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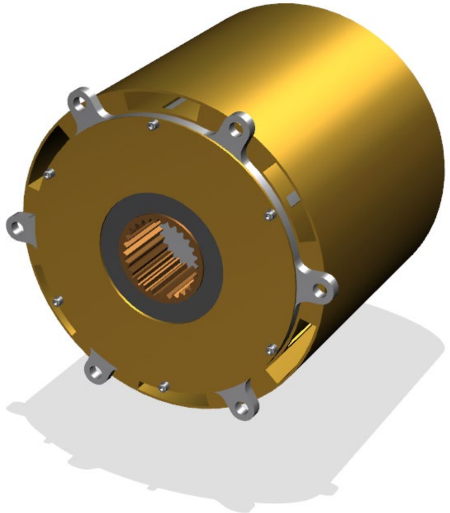
CHANGING WHAT'S POSSIBLE

Adv Electric Propulsion System (AEPS)

Arif Salam (PI), Honeywell International

Project Vision

The AEPS team is solving future aerospace issues today to meet increased electrification demands and reduced emission targets by designing, developing, and demonstrating a new and novel solution, building on existing experience while developing innovative technologies.



REEACH / ASCEND / CABLES
Annual Program Review Meeting
June 28-30, 2022

Honeywell
UNIVERSITY OF MARYLAND

Brief ASCEND Project Overview

Fed. funding:	$1.8M
Length	18 mo.

Team member	Location	Role in project
Honeywell International	Torrance, CA	Overall system design, integration and test, T2M
University of Maryland	College Park, MD	Thermal management system design and fabrication

Project History

- Honeywell and the University of Maryland (UMD) have collaborated on projects for over 20 years
- Honeywell is an aerospace leader of engines and power systems with 100+ years of experience
- UMD has over 20 years of experience in the fields of material science, advanced heat and mass transfer, and thermal management systems, with innovative design optimization
- With UMD's expertise in innovative TMS solutions along with Honeywell's expertise in propulsion systems, the Advanced Electric Propulsion System (AEPS) is positioned to exceed the ASCEND charter's expectations

AEPS System Integration Design & Performance Summary

Design Innovations

- Air-cooled, integrated Design Incorporates:
  - Motor Stator & Rotor
  - Motor Drive
  - Heat Exchanger Cooling Sleeve
- Compact and modular allowing for motor drive and motor interchangeability
- Motor output drive to be able to interface with customer equipment
- Very efficient and high-power density propulsion system

Design Performance

- Component level proof of concept testing planned in Q2/Q3 2022
- Module testing planned in Q4 2023 (Phase 2)
- System testing planned in Q3 2024 (Phase 2)

AEPS Motor Design & Performance Summary

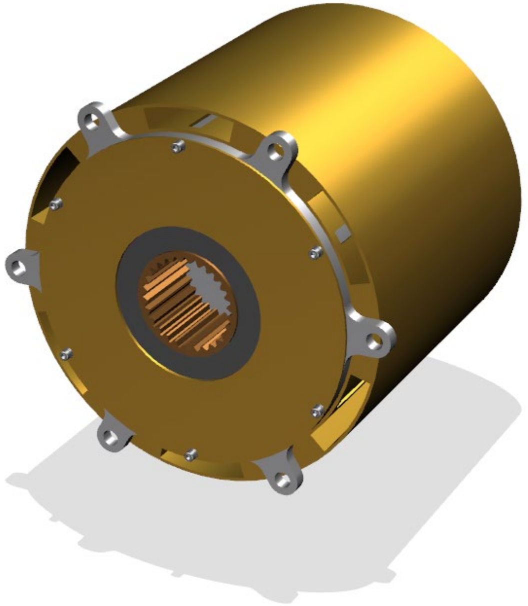
Design Innovations

- Air-cooled, direct drive, permanent magnet machine
- High efficiency and high-power density
- High performance windings to increase copper fill factor
- Composite materials utilized to reduce weight

Metric	Requirement
System Capacity (Peak)	> 250 kW
Input Voltage	> 1 kV
System Power Density	>12 kW/kg
EM Efficiency (Cruise)	> 93%

Design Performance

- Motor design & EM analysis complete
- Adv winding design complete & component testing in progress
- Motor rotor design complete; component test planned start Q3 2022



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AEPS Motor Drive Design & Performance Summary

Design Innovations

- Air-cooled, Wide-Band-Gap semiconductor devices
- High efficiency and high-power density power electronics
- High voltage to reduce current and losses
- State of the art processor and control scheme

Metric	Requirement
System Capacity (Peak)	> 250 kW
Input Voltage	> 1 kV
System Power Density	>12 kW/kg
EM Efficiency (Cruise)	> 93%

Design Performance

- Motor drive design & analysis complete
- Key components selected; hardware procurement in progress
- Hi-Pot testing of critical components planned in Q3 2022
- Designed high voltage gate driver; test planned in Q3 2022

AEPS TMS Design & Performance Summary

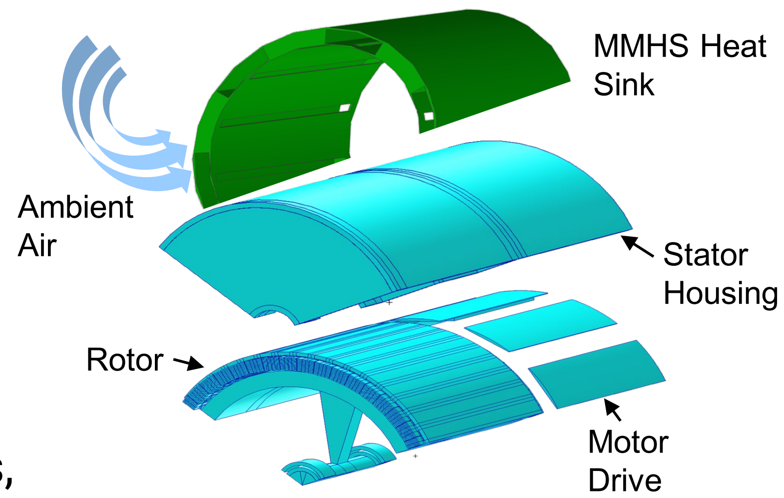
Design Innovations

- Thermal Management System (TMS) incorporates:
  - High performance heat exchanger cooling sleeve
  - Stator winding architecture
  - Novel high temperature winding insulation
- System integration of TMS technologies reduces thermal resistances, yielding higher operating temperature capacities

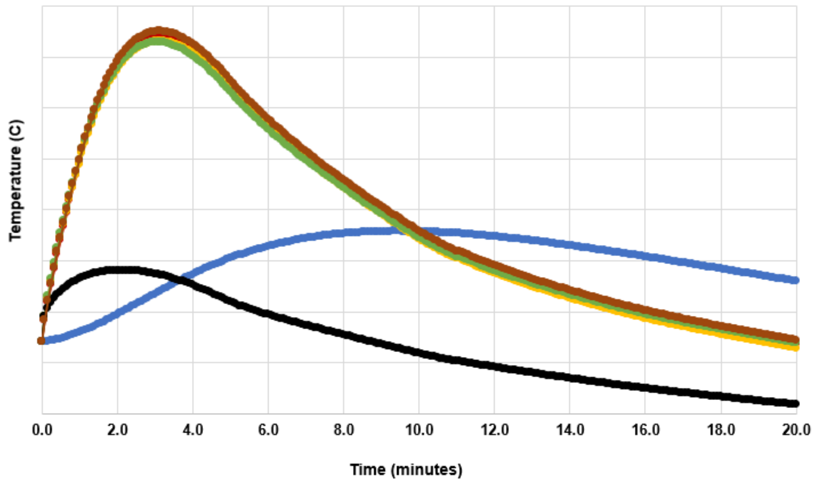
Design Performance

- UMD heat exchanger design & analysis complete
- UMD performing component testing to ground thermal models
- Stator winding insulation testing complete
- Thermal model & design iteration planned after test (Q4 2022)

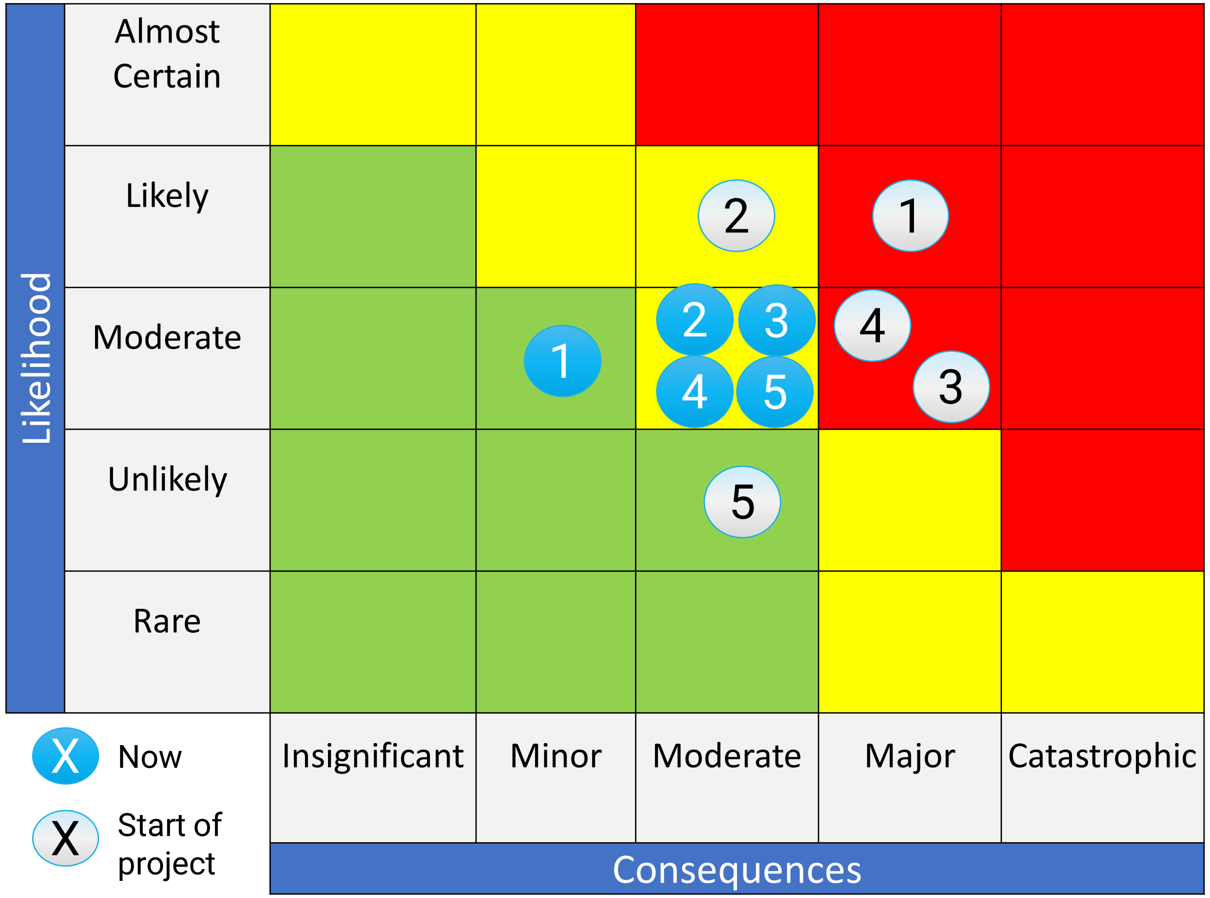
System Thermal Model



Transient Component Thermal Predictions



AEPS Key Technical & Programmatic Risks



#	Risk	Current Status
1	Winding Performance & Manufacturability	Red risk reduced to green; Will retire after 2022 testing
2	HTI Performance & Manufacturability	Risk partially retired, will retire fully after 2022 testing
3	TMS Performance	Risk reduced from red to yellow thru analysis; will retire after 2022 testing
4	High voltage power electronics performance	Risk reduced from red to yellow thru analysis; will retire after 2022 testing
5	Cost targets	Risk increased due to preliminary quotes; Mitigation plan development in progress

Looking Ahead – What is anticipated for an Eventual Phase II?

Remaining Phase 1 Scope (thru 2022)

- Finish risk reduction component testing
  - High voltage testing on drive components
  - Motor rotor structural testing
- Revise analytical models & iterate mechanical design
- Preliminary Design Review (PDR)
- Submit Initial Commercialization Plan (T2M)
- Continue to seek near term platform (T2M)

Phase 2 Scope (2023 – 2024)

- Final analysis & design iteration
- Concept Design Review (CDR)
- Hardware procurement for subsystem and system testing
- Final risk reduction subsystem testing
- Build and test full system
- Commercialization Plan Finalized (T2M)
- Platform identified to support full scale development (T2M)

Q & A

https://arpa-e.energy.gov