# Dual-mode hybrid two-phase loop for data center cooling


## Chanwoo Park, University of Missouri

**Team Members: ACT and NREL**


COOLERCHIPS™

## Project Vision

We aim to develop a *dual-mode* (passive, active) two-phase loop technology that provides a highly efficient cooling solution for data centers, offering high heat flux cooling capability, low thermal resistance, high energy efficiency, and reliable operation through a fully scalable design.

| | |
|---|---|
| Total Project Cost: | $1.8M |
| Length | 36 mo. |


COOLERCHIPS Kickoff Meeting
*October 18 & 19, 2023*

# Brief COOLERCHIPS Project Overview

| | |
|---|---|
| Fed. funding: | $1.8M |
| Length | 36 mo. |

| Team member | Location | Role in project, core competencies |
|---|---|---|
| University of Missouri (MU) | Columbia, MO | *PI*, pumped two-phase loop, thin-film evaporation |
| Advanced Cooling Technologies (ACT) | Lancaster, PA | *Subrecipient*, thermal testing, manufacturing, T2M |
| National Renewable Energy Lab (NREL) | Golden, CO | *Subrecipient*, thermal analysis/characterization, power electronics, data center operation |

## Context/history of the project

A hybrid (mechanical-capillary-driven) two-phase loop technology has undergone significant development over almost two decades by PI. This innovative system presents an ideal cooling solution for data centers, delivering a multitude of benefits.

The leading thermal solutions provider, ACT, along with NREL APEEM, which specializes in power electronics, will join forces with MU to advance and bring to market the hybrid two-phase cooling technology.

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# Concept Detail

- The proposed dual-mode hybrid two-phase loop (HTPL) operates in both passive and active modes, adapting to cooling requirements as needed.
  - A passive loop thermosiphon operates with zero energy consumption, delivering exceptional and dependable cooling performance.
  - An *active* mode pumped two-phase loop offers exceptional capabilities, including low thermal resistance, high heat flux, minimal energy consumption, robust operation, design flexibility, and full scalability.
- We will develop dual-mode HTPL systems, with power ratings of 3 kW and 10 kW, using simulated heat sources designed to replicate the thermal characteristics of advanced chipsets with a Thermal Design Power (TDP) exceeding 750W.

| FOA Metrics | Units |
|---|---|
| *Resistance Target* | 0.01 K/W |
| *Cooling Power % of IT power* | < 0.5 % |
| *System availability* | 99.998 % |
| *Chipset* | Socket E type |
| *Chip Power (mock-up heat sources)* | >750 W |
| *Power per server* | 3 kW per 1U |
| *Demonstration power mid project* | 10 kW |

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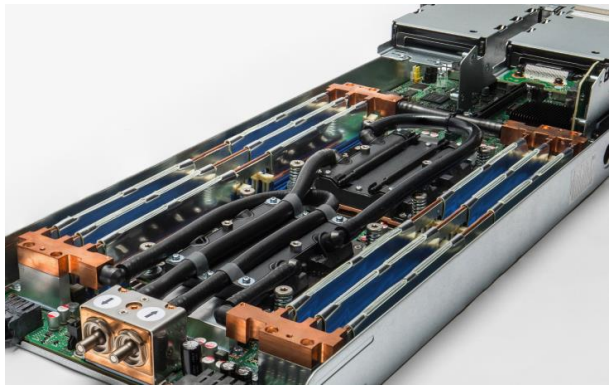
# Task Outline & Technical Objectives

- Develop a dual-mode hybrid two-phase loop featuring a fully scalable design, the ability to hot-swap servers, low power consumption, and minimal thermal resistance.
- Conduct component and system design, analysis, and testing.
- Perform reliability analysis, thermal characterization, and long-term operation.
- Evaluate manufacturing process, and explore T2M strategies
- Achieve 3 kW system performance milestones by Q6; 10 kW system performance milestones by Q12



Liquid-cooled server (Dell, CoolIT) and data center as *benchmark* for the two-phase cooling loop technology

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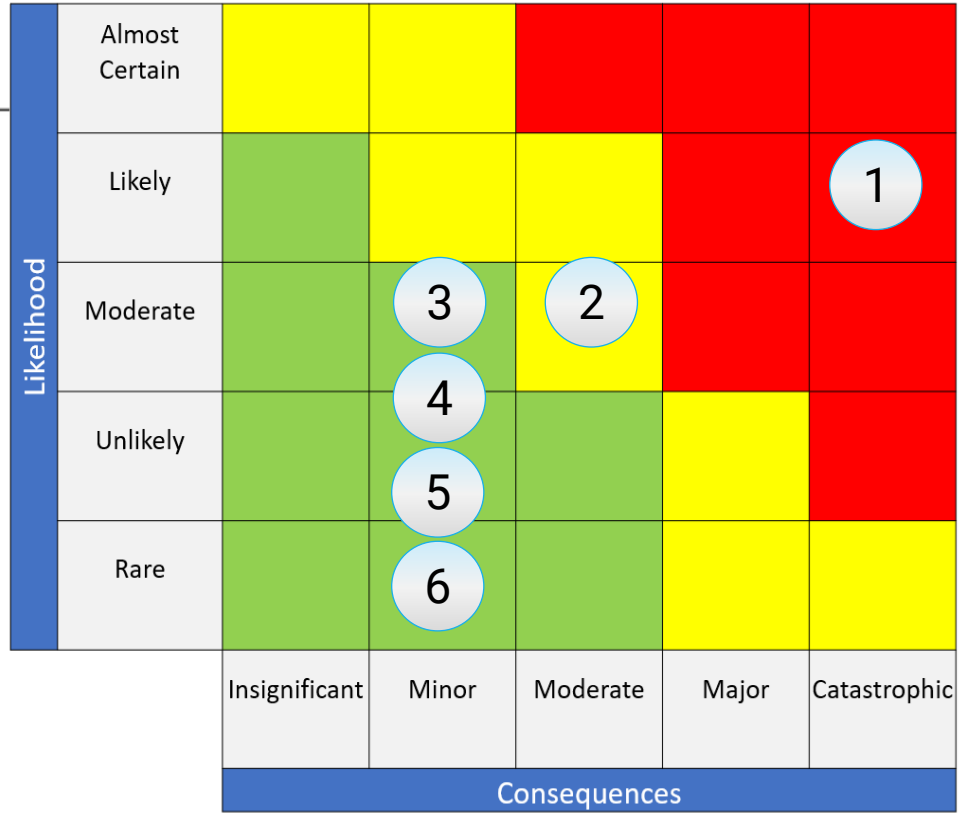
# Challenges and Risks

- Achieving evaporator thermal performance target using optimized design and cost-effective manufacturing
- Dual-mode operation between passive and active systems
- Air leak control during hot swapping
- Multiple evaporator operation under asymmetric heat loadings
- Flow balancing between servers
- Long-term reliable operation of active components




## Risk Status

| Risk | # |
|---|---|
| Evaporator thermal performance | 1 |
| Dual mode operation | 2 |
| Air leak control during hot swapping | 3 |
| Multiple evaporator operation | 4 |
| Flow balancing | 5 |
| Reliable operation of active components | 6 |

# Technology-to-Market Approach

- We will commercialize dual-mode hybrid two-phase loop technology through licensing with industrial partners.
- Cost-effective, high-performance two-phase cooling solution will draw in investments for commercialization.
- The initial target markets encompass data center server cooling, consumer computer cooling, power electronic cooling, and military applications.

# Needs and Potential Partnerships

- Server manufacturers
- Component vendors (pump, condenser, thermal interface materials)
- Thermal test vehicle manufacturer

# Q & A

https://arpa-e.energy.gov