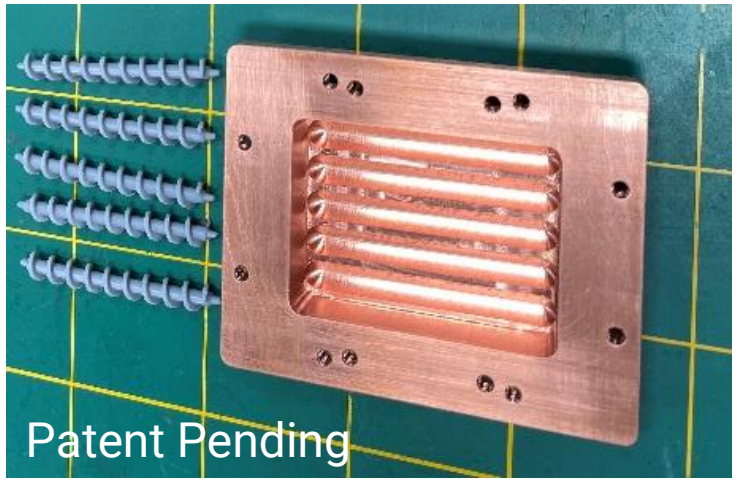
Helical Turbulator Cold Plate

Steve Harrington Chilldyne

Cooler Chips team members:
Schneider Electric, Avnet and TACC

Efficient and failure tolerant liquid cooling



- *Chilldyne provides robust liquid cooling systems with no single point of failure.*
- *Liquid cooling is a more efficient way to cool computers. For it to be widely accepted, it must be more reliable and less expensive than air cooling*
- *Chilldyne has developed a cold plate design that is efficient, reliable and easy to manufacture. Chilldyne has also developed an automated chemical additive system that maintains the efficiency of the liquid cooling system for the life of the servers.*

Total Project Cost:	$0.55M
Length	12 mo.

Testing Chilldyne's cold plate at rack scale at TACC

Fed. funding:	$0.55M
Length	12mo.

Team member	Location	Role in project, core competencies
Chilldyne	San Diego, CA	Fluid dynamics and thermodynamics engineering
TACC	Austin, TX	Supercomputer center using latest liquid cooling technologies
Schneider Electric	St. Louis, MO	Assist with Scalability risk assessment, manufacturing plan and assessing the regulatory landscape
Avnet	Phoenix, AZ	Assist with redefining barrier to entry and developing an engagement plan for liquid cooling implementation at colocation data centers

Liquid cooling must be cheaper and more reliable than air cooling for wide adoption and significant energy savings

- First generation technology: 9000 Cold plates and 20 CDUs in *production starting in 2015*
- Chilldyne completed an OPEN project, developed a 2 kW cold plate with .009 C/watt at 2.5 lpm
- Goal is to reduce/eliminate the need for Chillers anywhere in USA for future 2 kW chips.
- Will work with TACC to allow users to test liquid and measure power and compute performance at low case temperatures. Plan is to test 4 racks of latest CPU and GPU servers with new cold plate and CDU.
- Schneider Electric and Avnet will help Chilldyne scale up.

Lower thermal resistance cold plates require less energy to cool servers.

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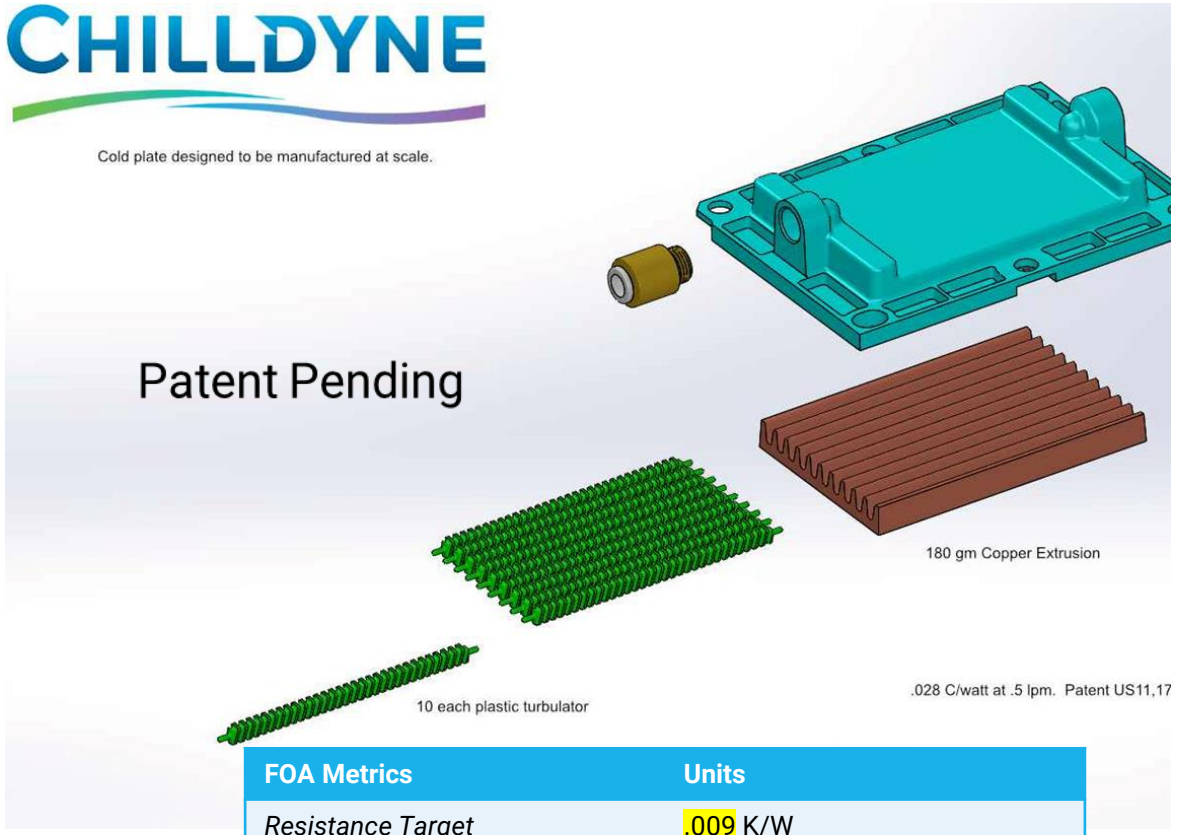
Mass producible high performance Cold plate.

- *Cold plate includes copper extrusion with copper turbulators brazed in.*
- *Goals include minimum thermal resistance, manufacturable in millions, adaptable design for future*
- *KPI's for Plus-Up:*
  - *Data Center Power Reduction of 15%*
  - *Low CDU cooling power <2%*
  - *99.999% uptime for 5+ years with failure tolerant systems.*
- *Commercialization plan includes:*
  - *Work with consultants to develop marketing strategy.*
  - *Work with Schneider Electric and Avnet to develop manufacturing and customer engagement*
  - *Work with national labs to develop a calculator for liquid cooling TCO*
- *Closed form thermal performance design math model is accurate to 20% for thermal resistance and pressure drop.*
- *Planned testing up to 300 W/cm^2 Application is GPU and network switches.*



FOA Metrics	Units
Resistance Target	.009 K/W
Cooling Power % of IT_power	<2 %
System availability	99.999 %
Chipset	Future GPU and Network chips
Chip Power	2000 W
Power per server	5 kW (1 U server)
Demonstration power mid project	100 kW

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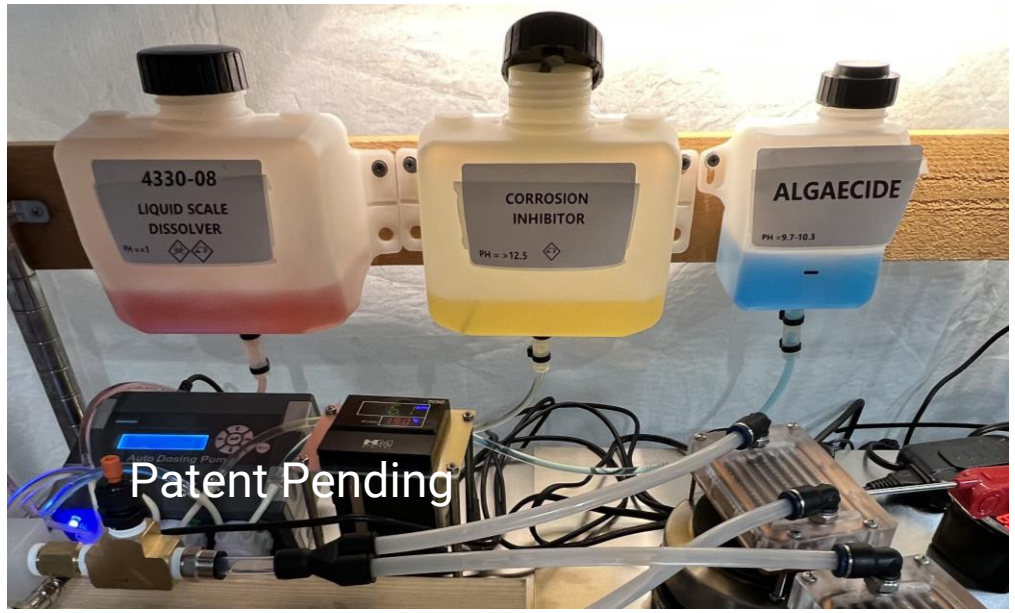
Automatic Coolant Quality Control.

- *All heat exchangers lose performance over time, we are testing a coolant additive system to minimize this.*
- *KPI's for Plus-Up:*
  - *Cold plates resistant to fouling and able to withstand 100 microns of corrosion with less than 10% reduction in thermal performance over 8 years)*
- *Commercialization plan includes:*
  - *Work with chemistry consultants to develop robust additive system with low toxicity.*
  - *Work with national labs to test coolant additive system under real loads.*
- *System must be tested in various climate zones with different bacterial loads.*
- *Planned testing up to 300 W/cm^2 Application is GPU and network switches.*



FOA Metrics	Units
Thermal Resistance Target	10% reduction in 8 years
Fluid Toxicity	Meets Federal Effluence Standards
Fluid replacement interval	1 year
Corrosion Tolerance	100 microns of Corrosion
Chip Power	2000 W
Power per server	5 kW (1 U server)
Demonstration power mid project	100 kW

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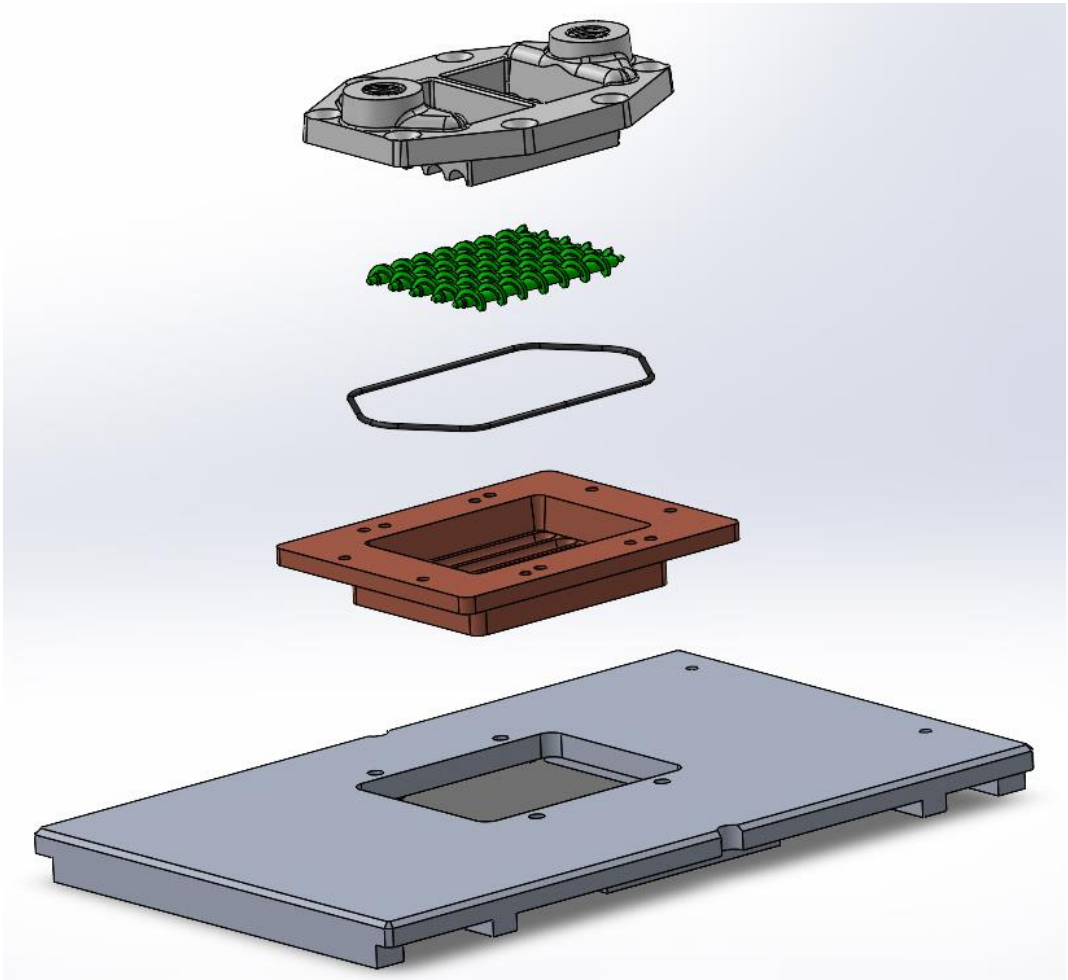
Prove savings and longevity with real world testing

- *Primary Tasks and goals:*
  - *Set-up a test rack and CDU at a supercomputer facility to measure performance and power to complete real world user applications on state-of-the-art GPU and CPU systems.*
    - *Chilldyne will supply cold plates and CDU with automated coolant additive control*
    - *TACC will provide servers and technical support*
  - *Develop a coolant additive system and test it with cold plates for thermal resistance over time. Verify the coolant complies with federal industrial effluent standards*
  - *Work with national labs to create a public calculator for liquid cooling TCO.*
  - *Engage with strategic partners (Avnet and Schneider Electric) to increase data center efficiency globally.*
- *A very low thermal resistance cold plate has been developed. The design needs to be optimized for low cost and mass production with automated assembly.*
- *Our coolant additive control system needs to be tested at multiple locations. The microbiological challenge will be different at each location.*



Patent Pending

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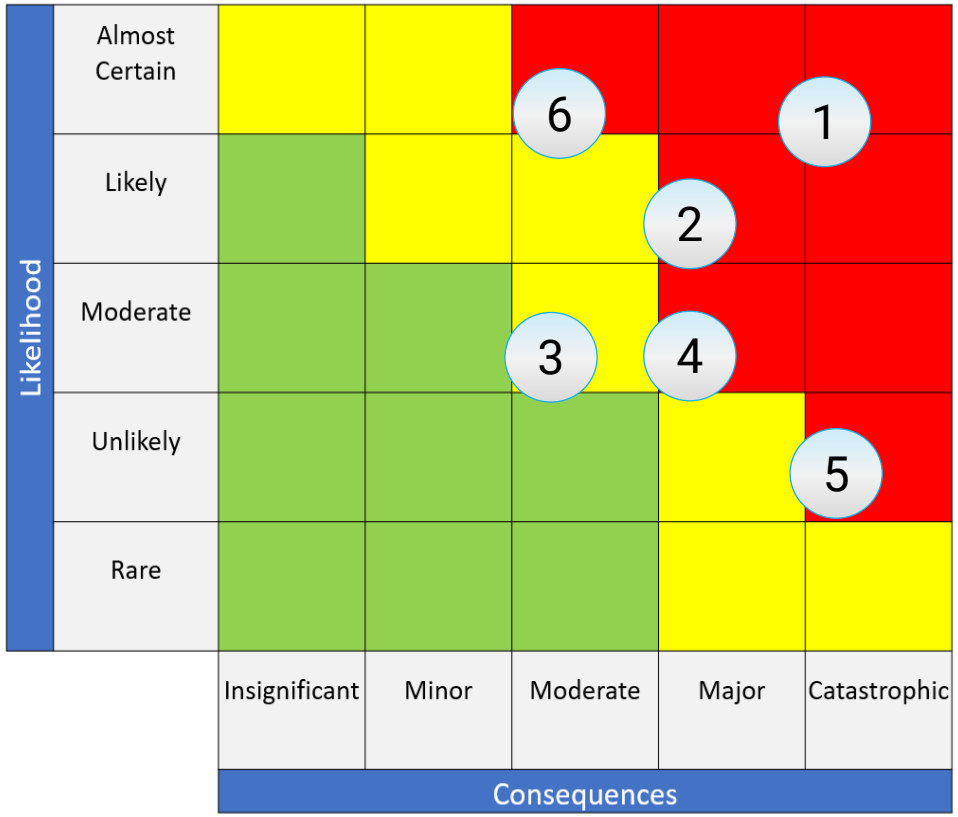
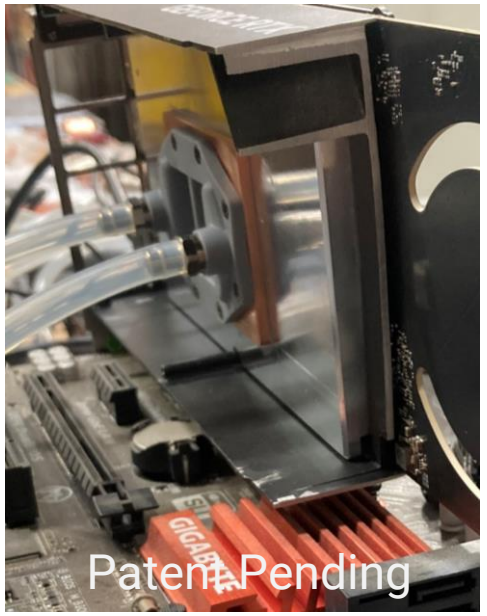
Challenges and Risks

- *Chilldyne's strength is our technology. Our weakness is our size.*
- *Our failure tolerant technology offers the 99.999% uptime, works with any server and low TCO that our customers need*
- *Our partnerships with Schneider Electric and Avnet solve the size issue.*





Risk Status

Risk	#
Customers worry that system is not scalable	1
Customers are concerned about coolant life	2
Customers are concerned about coolant toxicity	3
Customers don't believe power savings	4
Customers avoid liquid due to TCO concerns	5
Market moves to positive pressure system due to perceived maturity relative to negative pressure	6

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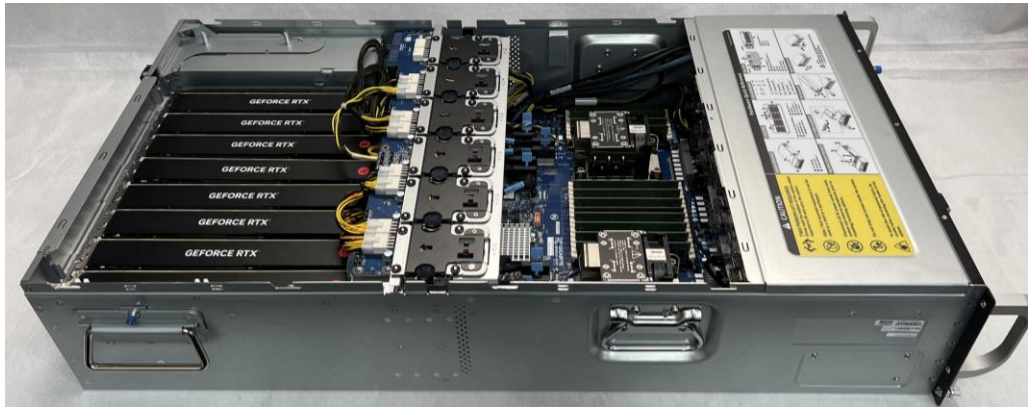
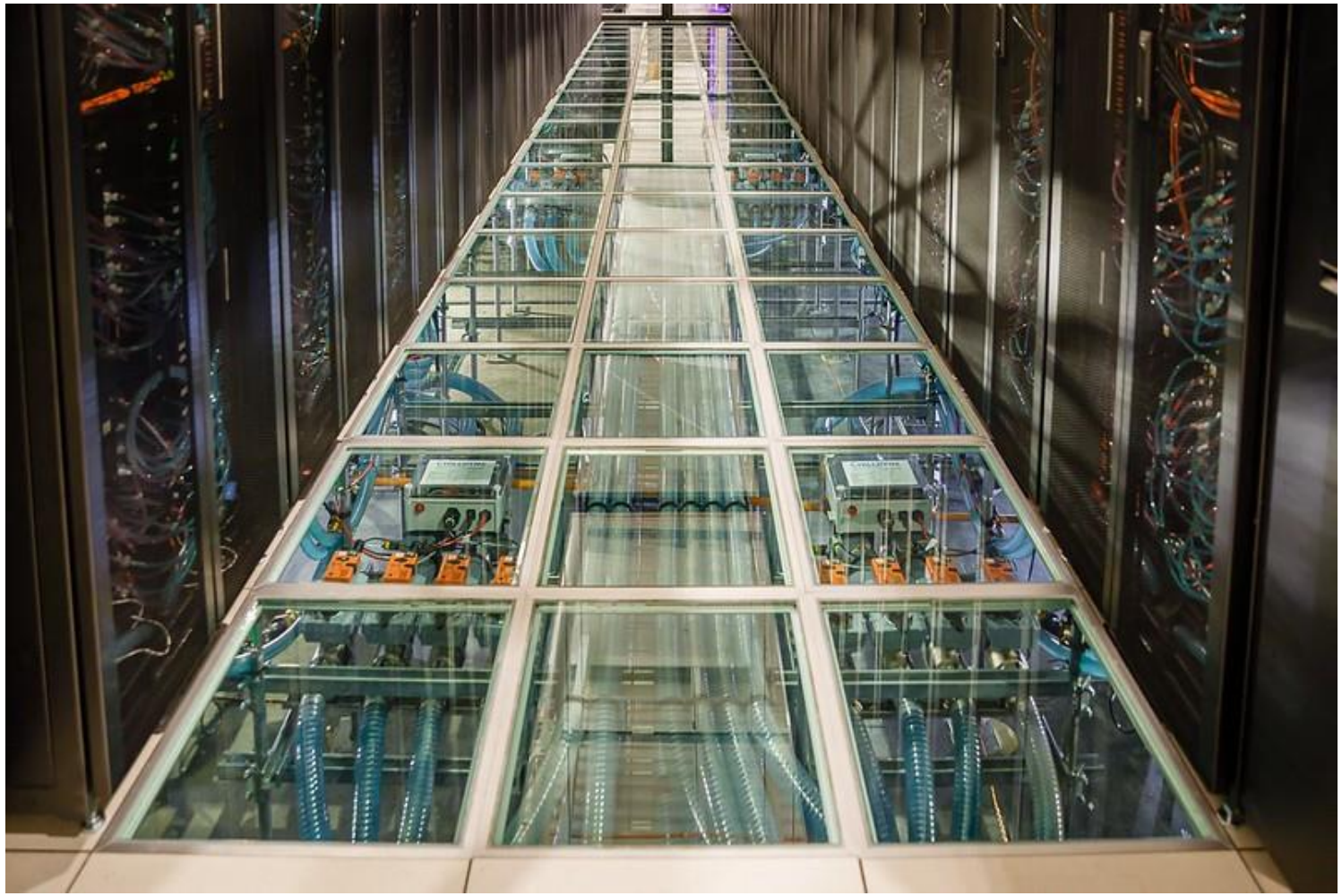
Technology-to-Market Approach: 3rd party evaulations

- *Will work with strategic partners Schneider Electric and Avnet to develop a manufacturing plan, navigate the regulatory field, develop a customer engagement plan for liquid cooling implementation at colocation data centers. Chilldyne will work with the Advocom group (matched at ARPA-E technology summit).*
- *Chilldyne's current business model is to design, build and sell systems. We can offer licensing and cooling as a service business models, but we need more installations first.*
- *The market for AI is growing fast, and the next generation of chips will need liquid cooling. Our high-performance cold plate, combined with our low-risk negative pressure system and redundant CDUs provides the best uptime.*
- *Our initial market has been government labs. These customers want the best technology, even if it is not widely deployed. Our next target is colocation Vendors. They need to offer liquid or lose customers to other COLOs who already have it.*
- *The next market is the hyperscaler market. They are trying to develop their own liquid cooling, but this is a risky proposition. The potential losses are huge if their cold plates leak on a significant percentage of their servers or get clogged due to improper coolant chemistry.*



Needs and Potential Partnerships

- *We need to have chipmakers, colocation providers, universities and hyperscalers test our technology, we are sure that they will be delighted with the performance, uptime and ease of use.*



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Q & A

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