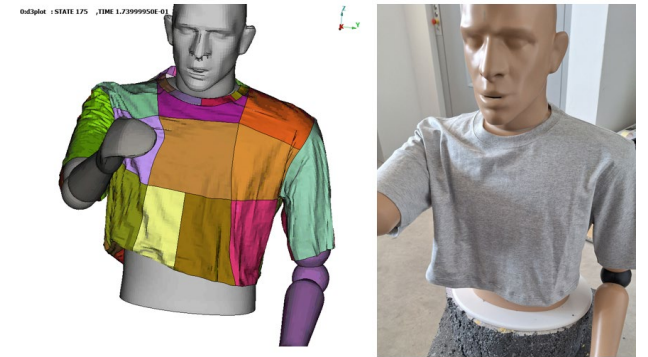
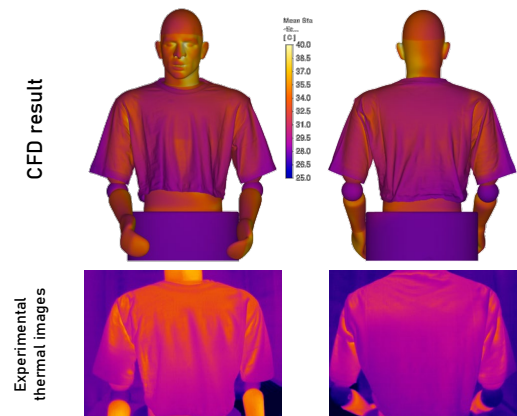
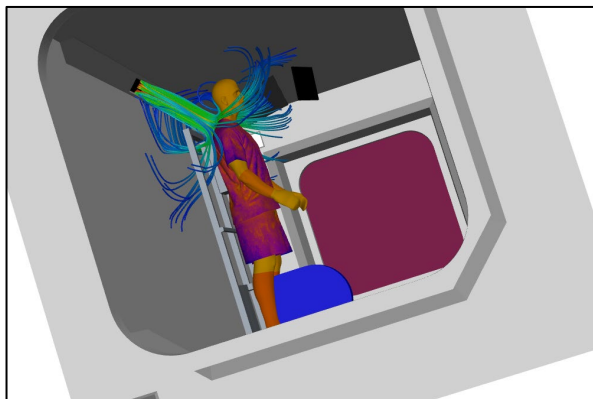


# ECON Human Body Thermocomfort Assessment

**Background:** As part of the **Axiom-4 mission**, our team participated in the **HUNOR** program. The study, titled CINCINNATI, was motivated by the goal of advancing the virtualization of thermal comfort.

**Our aim** was to develop a demonstration version of a **thermo-physiological comfort simulation framework** for the human body, supported by physical measurements conducted both on Earth and aboard the ISS.

- **Characterization of mechanical and thermal properties of raw fabric**
- Application of structural finite element methods to model the draping and wrinkling of worn garments.
- **Validation of CFD models** through comparison with thermal manikin measurements;
  - Experiments in a thermally controlled environment using a thermal manikin torso;
  - Collection of thermal imaging data and localized skin temperature measurements.
- Development of a **coupled CFD and human thermoregulation simulation environment** (JOS-3), including
  - Both **explicit** and implicit garment modeling techniques.
- Simulation and validation of human thermal comfort during prescribed physical exercise using a cycle ergometer, including:
  - **Validation measurements** conducted both on Earth and **aboard the ISS** with a single astronaut.



## Tools

- Human body and garment 3D scan using tools from Creaform
- 3D CAD model generation from raw 3D scan files using CAE tools
- Fabric motion finite element simulation
  - Pre- and postprocessor BETA CAE Systems ANSA+META
  - LS-DYNA solver
  - Usermat for custom fabric constitutive model
- Thermal comfort CFD simulations
  - Ansys Fluent linked with JOS-3 human thermoregulation model
  - Set of custom Python-based scripts and UDFs developed in-house

## Initial ideas for cooperation

- **Integrated human thermal modeling for space:** Combining ECON Engineering's CFD and thermophysiological simulation expertise with KBR's spaceflight operations knowledge to develop validated models for microgravity environments.
- **Validation with real mission data:** Using astronaut and ISS-related measurements (via KBR) to validate and refine simulation frameworks developed by ECON.
- **Garment and spacesuit simulation:** Joint development of advanced clothing/suit models, including draping, insulation, and ventilation effects on thermal comfort.
- **Cabin environment optimization:** Coupled human–environment simulations to improve spacecraft ventilation and personalized thermal comfort.
- **Exercise and digital twin applications:** Modeling thermal response during physical activity and moving toward real-time astronaut “digital twins” using sensor data.