C&R TECHNOLOGIES

Integration of ATAC within Thermal Desktop

Mark J. Welch

Timothy Panczak

C&R Technologies

September 2007

C&R TECHNOLOGIES
303.971.0292
Fax 303.971.0035

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)

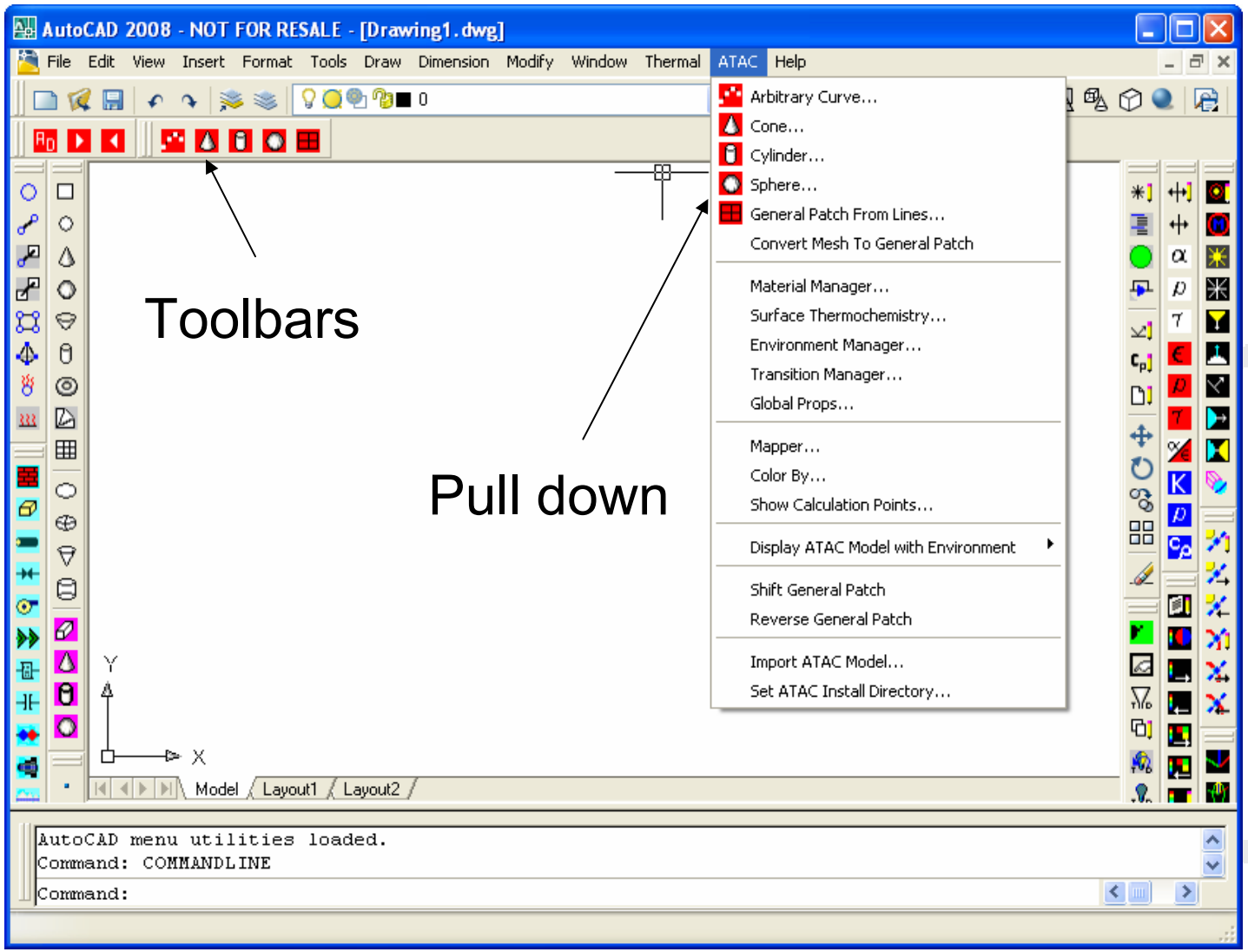
C&R TECHNOLOGIES
www.crtech.com

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

C&R TECHNOLOGIES
www.crtech.com

ATAC Interface



C&R TECHNOLOGIES
www.crtech.com

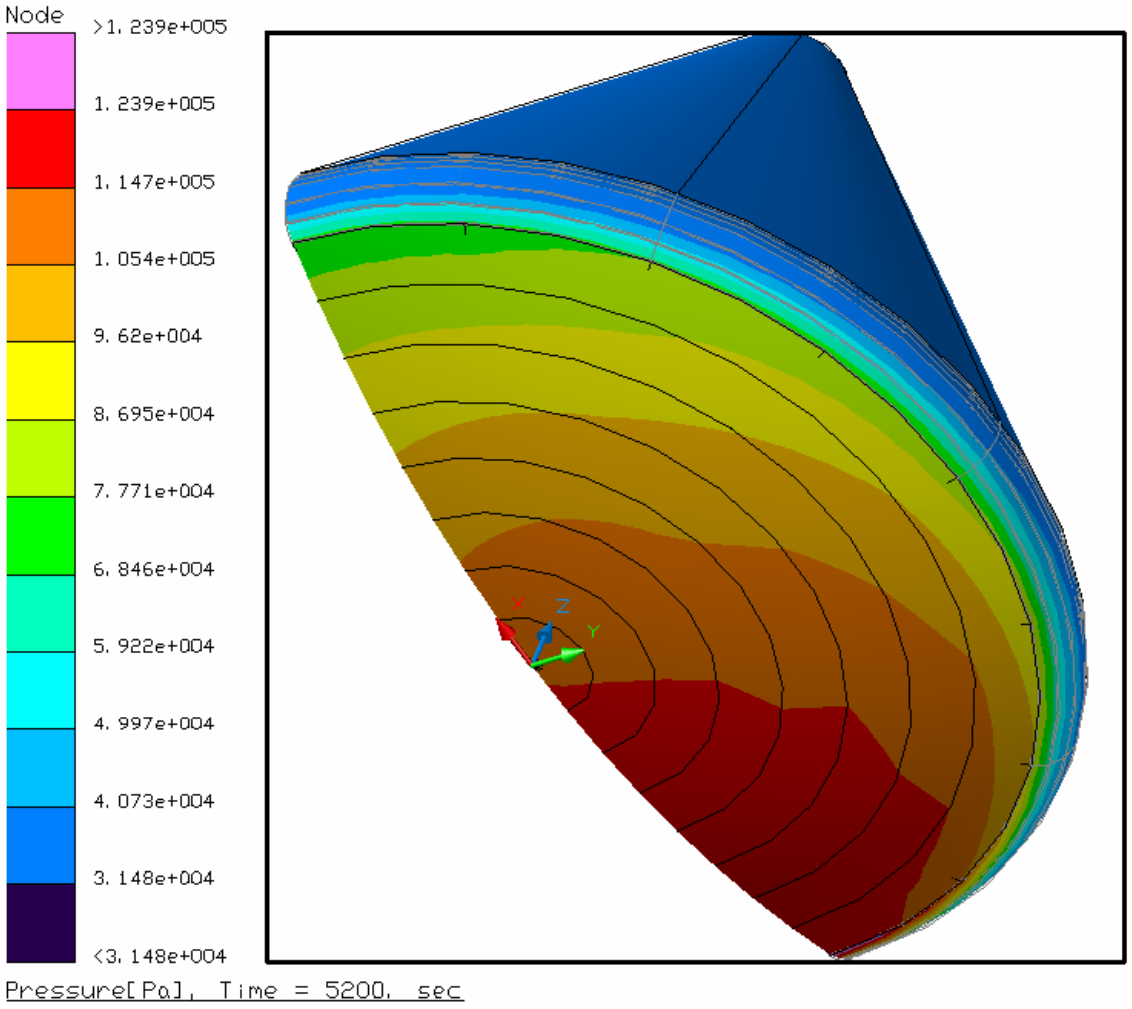
ATAC Interface

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

C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

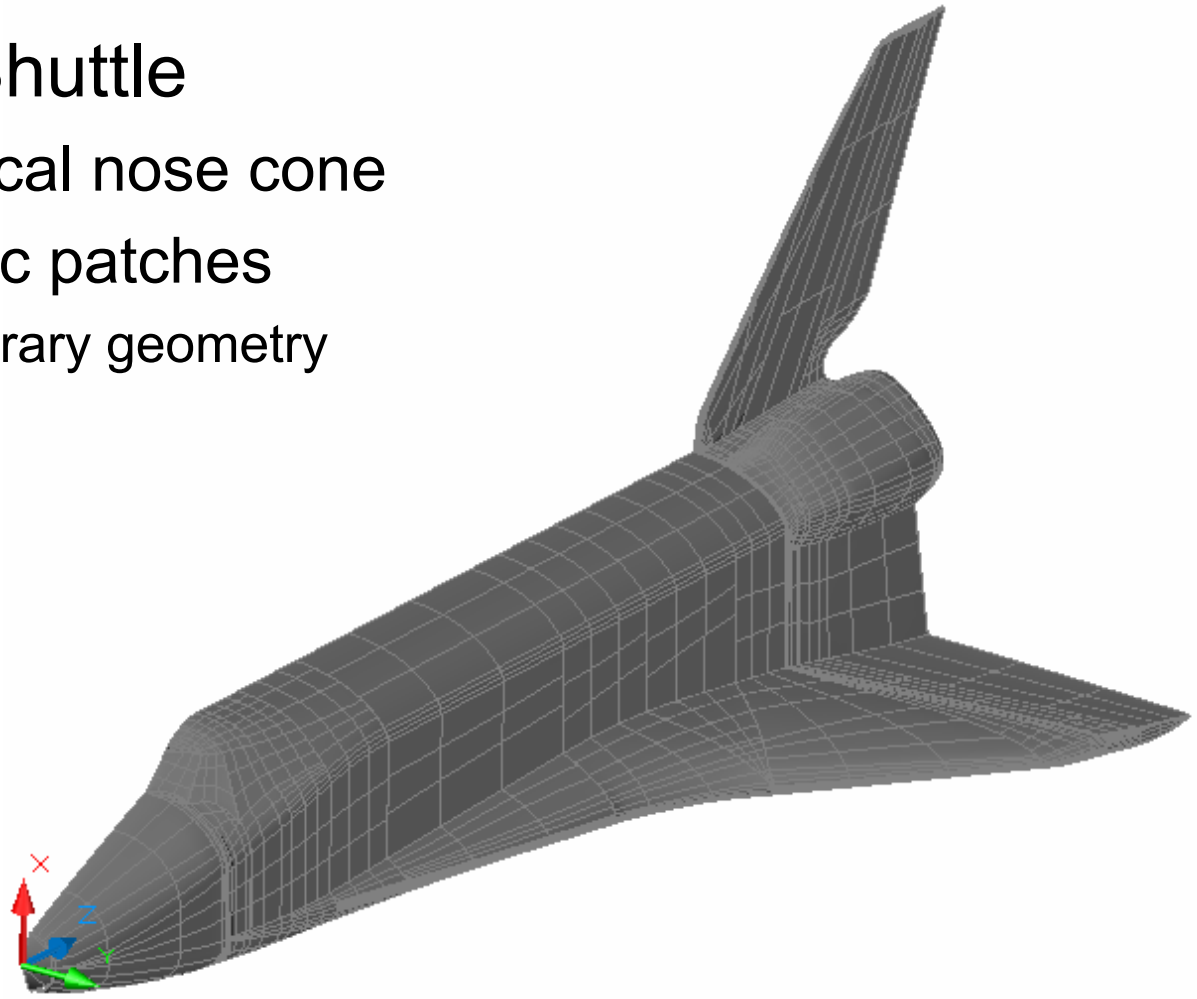
- Apollo Module
  - Sphere
  - Cone
  - 4 pt curve



C&R TECHNOLOGIES
www.crtech.com

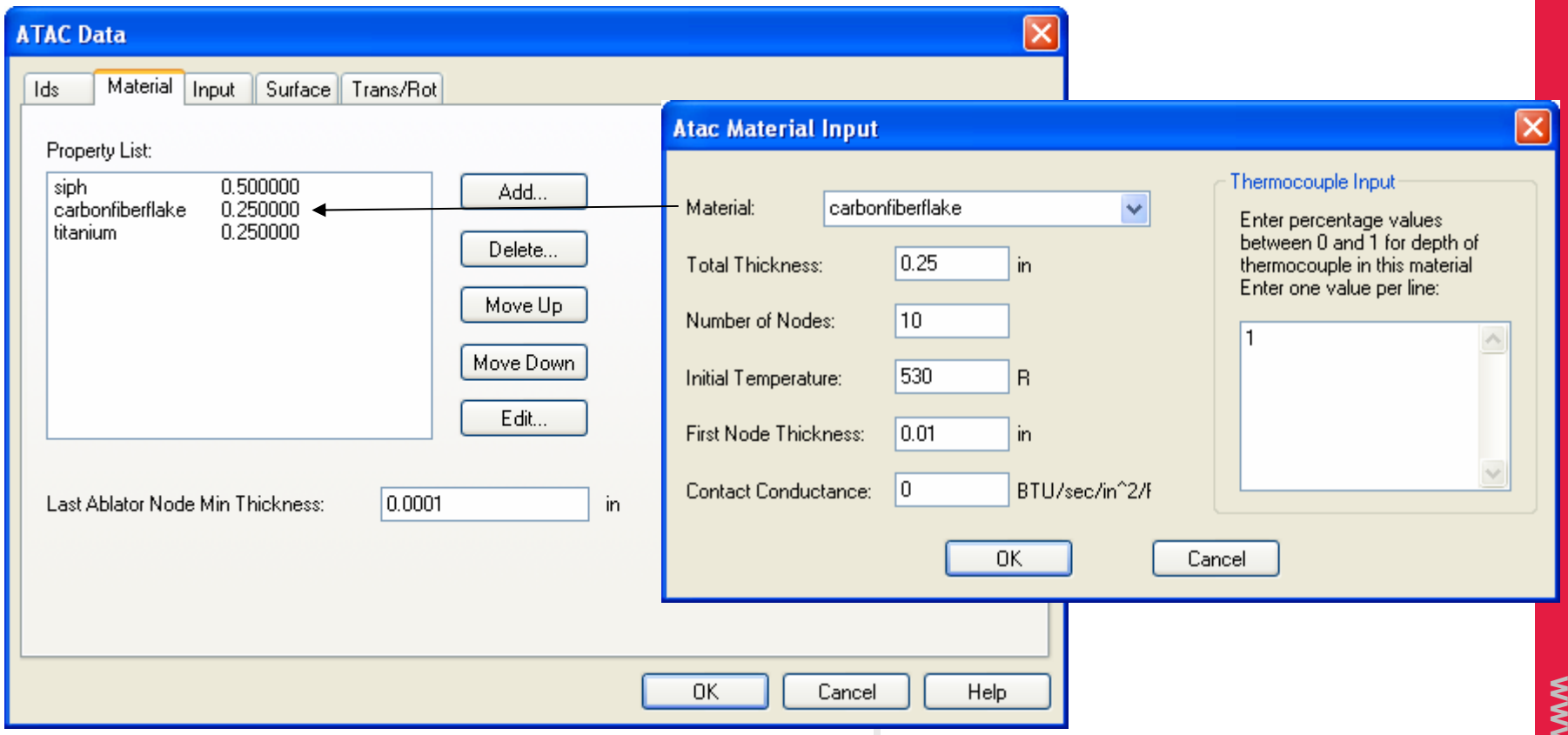
ATAC Interface

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



C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

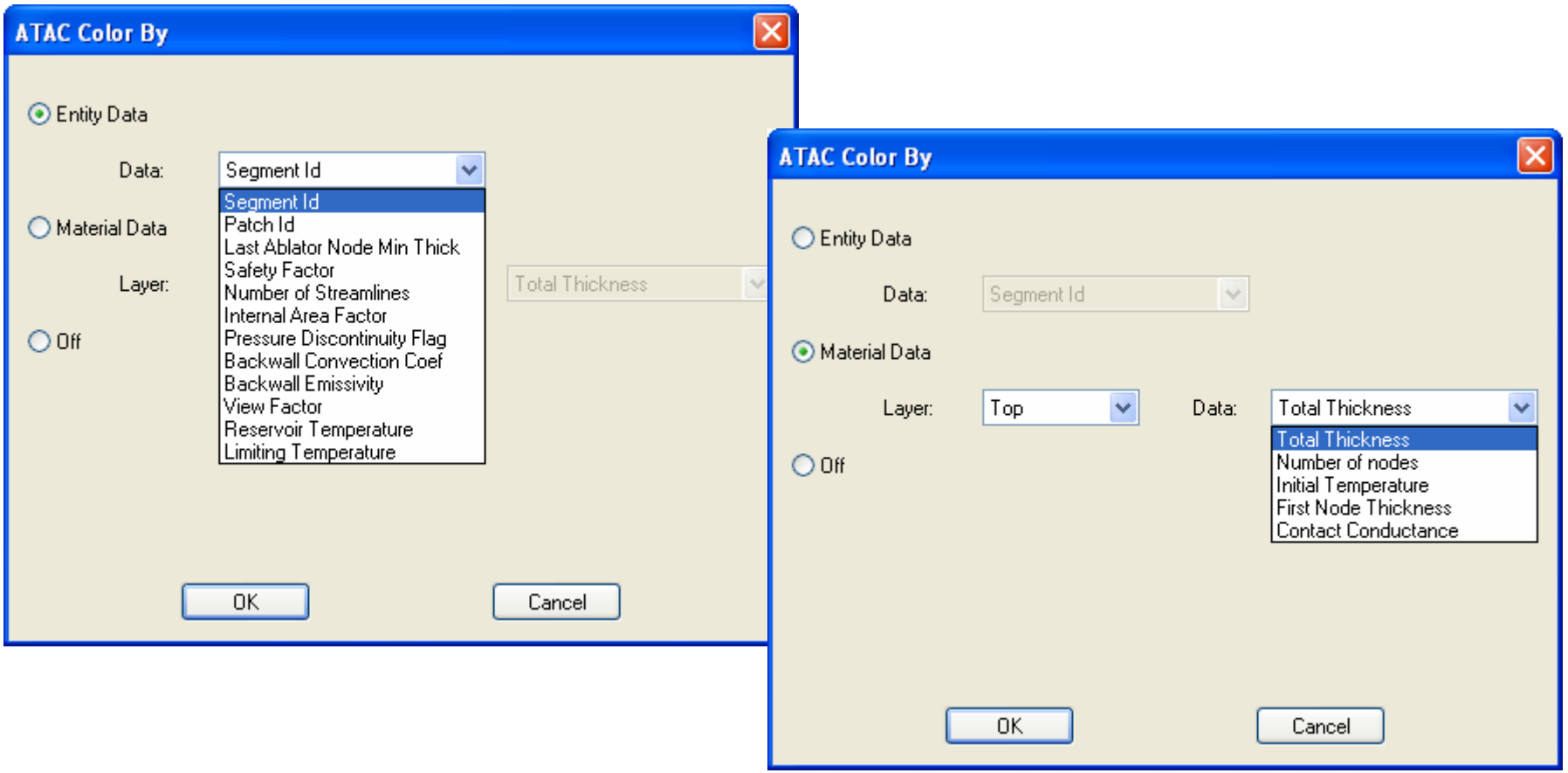


ATAC entity properties

C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

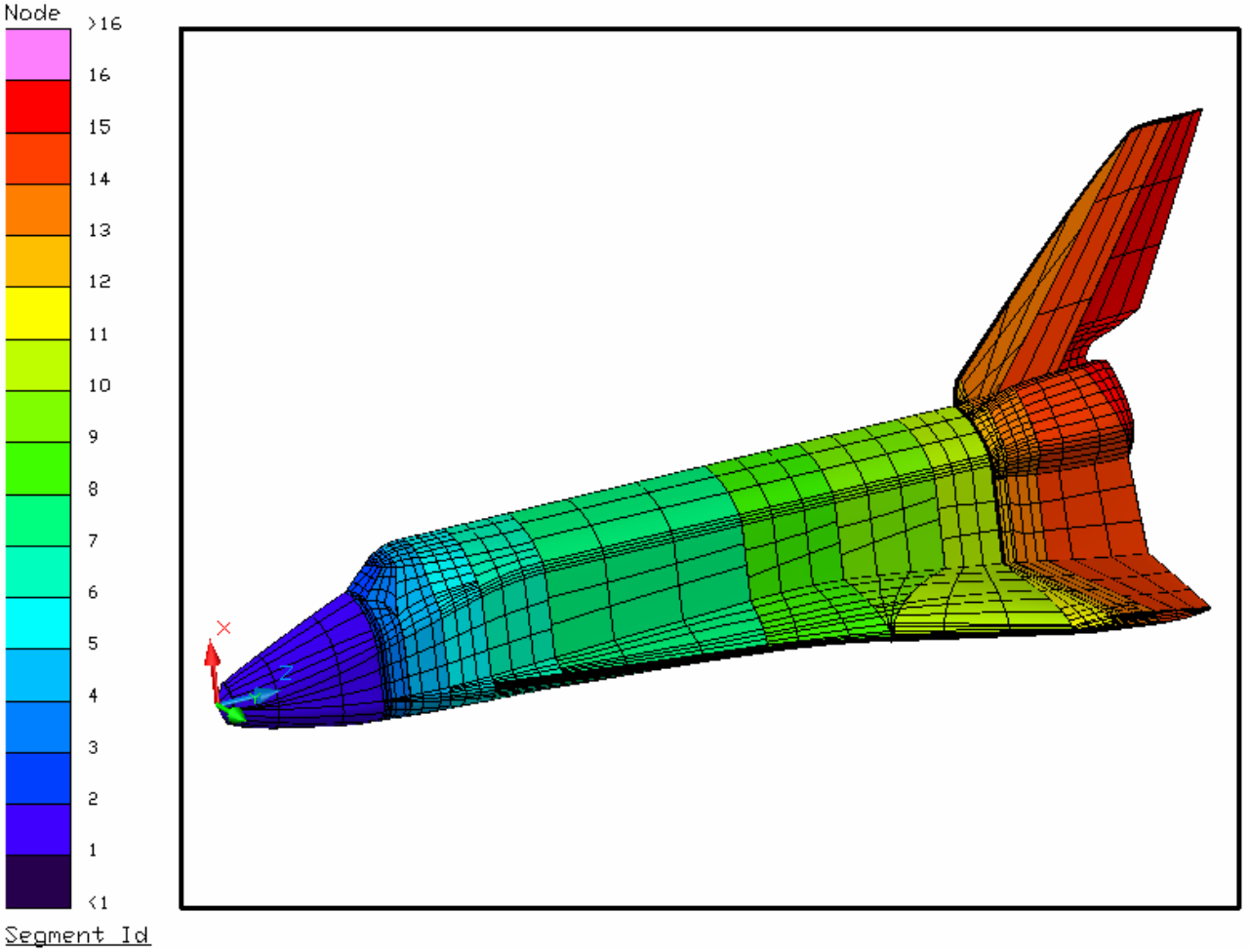
- Color by properties allow model input verification



C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

- Segment IDs displayed on model



C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

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

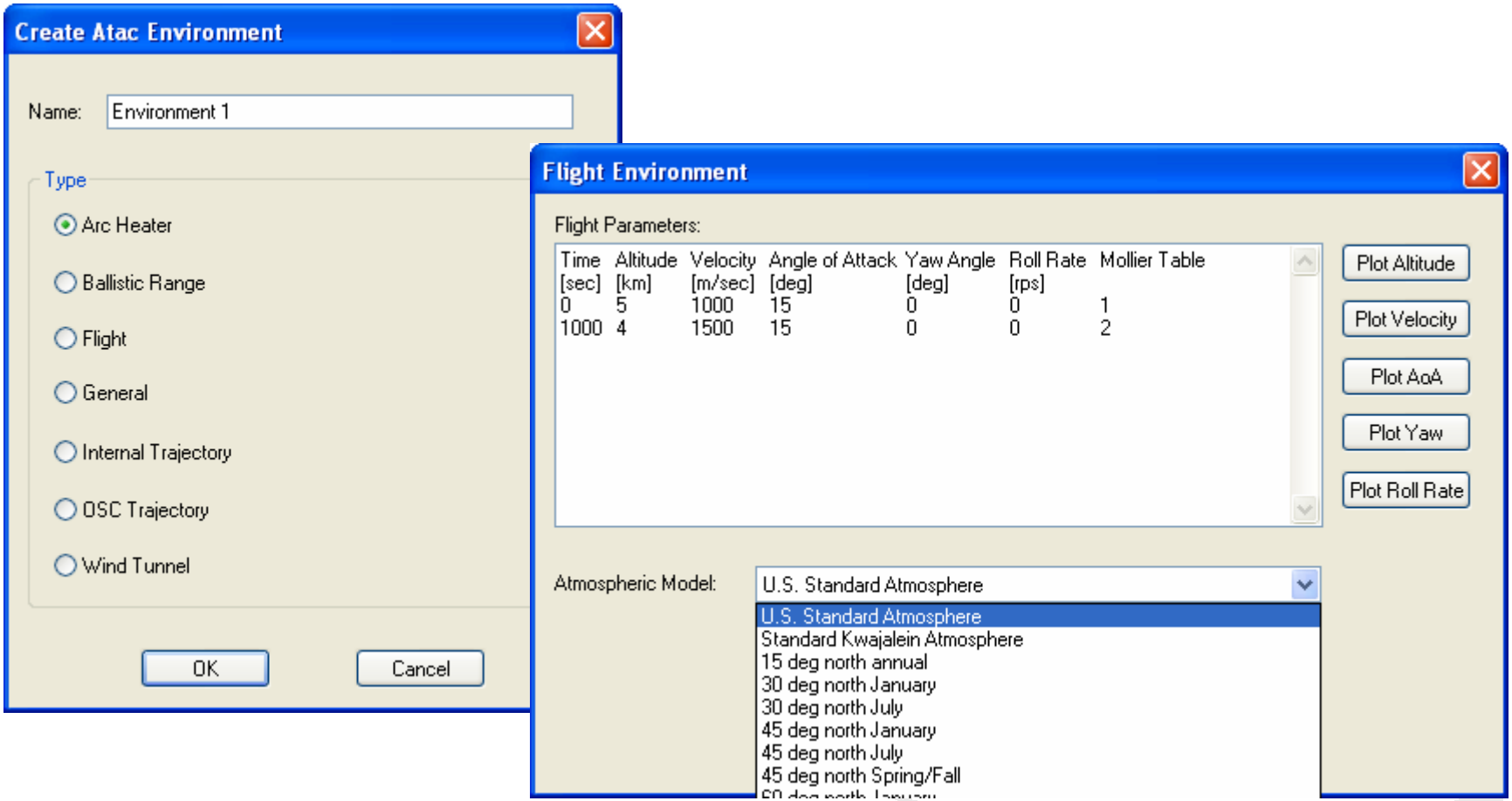
C&R TECHNOLOGIES
www.crtech.com

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

C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

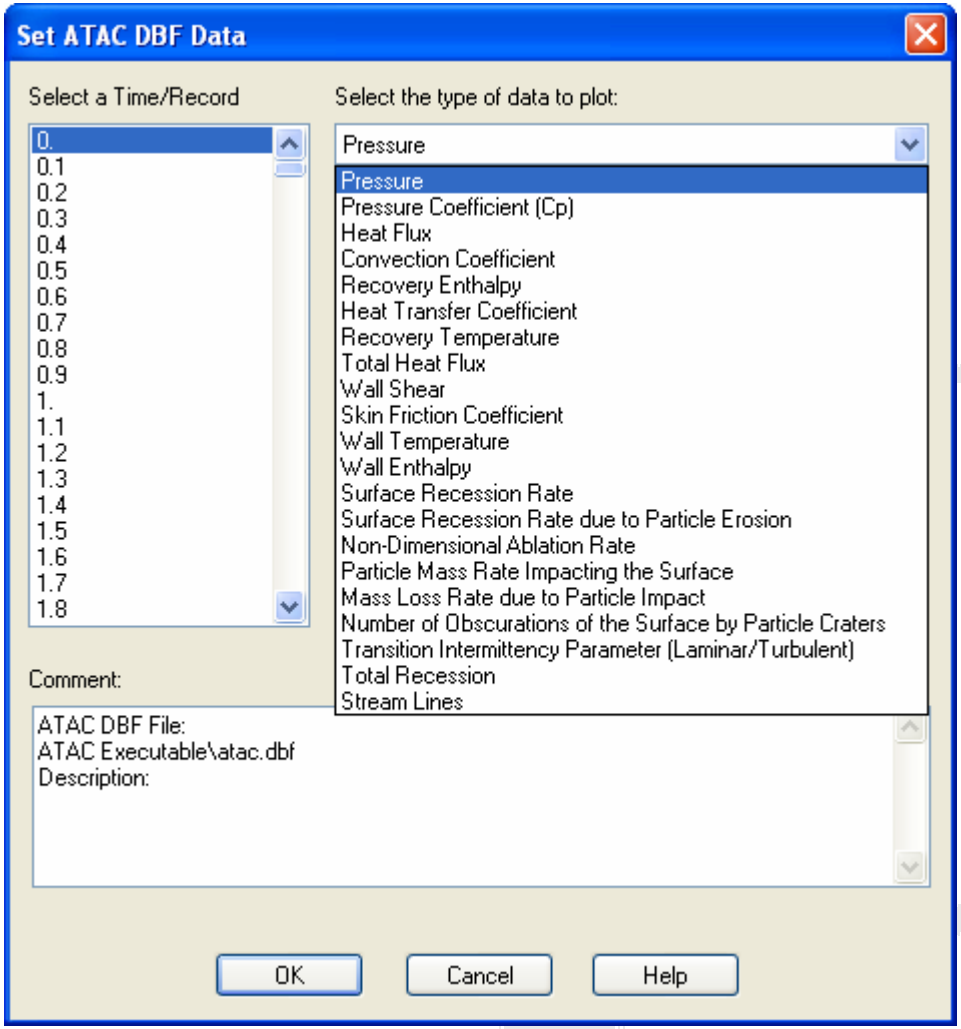


ATAC environment input forms

C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

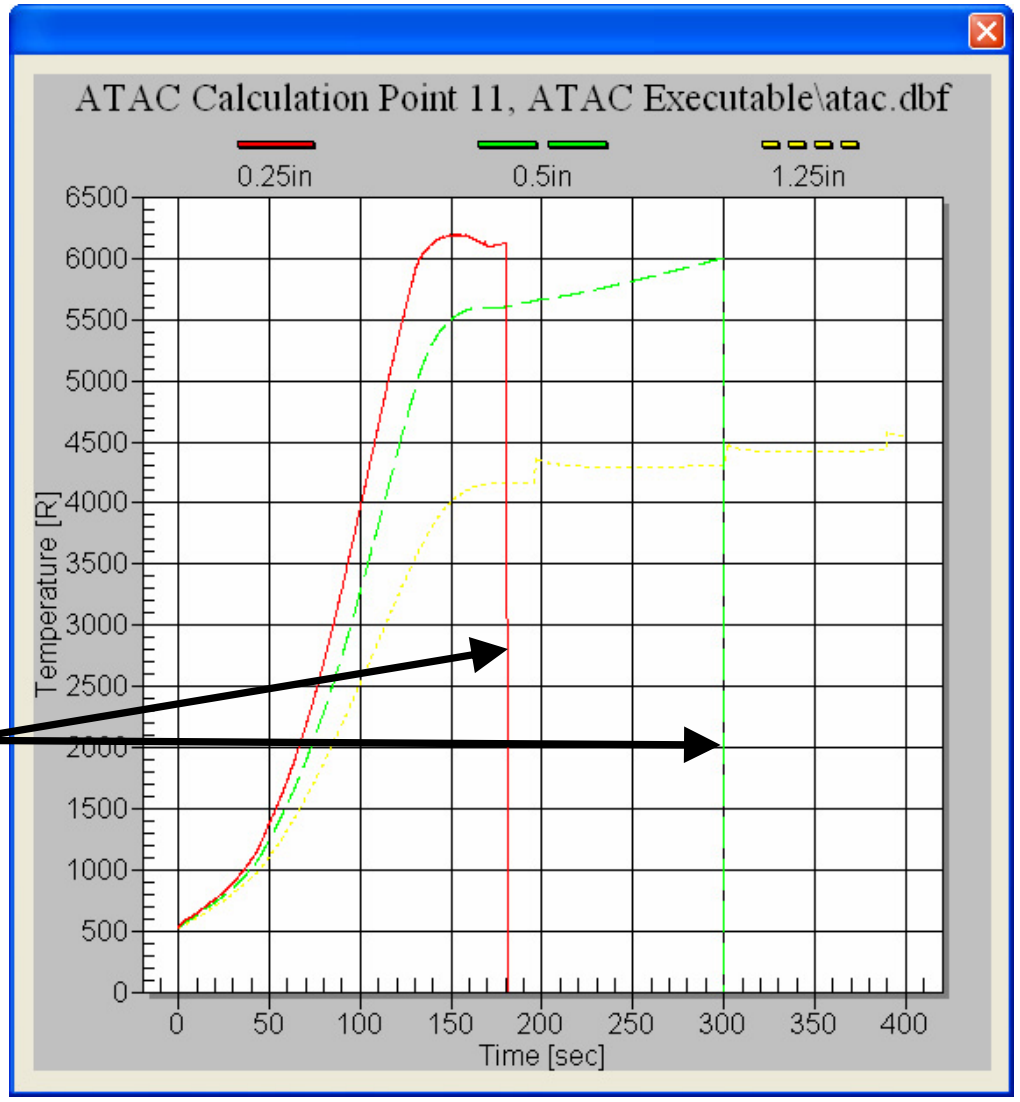
- Post Processing



C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

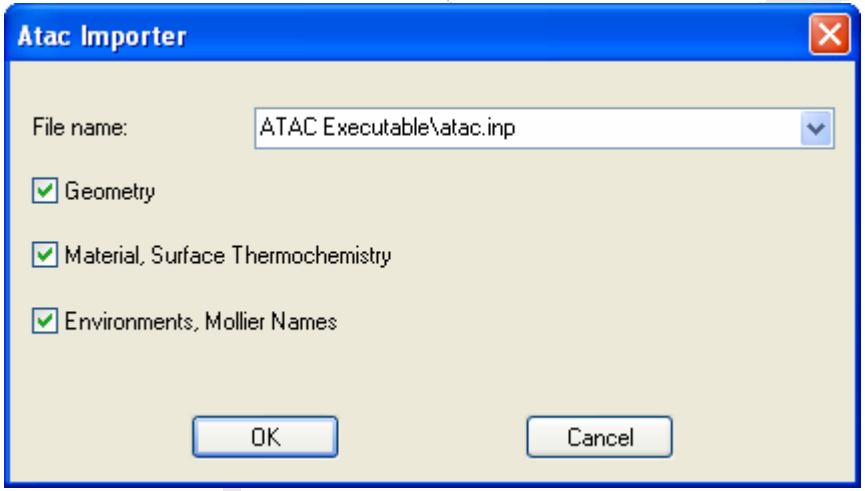
- XY Plotting
  - ATAC calc data
  - Thermocouples
  - Drop off indicates burn through of that TC



C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

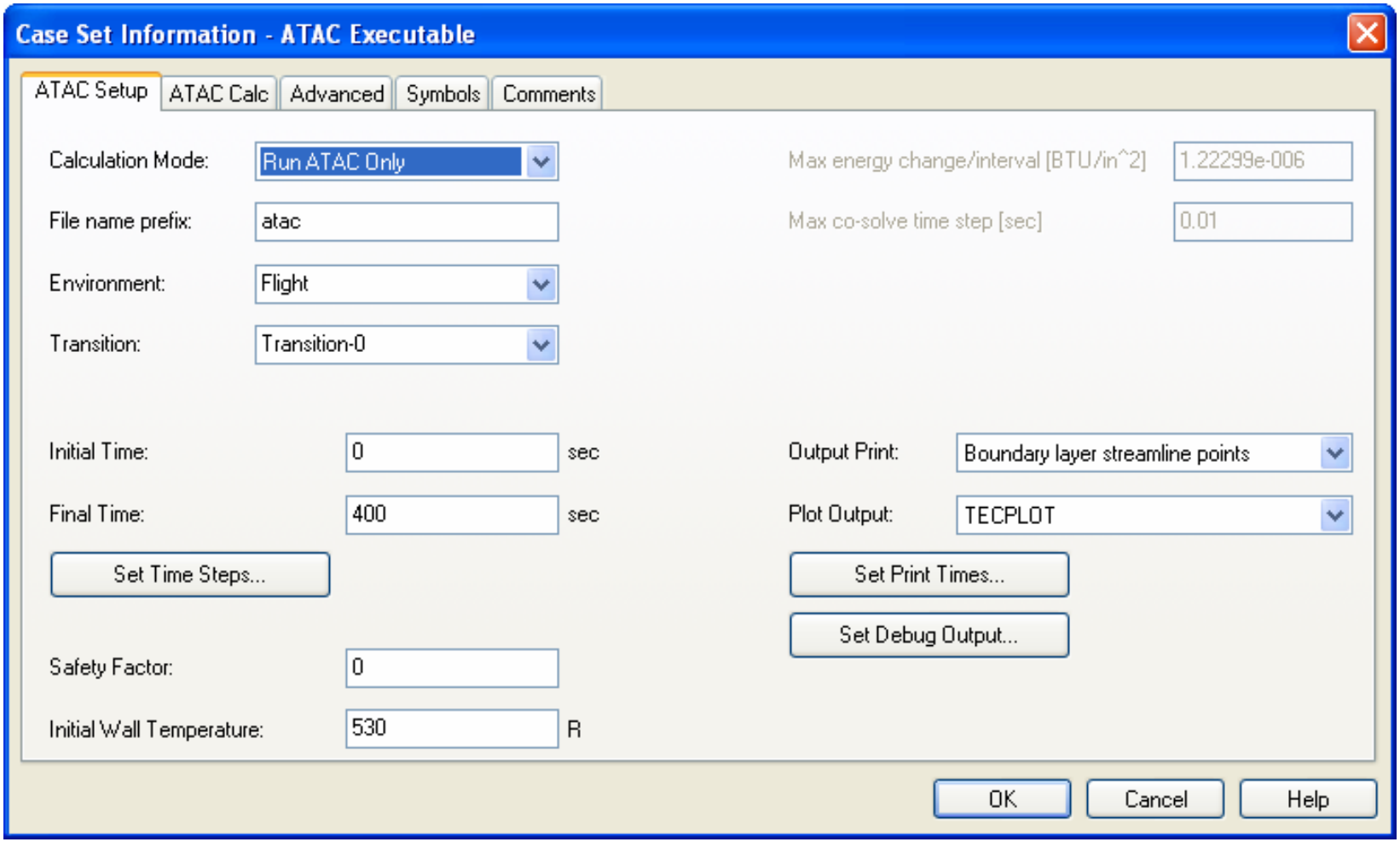
- Importer
  - Control of importing Geometry, Materials, and Environments



C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

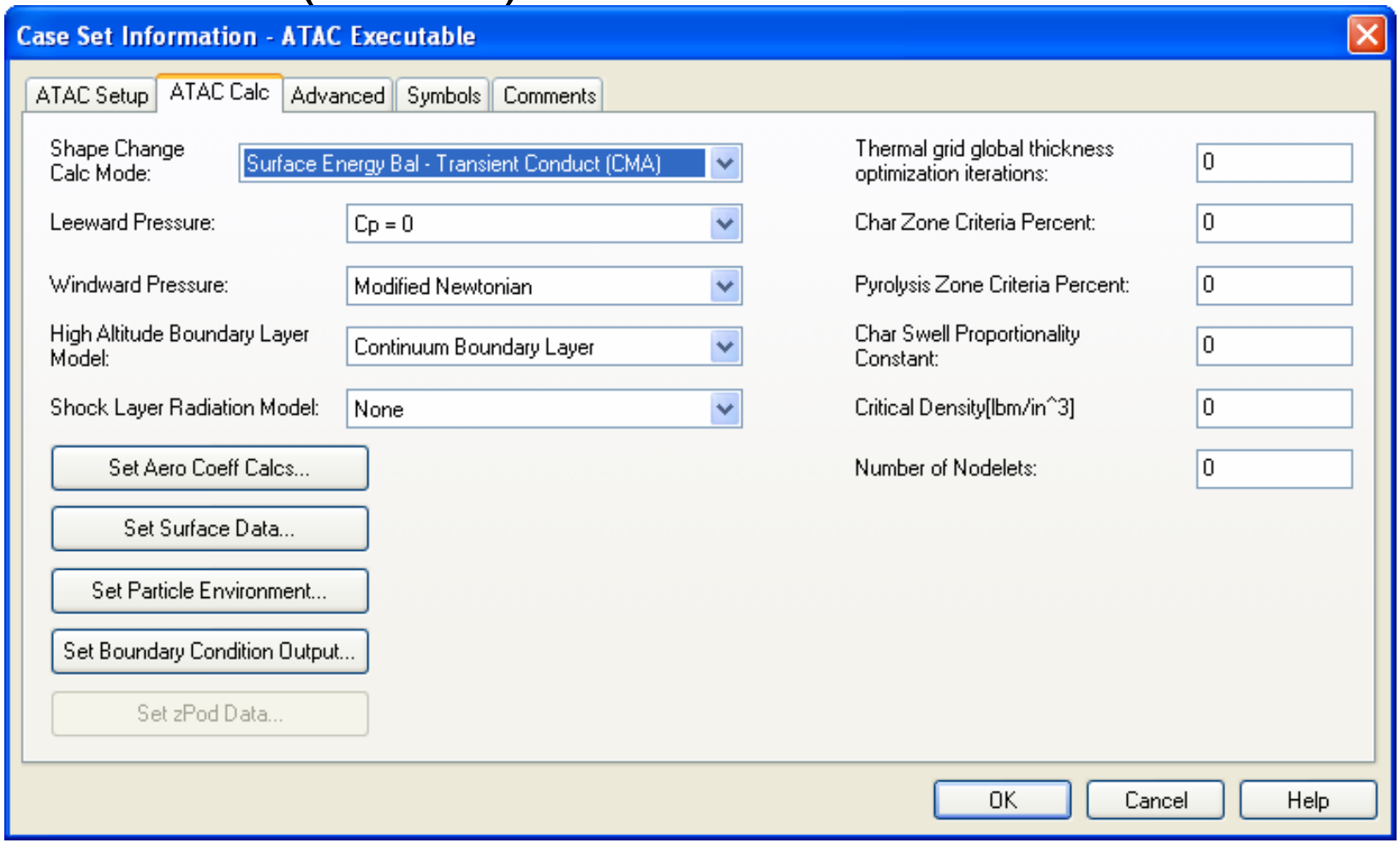
- Case Sets



C&R TECHNOLOGIES
www.crtech.com

ATAC Interface

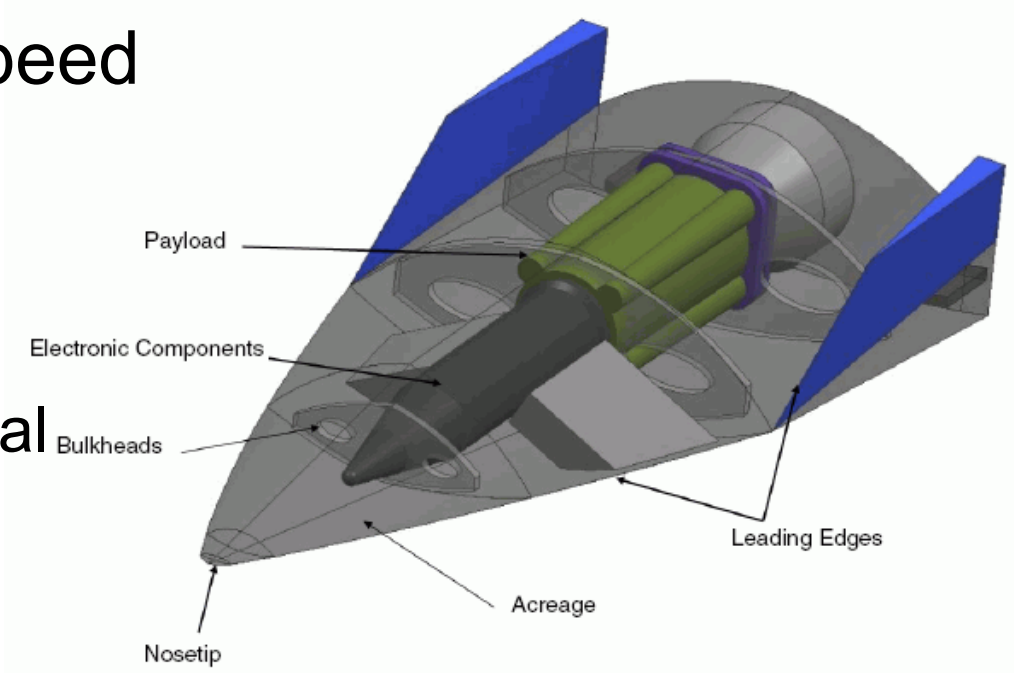
- Case Set (cont…)



C&R TECHNOLOGIES
www.crtech.com

Background

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



C&R TECHNOLOGIES
www.crtech.com

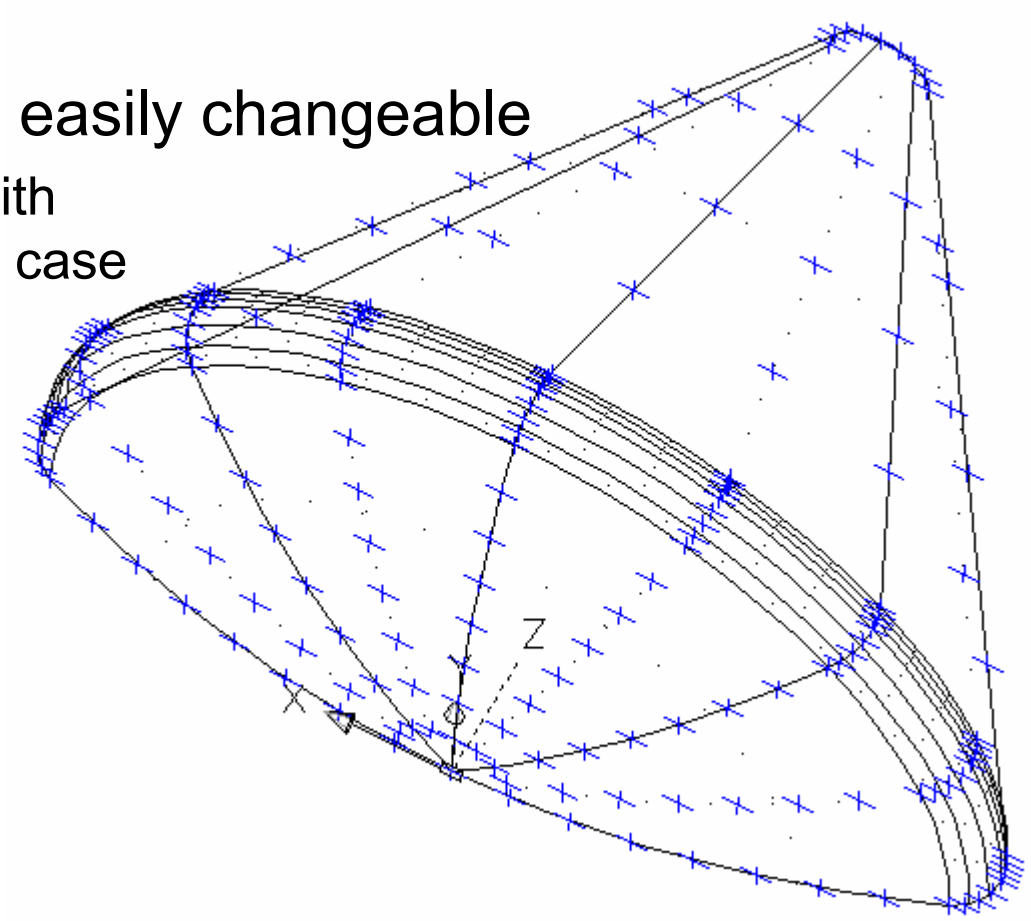
Background

- 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

C&R TECHNOLOGIES
www.crtech.com

Calculations

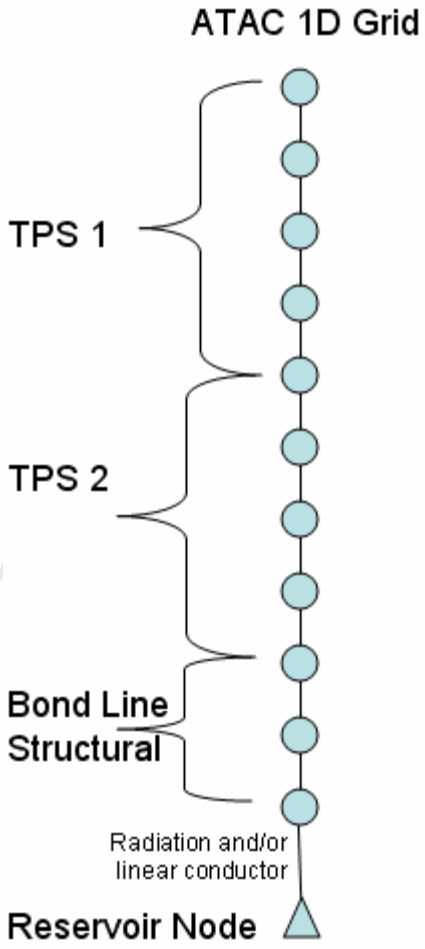
- ATAC performs 1D calculations at points on the vehicle
  - Number of points easily changeable
    - Programmable with symbols for each case



C&R TECHNOLOGIES
www.crtech.com

Calculations

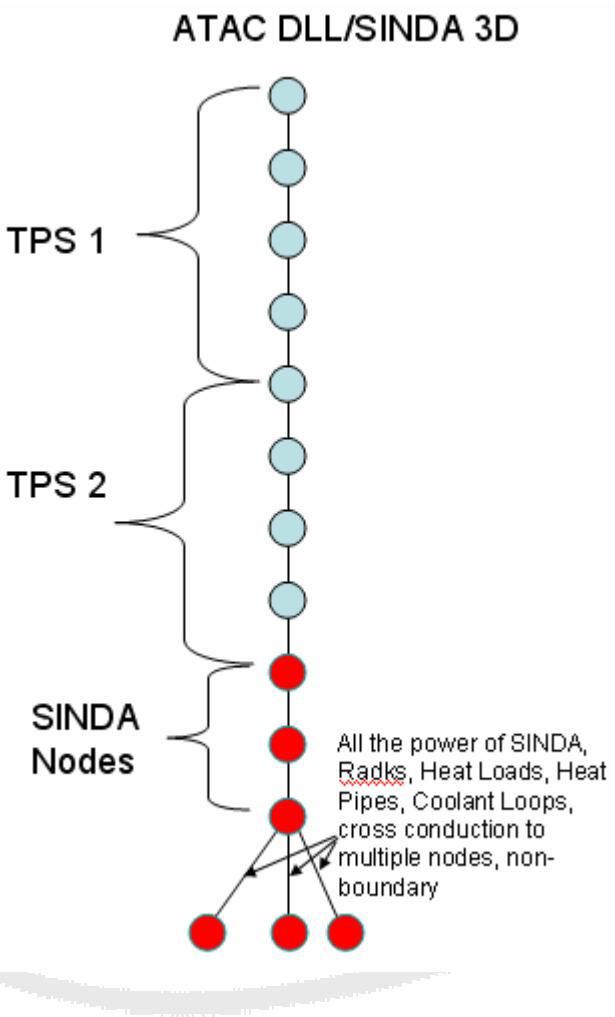
- 1D Limitations
  - Constant reservoir
  - Constant conductance to reservoir
  - Difficult to model structural ribs
  - Lack of user logic disallows time dependent events in the vehicle
  - Challenging to make ATAC calculation point locations line up with thermal-structural node locations



C&R TECHNOLOGIES
www.crtech.com

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



C&R TECHNOLOGIES
www.crtech.com

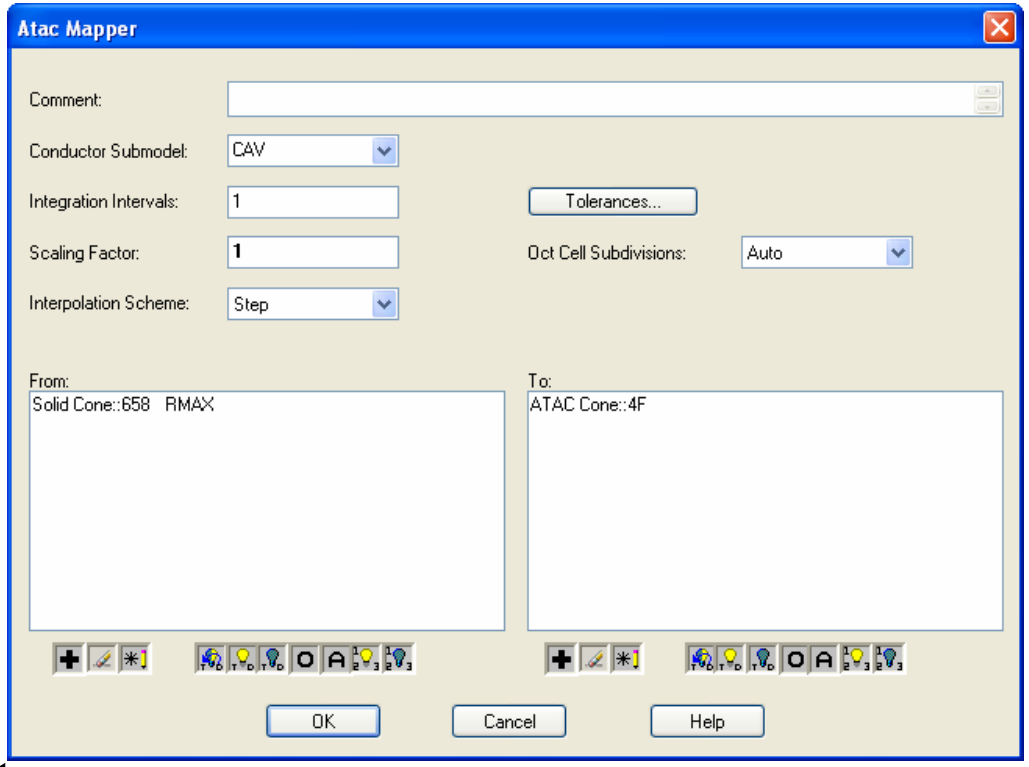
Co-solve Calculations

- 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

C&R TECHNOLOGIES
www.crtech.com

Calculations

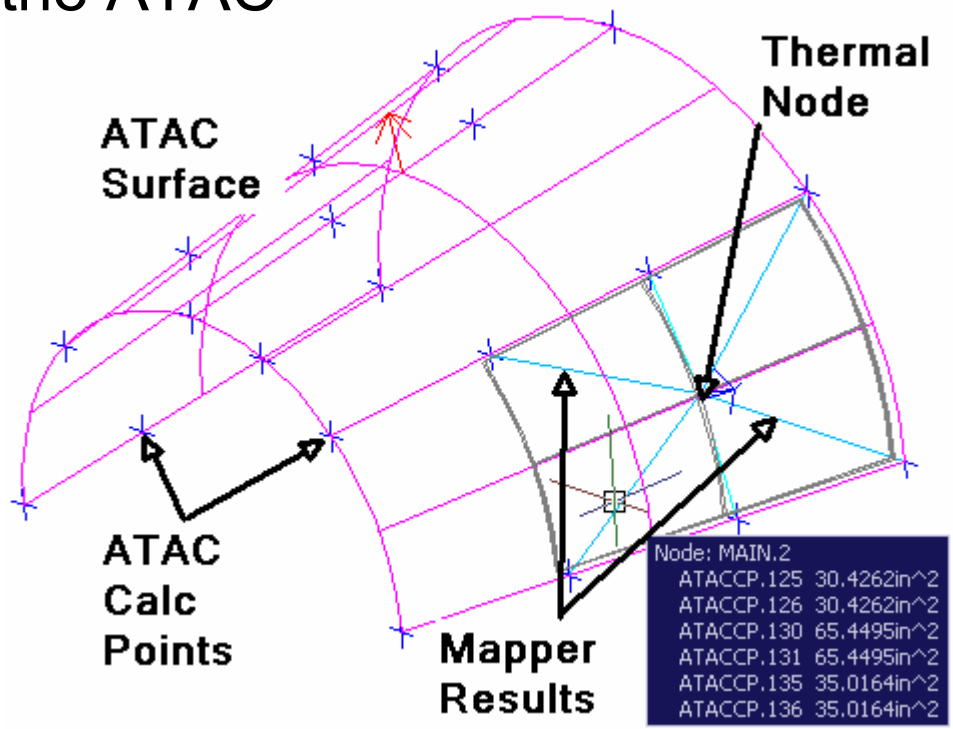
- Interface ATAC calc point to thermal nodes
- ATAC Mapper
  - Maps points from thermal model to ATAC calc points
  - User controls fidelity of the points mapped



C&R TECHNOLOGIES
www.crtech.com

Calculations ATAC Mapper

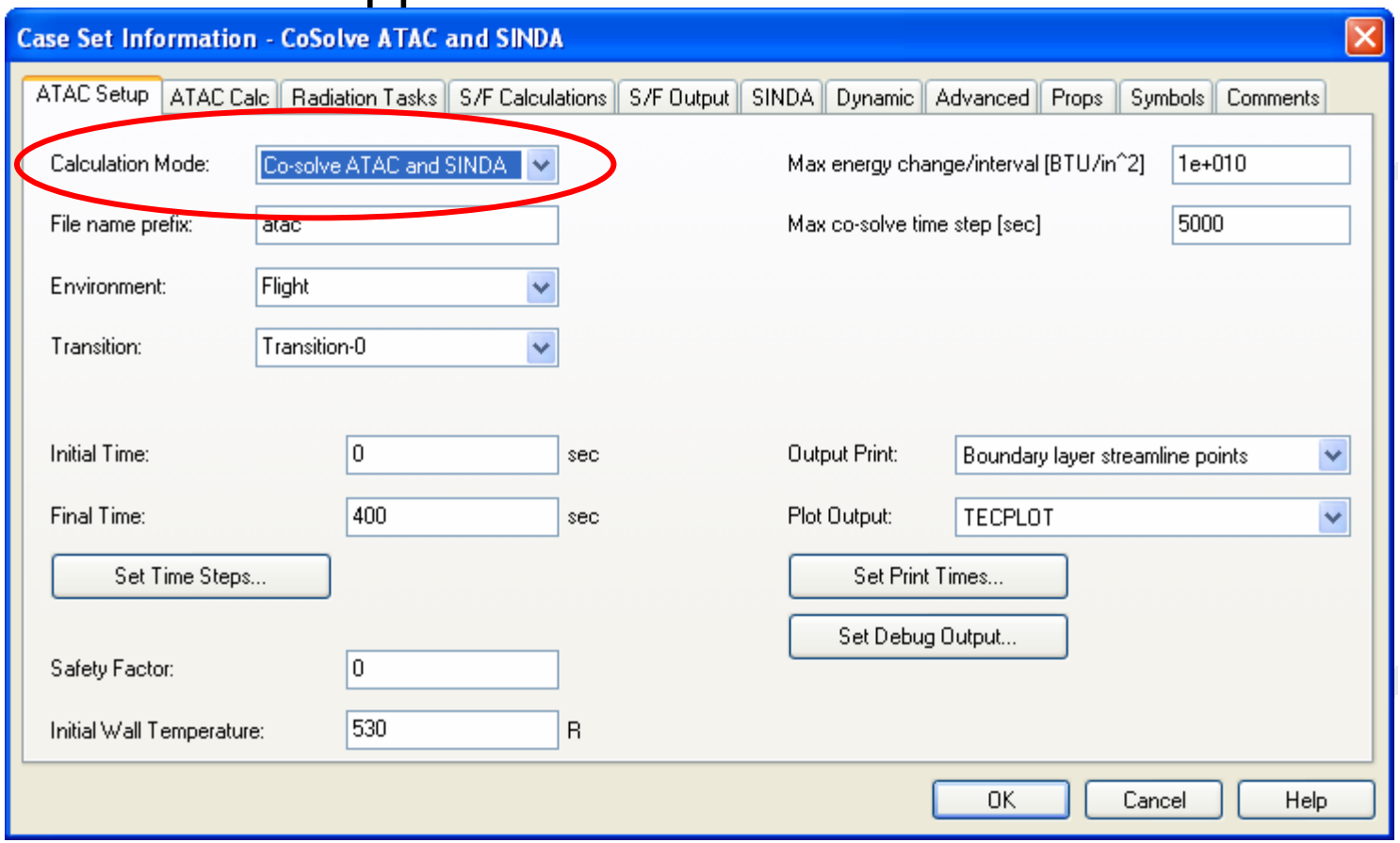
- ATAC Mapper Calculations
  - 100 points sampled (10 integration intervals)
  - Areas distributed to the ATAC calculation points



C&R TECHNOLOGIES
www.crtech.com

Co-Solve Interface

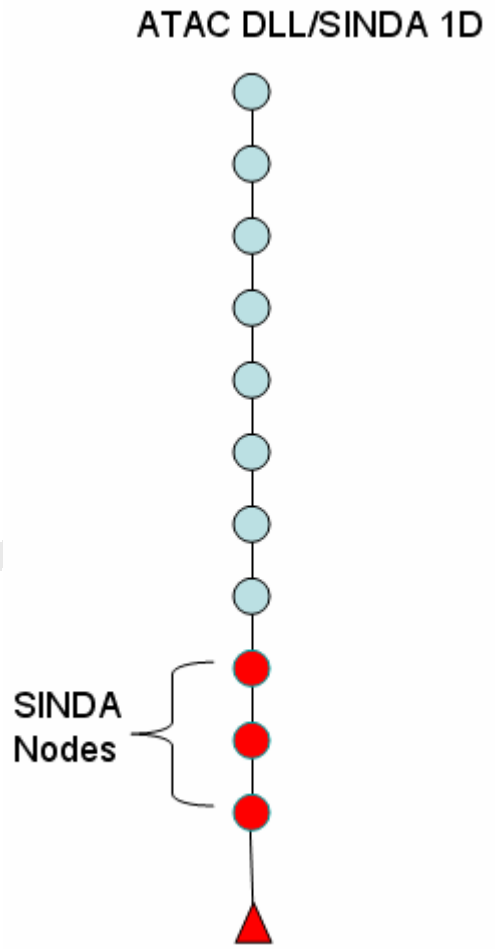
- Turn on SINDA ATAC Co-Solve
  - SINDA Tabs appear when selected



C&R TECHNOLOGIES
www.crtech.com

Calculations

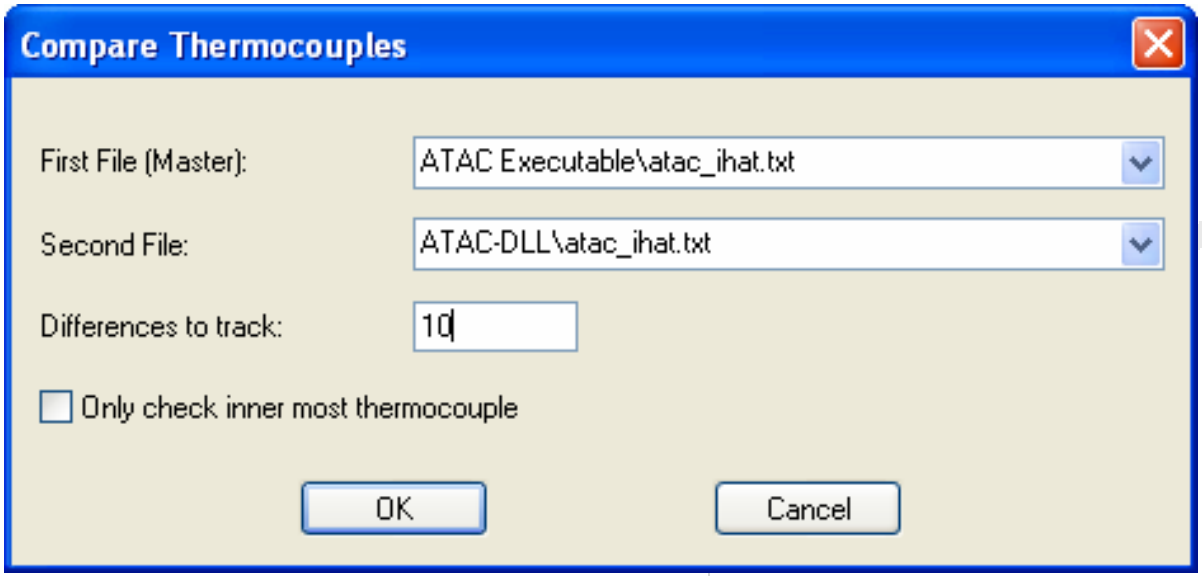
- Verification of the co-solve
- Build the SINDA model to be the same as the 1D ATAC model
- Perform the co-solve
- Compare thermocouple results
  - Find largest differences



C&R TECHNOLOGIES
www.crtech.com

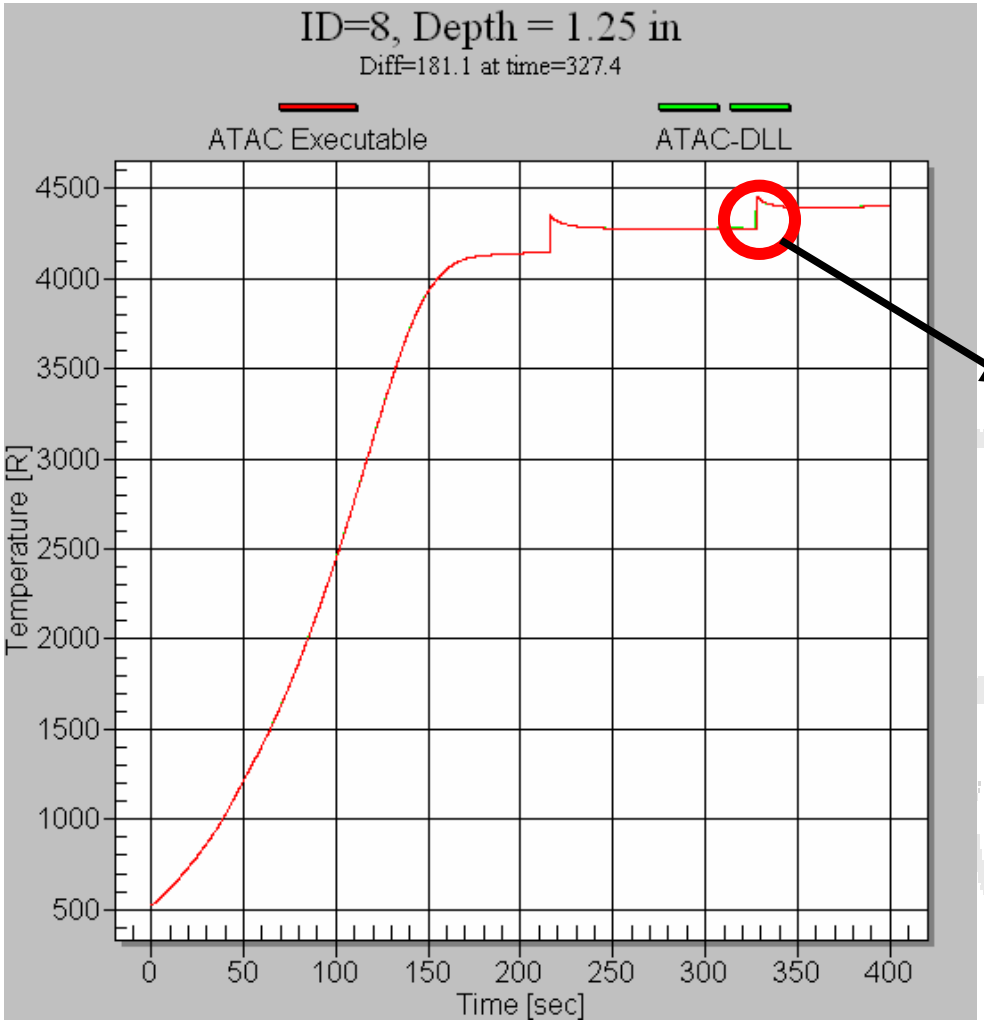
Calculations

- Comparison utility added

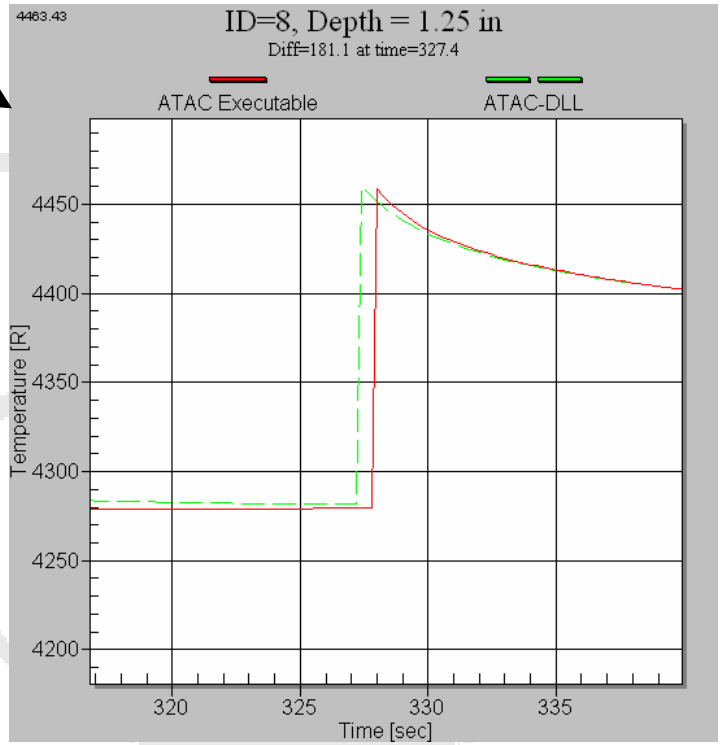


C&R TECHNOLOGIES
www.crtech.com

Calculations



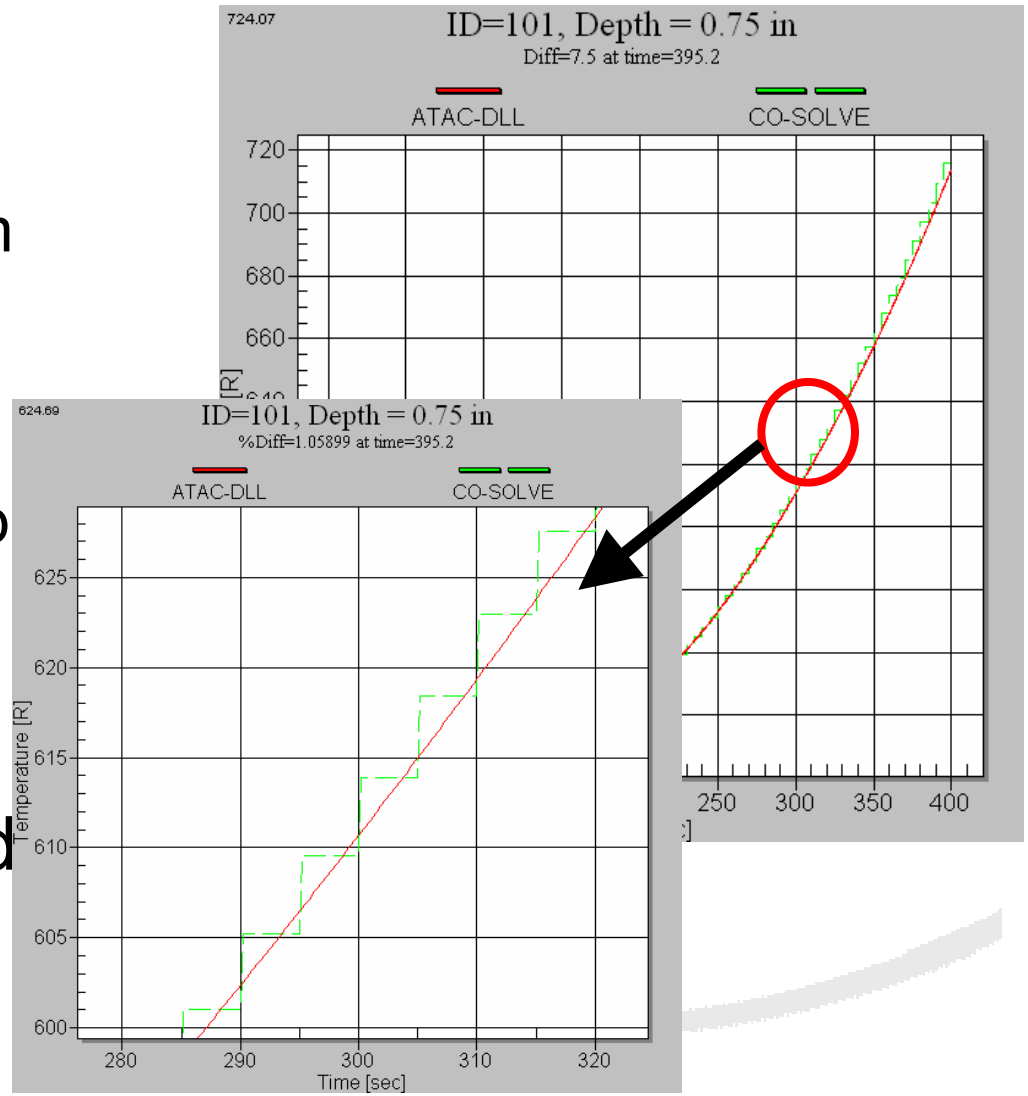
- Only slight differences found



C&R TECHNOLOGIES
www.crtech.com

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



C&R TECHNOLOGIES
www.crtech.com

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)

C&R TECHNOLOGIES
www.crtech.com