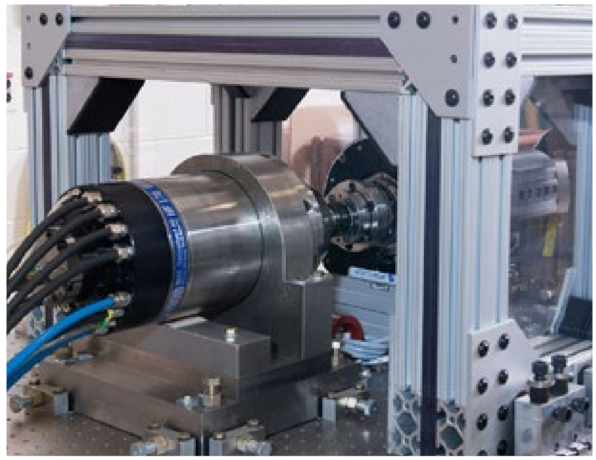
HEATheR Activity

High-power, megawatt- (MW-) class electric aircraft propulsion (EAP) concepts have performance benefits for aircraft but produce large amounts of waste heat that must be rejected. How do we achieve the performance and operational cost benefits that EAP offers while minimizing the mass, drag, and power penalties of an associated thermal management system? Technology being developed as part of the High-Efficiency Electrified Aircraft Thermal Research (HEATheR) activity under NASA's Convergent Aeronautics Solutions project seeks to address this challenge. MW electrical power systems produce a large amount of waste heat with relatively low rejection temperatures (<200 °C), requiring large, heavy thermal management systems that often produce additional drag.



HEATheR's high-efficiency megawatt motor (HEMM) uses superconducting coils to carry large currents with almost no energy loss.

The HEATheR solution is a two-pronged approach: first, minimize thermal load by building an innovative power system with four times lower losses; and second, manage the remaining waste heat through local air cooling or direct outer mold line (OML) cooling.

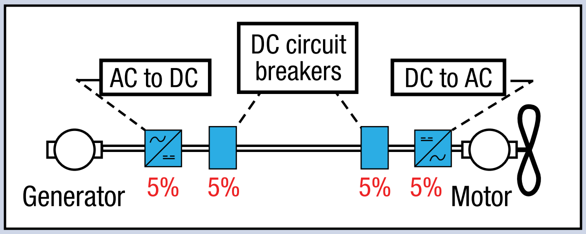
Losses will be reduced by eliminating half of the conversion steps and associated components and by making low-loss components, including a high-efficiency MW AC-to-AC converter and a high-efficiency MW motor (HEMM). Heat losses for a state-of-the-art power system are 20%, whereas anticipated heat losses for the HEATheR powertrain are just 5%.

Aircraft with MW electric power manage waste heat by moving it from the source to a heat exchanger, using a pumped fluid. The heat is rejected into the fuel and/or into the airstream through the heat exchanger with a penalty of additional mass and drag. HEATheR's approach is to reduce the complexity of the thermal management system by locally rejecting heat through the skin of the aircraft, minimizing mass and drag penalty. This approach is called OML cooling.

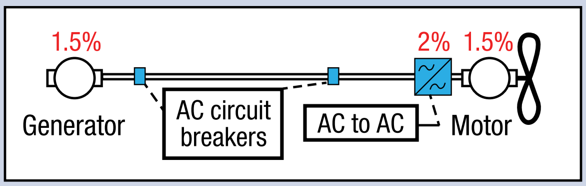
Megawatt-level electrified aircraft propulsion (EAP) systems reduce emissions and expand air travel, but they also generate a lot of heat. EAP concepts like these will need lightweight thermal management systems that do not produce drag.

Powertrain Goal: Minimize Thermal Load

State of the art: 20% heat loss

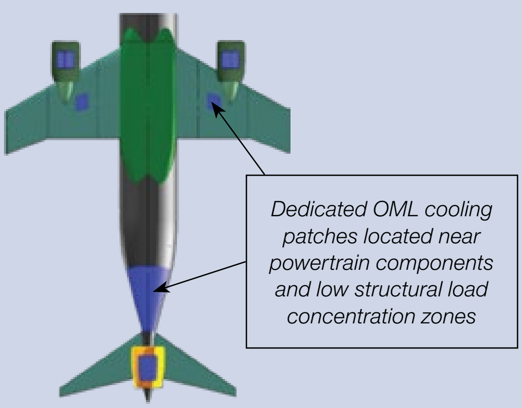


HEATheR: 5% heat loss



Thermal Goal: Use Local Passive Thermal Management

Compared with fluid cooling and air cooling, direct heat removal via outer mold line (OML) cooling has no substantial penalty of added mass or drag.



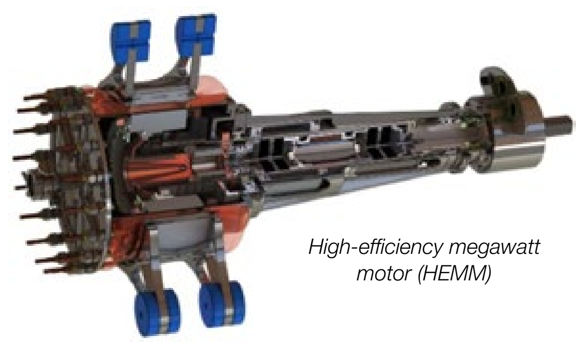
HEATheR Accomplishments

- Methodologies were developed to integrate power and thermal system modeling and sizing into the systems analyses of three NASA EAP concepts: a tilt-wing urban air mobility (UAM) reference concept, the fixed-wing Single-Aisle Turboelectric Aircraft with an Aft Boundary-Layer Propulsor (STARC–ABL) concept, and the regional Parallel Electric–Gas Architecture with Synergistic Utilization Scheme (PEGASUS) concept. These methodologies showed the potential for a 15% decrease in fuel burn for the turboelectric tilt-wing concept, a 3% decrease in fuel burn for the STARC–ABL concept, and a 3% decrease in total energy for the PEGASUS concept.

- The feasibility of OML cooling of electric components for conventional takeoff and landing EAP vehicles was established using computational fluid dynamics heat transfer modeling, heat pipes, and an oscillating heat pipe heat spreader.

- The HEATheR converter: Architecture for a 1.4-MW converter was designed, and a 72-kW version was built and tested for two critical feasibility items: interleaving and multilevel topologies for the converter power stage.

- The HEMM: A 1.4-MW high-efficiency motor prototype was designed, and feasibility was established for the superconducting coil pack, the slotless stator, and part of the integrated cryocooler.



High-efficiency megawatt motor (HEMM)

HEATheR Benefits

- Tools and methods developed under HEATheR can be used for evaluation of new EAP and UAM concepts.

- Technology successfully developed through the HEATheR project could enable certain highly distributed or tilt-wing electric aircraft concepts and improve performance and operational costs for any MW-level electric aircraft.

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