NEXALUS
COOLING THE CLOUD

Tyndall
National Institute
Institiúid Náisiúnta

PIONEERING COOLING SOLUTIONS

about nexalus

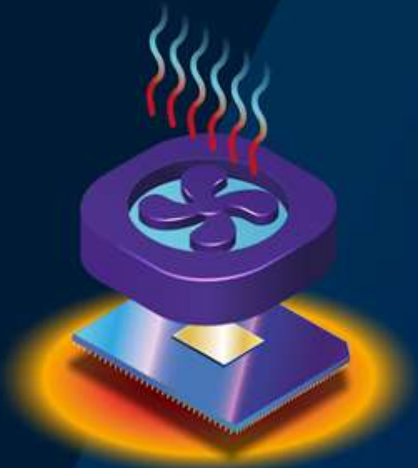
We specialise in sustainable electronic cooling, with patented technology that prioritises not only performance and profit, but also the planet. Harnessing thermodynamics alongside clever thermal-fluid science and engineering, Nexalus systems integrate with electronics that produce excessive heat, to cool, capture and reuse this thermal energy, while also increasing efficiency and reducing costs.

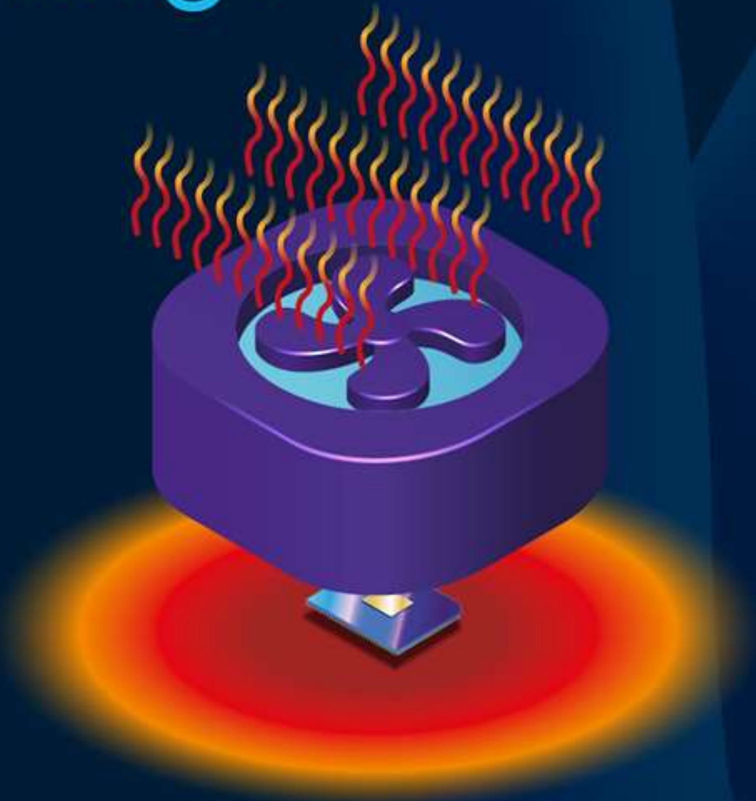
PERFORMANCE, PROFIT & PLANET

our expertise lives

why liquid cooling?

Industry Issue:





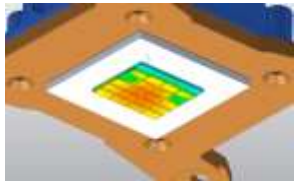
Increasing power/heat flux & decreasing size of electronics components and packages, especially CPU/GPU based tech.

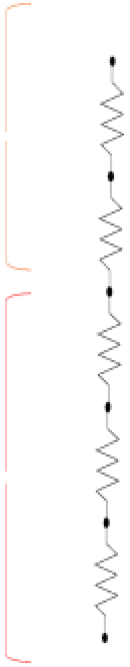
Traditional air cooling alone is no longer sufficient to maintain optimal operating temperatures.

Cooling technology needs to evolve...introducing Nexalus liquid cooling

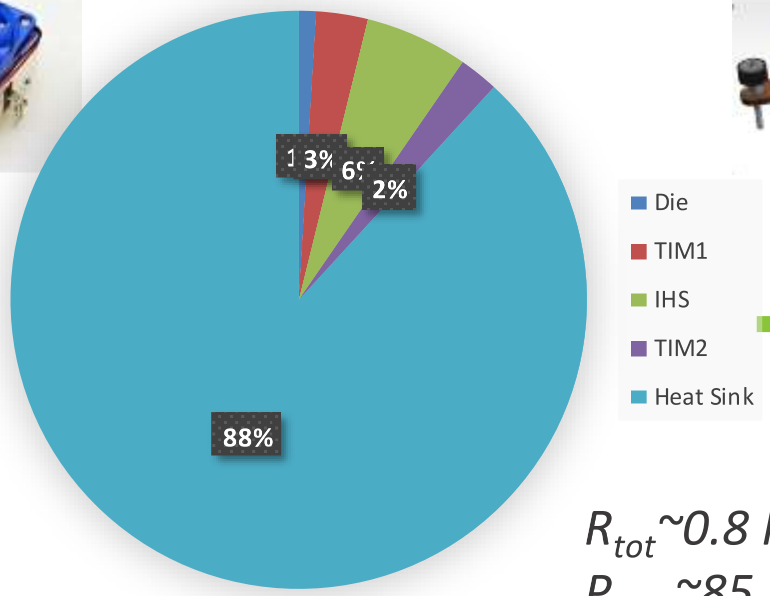
Liquid Cooling - **Implication #1**

Thermal Budget



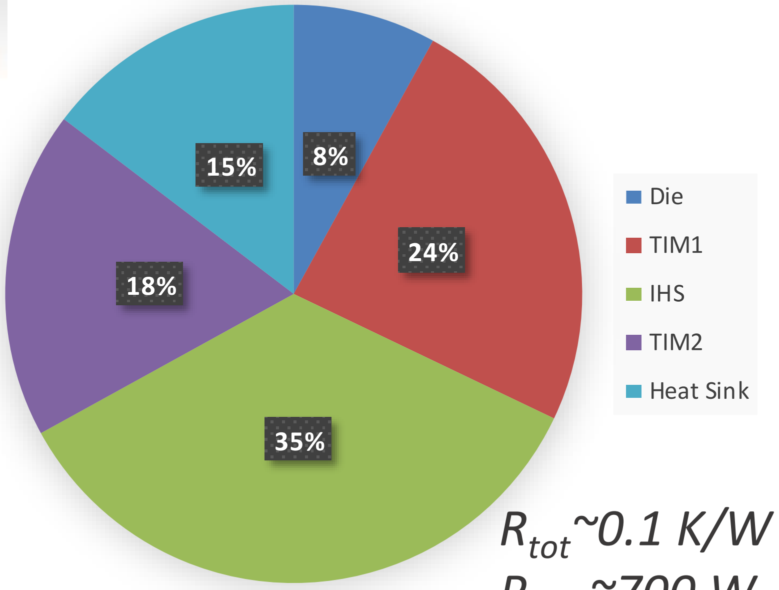


Standard Performance – Air



R_{tot}~0.8 K/W
P_{max}~85 W

High Performance – Liquid



R_{tot}~0.1 K/W
P_{max}~700 W

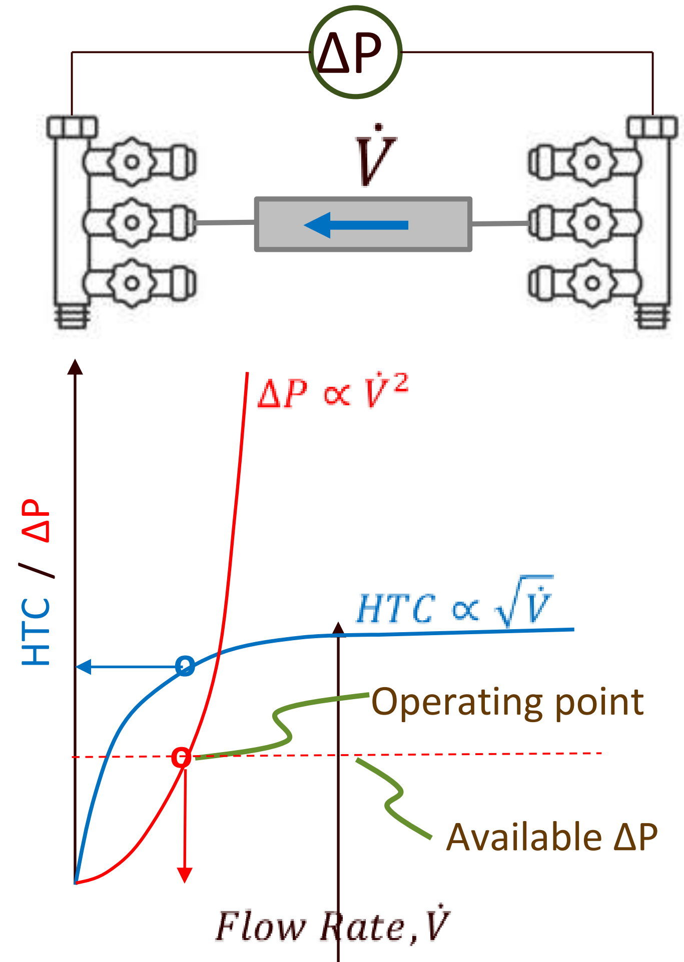
- Cooling performance dramatically improves – ***We can deal with higher power etc.***
- Thermal budget completely redistributes – ***Broad-spectrum design approach required***

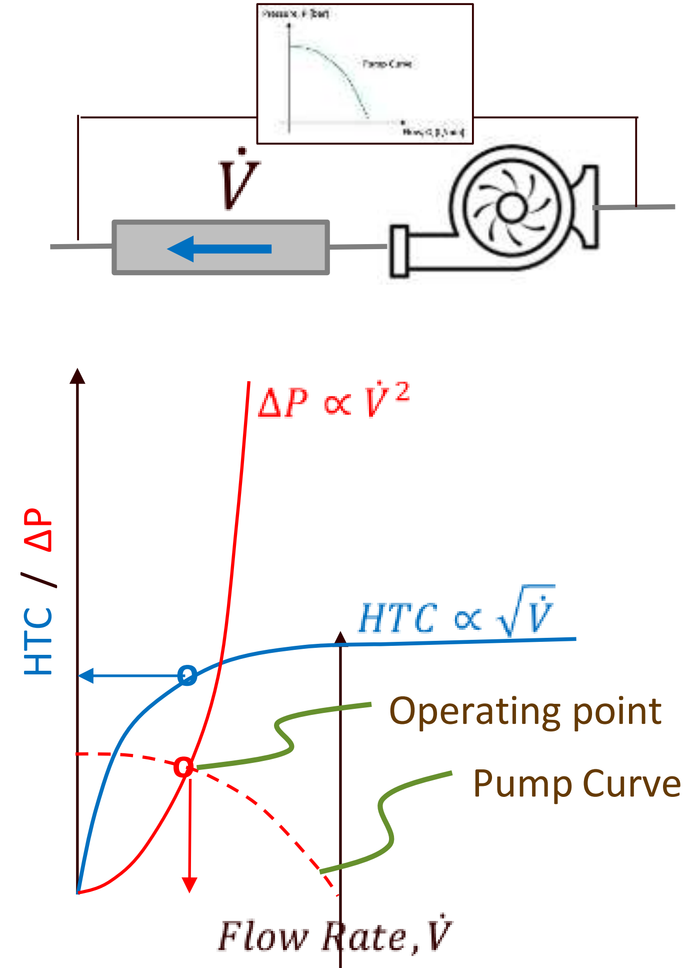
Liquid Cooling - **Implication #2**

Need low flow resistance to:

- Reduced pressure drop
- Reduced hydraulic power consumption
- Reduce line pressure
- Achieve target flow rate
- Achieve high cooling intensity
- ….and more

*Cooling and hydraulics must be considered **holistically** in the heat exchanger design*





Liquid Cooling - **Implication #3**


Contents lists available at ScienceDirect

Case Studies in Thermal Engineering

journal homepage: www.elsevier.com/locate/csite

ELSEVIER

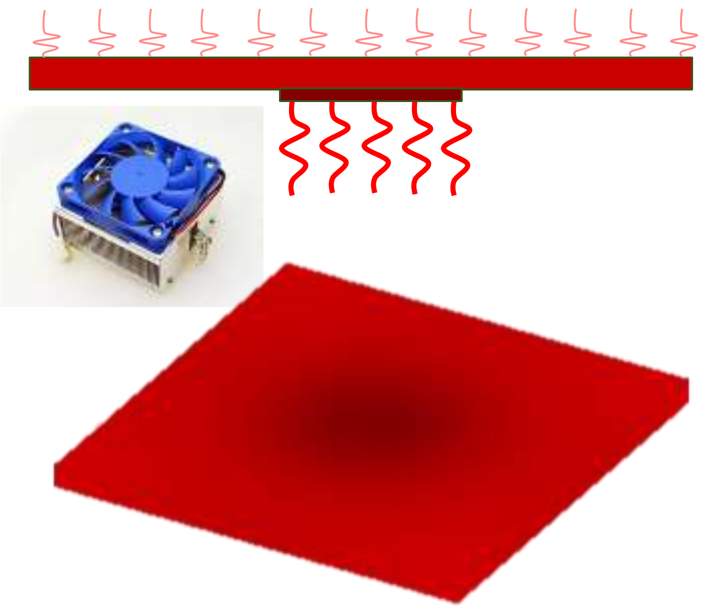
Optimising integrated heat spreaders with distributed heat transfer coefficients: A case study for CPU cooling

J.W. Elliott, M.T. Lebon, A.J. Robinson

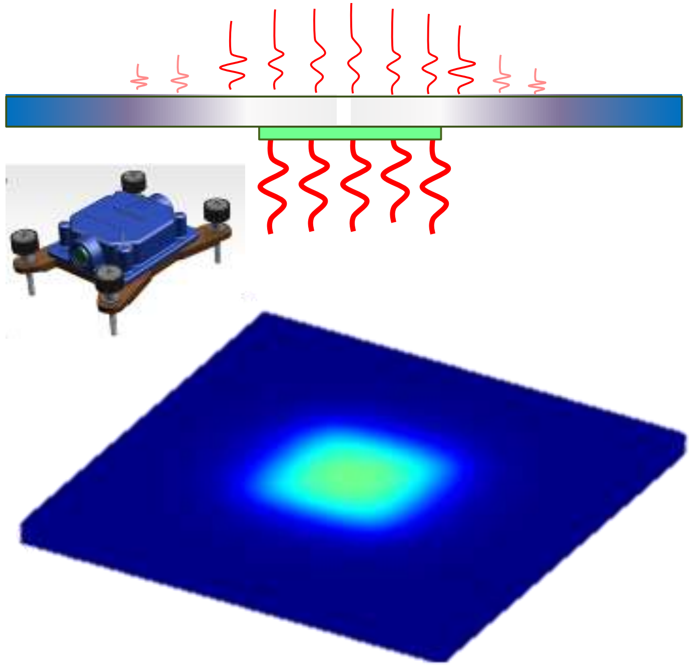
And there's more…

- As cooling intensity increases - **heat spreaders get progressively less effective** (a.k.a. conjugate heat transfer effect)
- But hydraulics dictates available coolant flow
- Thus, must use available coolant wisely - **targeted cooling**

Low Cooling Intensity



High Cooling Intensity



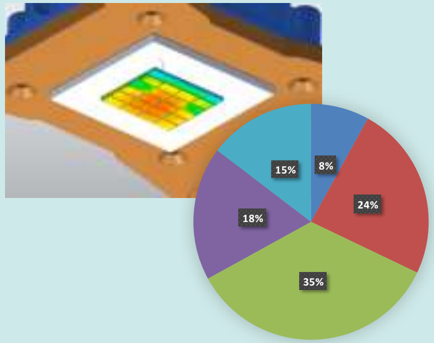
Hydraulics + Convection + Conduction → Holistic Design

Liquid Cooling Considerations

Diverse & rapidly evolving tech

+

Broad-spectrum design problem



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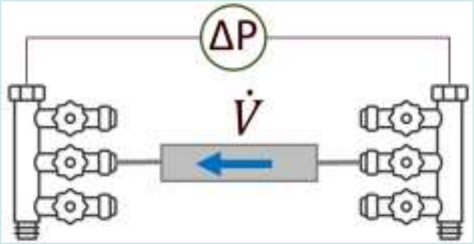
Thermal-hydraulic coupling



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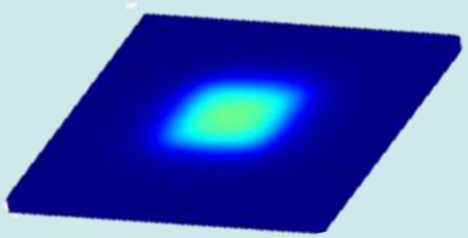
Rational use of coolant



What does tech need ?

- Design agility
- Low design cycle times
- High cooling intensity
- Low pressure drop
- Targeted cooling

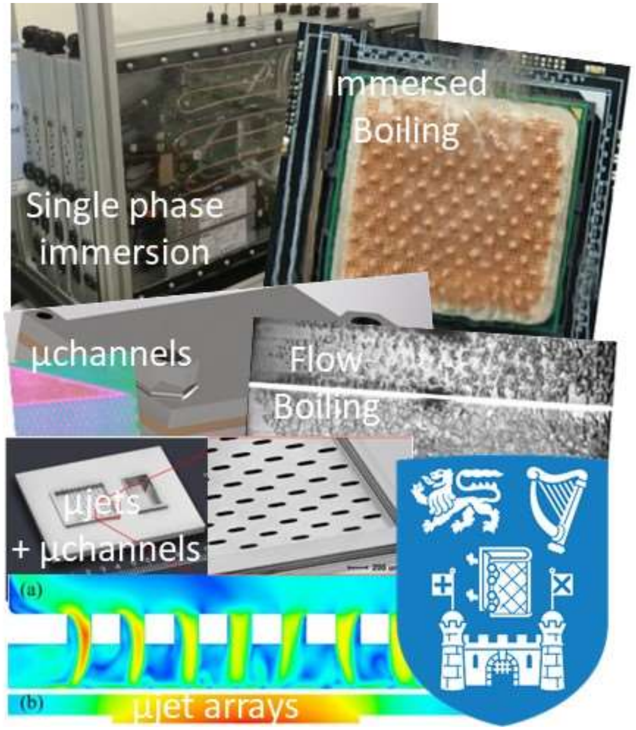
Potential Choices

- Single-Phase Immersion
- Two-Phase Immersion
- Forced Convective Boiling
- Single-Phase Microchannels
- Single-Phase Jet Array **Impingement**

How to Choose? → **Intensive R&D**

Extensive Experimental & Computational Research in:

- Boiling & Condensation
- Two-Phase Flow
- Heat Pipes & Vapour Chambers
- Thermoelectrics
- Thermal Interface Materials
- Microfluidic Heat Exchangers
- Thermal Materials
- Energy & Buildings
- Solidification
- …& more



Research Metrics

- H-index = 43
- Citations > 6,000
- Stanford/Elsevier World's Top 2% Scientists

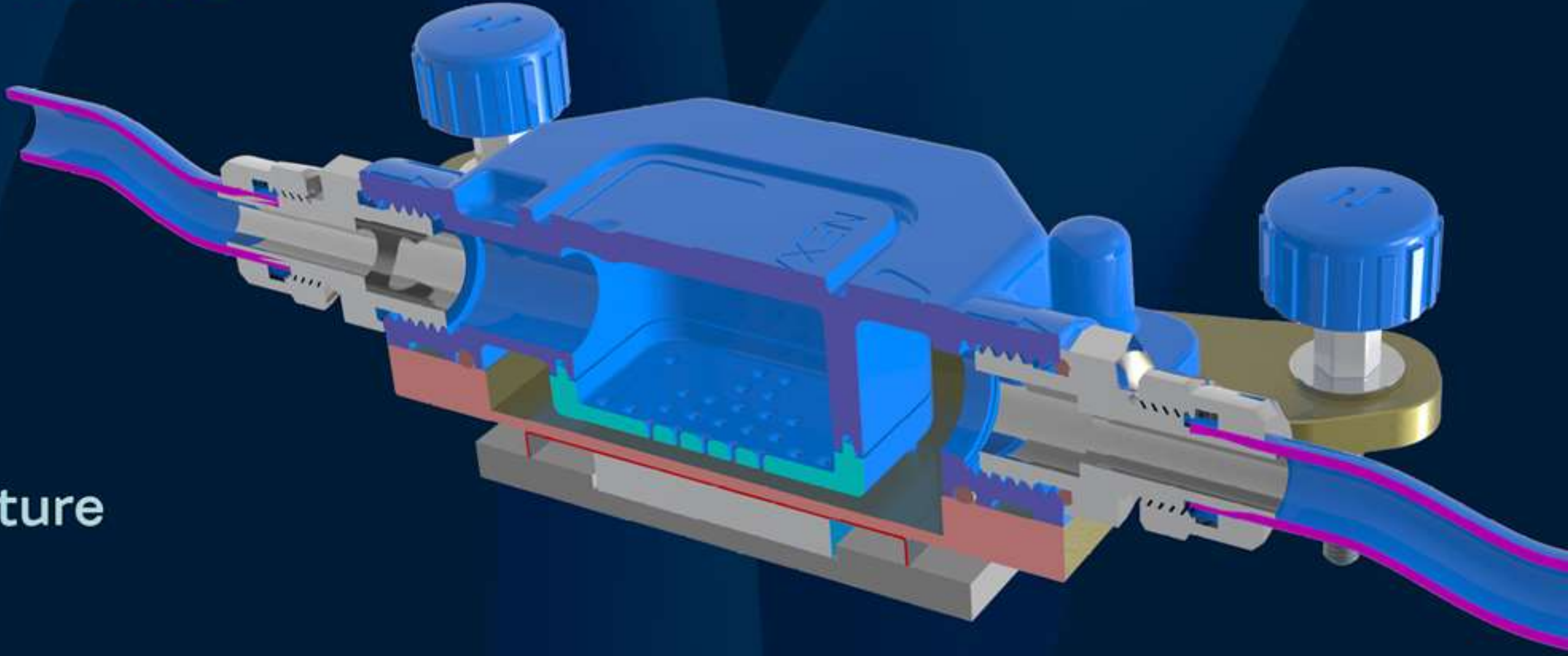
Google Scholar

Knowledge-Driven Down-Selection

			Design Agility	Design Cycle Time	Cooling Intensity	Target Cooling	Low Pressure Drop	Comment
Bath Cooling	Dielectric Fluid	**Single-Phase Immersion**	Red	Yellow	Red	Red	Green	-Very poor thermophysical properties of fluids -Extremely low flow velocities -Brute-force design with limited options
Bath Cooling	Dielectric Fluid	**Two-Phase Immersion**	Red	Yellow	Red	Red	Green	-Low cooling intensity when boiling dielectric fluids -Requires specialized/enhanced surfaces -Fully empirical design (non-deterministic)
Direct Liquid Cooling	Dielectric Fluid	**Forced Convection Boiling**	Yellow	Red	Yellow	Yellow	Green	-Moderate cooling intensity with specialized/enhanced surfaces -Fully empirical design (non-deterministic)
Direct Liquid Cooling	H2O-Based	**Single-Phase Microchannels**	Yellow	Green	Green	Red	Red	-Good cooling intensity but limited design options -Trivial & deterministic design but global cooling -High pressure drop
Direct Liquid Cooling	H2O-Based	**Single-Phase Jet Array Impingement**	Green	Green	Green	Green	Green	-Highest cooling intensity -Rapid, deterministic and agile design potential -Ideal for target cooling -Low pressure drop

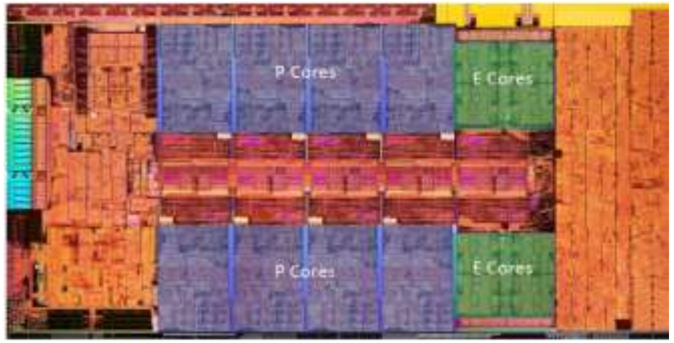
components / technology

jet impingement

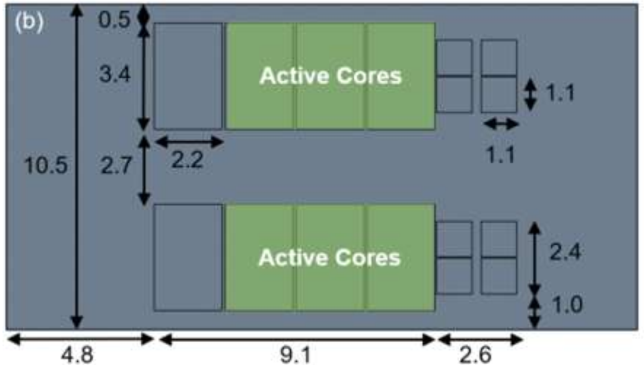


- Enhanced Heat Transfer
- Uniform coolant temperature
- Targeted Cooling
- Reduced Risk of Fouling
- Longevity and Reliability
- Effective Cooling of Non-Uniform Surfaces

The Test CPU → Intel Core i5-12600K



Die Shot



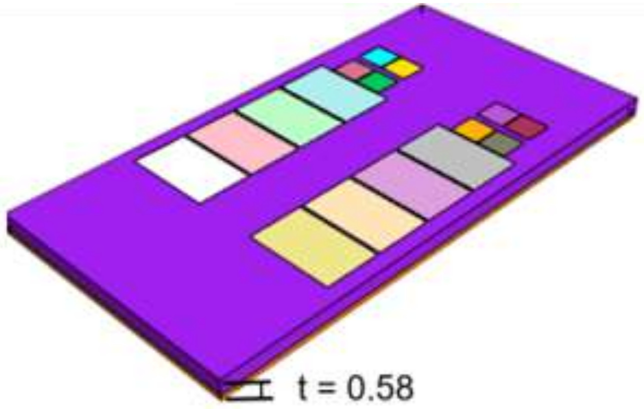
Digitized

Why This CPU?

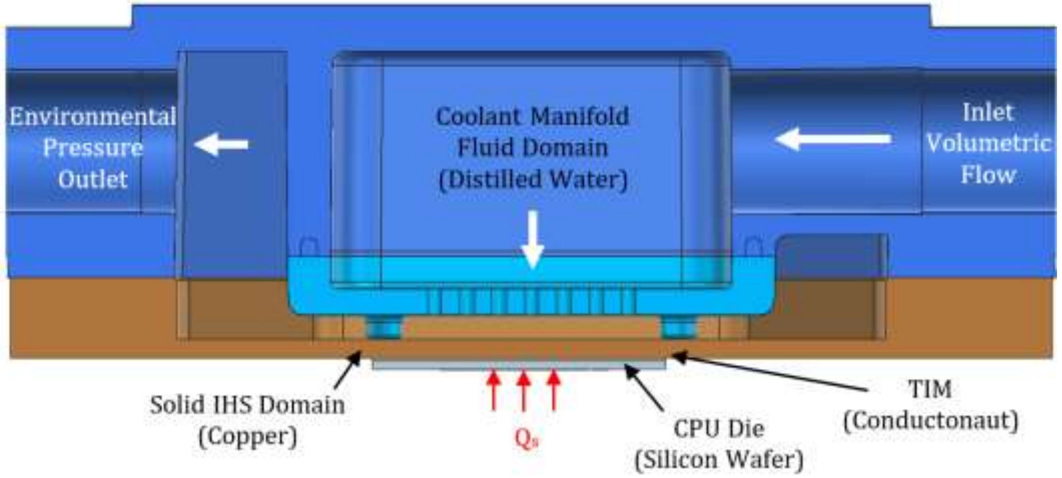
- TDP→125 W, Turbo → 150 W, **Overclocked → 210 W**
- 6 P-cores overclocked to 210 W → **Very tough to cool**;

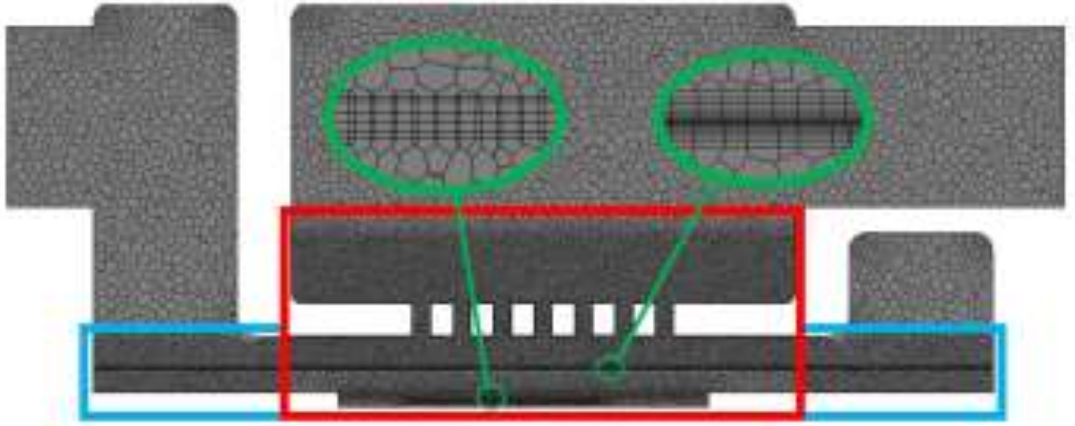
  Heat load highly concentrated, discrete sources & off-centre

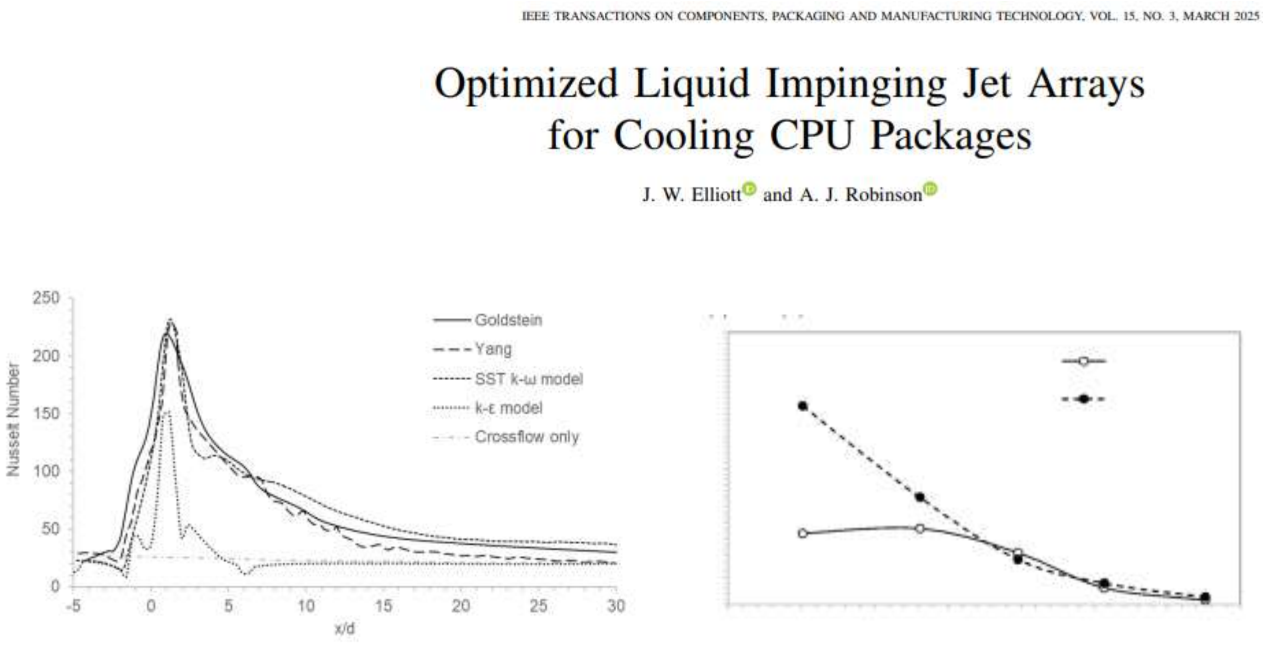
  Core-level heat flux ~**470 W/cm²!!**



Simulation & Validation






IEEE TRANSACTIONS ON COMPONENTS, PACKAGING AND MANUFACTURING TECHNOLOGY, VOL. 15, NO. 3, MARCH 2025

Optimized Liquid Impinging Jet Arrays for Cooling CPU Packages

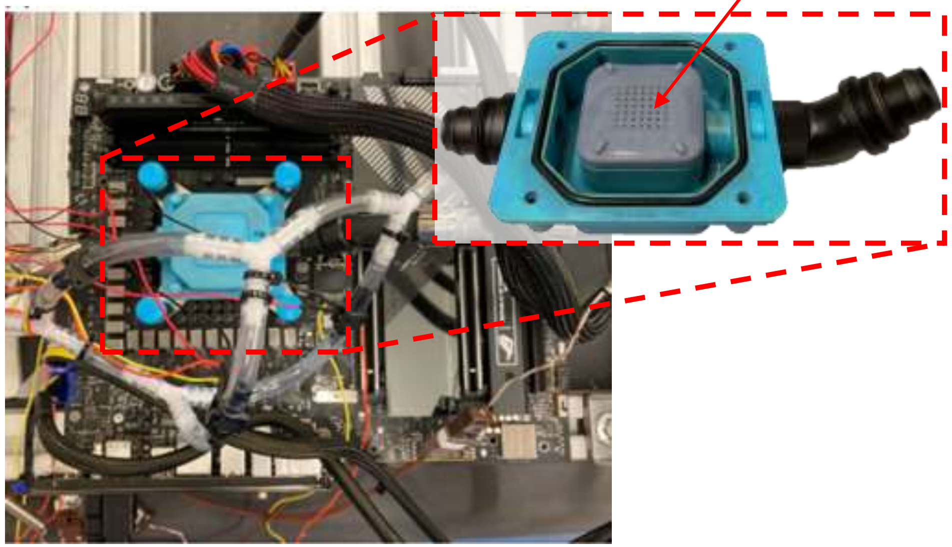
J. W. Elliott and A. J. Robinson

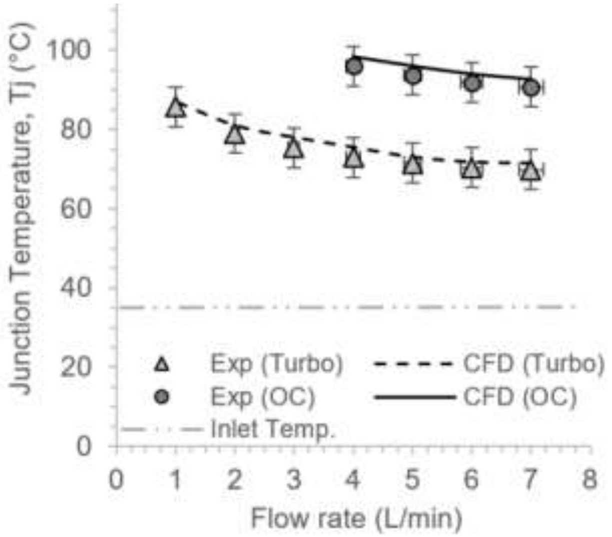
CFD Due Diligence

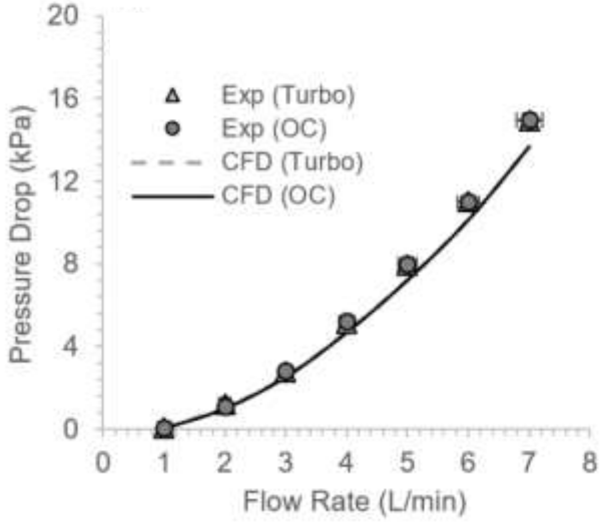
- Verified turbulence model (SST k-ω)
- Grid independent @3.1 million cells
- Converged RMS residuals < 1×10^{-6}
- etc…

Simulation & Validation

AM Prototyping



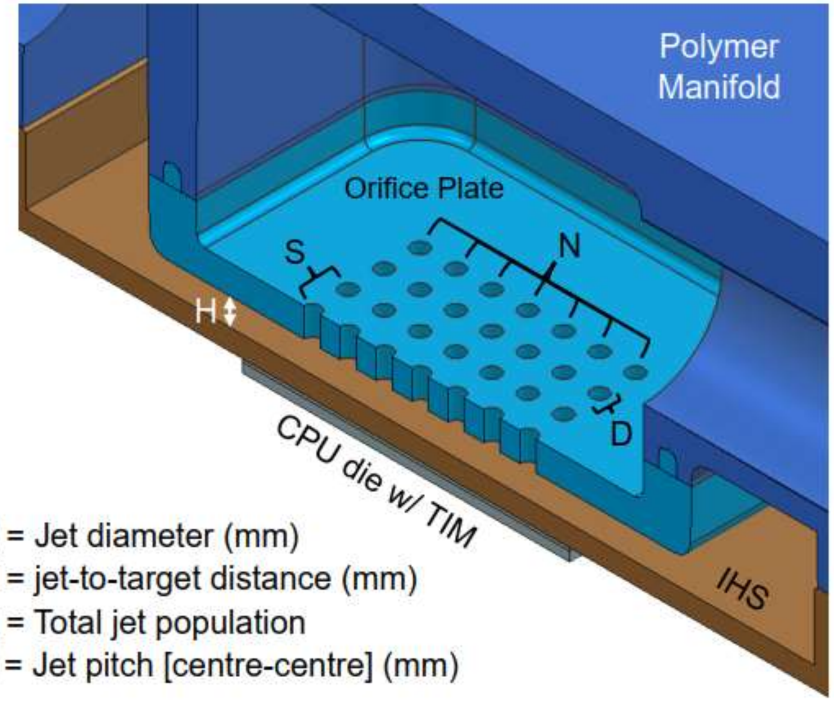




CFD Validation with Live CPU Testing

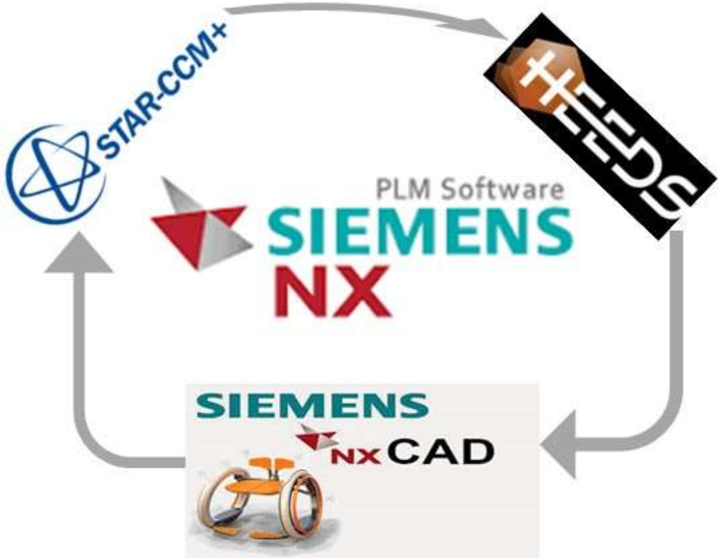
- CFD predicts thermals within exp. error
- CFD predicts hydraulics within exp. error
- **CFD validated** and thus **viable design tool**

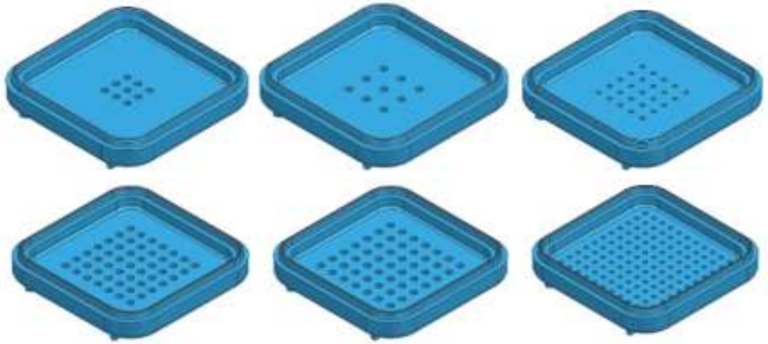
Automated Simulation-Driven Design Optimization



D = Jet diameter (mm)
H = jet-to-target distance (mm)
N = Total jet population
S = Jet pitch [centre-centre] (mm)

Parameter	Description	Unit	Range
S/D	Jet spacing ratio	-	1.17 – 6.5
H/D	Jet-target ratio	-	0.17 – 5.5
N	Jet population	-	9 - 169
D	Jet diameter	mm	0.5 – 1.5



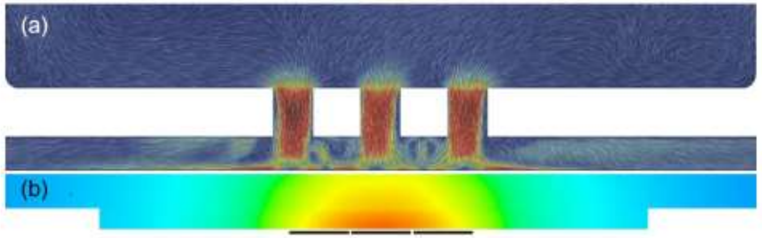


X 150

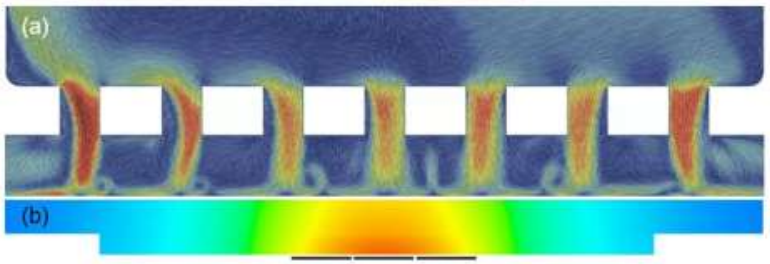
(~2 weeks on workstation)

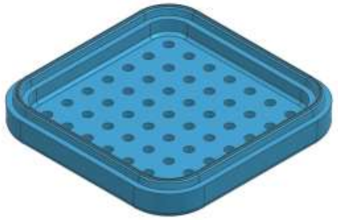
Simulation & Validation

Single-Objective Optimized

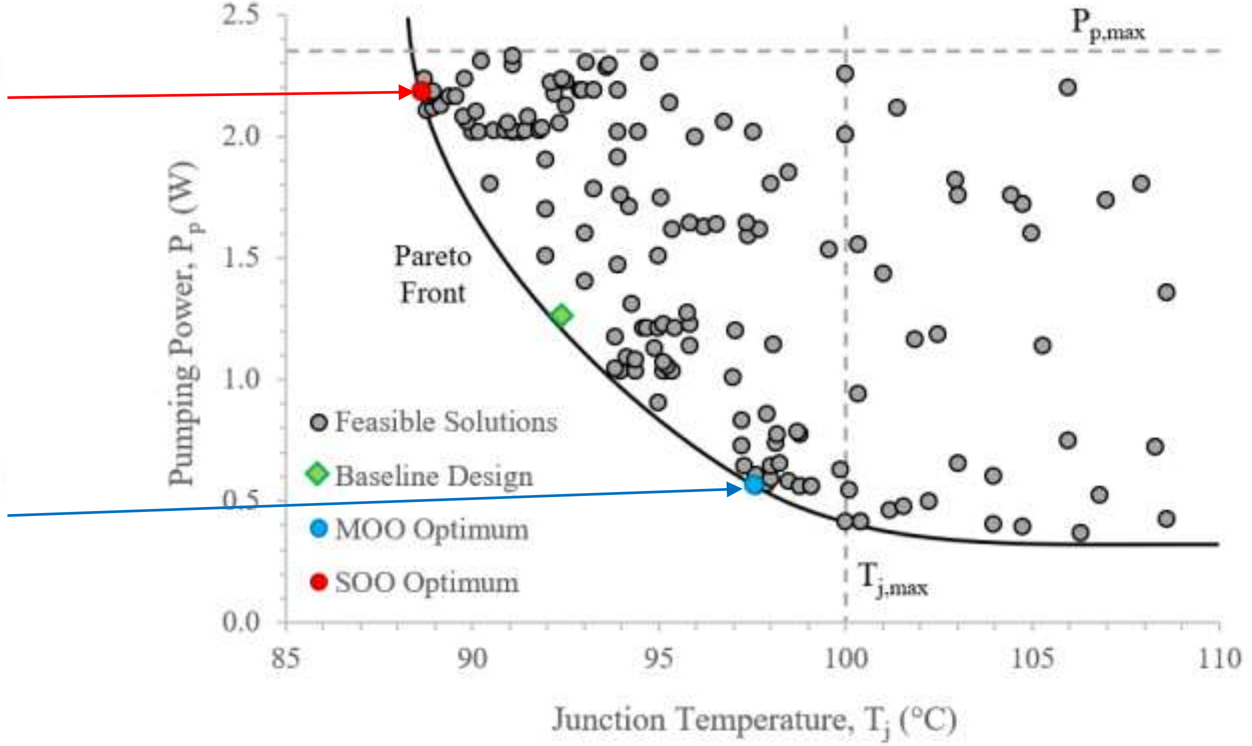


Multi-Objective Optimized





Pareto Plot

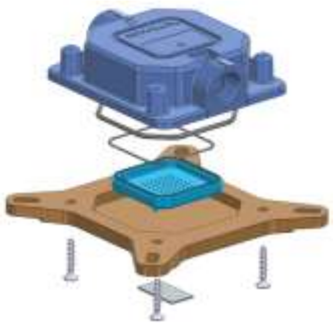


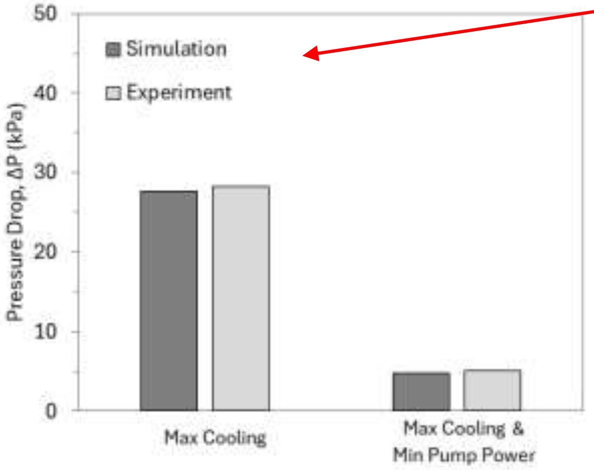
Core-Level Optimized Designs for:

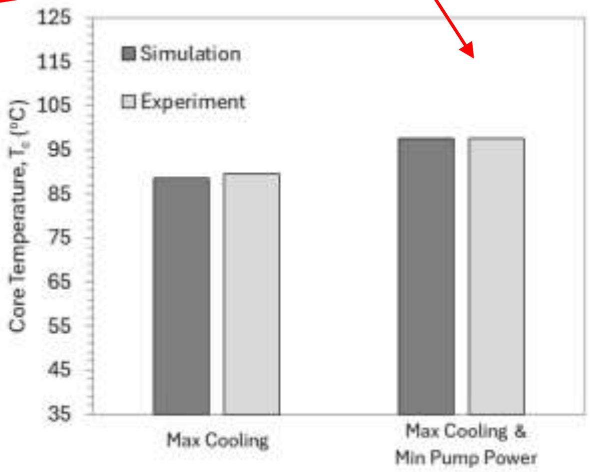
- Specific fluid delivery scenario
- Tailored cooling of specific processor
- **Minimum hydraulic penalty and/or maximum cooling**

Summary → **Problem-To-Product Design Workflow**

Platform Technology + *Specific Processor* + *Automated Design Optimization* + *Application/Customer Specific Designs* + *Experimental Verification*







- ☑ **Agile Design Workflow**
- ☑ **Rapid Design Cycle Time**
- ☑ **Very High Cooling Intensity**
- ☑ **Target Cooling Enabled**
- ☑ **Low Hydraulic Penalties**

Coolant Temperature of 35°C

Nexalus Cold Plate:

Example Design Architecture Overview

Upper Housing

- Contains fluid inlet and outlet ports
- Houses internal stagnation chamber to create uniform pressure above jet orifice array(s)
- Pressure equalization ensures uniformity of high velocity jets across entire array

Jet Orifice Plate

- Polymer insert between upper housing and baseplate
- Contains array of jet orifice nozzles
- Nozzles and array pattern designs optimized for specific processor using CFD

Baseplate

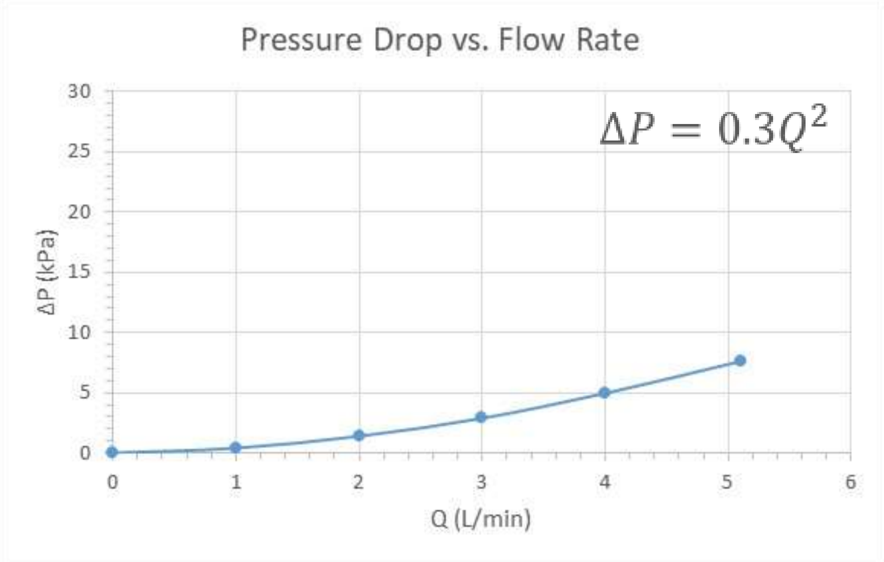
- Typically nickel-plated copper or aluminium
- Target cooling plate with processors mounted on bottom side and jets impinge on upper side
- Jets can impinge into cylindrical wells for enhanced heat transfer in jet impingement zone if required
- Miniature pin fins or other surface features can be included to enhance heat transfer in jet-peripheral region with minimal additional hydraulic penalty

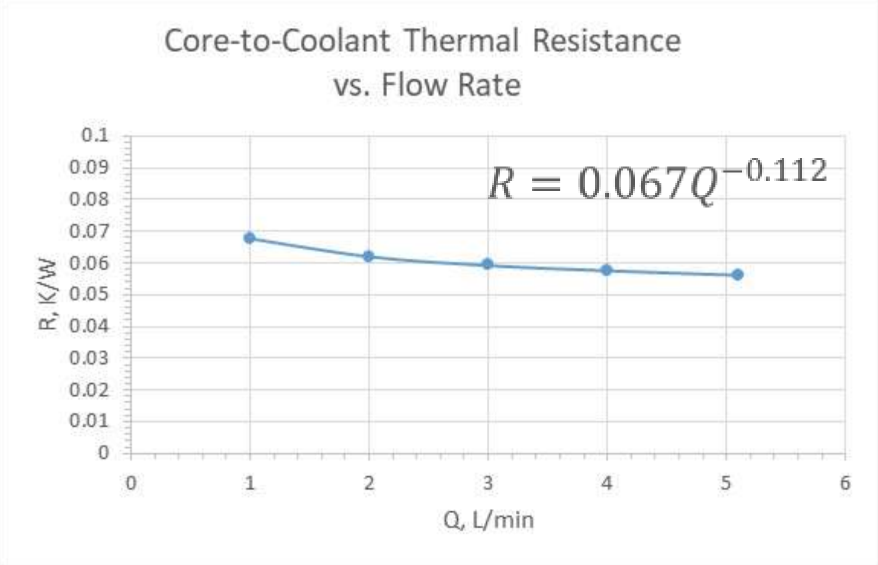
Nexalus Cold Plate:

For AMD EPYC 9474F

General Description

- Polymer or metal upper housing
- Polymer jet orifice plate
- 57 inline jets: 1.0 mm diameter, 3.2 mm pitch, with core-targeting design
- Nickle-plated copper baseplate
- 520 inline square pin fins





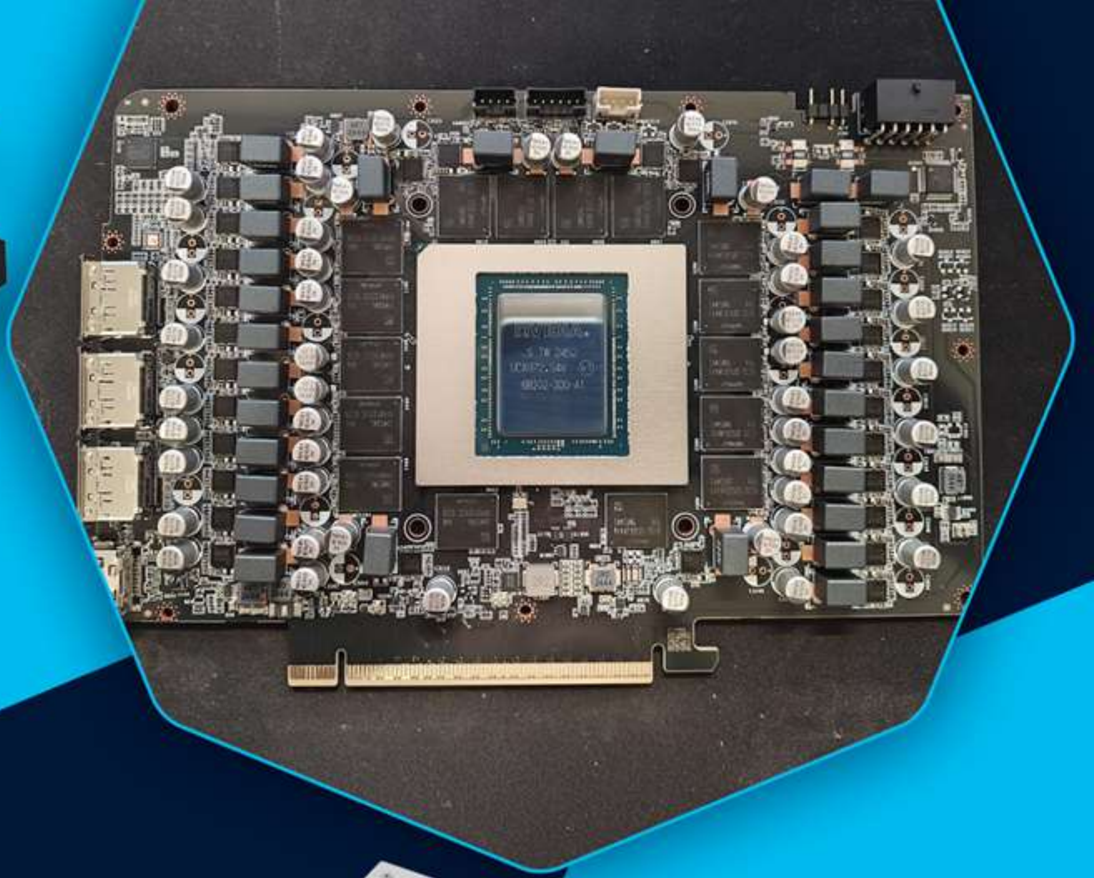
nexalus cold plates

AMD RYZEN THREADRIPPER 3990X
64 CORE RUNNING AT 4.9GHZ
820W 90C MAX. 280 W TDP

INTEL SAPPHIRE RAPIDS
OVERCLOCKED TO 920 W
FROM 350 W TDP

PRELIMINARY TEST RESULTS FOR DLC OF INTEL® XEON® W9-3495X PROCESSOR	
FLOW RATE (L/m)	5.6
INLET T (°C)	21
AVERAGE CORE TEMPERATURE (°C)	68
CPU PACKAGE TEMPERATURE (°C)	76
TOTAL PACKAGE POWER (W)	920

SoloFlux



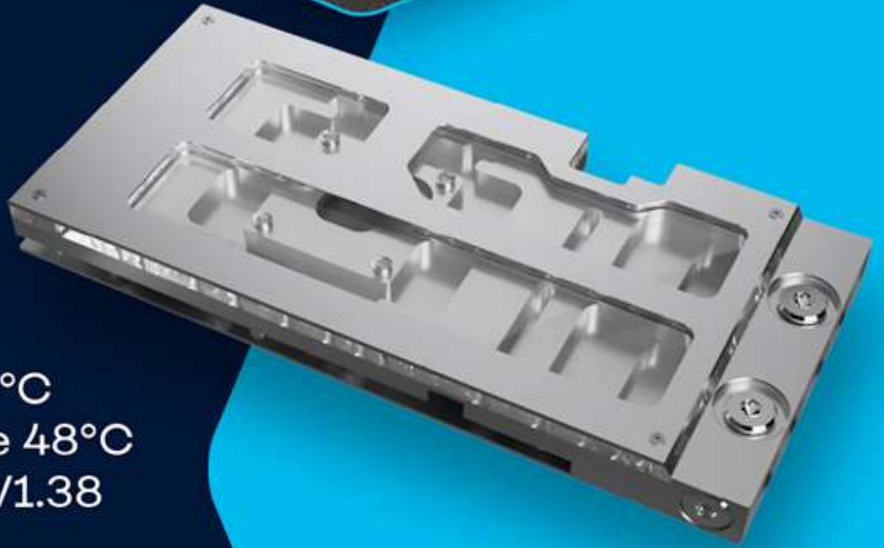
NVIDIA GeForce RTX 4090

Reference DLC tests on the Nvidia GeForce RTX 4090 were performed using the Nexalus SoloFlux heat exchanger. The GeForce It was tested in an ASUS Pro WS W790-ACE board and stressed using FurMark to assess GPU performance full load.

This stress test produced a very high GPU power of 445 W. At full GPU power an average core temperature of 36oC was achieved for flow rate of 4.8 L/min with associated pressure drop of 23 kPa and hydraulic power of 1.8 W.

NVIDIA GeForce RTX 5090

460 W power draw,
GPU temperature 39°C
Memory temperature 48°C
Stress test Furmark V1.38



8PACK Supernova MK3

Extreme overclocked PC designed and tuned by the world-famous 8Pack

Equipped with AMD Ryzen Threadripper Pro 7995WX CPU, boasting 96 cores and 192 threads

NVIDIA GeForce RTX 4090 GPUs, each with a dedicated Nexalus SoloFlux water block

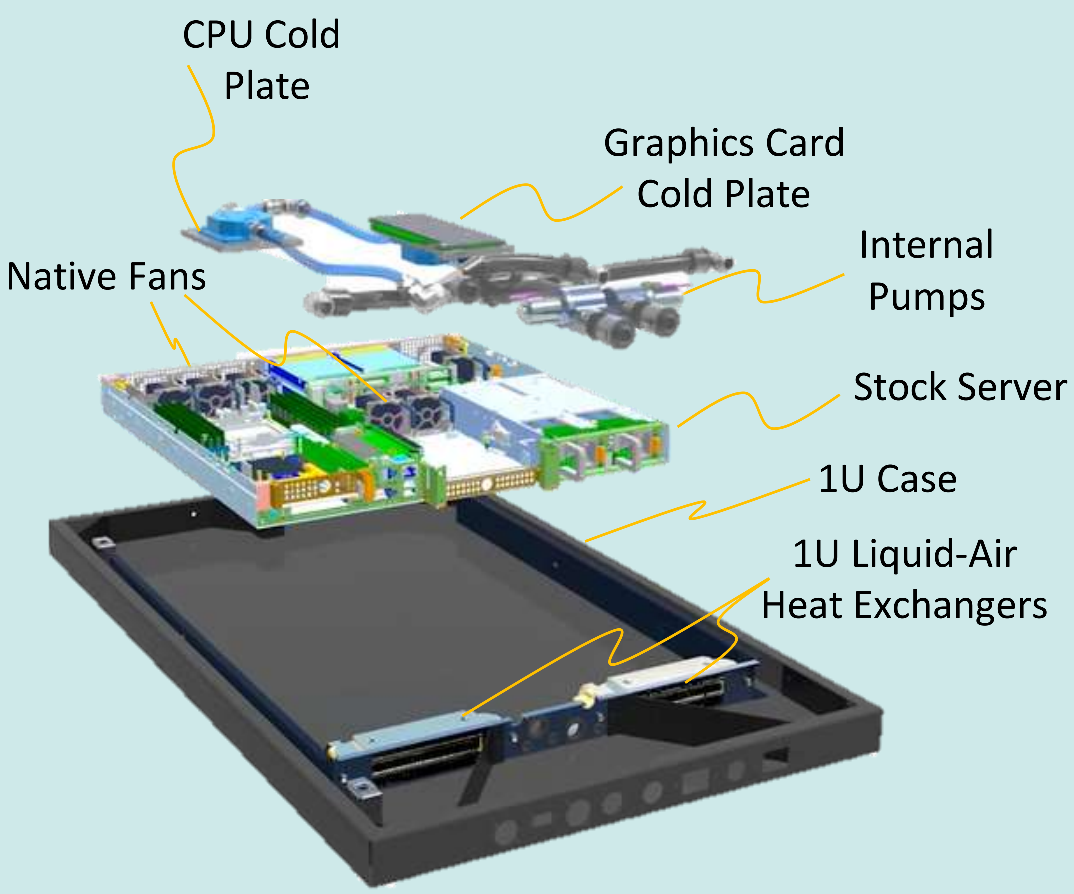
512GB 5600MHz DDR5 quad-channel memory

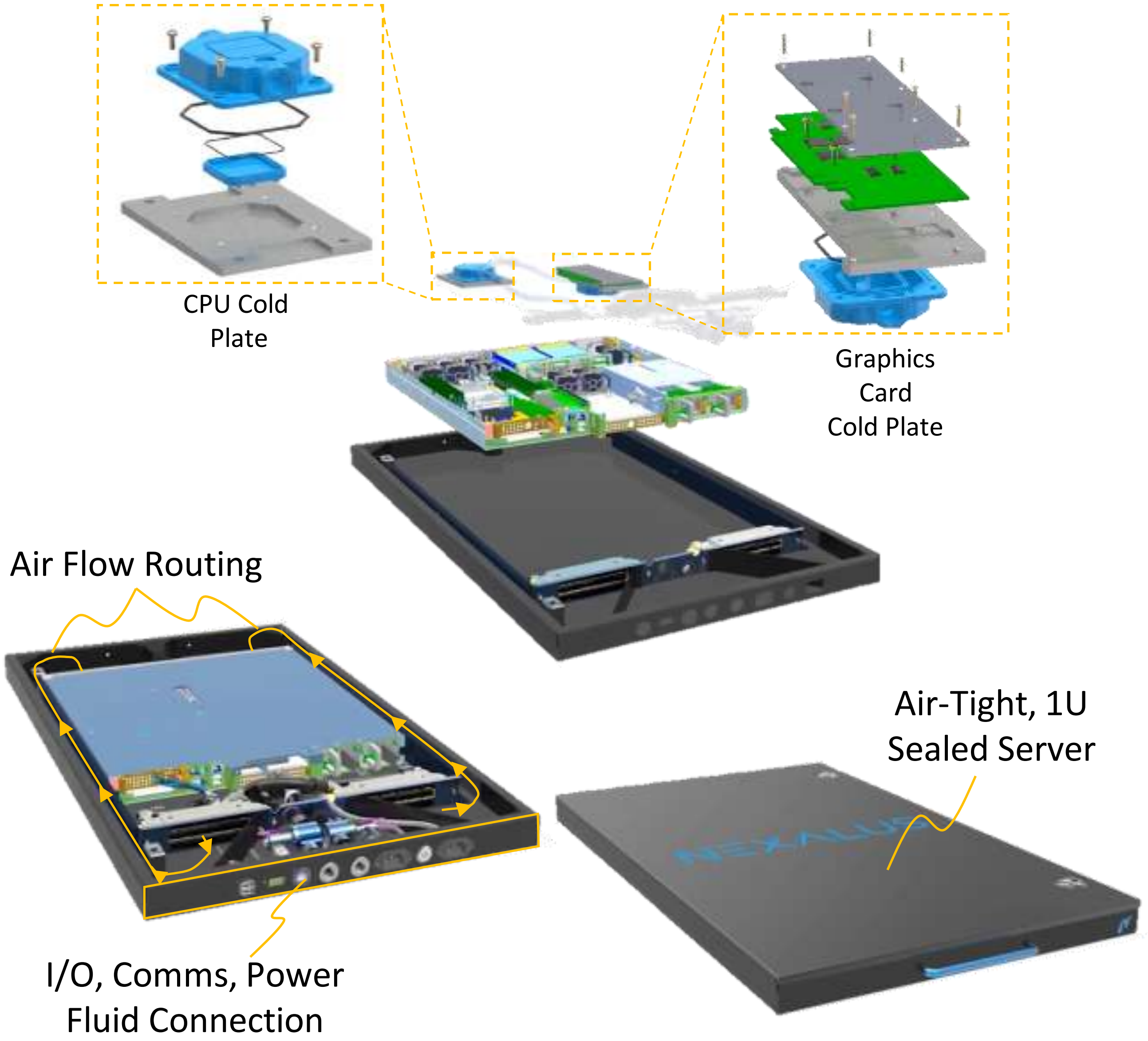
Phenomenal 24TB total storage

...all made possible thanks to custom Nexalus water-cooling

the solution

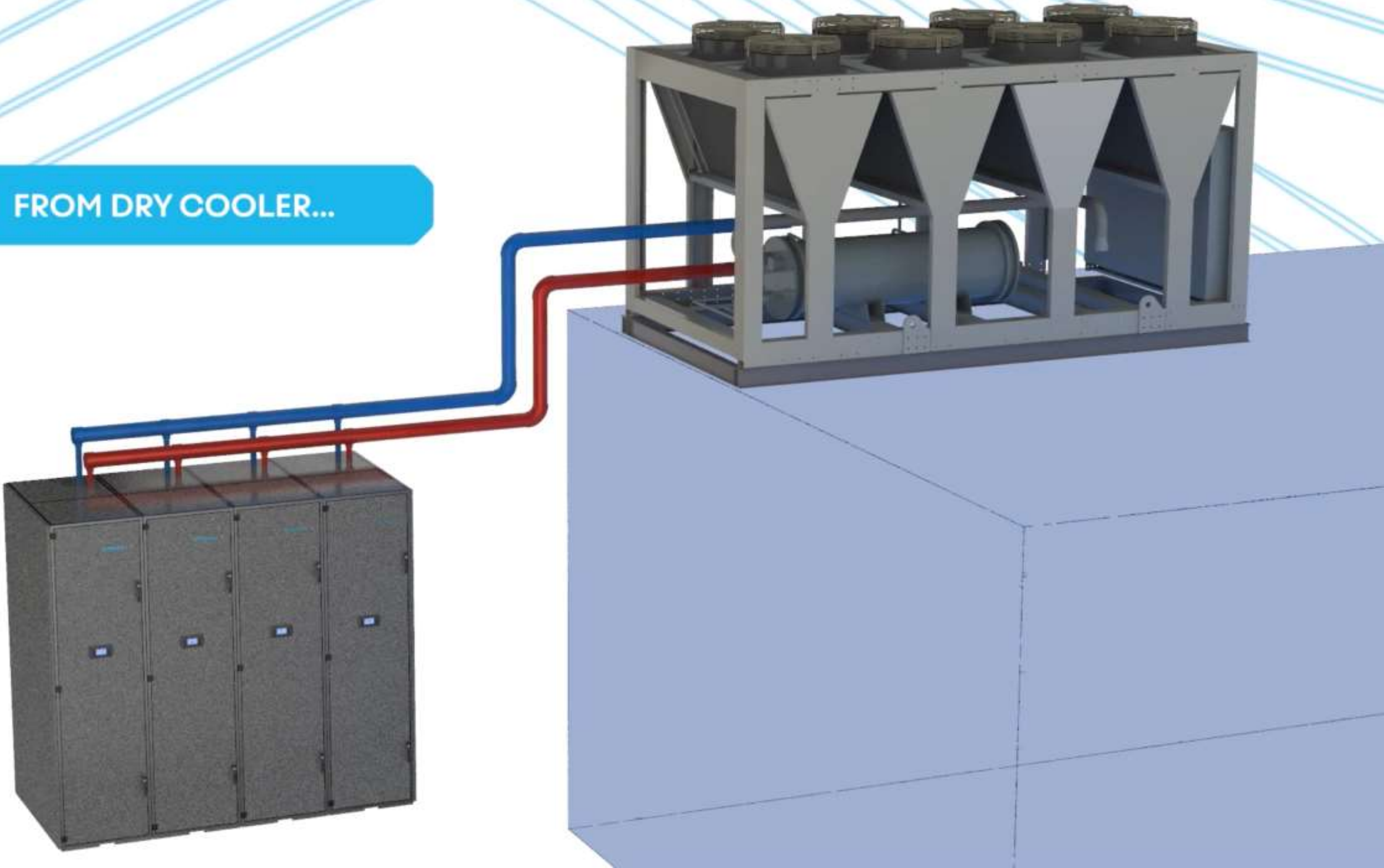
Our Cooling Solution





showcases

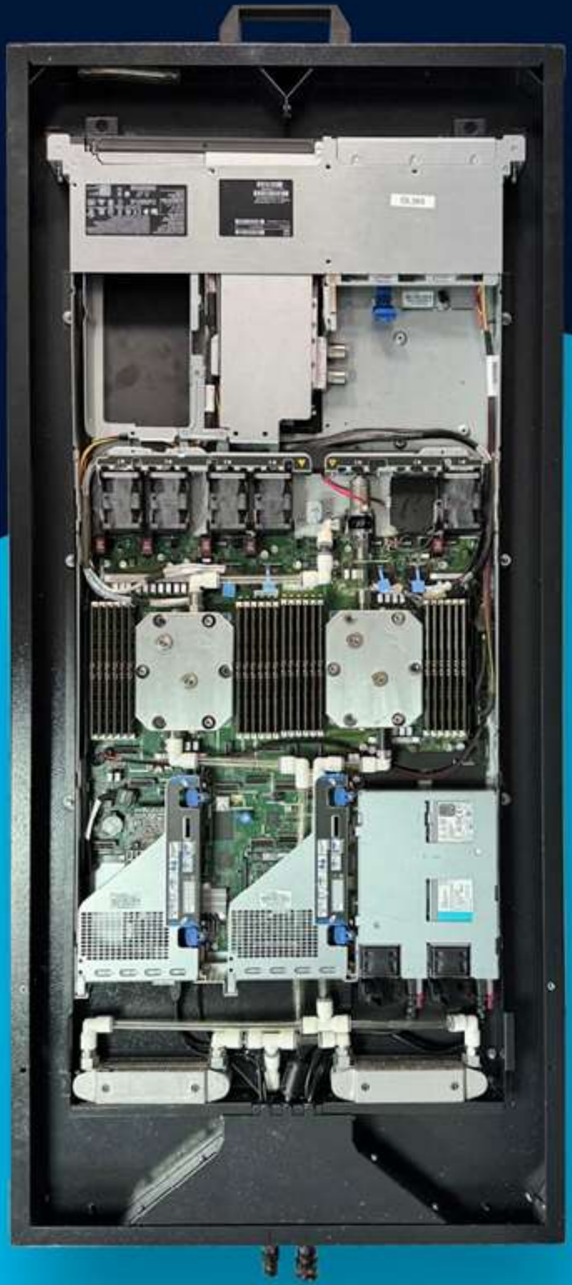
FROM DRY COOLER...



Hewlett Packard Enterprise

ProLiant DL365 Gen11

CPU	2 x AMD EPYC 9124 (200W TDP), 16 cores, 64 MB L3 cache, 3 GHz
GPU	Nvidia A16 (150W TDP)
MEMORY	DDR5 EC8 RDIMM 16gb-1Rx8-PC5-4800B, 24 memory slots
PSU	2 x 1000 w Power Supplies
COOLING	Liquid Cooling (Closed Loop) with fluid volume of 300 ml (One time fill)
INFRASTRUCTURE MANAGEMENT	HPE iLO Standard with intelligent provisioning, HPE OneView Standard (optional HPE iLO Advanced, OneView Advanced, HPE GreenLake COM)



Hewlett Packard Enterprise

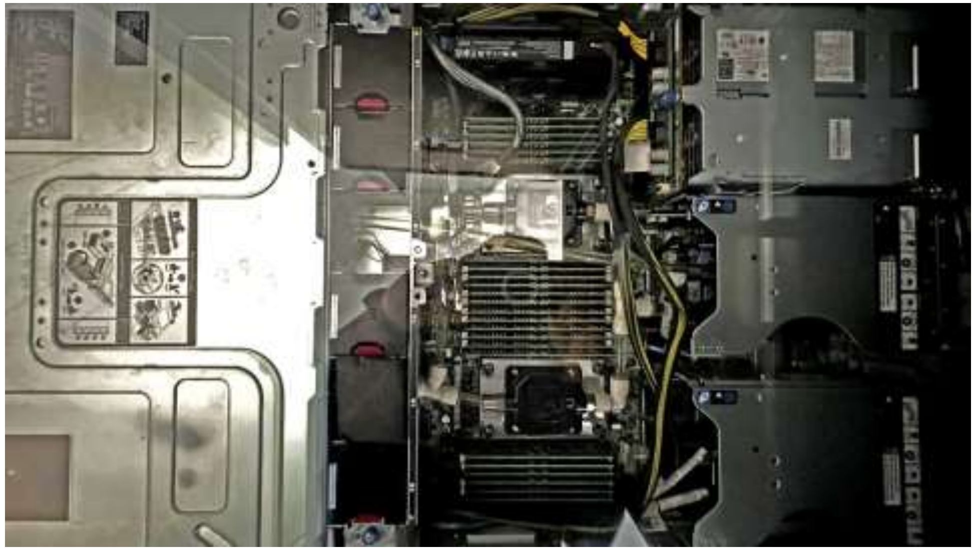
ProLiant DL380a Gen11

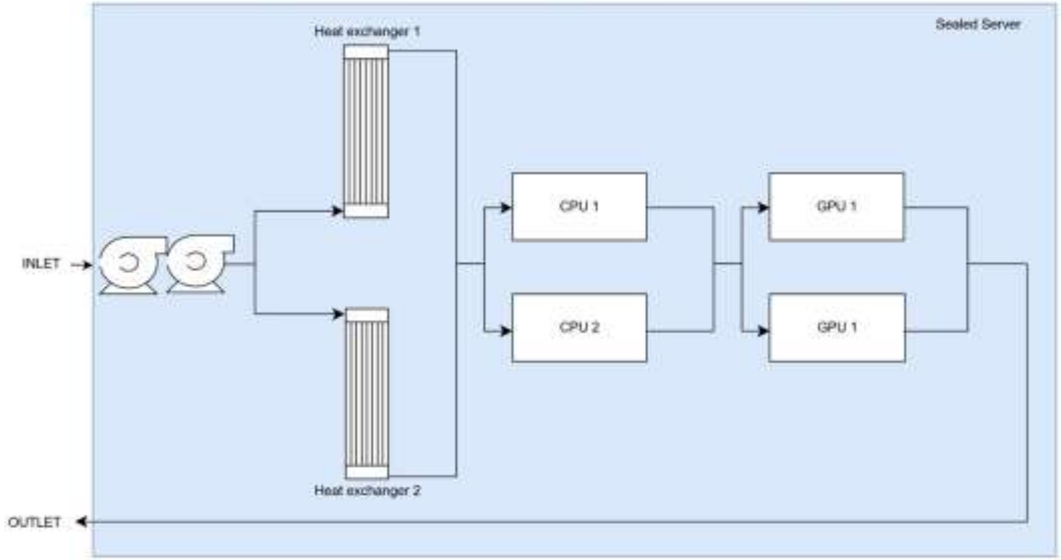
CPU	2 x Intel Xeon Silver 4416 (165W TDP), 20 cores, 37.5 MB L3 cache, 2 GHz
GPU	Nvidia L40 (250W TDP)
MEMORY	DDR5 EC8 RDIMM 16gb-1Rx8-PC5-4800B 24 memory slots
PSU	4 x 2200 w Power Supplies
COOLING	Liquid Cooling (Closed Loop) with fluid volume of 400 ml (One time fill)
INFRASTRUCTURE MANAGEMENT	HPE iLO Standard with intelligent provisioning, HPE OneView Standard (optional HPE iLO Advanced, OneView Advanced, HPE GreenLake COM)

Nexalus Sealed Server:

HPE ProLiant DL380 Gen11

Thermal performance for T_{inlet}=31°C				
	NAME	QTY	Power, W	$T_{core,avg}$,°C
SERVER	HPE ProLiant DL380 Gen11		1106	
CPU	Intel Xeon Silver 4416	2	165	40
GPU	L40	2	278	51
DIMMs	DDR5 ECC RDIMM, 16 GB (1Rx8) PC5-4800B	24	15	40
Hydraulic performance				
	NAME	QTY	Flow rate, L/min	Total pressure drop, kPa
PUMP	NXP20	1+1 redundant	2	4.5

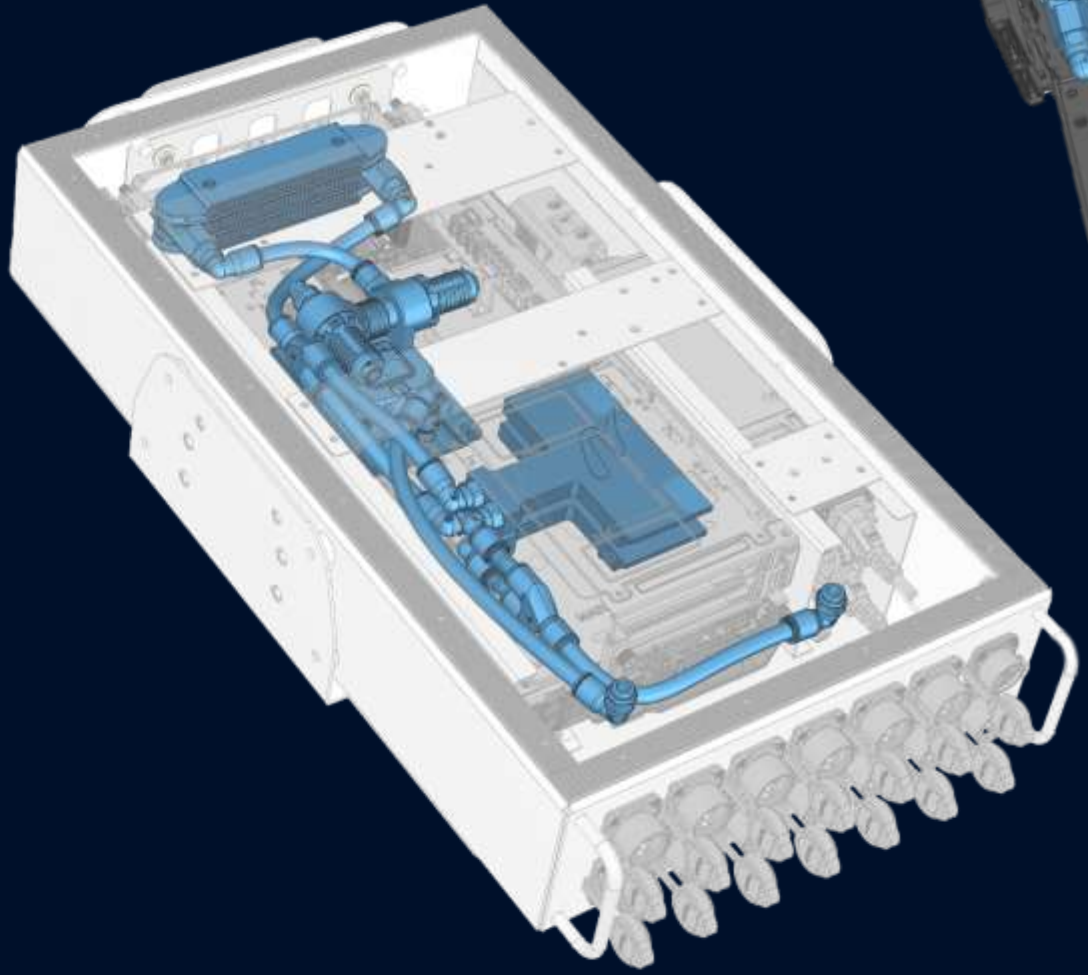


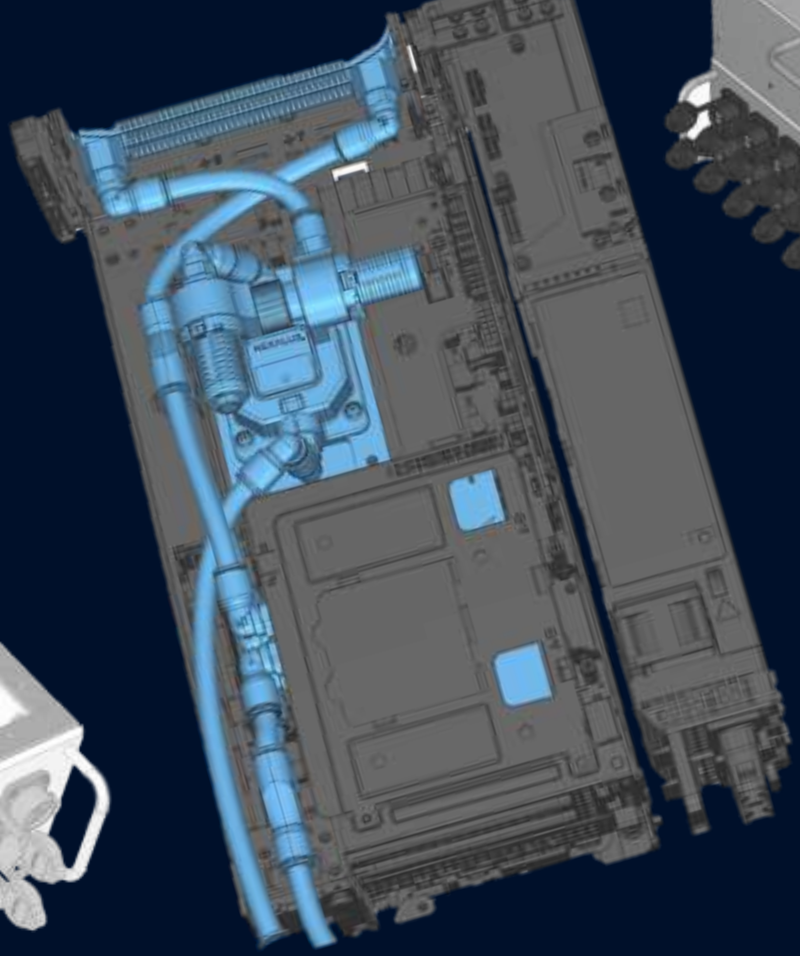


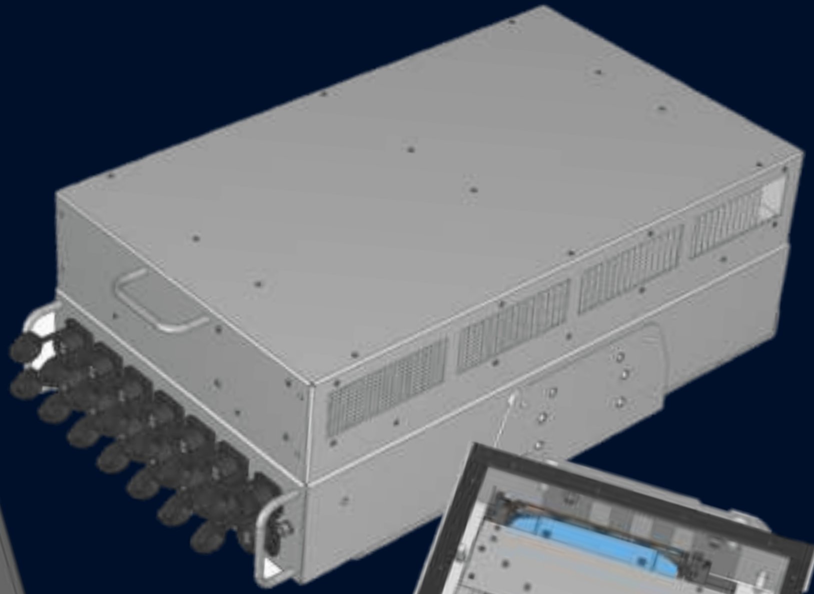
green data centers

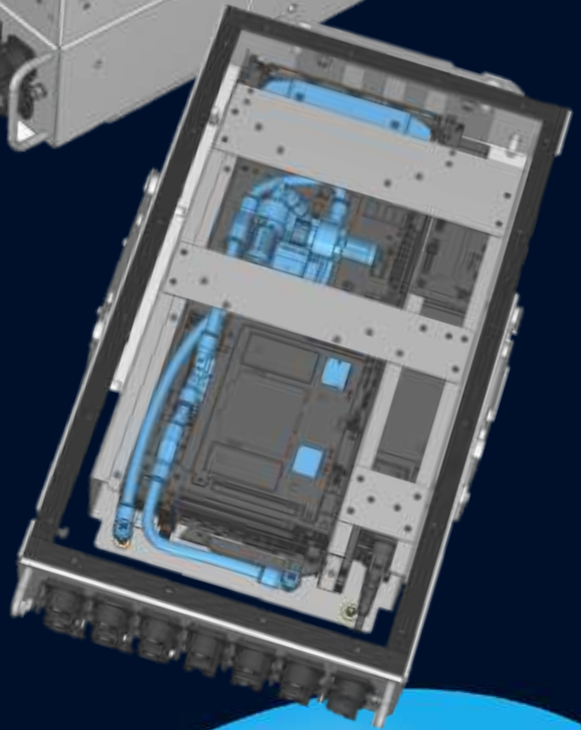
Edge Deployment

Nexalus Endeavor DX-820









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