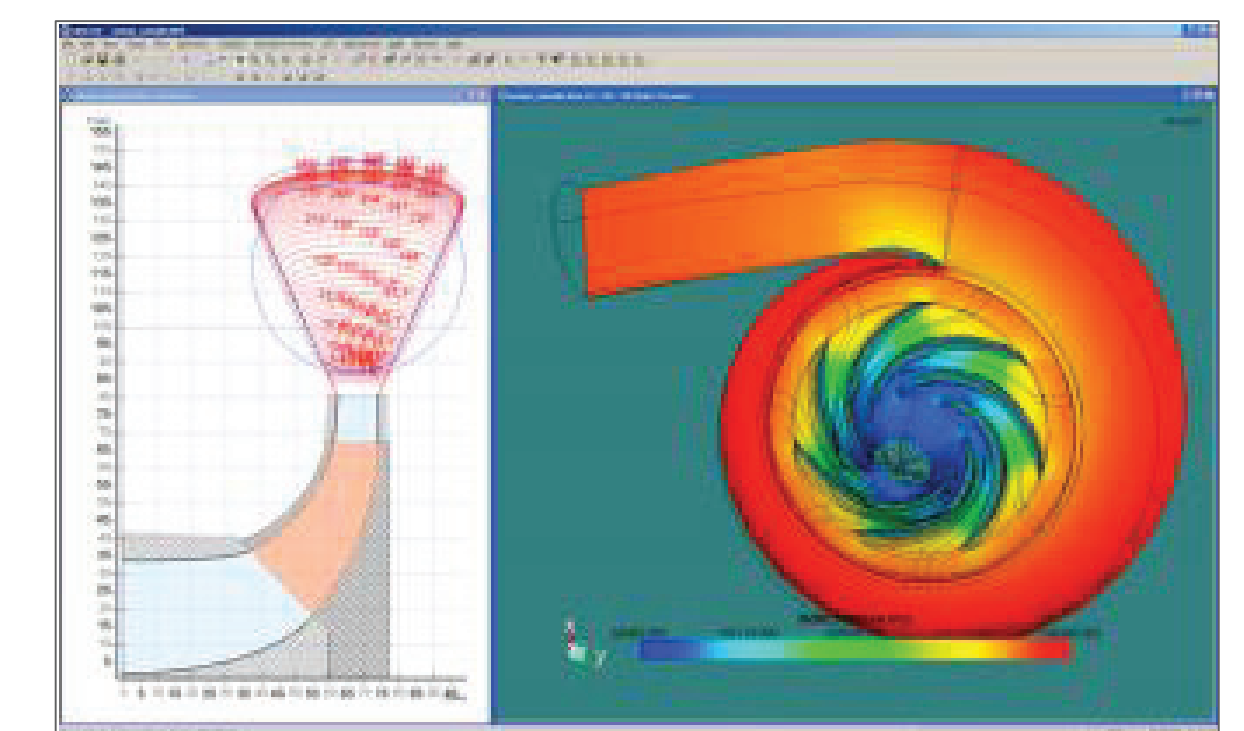
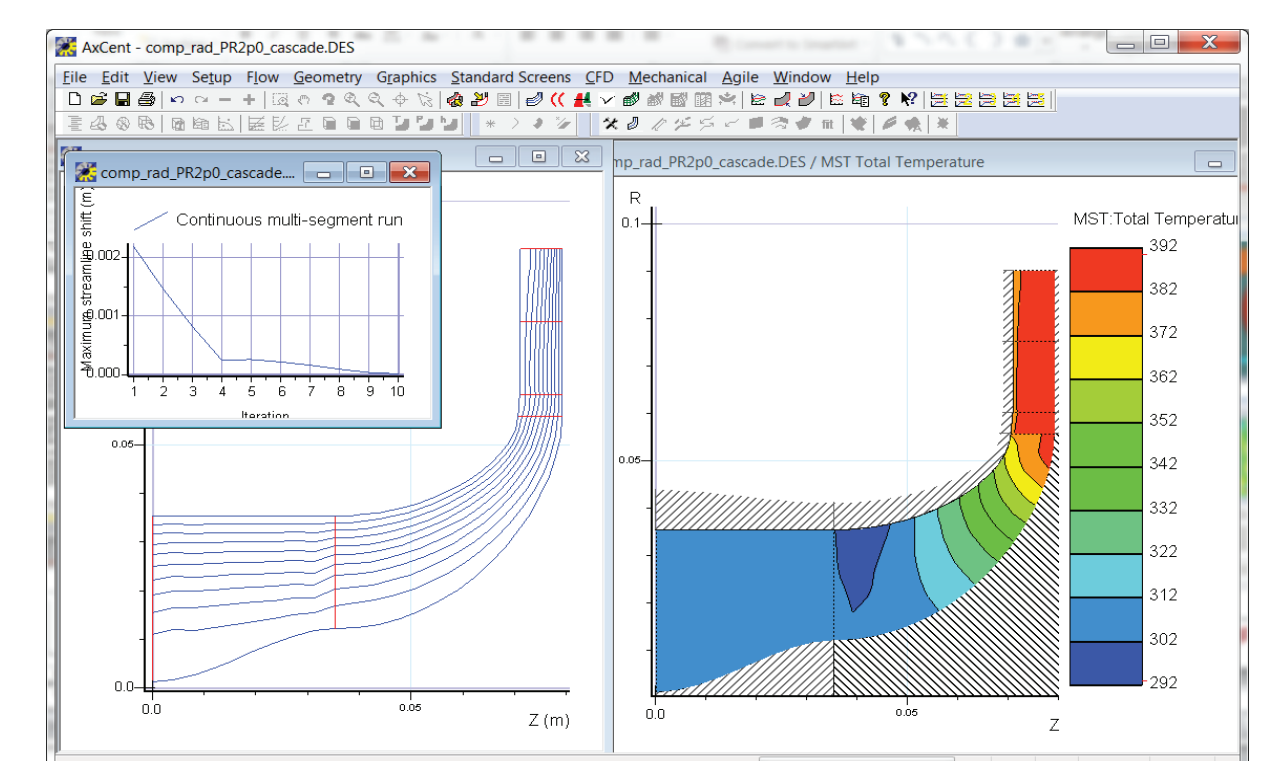
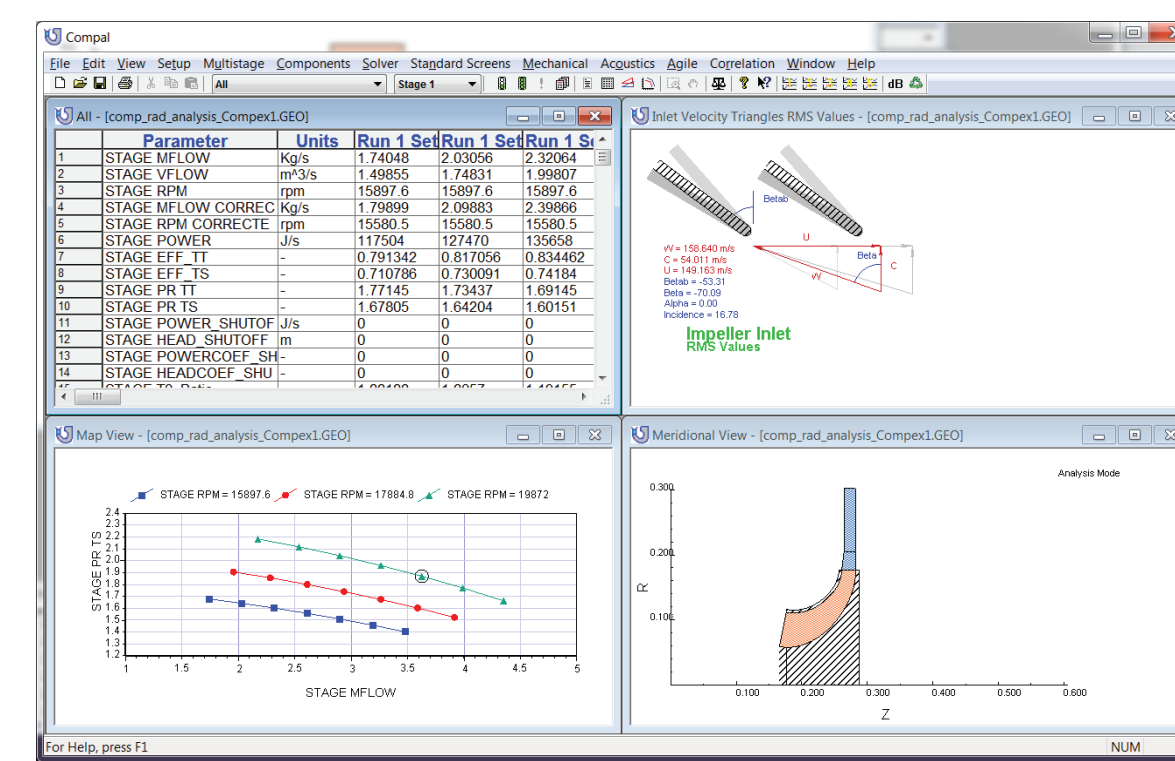


Supercritical CO₂ Turbomachinery Design

Agile Engineering Design System[®]

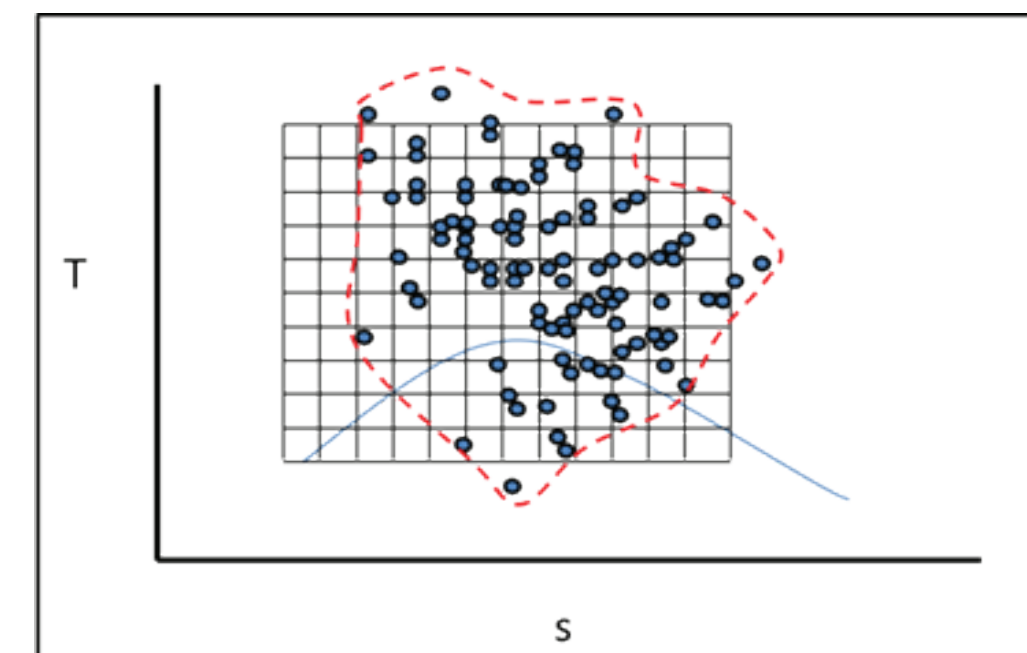
► Encompasses the Entire Engineering Process

- Initial design and map generation
 - Meanline design mode
 - 1D map generation
- Detailed Design
 - **AxCent[®]** - design and analyze 3D stage geometries
 - Streamline curvature- rapid analysis for establishing 3D potential flow field
- Computational Fluid Dynamics
 - **FINE[™]/Turbo** - quickly generates design level CFD calculations for full Navier-Stokes CFD system
- Finite Element Analysis
 - **Pushbutton FEA[™]** - flexible parametric modeling and stress analysis

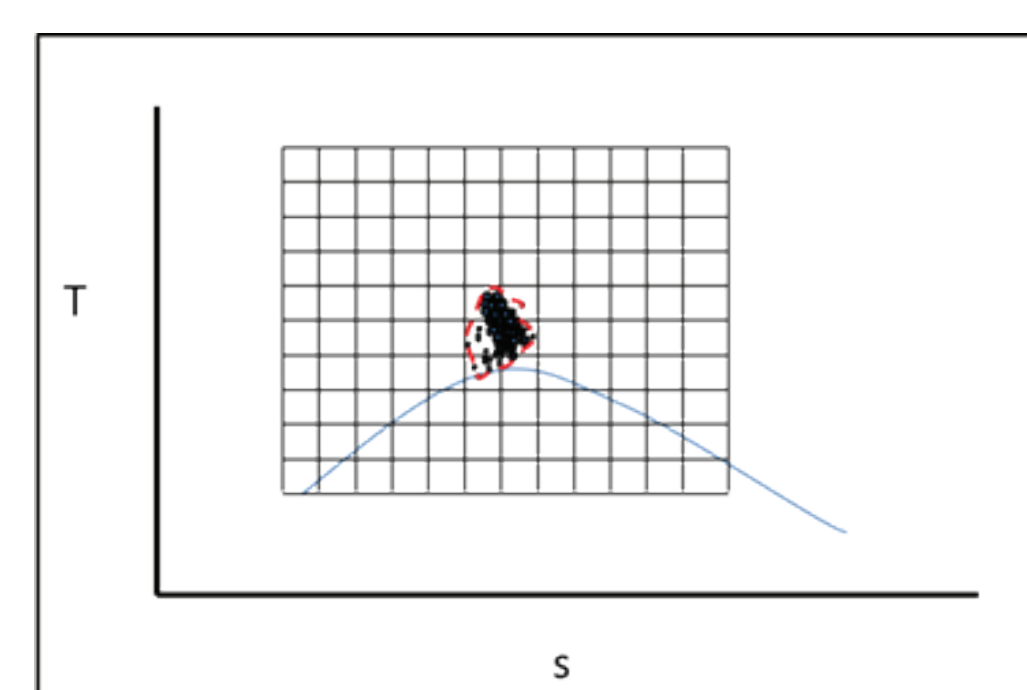


► Thermodynamics

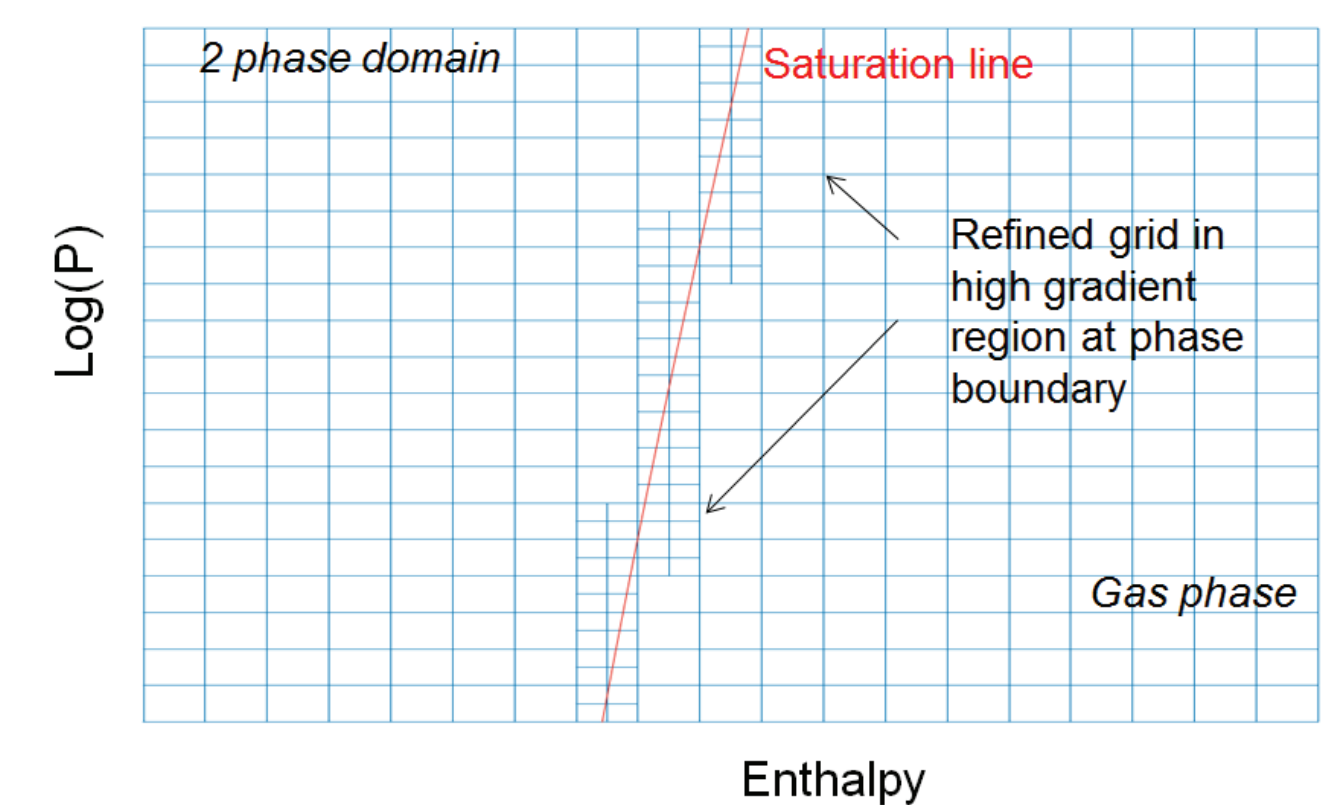
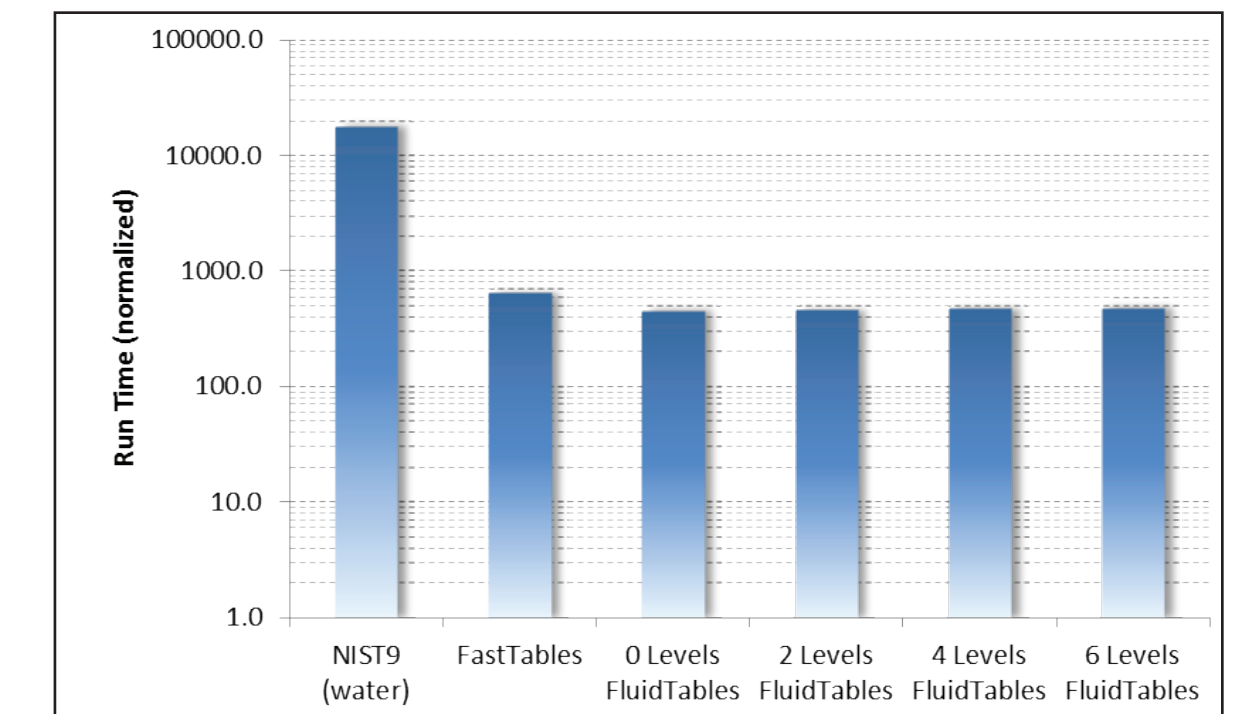
- Broad thermodynamic table range
 - Flow transients require a wide range of thermodynamic tables
 - Converged results require higher accuracy in smaller range
- Table functions dramatically improve runtime
- New generation of tables is significantly faster still
- New thermodynamic table functions for improved interpolation
- Selective refinement for maximum efficiency
 - Phase boundary
 - Solution targeted refinement



Transient Flow State

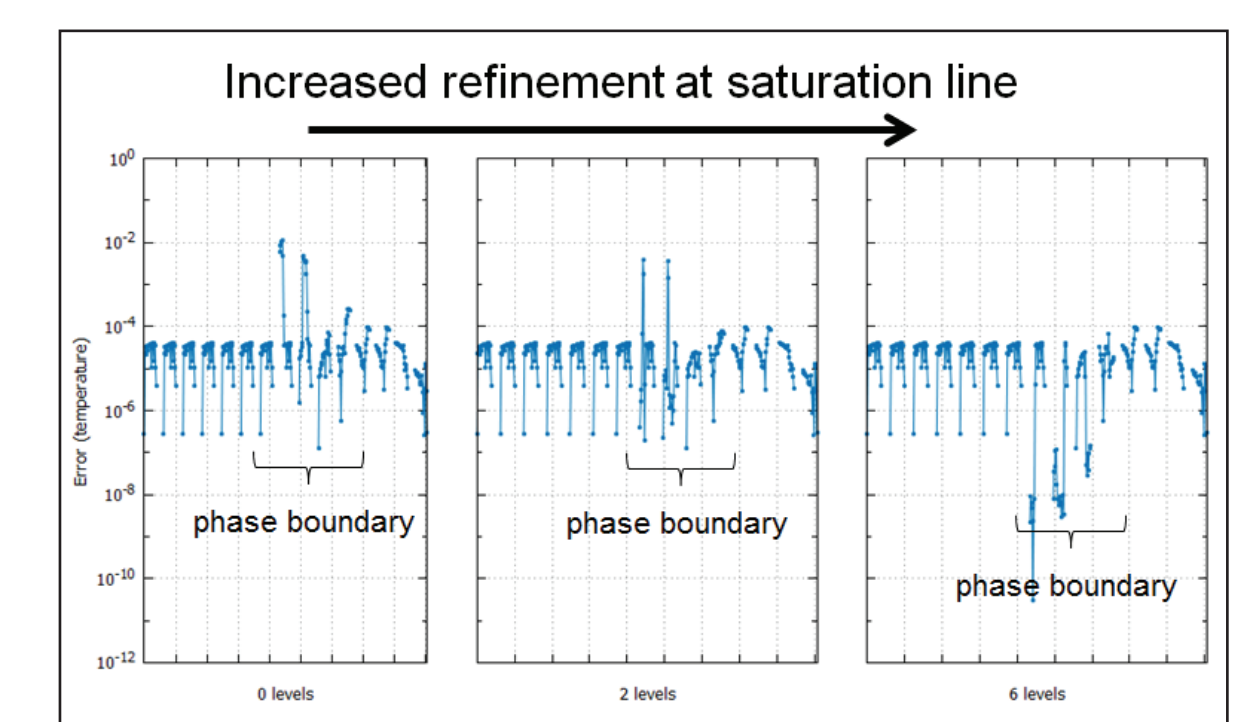


Converged Flow State



► Error Reduction

- Selective refinement significantly reduces error
- 2 orders of magnitude error reduction
- Minimal impact on run time



► Turbulence and Nucleation

- Most CFD turbulence models assume constant Schmidt and Prandlt number
 - Might not be accurate for highly non-linear thermodynamic properties
- Transient flows in sCO₂ compressors can pass through the saturation line
 - Rate droplet formation will be determined by rates of formation of droplets
 - Residence time in most real flows are short
 - Most likely an issue only for operating point very close to the critical point

