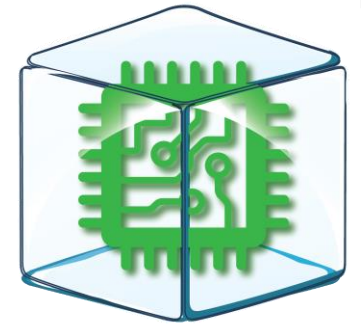


# Aligned Graphite Microchannel Cooling (AGMC) System With Additively Manufactured Manifolds

PI: Chris Roper, HRL Laboratories, LLC

Team Members: Swiftech



COOLERCHIPS



## Project Vision

- We are increasing the thermal-hydraulic performance of reliable, single-phase liquid cooling to meet the cooling demands of future data centers by **manufacturing** uncommon, high-performance **materials** in new cooling-block **architectures**.
- Rapid technology transition and commercial impact is enabled by focusing innovation on the cooling-blocks and leveraging existing COTS components for the rest of the data center cooling system.

Total Project Cost:	\$2.5M
Length	36 mo.

# Brief COOLERCHIPS Project Overview

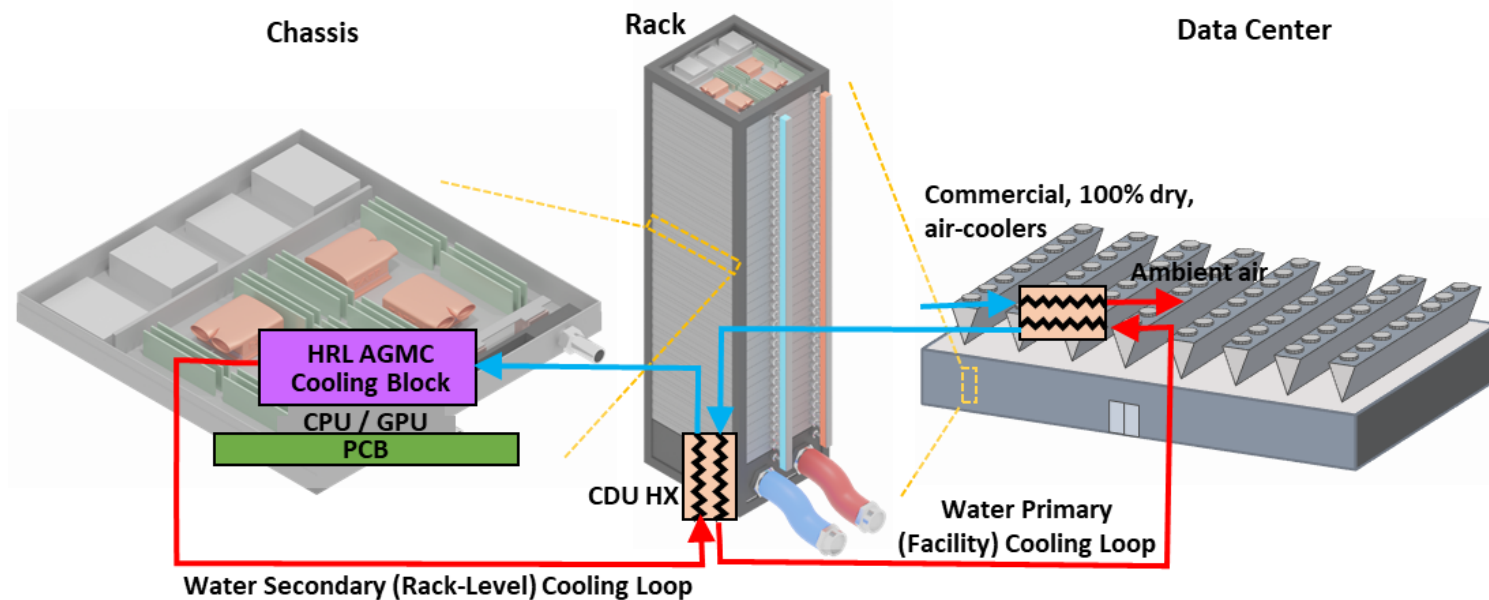
Fed. funding:	\$2.5M
Length	36 mo.

Team member	Location	Role in project, core competencies
HRL Laboratories, LLC	Malibu, CA	<ul style="list-style-type: none"><li>• Cooling block development and testing</li><li>• Oversight of chassis- and rack-level design, fabrication, and testing</li><li>• Expert in novel materials &amp; manufacturing</li></ul>
Swiftech	Anaheim, CA	<ul style="list-style-type: none"><li>• Design, fabrication, and testing of chassis-level and rack-level demonstrations</li><li>• Reliability consulting and testing</li><li>• Liquid-cooling chassis- and rack-level packaging expert</li><li>• Heat transfer component manufacturer</li></ul>

- *Innovations in materials, manufacturing, and architectures for unique cooling-block*
- *COTS for rest of system and single-phase for reliability and tech. adoption*

# Concept Detail – System

- ▶ *Single-phase water cooling solution integrated into proven COTS infrastructure*
- ▶ *System level performance metrics: thermal resistance below 0.0085 K/W at pumping powers <5% IT power*



FOA Metrics	Units (Mid-Project)	Units (Final Project)
Resistance Target	<0.015 K/W	<0.01 K/W
Cooling Power % of IT_power	<3.0 % secondary loop <5.0 % total	
System availability	>99.982 %	
Chipset	Proxy chipset	
Chip Power	1 kW	
Power per server	4 kW/U (1U demonstration unit)	4 kW/U (4U demonstration unit)
Demonstration power	4 kW	16 kW

# Concept Detail – Cooling Block

- ▶ *1. Microchannel array with aligned graphite (with thermal conductivity 3-4X higher than traditional copper) for superior heat transfer from source to fluid*
- ▶ *2. Additively manufactured flow manifold reduces channel flow length, thereby enabling acceptable pressure drop in microchannels*
- ▶ *3. Tailored manifold and baseplate to match CTE of underlying chipset for increased reliability*
- ▶ *Cooling block key performance metrics: thermal resistance < 0.006 K/W at <1.5% IT load pumping power*

# Task Outline & Technical Objectives

Task	#	Subtask
Design & Simulation	1.1	Cooling Block Design
	1.2	System Design
	1.3	Reliability Consulting
Fabrication and Manufacturing	2.1	Cooling Block Fabrication
	2.2	Chassis Fabrication
	2.3	Rack Fabrication
Testing & Demonstration	3.1	Test Coord. & Analysis
	3.2	Cooling Block Test
	3.3	Chassis Testing
	3.4	Rack Testing
Tech 2 Market	4.0	Strategy
Program Management	5.0	Program Management

- Primary Objectives:**
1. Develop a world-record performance single-phase cooling block
  2. Demonstrate system performance and reliability at chassis and rack levels
  3. Position for maximum economic impact and transition

# Challenges and Risks

- ▶ *Technical and commercialization risks identified and evaluated*
- ▶ *Mitigation plans prepared for all risks*

## Risk Status

Likelihood	Almost Certain					
	Likely			h		
	Moderate			f, e, c, d, a		
	Unlikely				b	g
	Rare					
		Insignificant	Minor	Moderate	Major	Catastrophic
Consequences						

	Risk	#
Technical	Technology does not meet the FOA target for thermal resistance	a
	Technology does not meet the reliability target due to manifold attachment & manufacturing	b, c, d
	Technology does not meet the FOA target for cooling power as a percentage of IT load (i.e. Sufficiently low pressure drop and cooling power consumption)	e
	Technology does not meet the FOA target for compute power density in full rack	f
Commercialization	Manufacturing cost prohibitively high.	g
	Differences from existing data center cooling systems lead to slow adoption rate	h

# Needs and Potential Partnerships

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- ▶ *Seeking to engage data center operators for input on unique data center requirements*