Early-Stage Multiphysics Simulations of Aircraft Systems

Thermal Management Expo
Novi, Michigan
04/29/2025-04/30/2025

Faiqa ANBREEN
Modelling & Simulation Engineer
Safran Cabin Inc

SAFRAN

A world leader in our core markets

No.1 worldwide

- Narrowbody commercial jet engines (in partnership with GE)
- Helicopter turbine engines

No.1 worldwide

- Interiors for regional and business aircraft
- Aircraft seats

No.1 worldwide

- Landing gear
- Wheels and carbon brakes (mainline commercial jets with more than 100 seats)
- Aircraft wiring
- Evacuation slides

No.1 in Europe

- Tactical drones
- Inertial navigation systems
- Optronic (electro-optical) systems

No.1 worldwide

- Space surveillance via RF sensors
- Modems for satellite station keeping and space probe control
- High-performance space optics

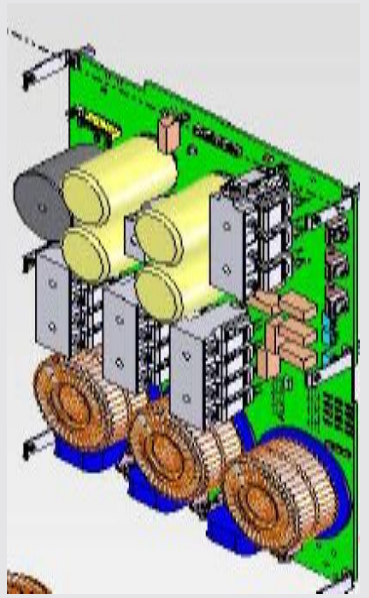
SAFRAN

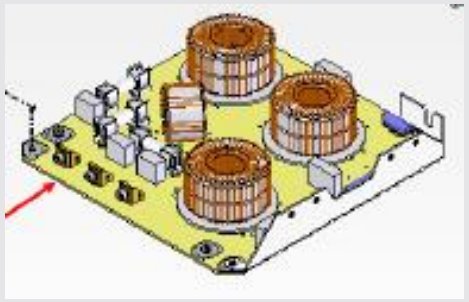
Capabilities

- Global high-tech leader in aviation, defense, and space.
- Delivers mission-critical solutions focused on reliability and performance.
- Pioneering microelectronics for compact, lightweight, high-performance aerospace systems.
- Utilizes high-fidelity simulations early in design to optimize thermal performance and reduce prototyping costs.

The Thermal Management Bottleneck

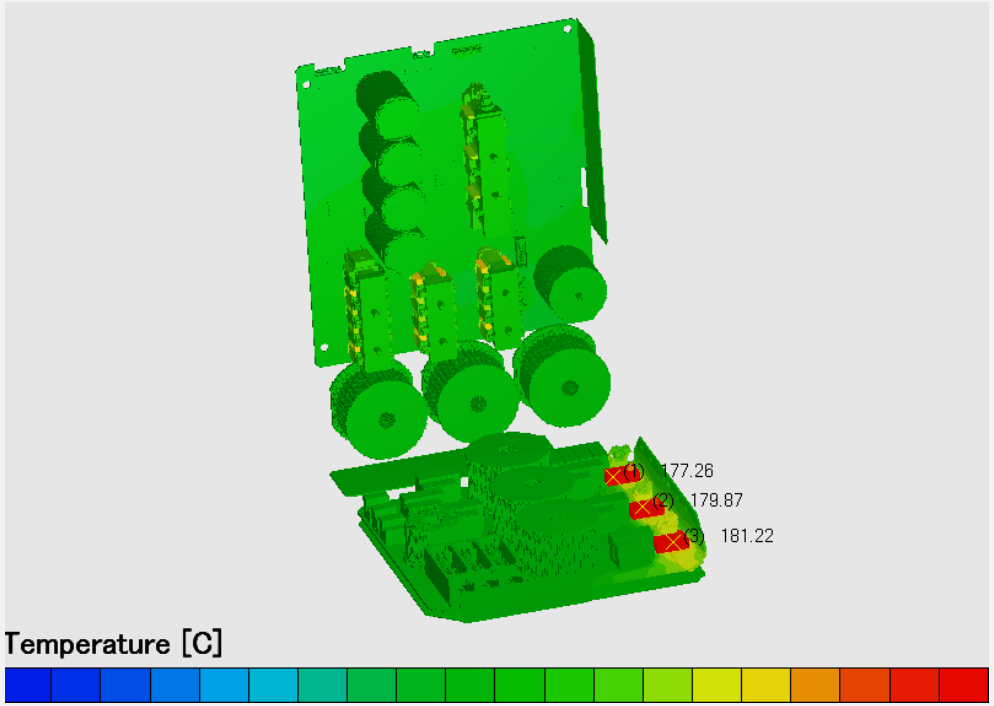
- Compact geometry
- Limited airflow creates hot spots
- Varying pressure and density at different altitudes natural convection is affected
- Avionics are repeatedly subjected to take off-landing cycles where temperature changes cause thermal stress
- Shielding and enclosures for EMI protection can trap heat and further reduce airflow.
- Aerospace systems must meet RTCA DO-160





How do we approach it using Early-Stage Simulation

- Safran Cabin integrates thermal and airflow domains using Hexagon's Cradle suite
- Predict and mitigate thermal runaway, hot spots, and identify optimal placement of heat-generating components
- Evaluate thermal interface materials (TIMs), resistor materials, and coatings for peak performance
- Virtual validation minimizes costly physical iterations and shortens development cycles



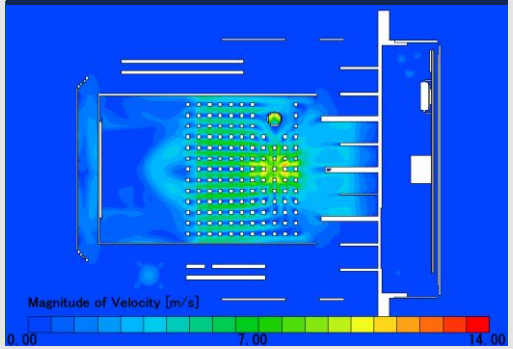
SAFRAN

Application Example

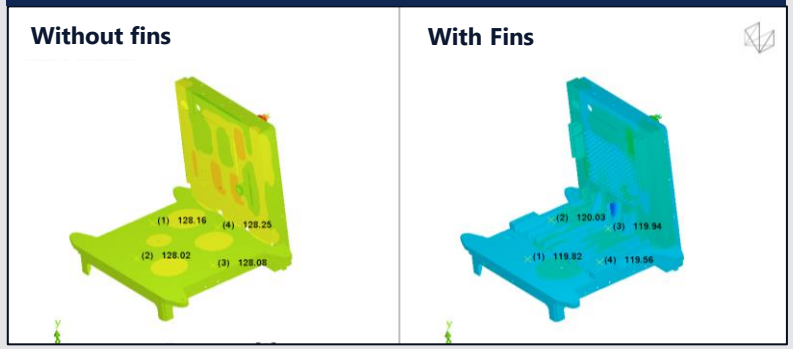
Vacuum Generator Thermo-Fluid Analysis

- **Major Components: Impeller, Cooling fan, heat sink and PCBs**
  - Vacuum generator is enabled on an aircraft during low altitude and ground operation when cabin differential pressure is below a certain number.
  - The brushless DC motor drives the impeller at a very high RPM to generate the vacuum
- **Analysis Focus: Multiple Case Studies to optimize the design**
  - Study the complex flow fields around impeller and understand thermal effects on the surrounding parts.
  - Analyze thermal behavior in PCB parts with different heat sink designs and part materials

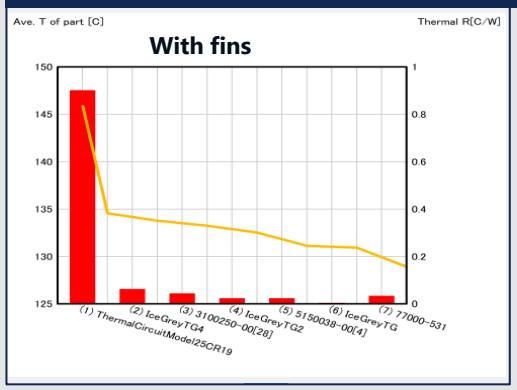
Air Flow Contour

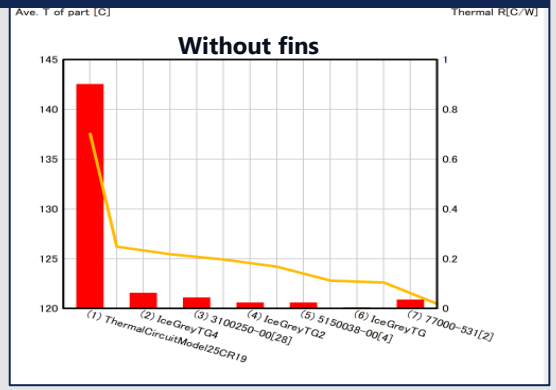


Temperature Comparison Studies



Thermal Resistance Comparison Studies





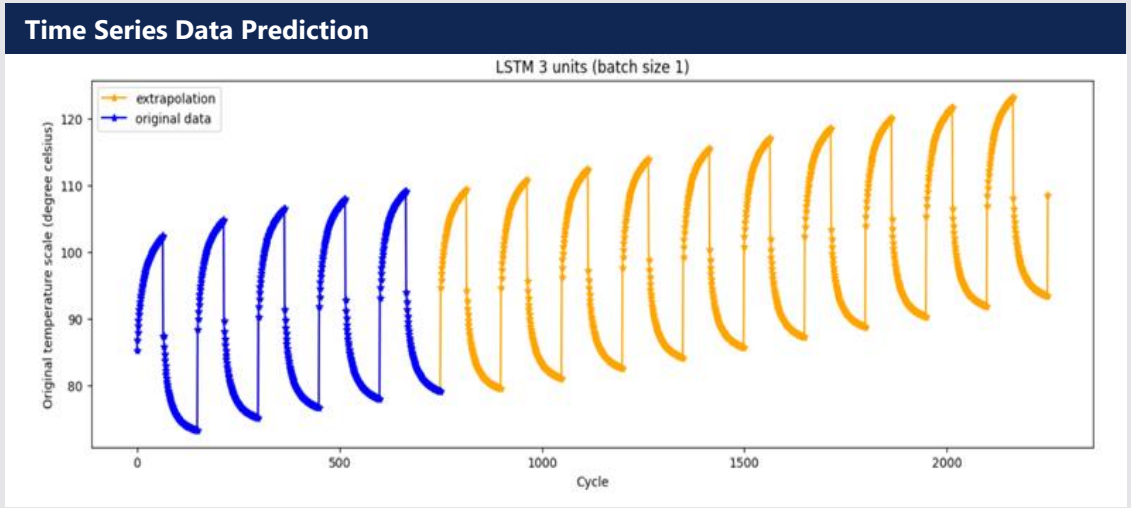
SAFRAN

The residual Challenges

- Complex Multiphysics Coupling
- High Sensitivity to Material Properties and Contact Resistances
- Mesh-Accuracy vs. Computational Cost Trade-off
- Validation Against Real-World Conditions

Future Outlook: AI driven simulation

- Use of models like Long Short-Term Memory (LSTM) networks to predict temperature evolution
- This approach has demonstrated the potential of AI-driven forecasting for thermal behavior in complex systems.
- Purely data-driven models like LSTM can struggle with generalization across new conditions and strict physics constraints.
- We are actively exploring Physics-Informed Machine Learning (PIML) methods to achieve greater accuracy.



SAFRAN

POWERED BY TRUST

Contact Info
Faiqa ANBREEN
Faiqa.anbreen@safrangroup.com
714-944-1749

SAFRAN