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Thermal Simulation Integrations with Other Disciplines

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Challenges for Spacecraft Thermal Simulation

- Thermal radiation connects all subsystems and the environment
  - Radiation cannot be ignored
  - The entire system must be modeled
- Transient solutions are for long duration, but some events are short duration
  - Missions can last for years
  - Orbits for hours
  - Events for minutes or seconds
- Contact and insulation heat transfer are difficult to predict
  - Testing and calibration of the model are necessary
- Variability should be evaluated
  - Properties degrade over time

Addressing the Challenges with Thermal-Centric Modeling

- Ignore details that don't affect the thermal solution
  - Create a model focused on surface area and volume more than details
- Keep the model as simple as possible but no simpler
  - Start simple and add complexity
- Zoom in and out for subsystems and times
  - Consider what's important
    - Do you need a detailed PCB in a system-level model?
    - Do you need each revolution over an orbit?
- Parameterize where possible
  - Allow design-space evaluation, variability, and correlation to test

Benefits of Integrating Simulations

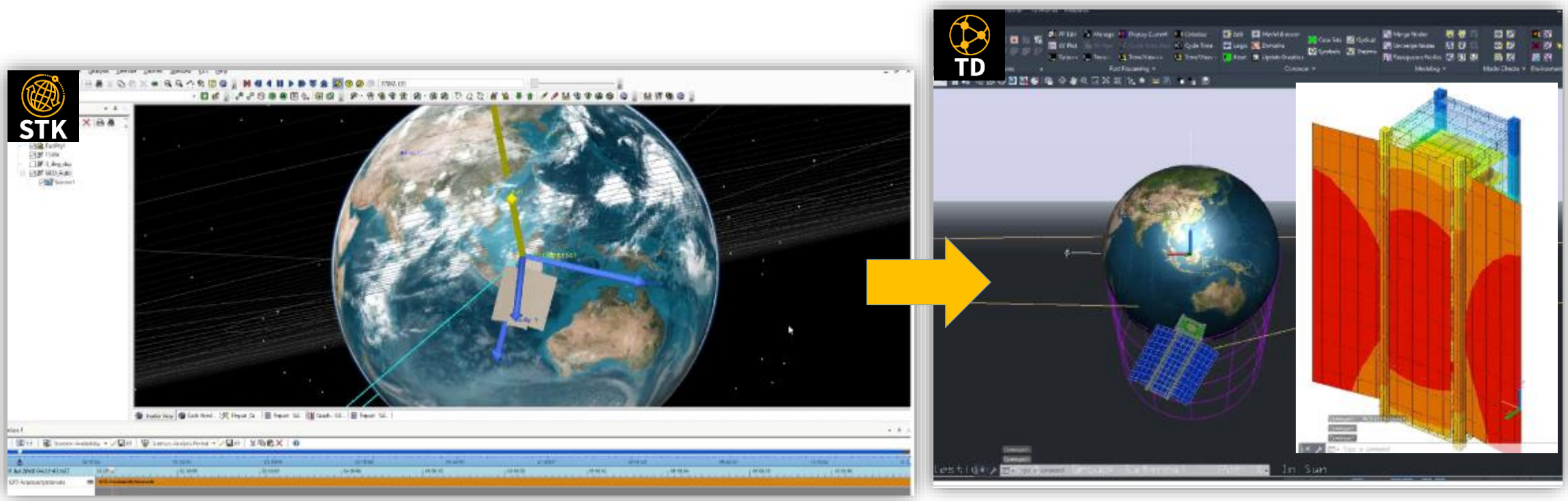
- Use the best tool for each task
  - Each tool brings its own strength
    - Thermal-centric modeling for the thermal simulation
- Simulation speed
  - Each model can be optimized for its focus
  - Only necessary details are included in each model
- Accuracy
  - Data transfer errors are eliminated

The Key to Integration – Application Programming Interface (API)

- Automates tasks that are typically interactive
  - Programmatically create, query, edit, delete, and run models
- Extends the built-in capabilities of the product
- Open-ended
  - Does not require “insider” information about the application
  - Can communicate between tools that weren’t built together or by the same company
  - Gives users great capability
- What’s good for the user is good for the developer…

Mission Planning Integration

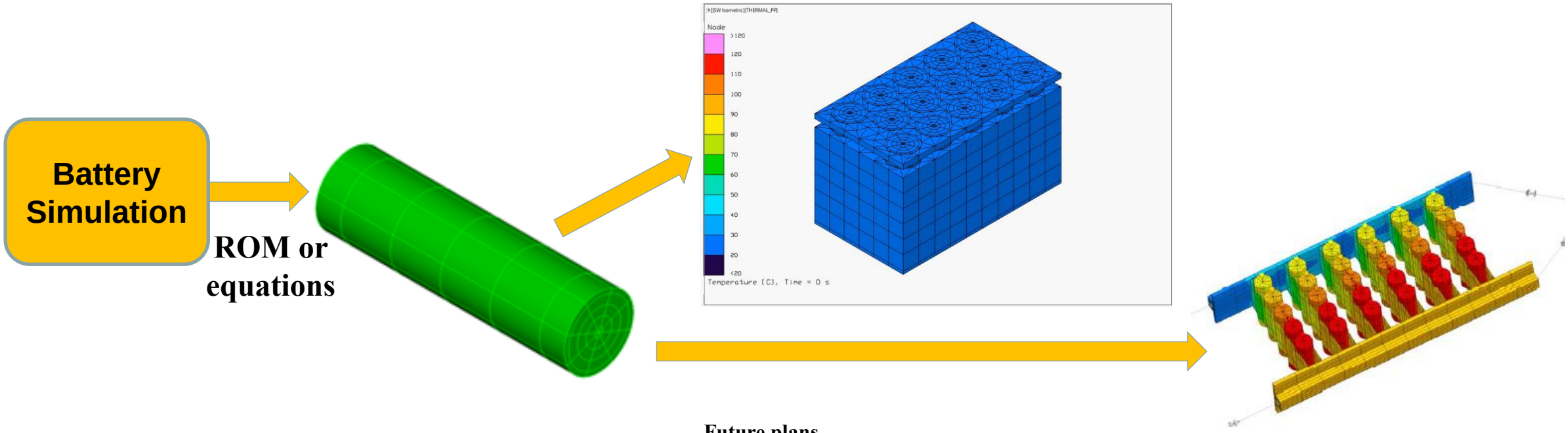
- Import orbit positions and attitudes from mission planning software
  - Precise attitudes (aiming at point on the planet)
  - More complex missions (cis-lunar)



Automated with Thermal Desktop API Plug-in

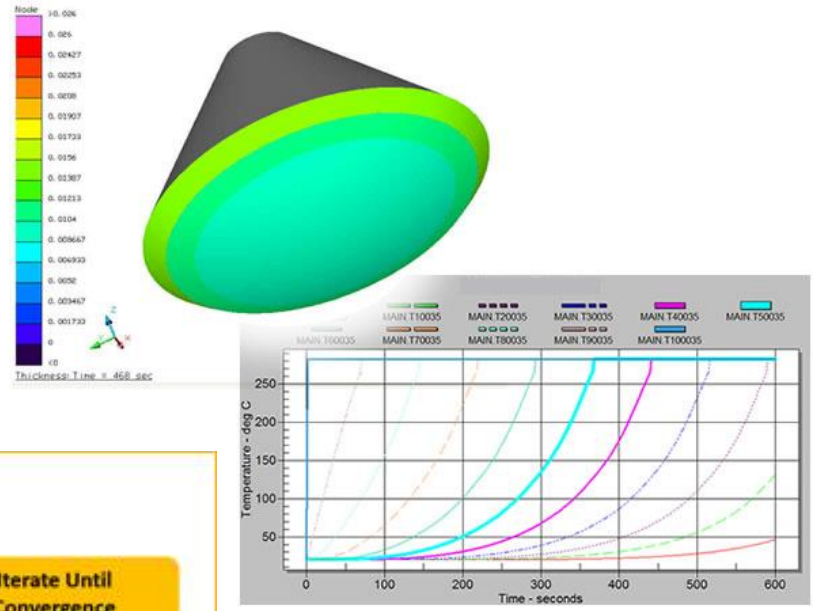
Electrical-Thermal Integration

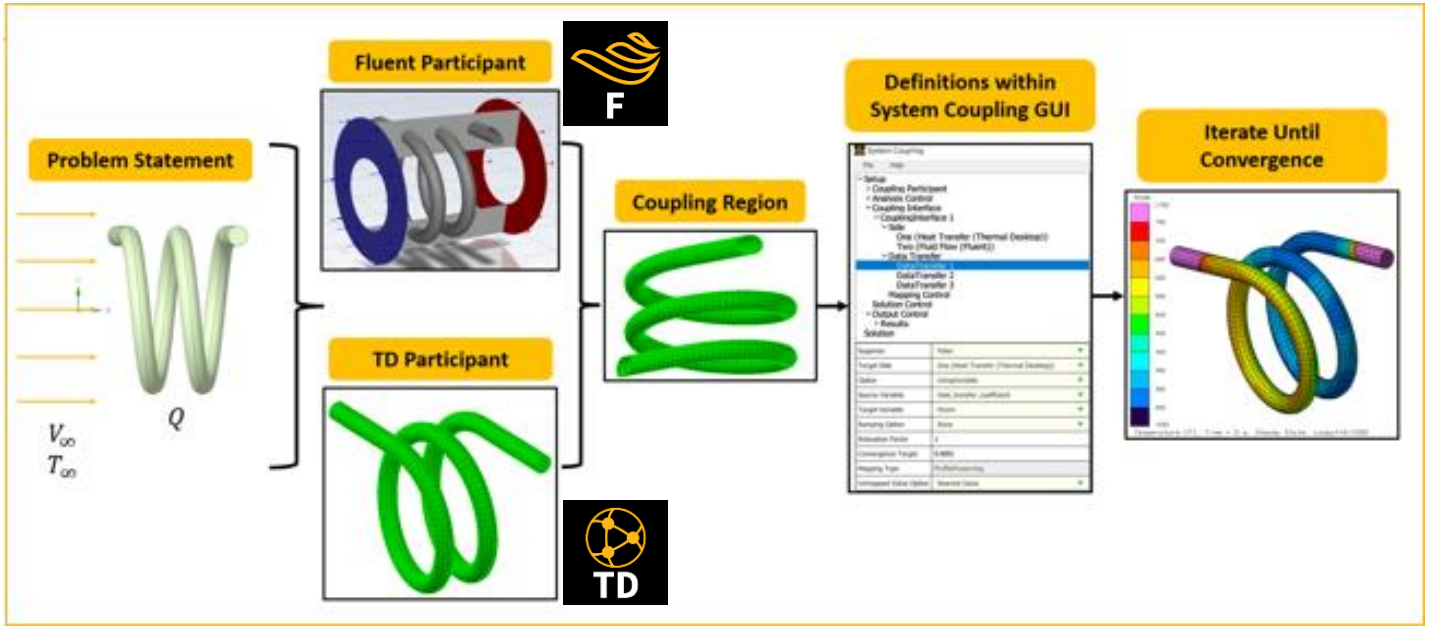
- Battery Thermal Management
  - Evaluate thermal behavior of battery cells for charging, discharging, and runaway
    - Heat loads as functions of state-of-charge and temperature
  - Evaluate various thermal management systems



CFD Integration

- Sequential solutions
  - CFD data mapped onto the thermal model
    - Thermal Protection System design and evaluation
- Co-solved solutions
  - CFD and thermal model exchange data during the solution
    - Flow dependent on temperatures

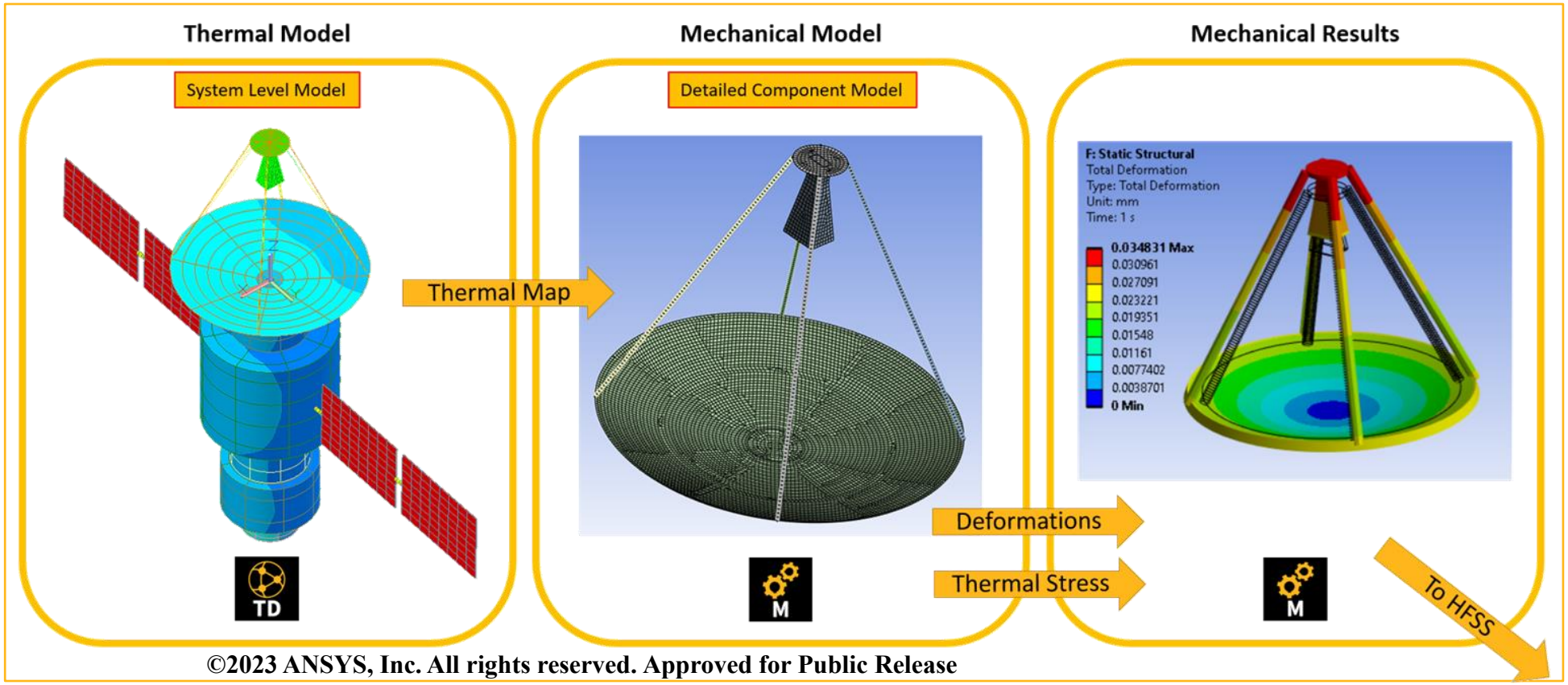




Sequential solutions have been available; API co-solving with Fluent is being updated

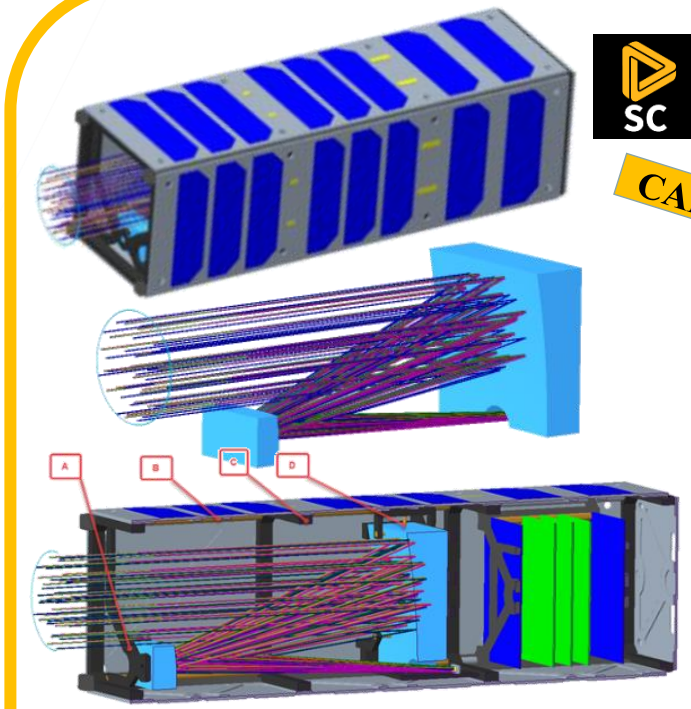
Thermal-Stress

- Map temperatures from the thermal model to the structural model
  - Thermal model includes environmental heating, interaction among all subsystems
  - Structural model may only be specific subsystems
- Deformations may be passed to other simulations
  - Optical
  - Antenna
  - Reliability



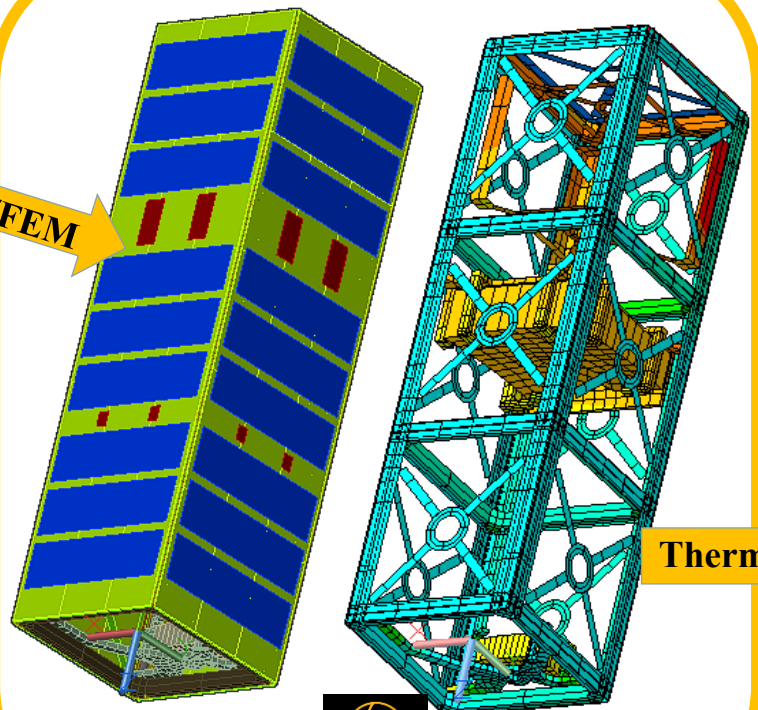
Structural – Thermal – Optical (STOP) Analysis

Initial Opto-Mechanical Design



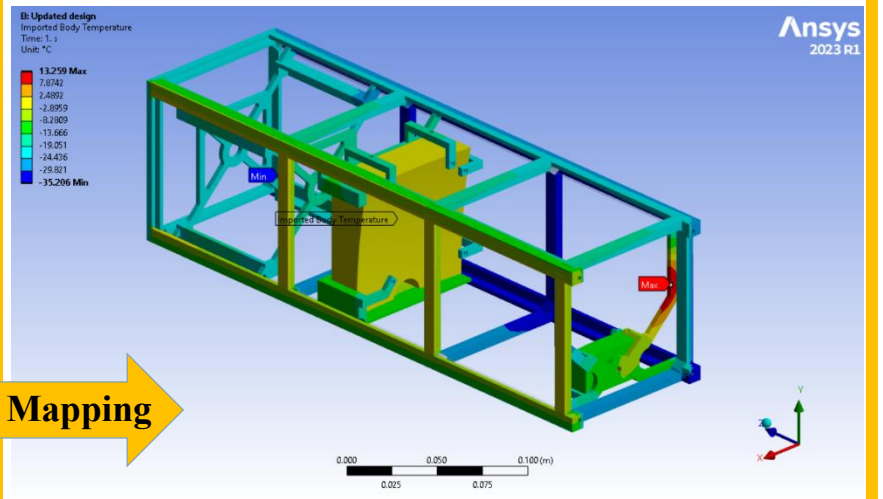
CAD to FD/FEM

Thermal Model



Thermal Mapping

Structural Model

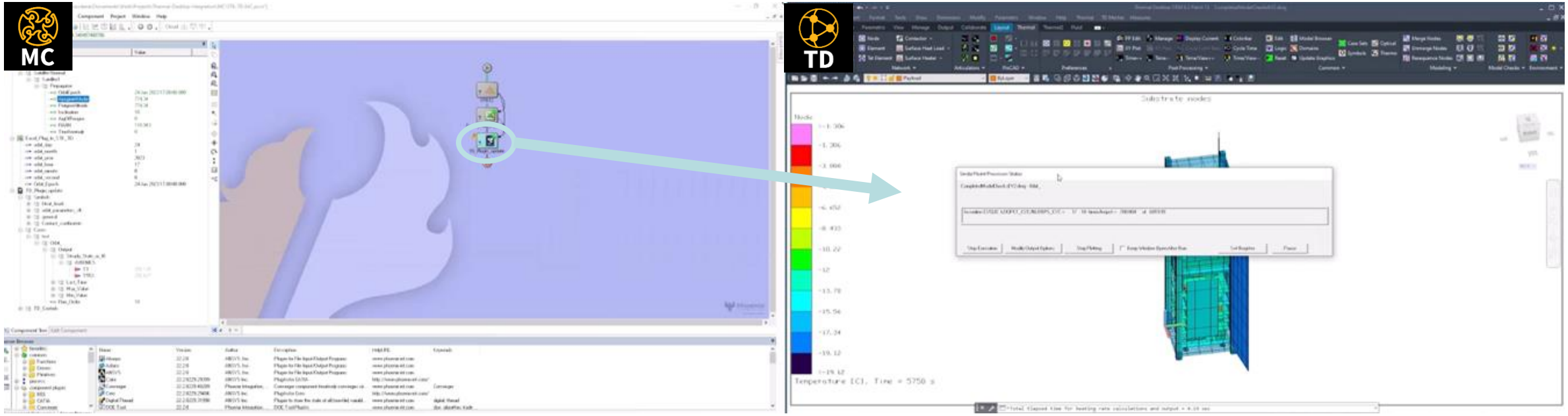


STAR Module

Thermal mapping exists; TD Direct connects to SpaceClaim; full STOP workflow development is in progress

Model-Based System Engineering

- Tying it all together
  - Design of experiments
  - Design optimization

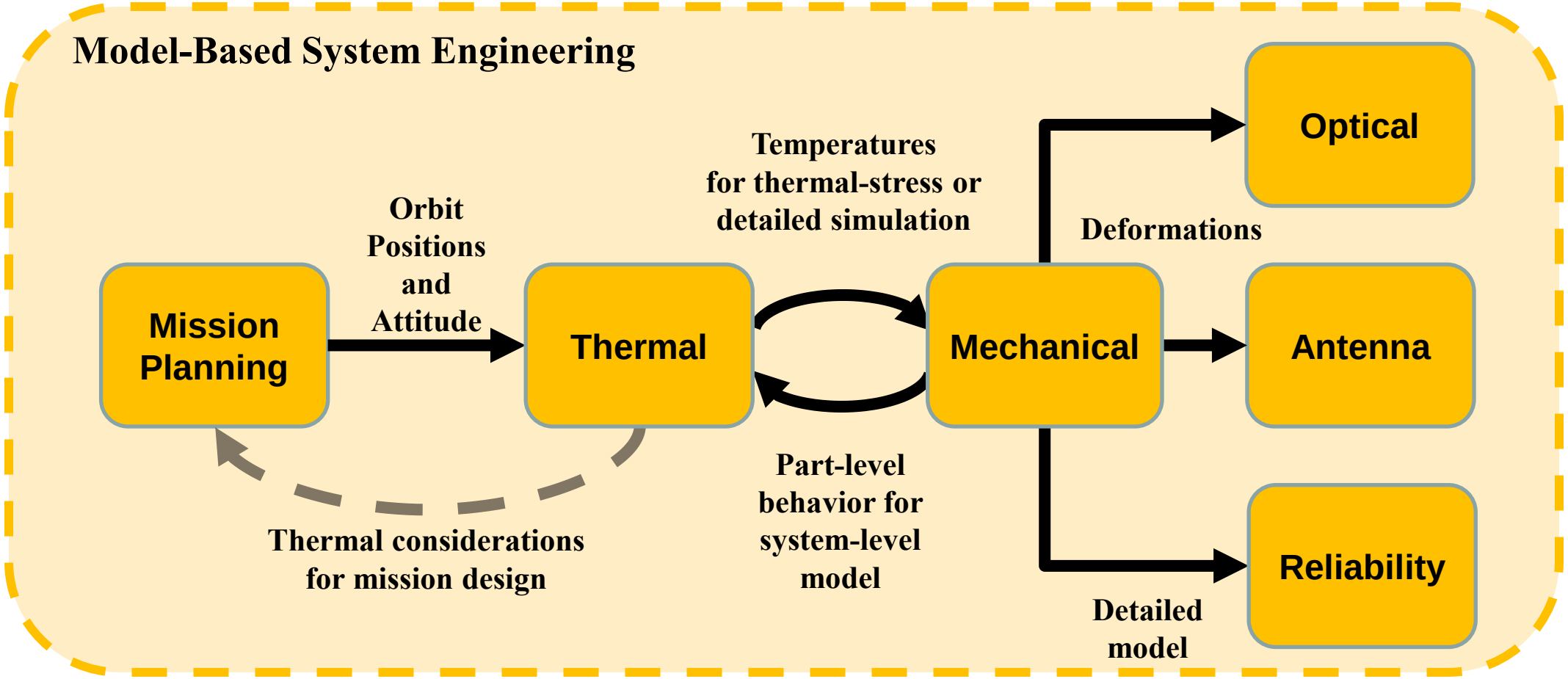


Thermal Desktop wrapper created for ModelCenter

Conclusions

- An API allows automating or improving integrations between simulation disciplines
- Many integrations have been implemented or planned since the acquisition of CRTech by Ansys
- The API allows integrations beyond the Ansys portfolio
  - The user can ultimately decide what integrations are made
  - Waiting for developers to integrate products is unnecessary

Spacecraft Analysis with Integrated Simulations



Preliminary Design → CAD Model Available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