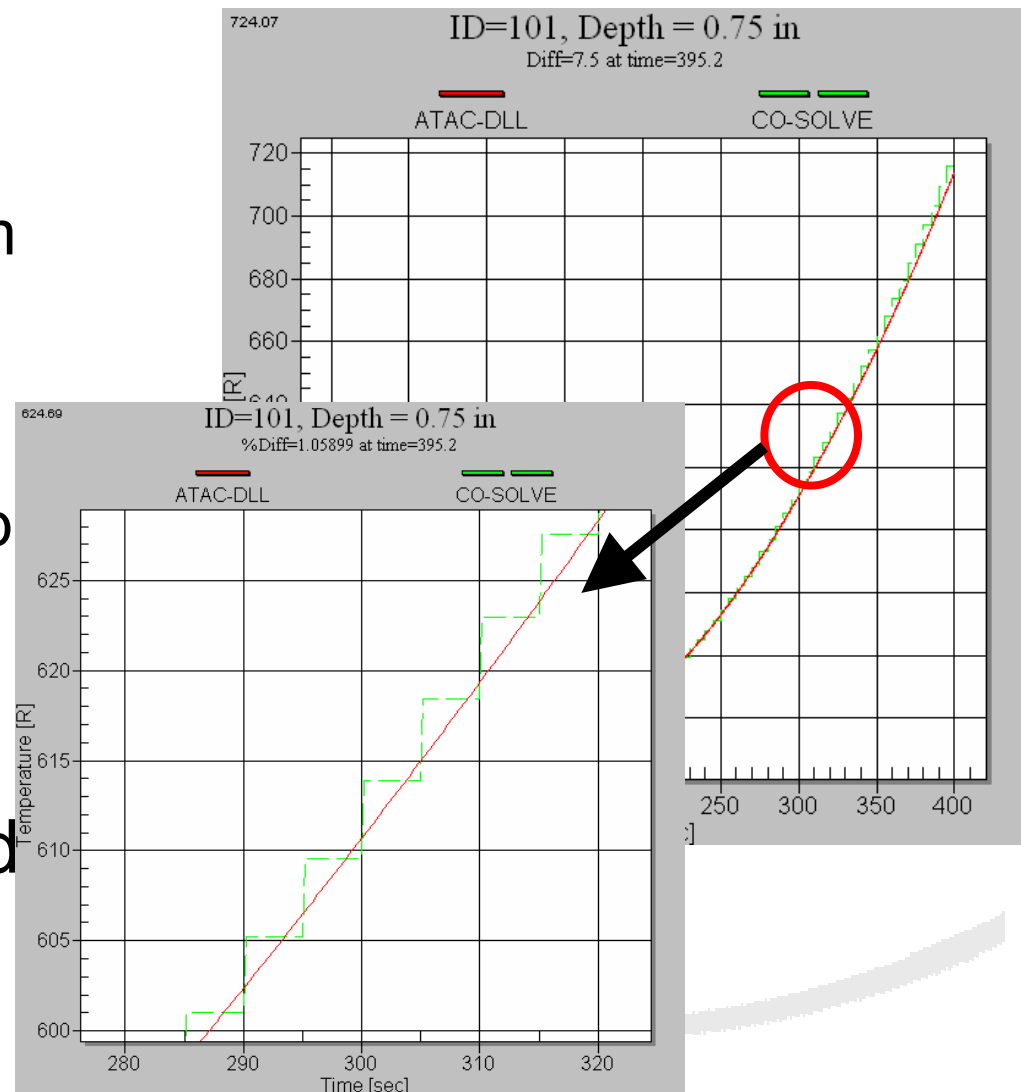
- Only slight differences found





Calculations

- Stair Step Result
 - ↙ Bond line is constant with from ATAC view
 - ↙ Output interval is greater than the co-solve time step interval
- This reduces as the co-solve interval is reduced





Conclusions

- All work presented is fully functioning
- SBIR contract end May 31, 2008
- Much work ahead
 - ↙ More ATAC options to add
 - ↙ Documentation
 - ↙ Sample model to be developed (AMARV)