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EXTRACT: Extra Efficient Data Centers with Avionics Cooling Technology

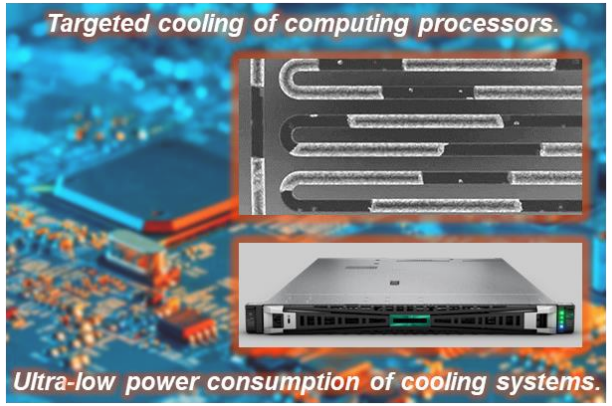
Kimberly Saviers, RTX Technology Research Center

Team Members: Hewlett Packard Enterprise, Purdue University, Vertiv Corporation

COOLERCHIPS™

Project Vision

- We are developing thermal spreading technology for computing servers by passively EXTRACTing heat from servers.
- The solution concept was inspired by high-heat flux cooling technology being developed for avionics applications.
- Oscillating heat pipes with key integration features will be developed for installation in an existing server architecture and closely integrated with CPUs and racks.
- Our solution reduces server-level thermal resistance by 3.5x compared to SOA liquid cooling, and with no input power for local CPUs.



Total Project Cost:	$3.13M
Length	30 mo.

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RTX Technology Research Center

COOLERCHIPS
Kickoff Meeting
October 18 & 19, 2023

Brief COOLERCHIPS Project Overview

Fed. funding:	$2.50M
Length	30 mo.

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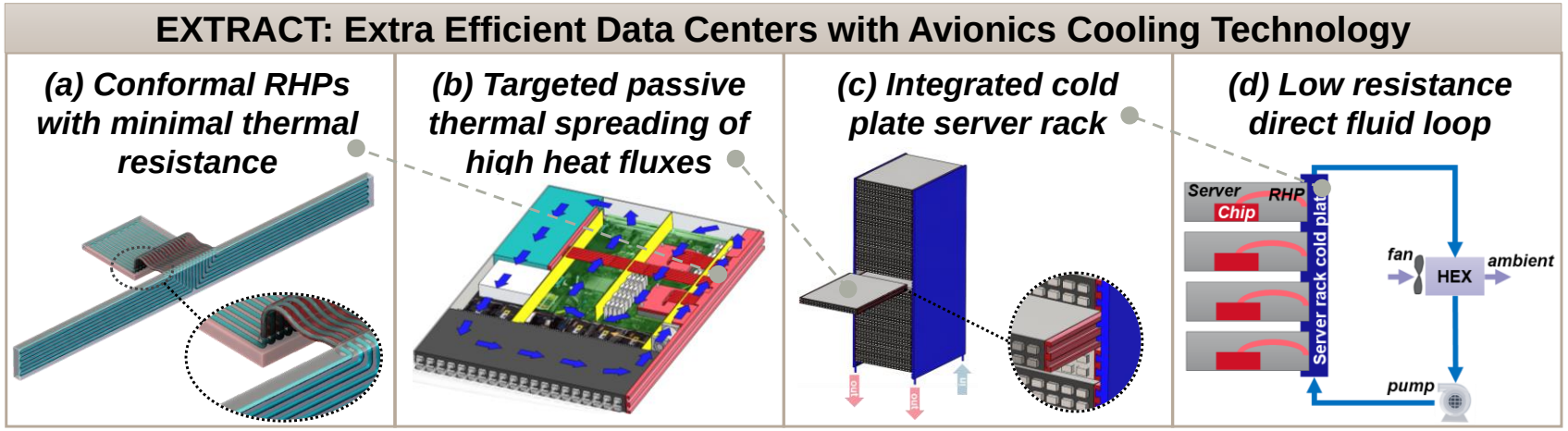
- **Bigger vision:** Off-chip heat rejection (as opposed to direct on-chip cooling) using highly efficient heat spreaders.
- **Success criterion:** Validation of thermal spreader operation with ≤ 0.01 K/W thermal resistance.
- **Enabling features:** Conformal/modular/adaptable heat spreaders integrated with on-rack cold plates.



Team member	Location	Role in project, core competencies
RTX Technology Research Center	East Hartford CT	Heat spreading technology for high heat flux electronics
Hewlett Packard Enterprise	Spring TX	Server R&D and supercomputing products
Purdue University	West Lafayette IN	Reliability modeling and testing
Vertiv Corporation	Westerville OH	Facility-level loops

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Concept Detail

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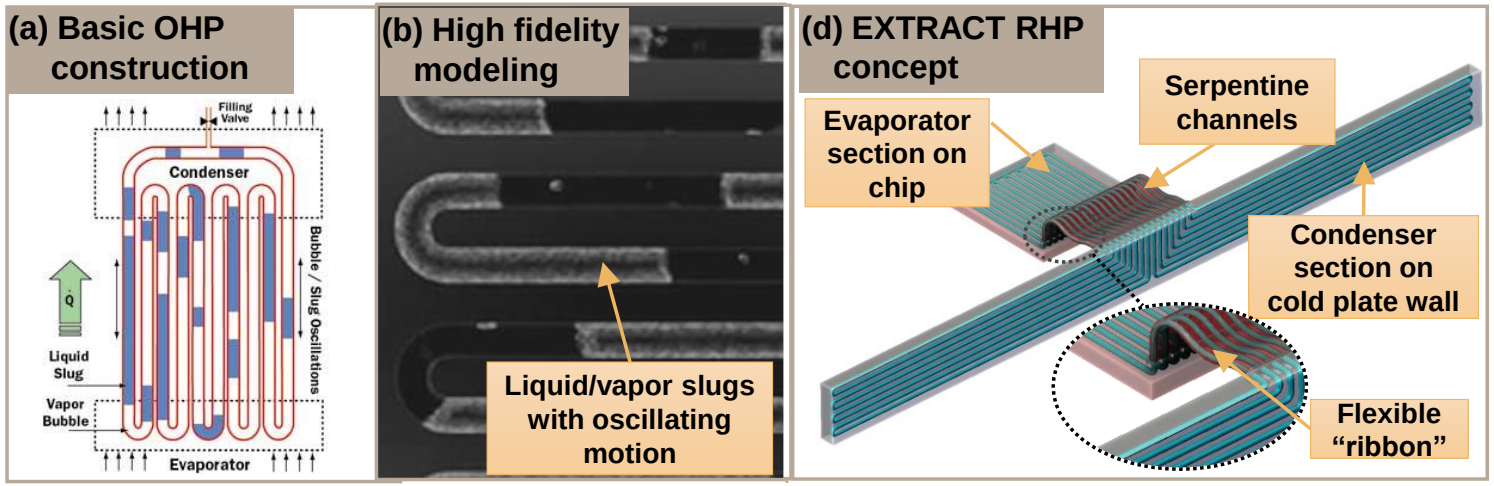
- **Key innovation:** Extra-efficient Ribbon Oscillating Heat Pipes (RHPs) and their direct integration with server and rack.
- **Key performance metrics:** Low thermal resistance, very low power input, test to 1000 hours, integrate with existing server.
- **Commercialization:** *Near-term:* Retrofit into existing server. Replace rack and connect with existing facility. To be sold as part of a server package. *Long-term:* Comprehensive integrated design of server, rack, and facility.
- **Tools:** High-fidelity physics-based OHP modeling coupled with reduced order modeling to be used to design the RHP fluid loops.
- **Mid-project milestone:** Demonstrate RHP on benchtop showing successful fabrication and thermal resistance metric.

FOA Metrics	Units
Resistance Target	≤ 0.01 K/W chip-to-coolant
Cooling Power % of IT power	≤ 3% target secondary loop (≤ 1.2% predicted)
System availability	99.982% (Tier3 Uptime)
Chipset	AMD Epyc Genoa CPUs 400W today; 500W in 2024; 700W capable
Chip Power	400 W each
Power per server	800W in ½ U server
Demonstration power mid project	Demo OHP component



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Task Outline & Technical Objectives

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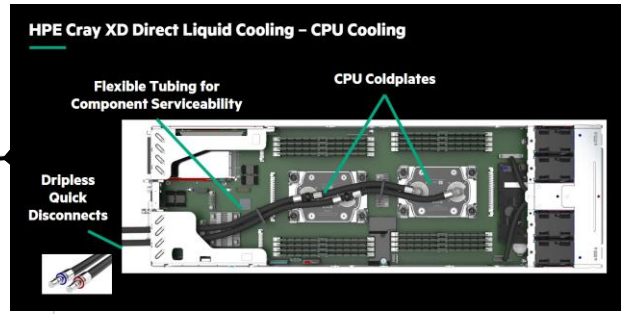
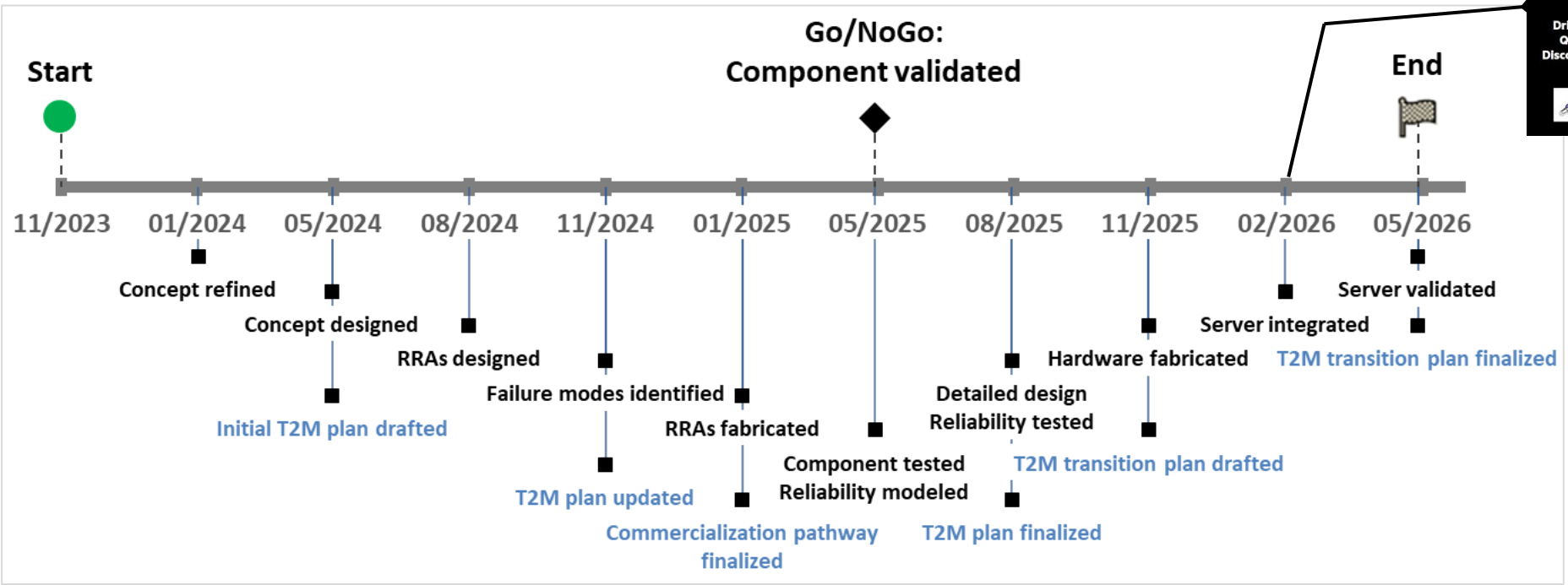
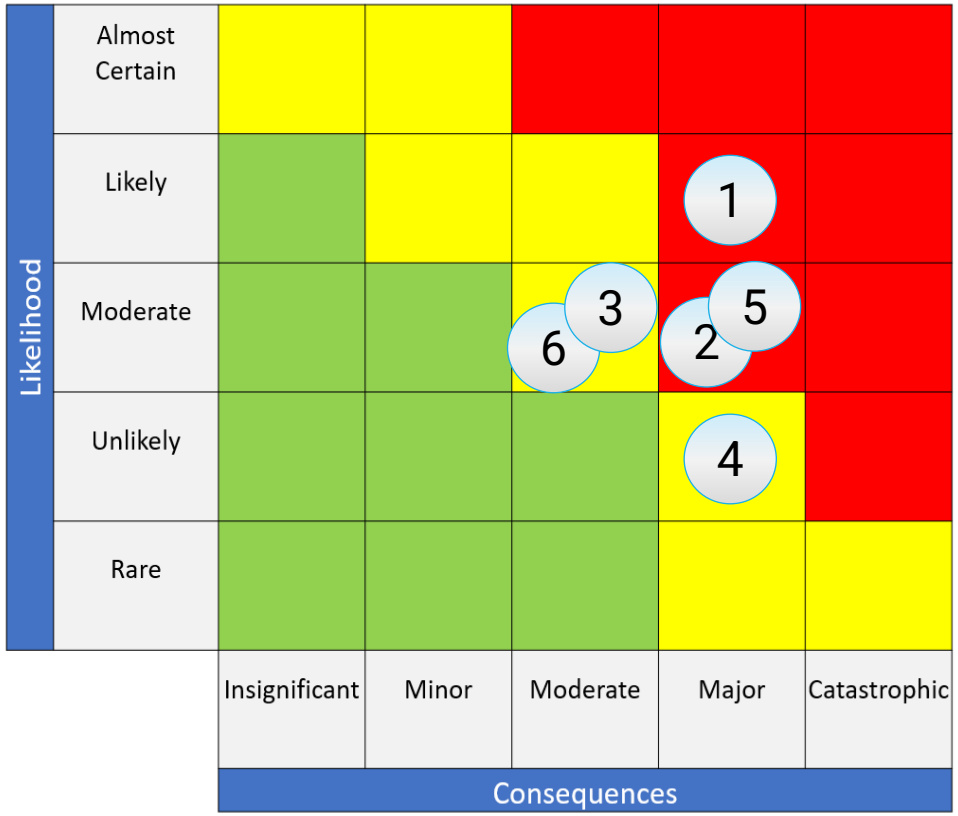
- **Key outcome:** Successful fabrication and validation of RHPs integrated into existing server architecture.
- **Roles:**
  - **RTRC:** Primary technology development of OHPs and integration solution. Detailed design, fabrication, and integration methods.
  - **HPE:** Provide consulting related to server designs and heat loads. Supply server hardware.
  - **Purdue:** Reliability modeling and testing.
  - **Vertiv:** Provide consulting related to data center facility requirements.
- **Timeline:** 2.5 years. Longer timeline in Phase 1 to provide time for vendor trials.
- **Prior work:** Physics-based OHP modeling, design, and fabrication. Electronics cooling technologies.
- **Targets/deliverables:** Component-level validation followed by server-level validation.





Challenges and Risks



Risk	#
RHP cannot be fabricated to meet thermal resistance (feature sizes) and retrofit into existing server (form factor).	1
RHP charging and sealing is not airtight, allowing the introduction of non-condensable gases. This results in performance degradation over time (reliability).	2
RHP condenser section cannot be fabricated as one integrated part with the server side rail.	3
RHP operating window is too small leading to dry-out. This will cause thermal runaway of the processor.	4
RHP/Cold plate interface has too-high thermal resistance when configured in a removable fashion.	5
Cost of the RHP is prohibitively high, causing a barrier to commercialization.	6

Technology-to-Market Approach – Commercialization Plans

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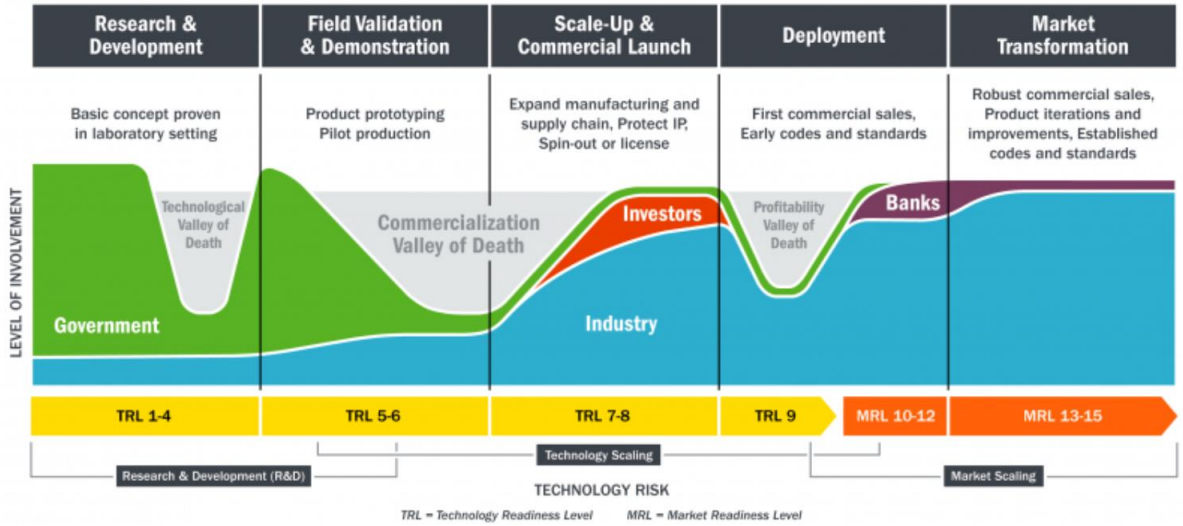
(1) Data center industry

- License the core technology/patents to a server company (such as HPE).
- Applied product development to be done under server company internal business unit funds.
- First market: High performance computing servers. Smaller market with higher cost threshold.
- Long-term market: Mass-scale computing servers. Larger market with lower cost threshold.

(2) Aerospace industry

- Core technology to be deployed in RTX business unit. Both Raytheon and Collins are viable options.
- Applied product development to be done under RTX internal business unit funds.
- Market: High heat flux electronics systems. Defense radar systems, avionics computing enclosures, electric aviation motor drive enclosures.
- Requirements are reliability, ruggedization, lightweighting.



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