

MAKING LIQUID COOLING AWARE OF ITS OWN HEALTH:

From Reliable Fluid Networks
to Intelligent, Self-Diagnosing
AI Infrastructure

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MARKET SIZE & GROWTH:

A \$27B+ OPPORTUNITY BY 2033

KEY LIQUID COOLING MARKET METRICS

20% | 31.5% CAGR

Consistent growth across all 3 independent research forecasts

\$18.8B | \$29.5B

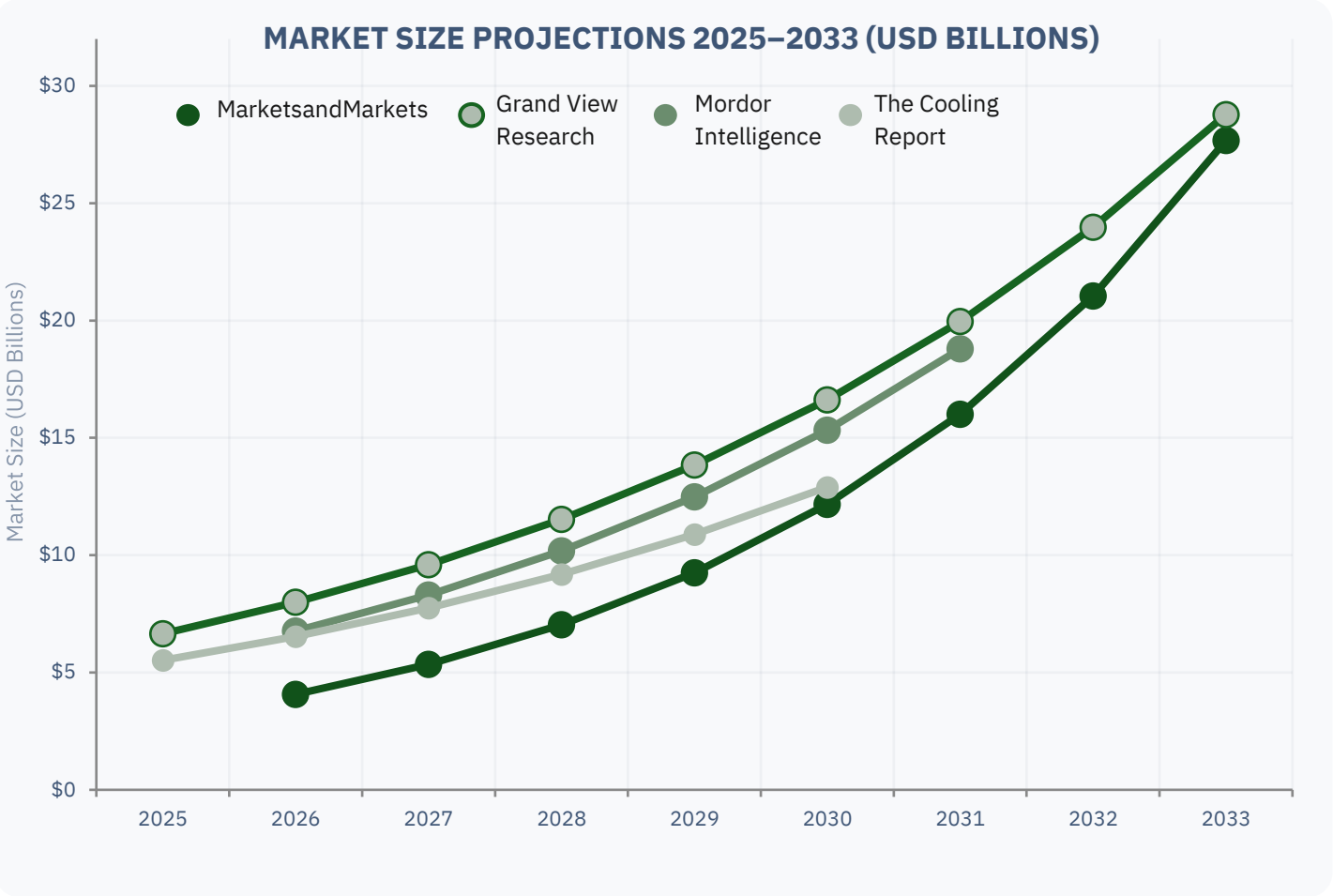
Projected market size by 2031 | 2033

China: 32% share / +90% YoY

2.8 GW new liquid cooling capacity added in 2025

Direct-to-Chip: \$1.96B

2024 sub-market size / 19.7% CAGR / driven by NVIDIA GB200 & next- gen GPU deployments



All market studies predict significant growth of the liquid cooling market

Sources: MarketsandMarkets (2024) | Grand View Research (May 2025) | Mordor Intelligence (2025) | The Cooling Report (Dec 2025) | Grand View Research Direct-to-Chip Report (May 2025); Blended forecast based on published CAGR projections from three independent research firms

AI IS CHANGING THE THERMAL EQUATION.

>\$1T

Global DC Capex Forecast 2026

1000W+

GPU TDP Escalation (per chip)

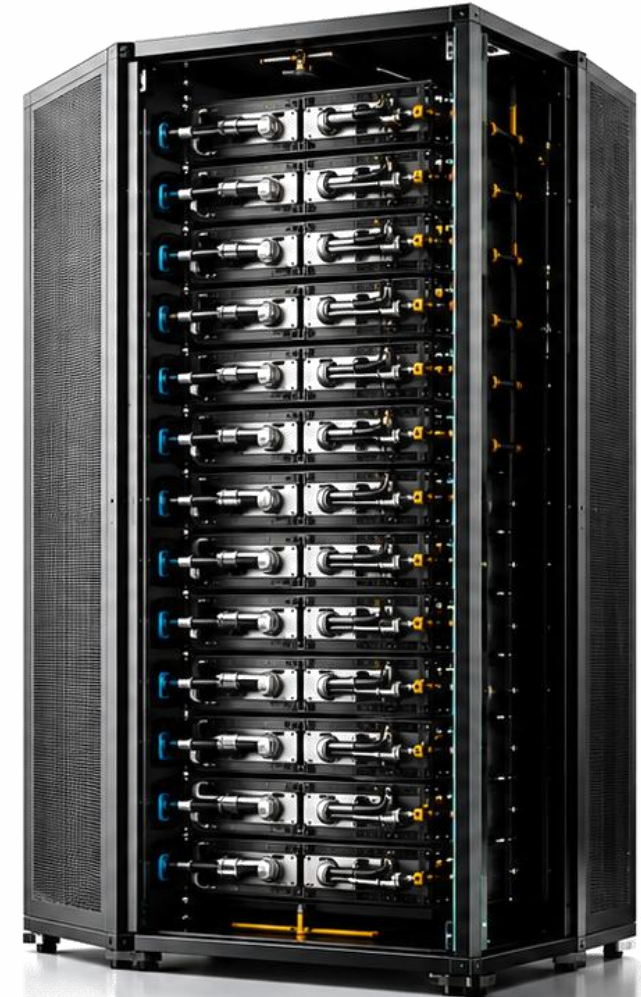
5-20 → 50-300 kW

AI Rack Power Density (peak)

→ far beyond air-cooling limits.

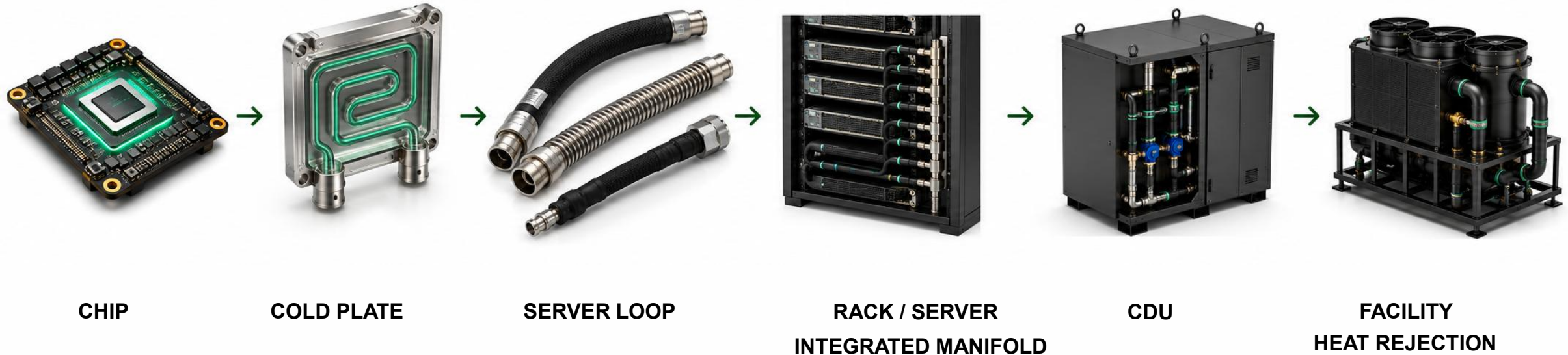
14%→33%

Liquid Cooling Adoption in AI DCs
(between 2024 and 2025)



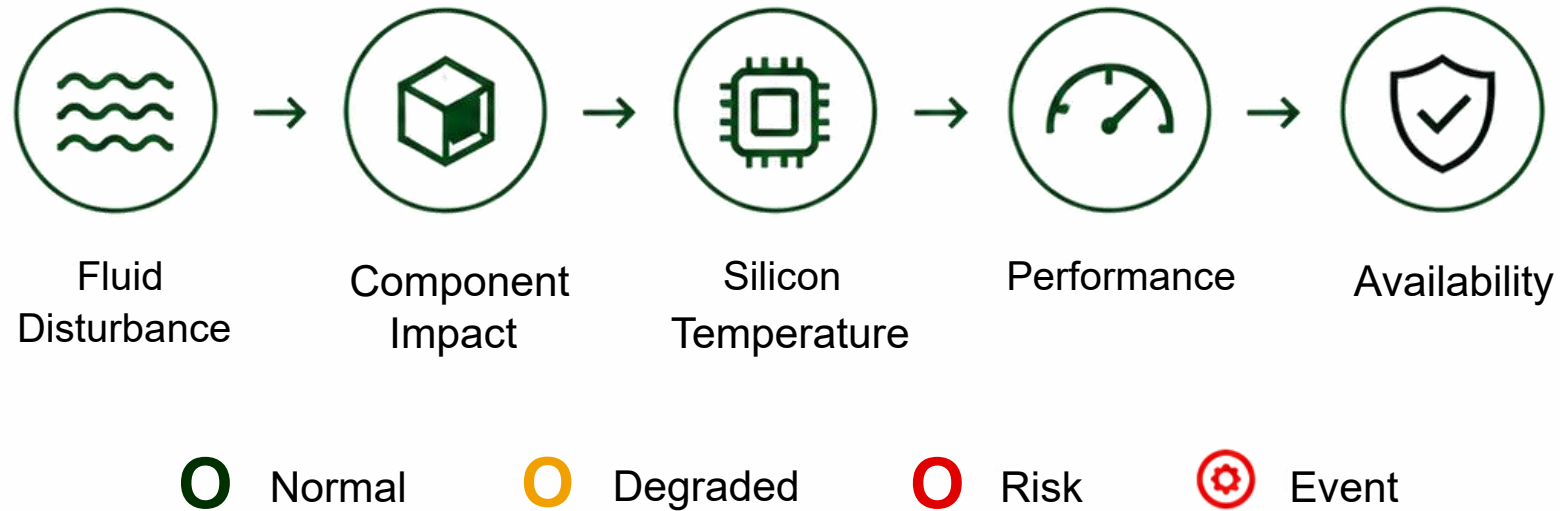
AI-class rack power is redefining the thermal equation.

LIQUID COOLING IS BECOMING PART OF THE COMPUTE ARCHITECTURE.



One continuous loop. Shared responsibility. System consequence.

A LOCAL DISTURBANCE CAN BECOME A COMPUTE EVENT.

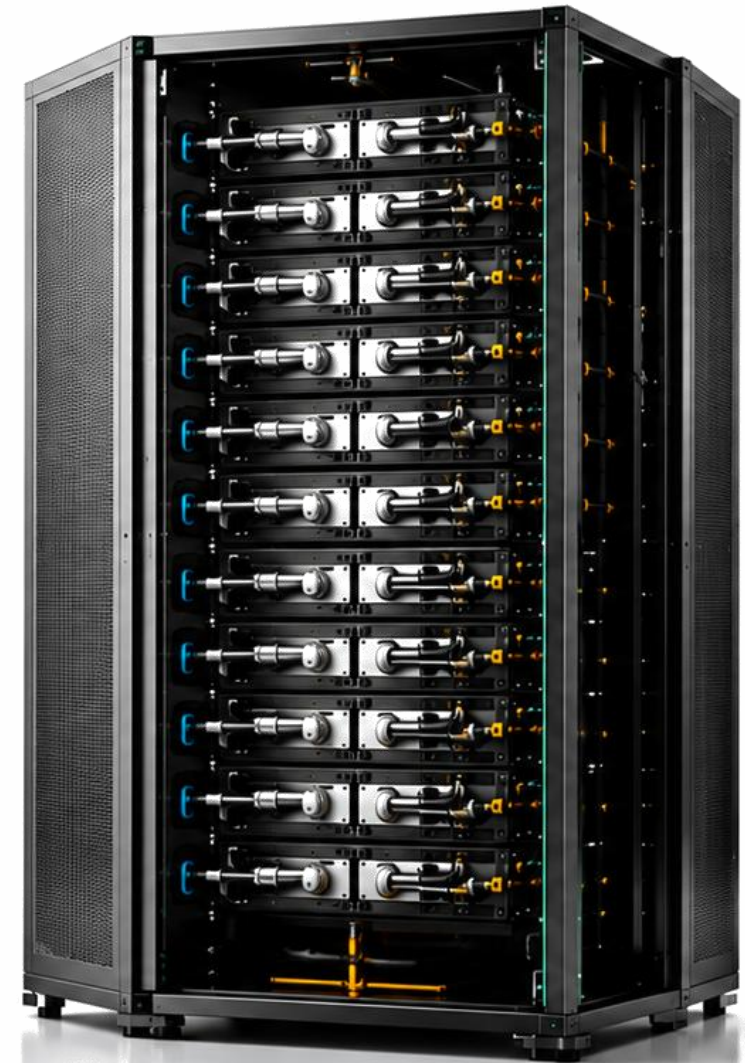


A local disturbance can escalate into a compute-level event.

COOLING HARDWARE CANNOT EXPLAIN ITSELF.

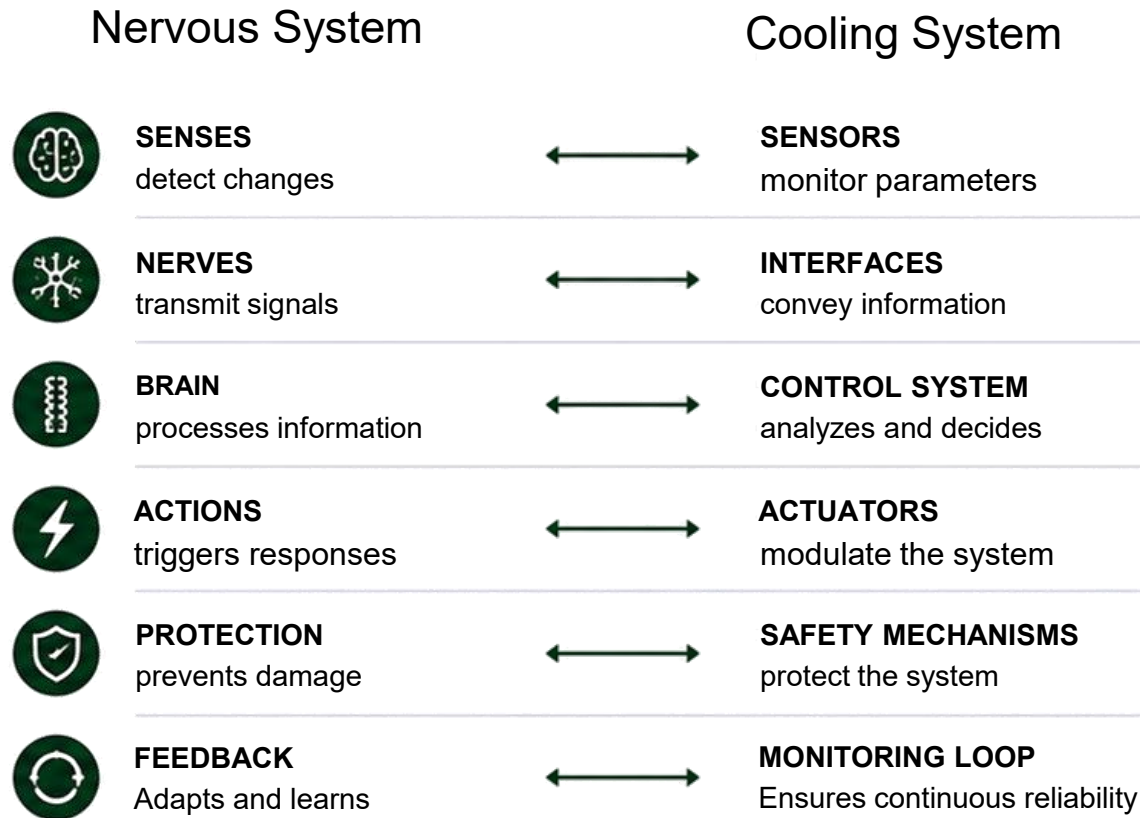
- ① Is the cooling reaching every branch?
- ② Is a restriction forming?
- ③ Is a leak beginning?
- ④ Is the pump changing condition?
- ⑤ Is coolant quality degrading?

Without perception and intelligence,
the system runs—but much of its
condition remains unknown.



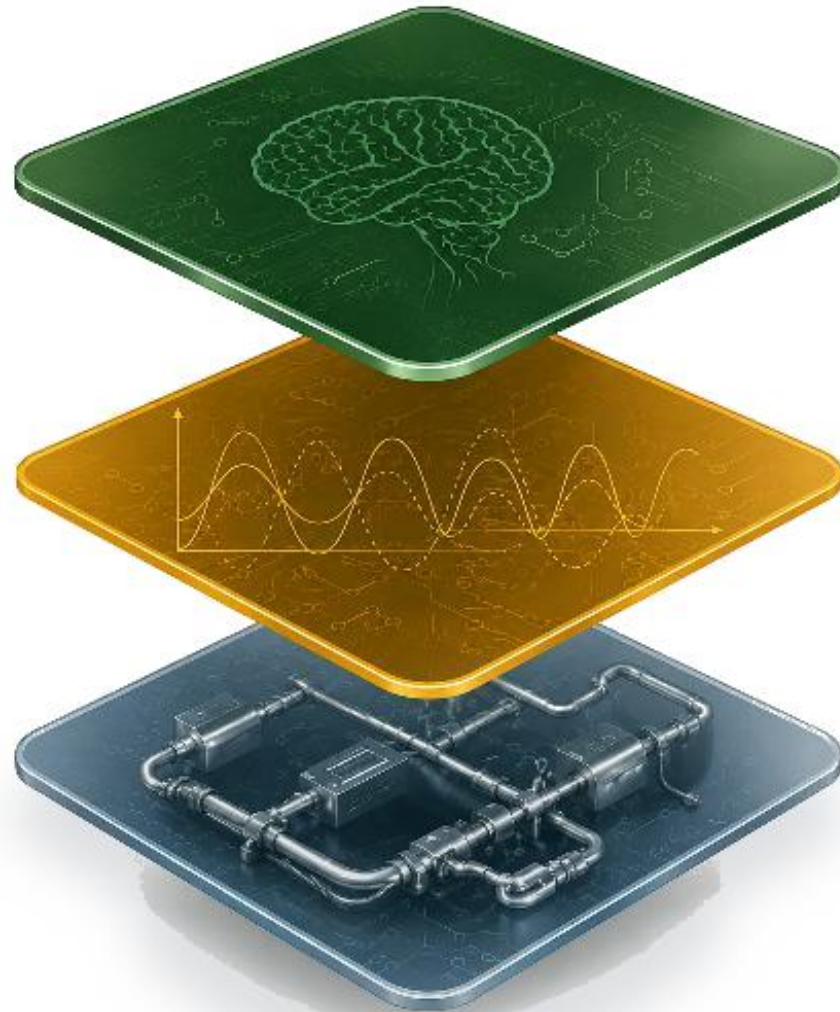
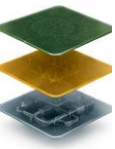
Cooling hardware cannot detect, nor predict its own condition.

THE COOLING SYSTEM BEHAVES LIKE A NERVOUS SYSTEM.



The cooling system behaves like a nervous system.

THREE LAYERS. ONE SYSTEM.



INTELLIGENCE LAYER

Reconstruct,
diagnose & act



PERCEPTION LAYER

Observe the
physical state



PHYSICAL LAYER

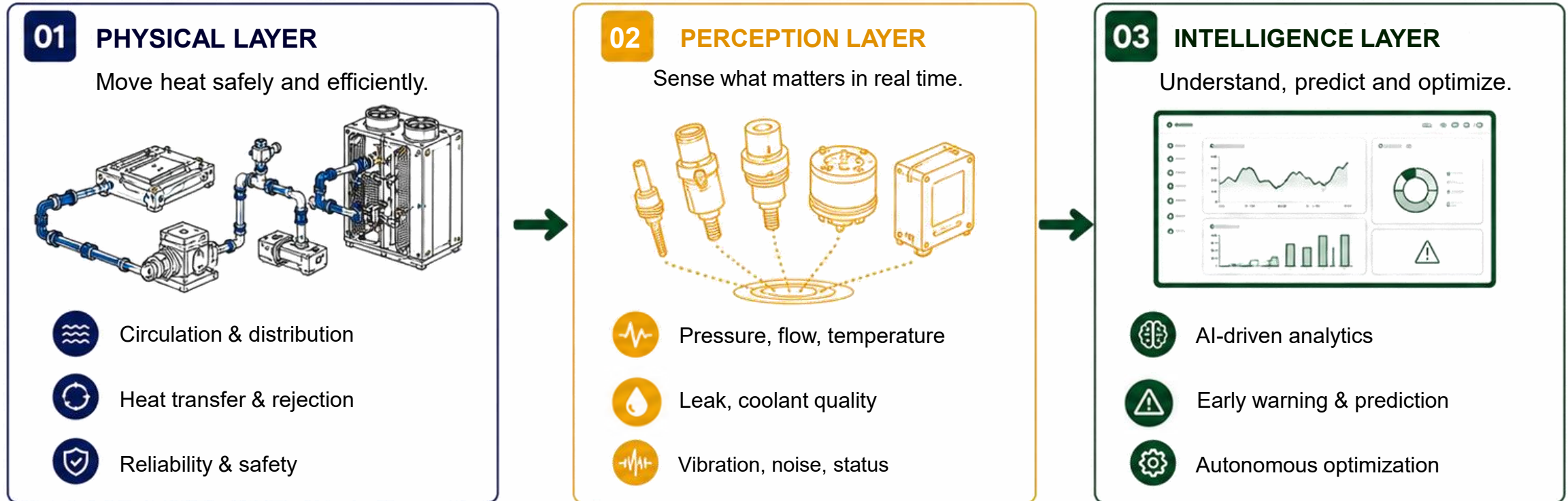
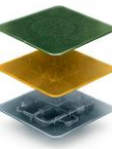
Fluid transport &
thermal infrastructure



Engineered hardware. Rich perception. Actionable intelligence.

A THREE-LAYER INTELLIGENT COOLING ARCHITECTURE.

From heat to insight. From insight to action.



Integrated layers create a self-aware system.

THE VISION: SELF-AWARE LIQUID COOLING.



SEE

Real-time sensing of the entire thermal ecosystem.



UNDERSTAND

AI-driven analytics turn data into meaningful insight.



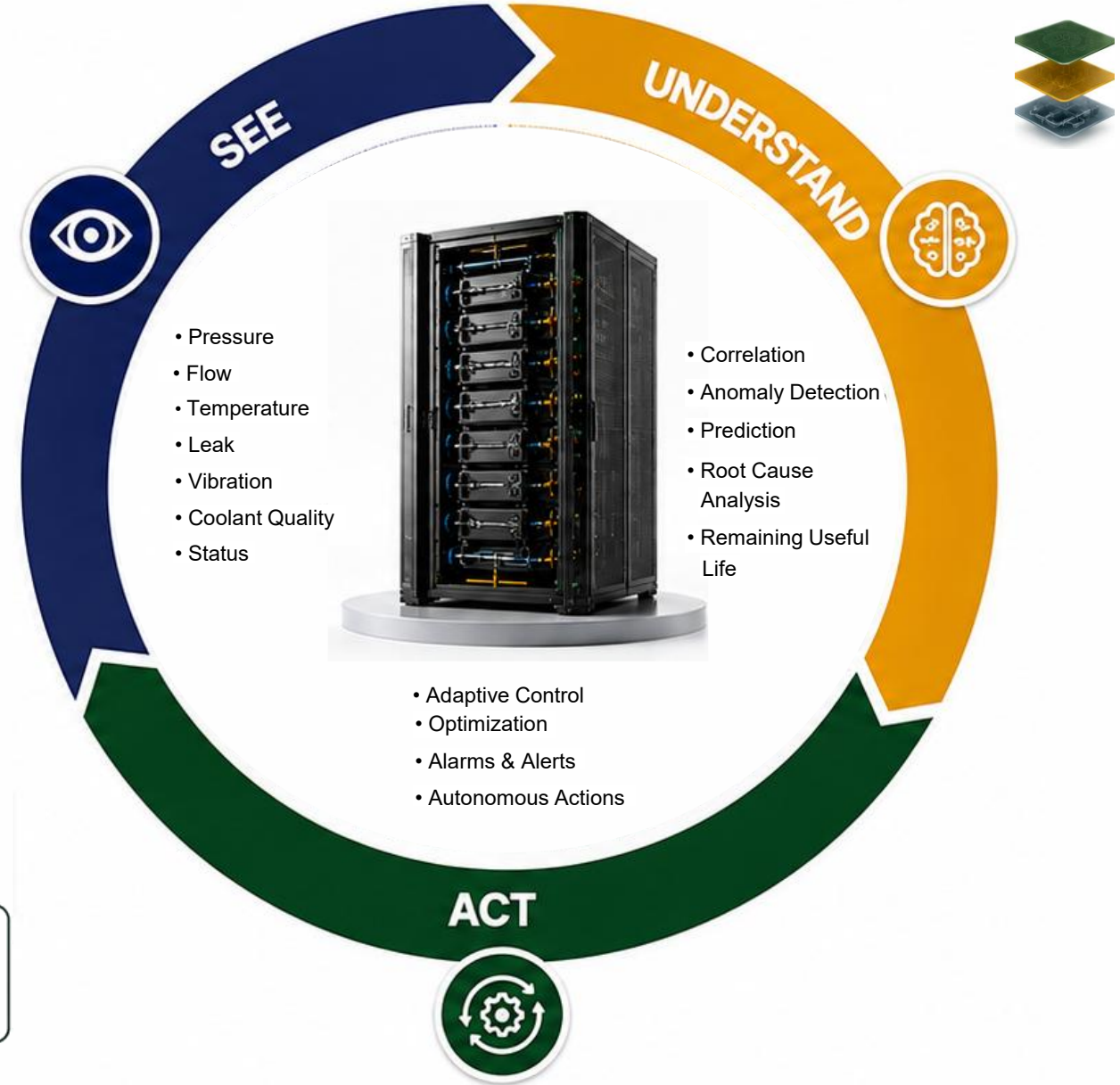
ACT

Intelligent control adapts the system to changing conditions.



The result: Maximum performance.

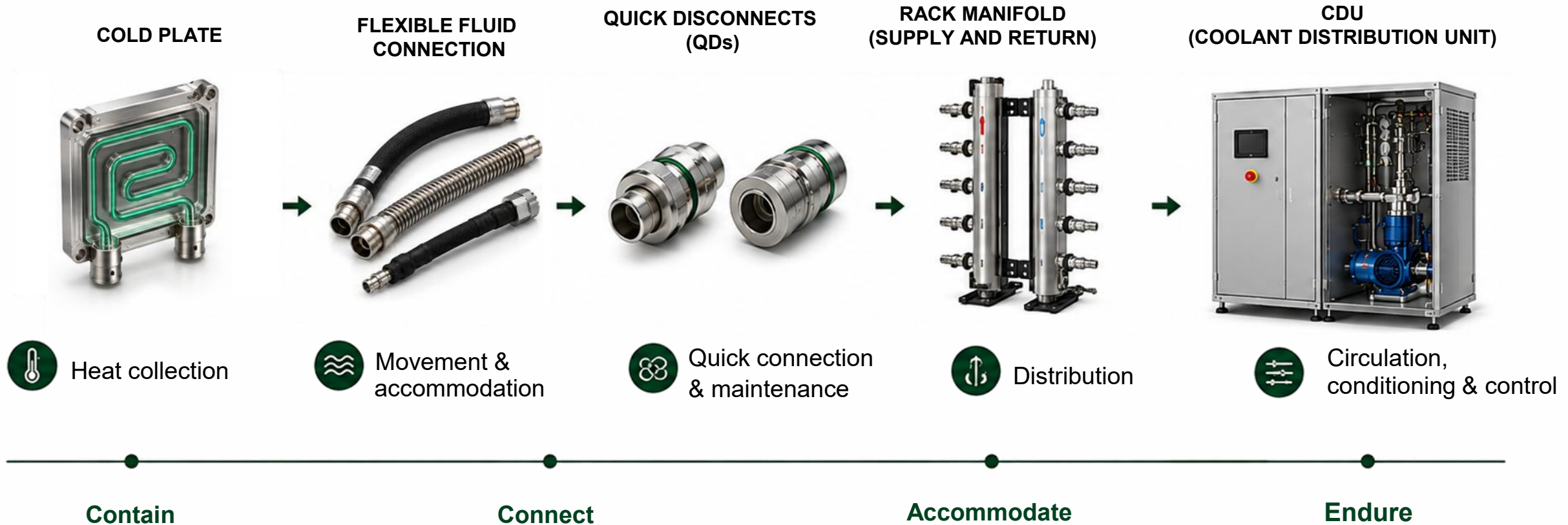
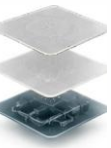
Maximum efficiency. Maximum Reliability



Maximum performance. Maximum efficiency. Maximum reliability.

RELIABILITY STARTS IN THE FLUID PATH.

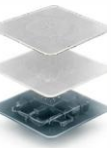
PHYSICAL LAYER



The fluid path is the backbone of the liquid cooling infrastructure.

EVERY INTERFACE IS A RELIABILITY DECISION.

PHYSICAL LAYER



Leak Prevention

Zero-tolerance sealing at every connection.



Pressure Resistance

Withstand high pressure, every day.



Cleanliness & Corrosion Protection

Materials and coatings built to last.



Vibration Tolerance

Stay sealed under dynamic conditions.



Thermal Cycling Endurance

Reliable across extreme temperature swings.



Long Lifetime & Consistent Performance

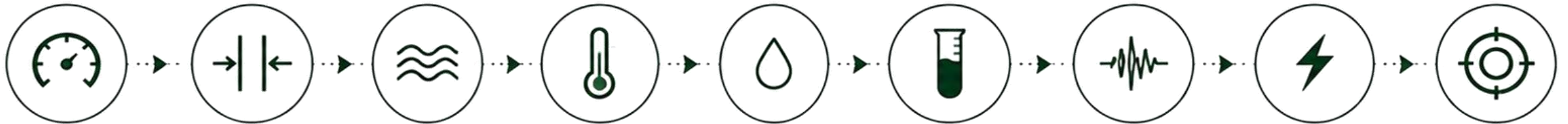
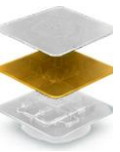
Reliability you can count on, system after system.



Liquid cooling demands reliability at every interface.

WE NEED SENSORS TO SEE WHAT MATTERS.

PERCEPTION LAYER



PRESSURE

DIFFERENTIAL
PRESSURE

FLOW

TEMPERATURE

LEAK

COOLANT
CONDITION

VIBRATION /
ACOUSTIC

ELECTRICAL
STATUS

POSITIONAL
STATE

A MULTIMODAL SENSING SYSTEM CREATES A MORE COMPLETE PICTURE.



Individually they show symptoms. Together they reveal the cause.



THE VALUE IS IN HOW THE SIGNALS ARE USED.



PRESSURE

Detects abnormal pressure and prevents leaks.



FLOW

Monitors flow rate and ensures stable operation.



TEMPERATURE

Tracks thermal conditions and prevents overheating.



LEAK DETECTION

Identifies leaks early and avoids downtime.



COOLANT CONDITION

Checks quality and detects contamination.

AI INTELLIGENCE LAYER



- ✓ Real-time analysis
- ✓ Anomaly detection
- ✓ Predictive maintenance
- ✓ Optimized operation
- ✓ Smart alerts



HIGHER RELIABILITY

Detect issues before they become failures.



MAXIMUM UPTIME

Less unplanned downtime, more productivity.



OPTIMIZED PERFORMANCE

Consistent efficiency and stable operation.



LOWER TOTAL COST

Prevents damage and extends lifetime.



The value is in how the signals are used.



REAL-TIME INTELLIGENCE. REAL-WORLD RELIABILITY.



CONTINUOUS MONITORING

High-frequency data capture across all critical parameters.



EARLY ANOMALY DETECTION

AI-powered algorithms identify deviations before they become failures.



SMART ALERTS

Actionable notifications delivered to the right people at the right time.



PREDICTIVE MAINTENANCE

Forecast issues, optimize service intervals, reduce downtime.



SYSTEM OPTIMIZATION

Close the loop. Improve efficiency, extend lifetime.



Real-time intelligence delivers real-world reliability.



WE MEASURE A LOT. WE STILL CANNOT MEASURE EVERYTHING.

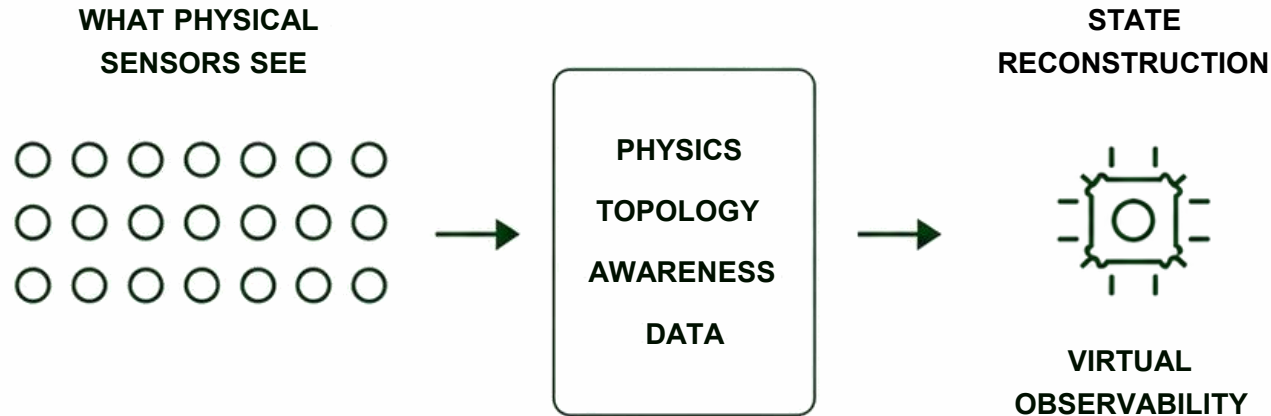
- Physical Sensors
Directly measurable parameters.
- Estimated States
Calculated from models and measurements.
- Hidden / Unmeasured
Not observable with current technology.



We measure a lot - but not yet everything.



HOW MUCH OF THE SYSTEM CAN WE UNDERSTAND BEYOND THE PHYSICAL SENSORS?



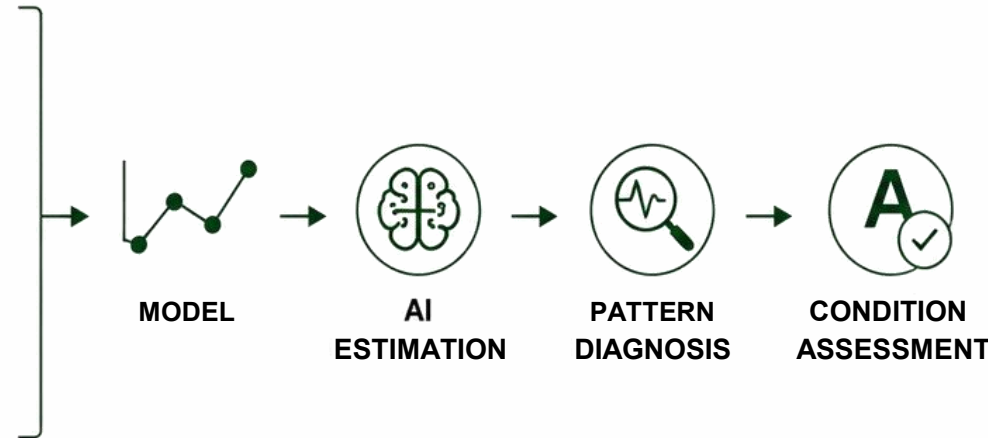
Extending understanding beyond the physical sensors.



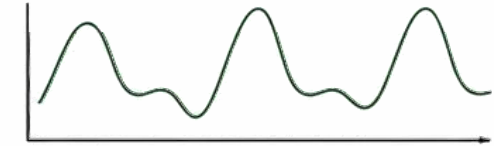
THE SYSTEM'S RESPONSE CAN REVEAL ITS CONDITION.

System Inputs

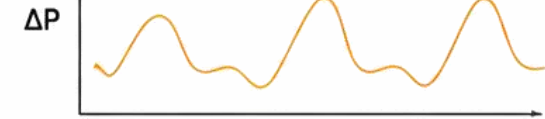
-  Valve / Pump State
-  Flow Demand
-  Workload Change
-  Disturbance



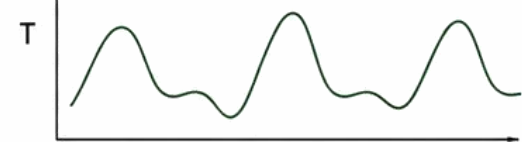
$P(t)$



$\Delta P(t)$



$T(t)$



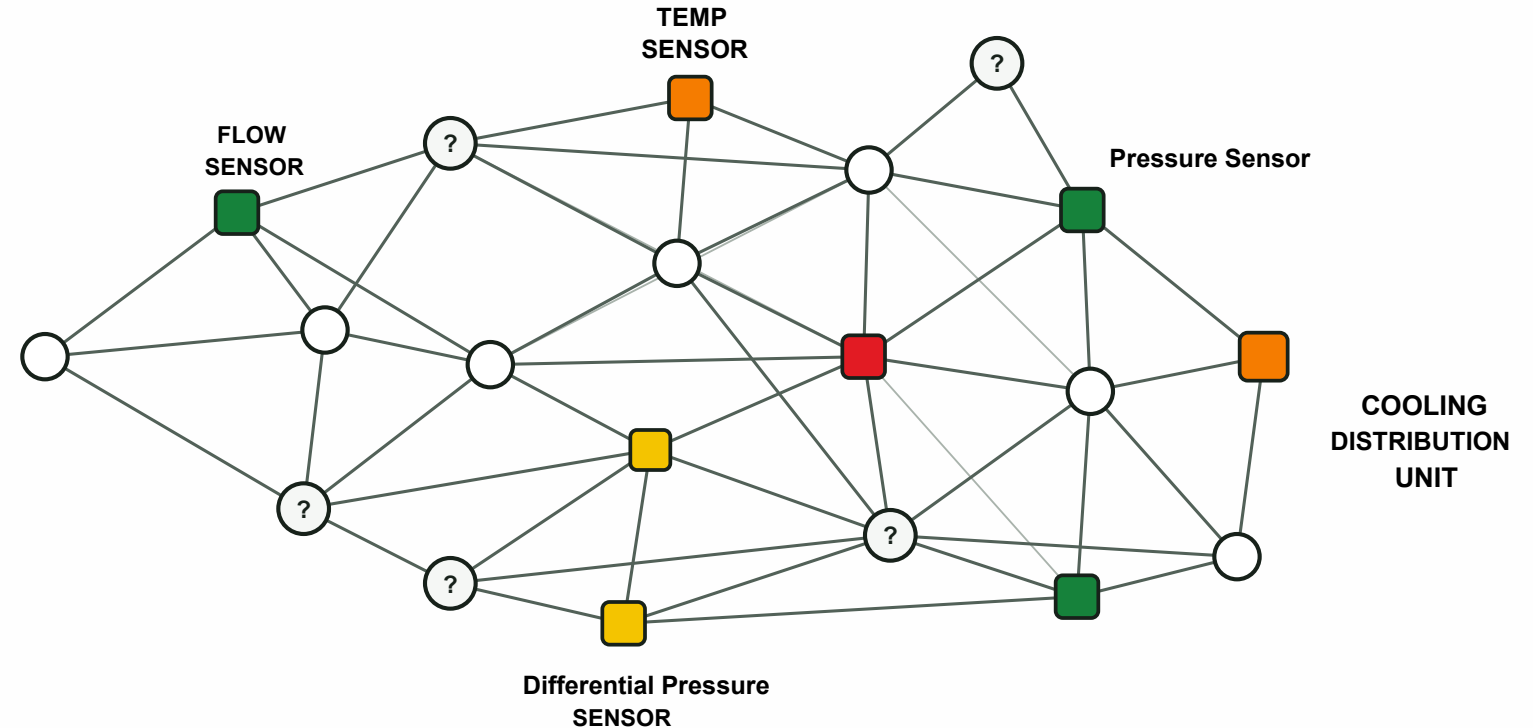
Dynamic fingerprints reveal restrictions, air and degradation.



CAN THE COOLING NETWORK DIAGNOSE ITS OWN HEALTH?

FAULT TYPES

- 1 LEAK
- 2 RESTRICTION
- 3 FOULING
- 4 AIR / GAS
- 5 PUMP DEGRADATION
- 6 SENSOR DRIFT
- 7 COOLANT DEGRADATION
- 8 INTERFACE DEGRADATION



Different causes. Different actions. Better outcomes.

SMART FLUID INTERFACES

TURN INTERFACES INTO INFORMATION POINTS.



PRESSURE



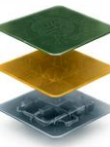
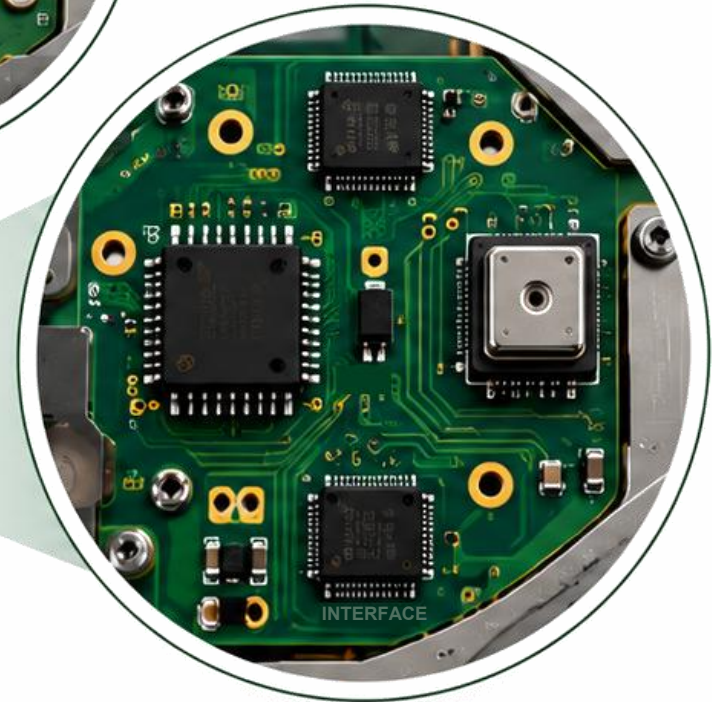
TEMPERATURE



FLOW

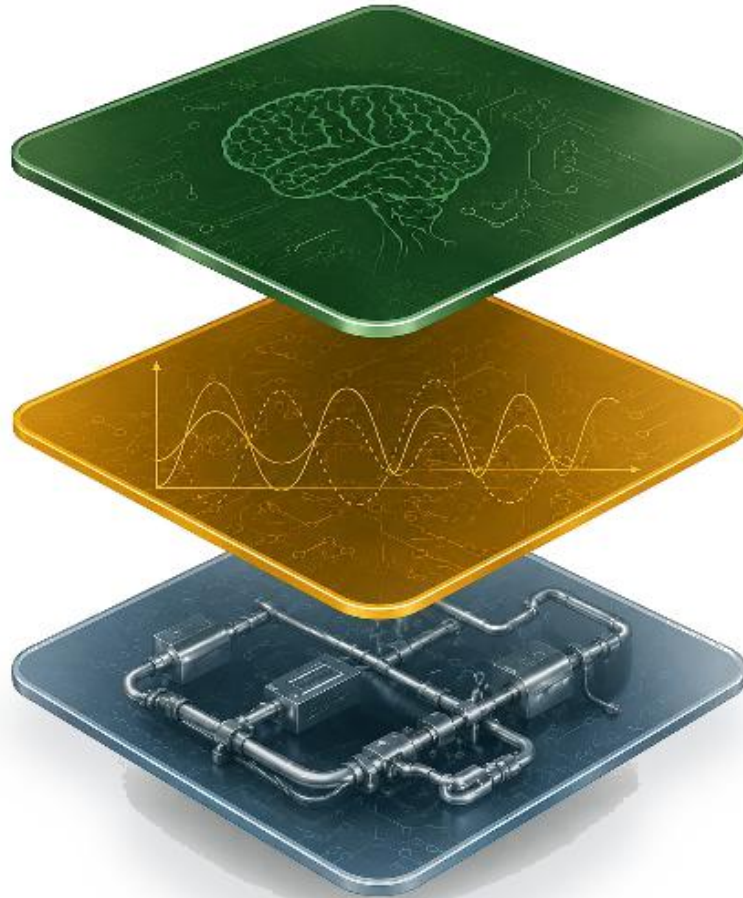
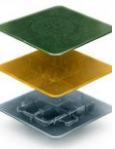


VIBRATION /
ACOUSTIC



We are exploring sensing nodes that can be integrated into liquid-cooling infrastructure.

ONE CHALLENGE. THREE LAYERS. AN UNUSUALLY STRONG POSITION.



INTELLIGENCE

Artificial Intelligence
AI — ML — Software

PERCEPTION

Sensors & Electronics
Signal Processing

PHYSICAL

Fluid Networks &
Precision Components



杭州电子科技大学
HANGZHOU DIANZI UNIVERSITY

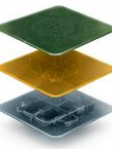


花园金波科技股份有限公司
HUAYUAN JINBO TECHNOLOGY CO., LTD.



One challenge. Three layers. An unusually strong position.
We are well-positioned to address all 3 layers, and we want YOU to join us.

INDUSTRIAL CAPABILITY MEETS RESEARCH INTELLIGENCE.



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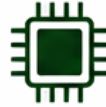
YOU?



Bellows &
Precision Manufacturing



Sensing
Technology



Electronics



Embedded Systems
& Internet of Things



AI / Algorithms
for Real Intelligence



Our consortium

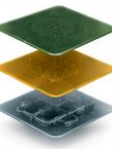
is open for:

- Customers
- Suppliers
- Universities
- Technology partners
to join



Industry strength. Academic excellence. Shared mission.

WE ARE NOT REBUILDING ANOTHER PROPRIETARY TELEMETRY ISLAND.



EXISTING SYSTEMS

We extend, not replace.

OCP + Redfish + Modbus +
SNMP + CAN + Others



SYSTEM-LEVEL
HEALTH
WITH TRUE
UNDERSTANDING



OUR VALUE

- ✓ Detect
- ✓ Locate
- ✓ Diagnose
- ✓ Predict
- ✓ Act

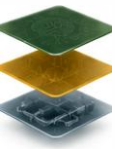


We connect the best. We add intelligence. We create real value.

PARTNER WITH US

BUILDING THE INTELLIGENT ECOSYSTEM TOGETHER.

We collaborate across academia, industry and the supply chain to co-create real value and accelerate innovation.



UNIVERSITIES & RESEARCH INSTITUTES

WHAT WE NEED

Research expertise & talent
Advanced labs & test facilities
Co-development of new technologies
Publications & academic impact

WHAT WE OFFER

Real-world research challenges
Joint projects & funding opportunities
Access to industry & market
Technology transfer & impact



CUSTOMERS & INDUSTRY PARTNERS

WHAT WE NEED

Real use cases & pain points
System requirements & feedback
Field testing & validation
Long-term collaboration

WHAT WE OFFER

Solutions to real problems
Higher performance & reliability
Co-development & customization
Faster time-to-market



SUPPLIERS & COMPONENT PARTNERS

WHAT WE NEED

High-quality components & systems
Timely delivery & support
Technology-roadmap alignment
Open communication & collaboration

WHAT WE OFFER

Stable & growing business
Joint innovation & integration
Visibility through our ecosystem
Long-term strategic partnership



TECHNOLOGY & SOLUTION PARTNERS

WHAT WE NEED

Complementary technologies
Software, AI & system integration
Standards & interoperability
Scalability & security

WHAT WE OFFER

Ecosystem collaboration
Joint solutions & platforms
Global market access
Mutual growth & success

TOGETHER, WE TURN KNOWLEDGE, TECHNOLOGY AND COLLABORATION INTO REAL-WORLD IMPACT AND SUSTAINABLE GROWTH.



Strong partnerships build the intelligent ecosystem.

LET'S MAKE LIQUID COOLING AWARE OF ITS OWN HEALTH – TOGETHER.

No single discipline can solve this alone
Let's build the intelligent systems
of tomorrow - together.



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