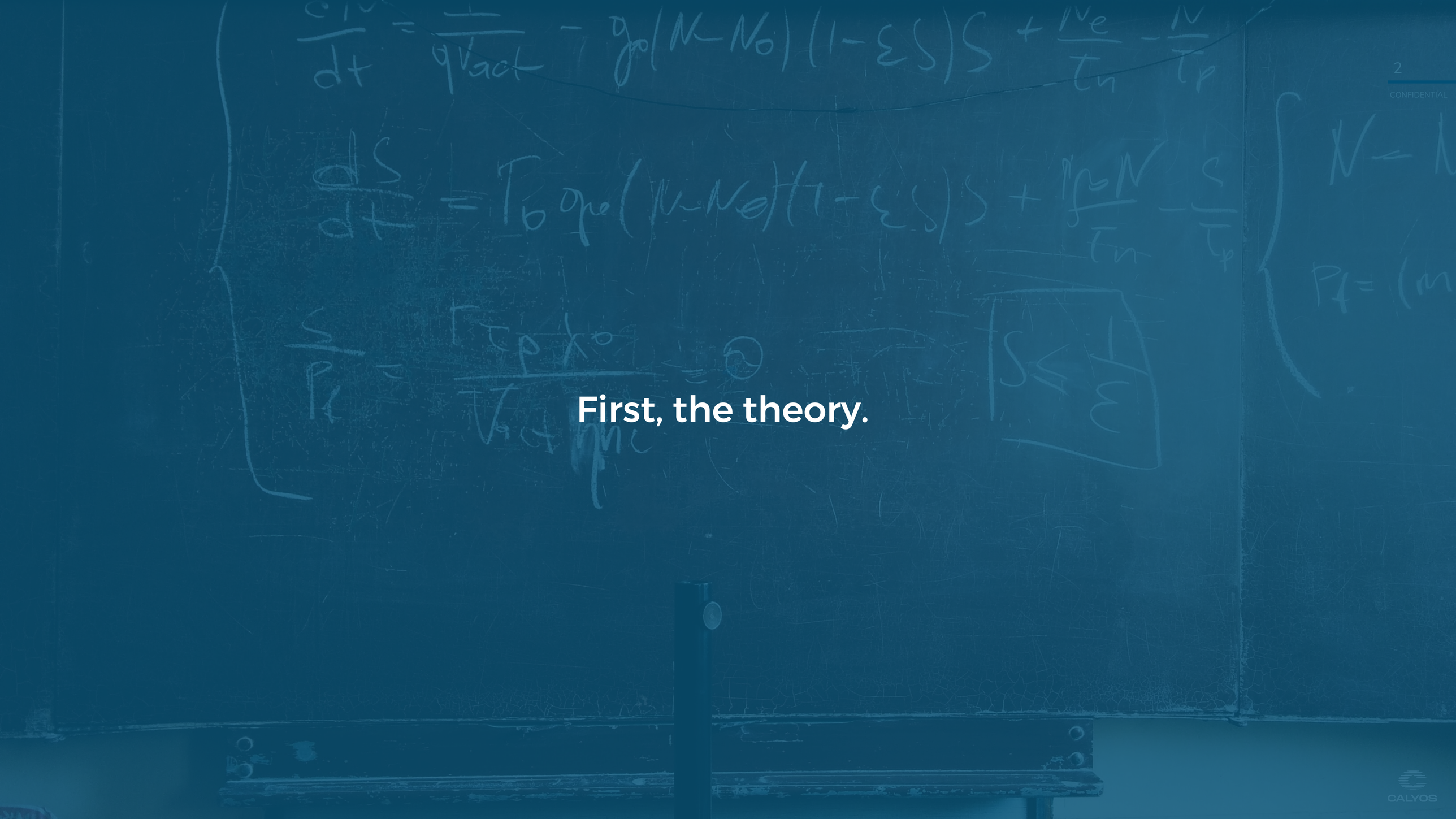
CALYOS

Technologies

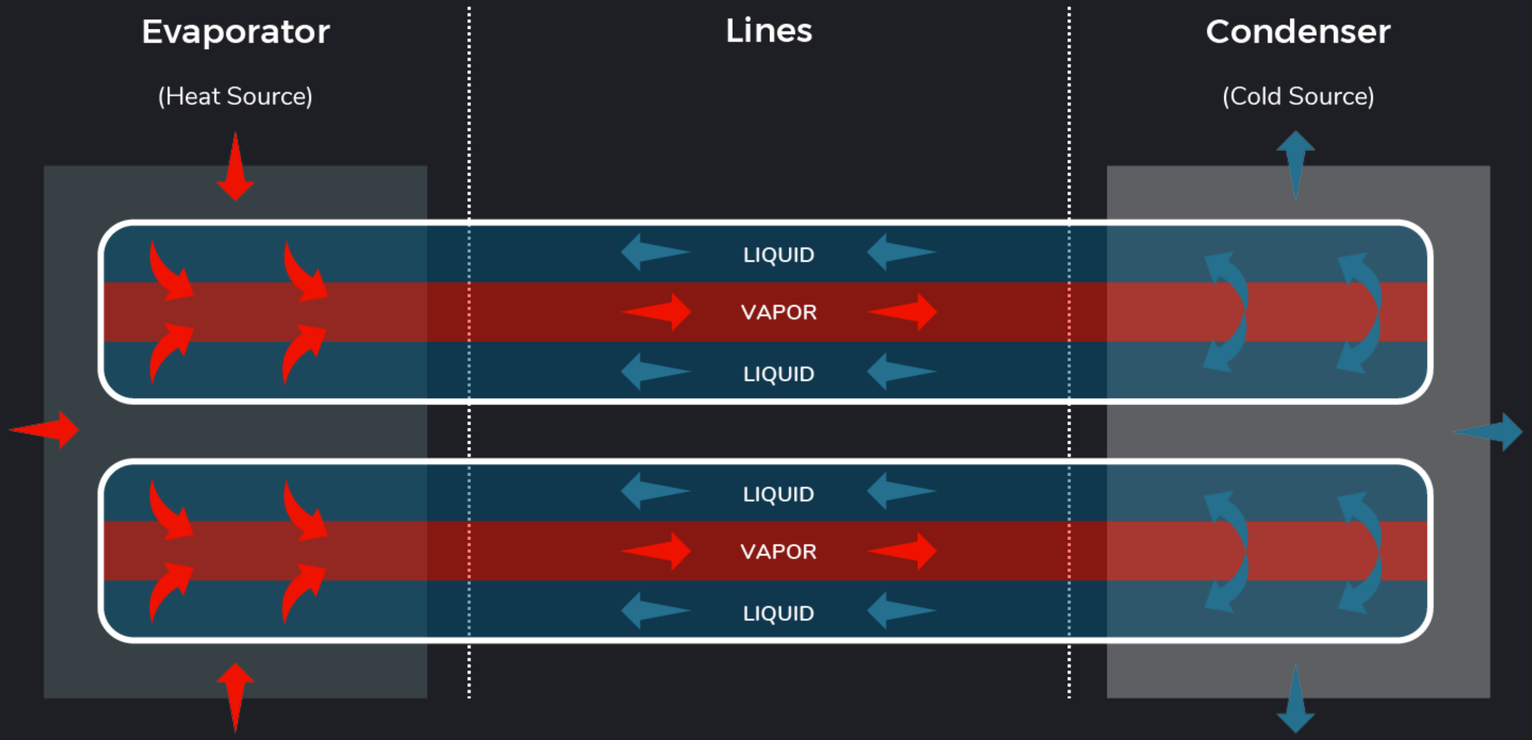
October 20

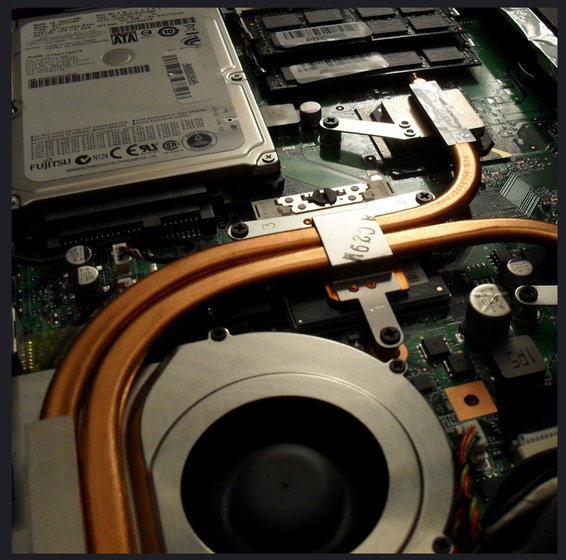
INFO@CALYOS-TM.COM



First, the theory.

Heat Pipe





Utilizing the latent heat of vaporization for heat transfer is brilliant.

HP Benefits

No power.

- Totally passive
- Reduces costs
- Environmental benefit

No maintenance.

- No moving parts
- Reduced failure rate Reduced maintenance costs

No water.

- Dielectric fluids
- No risk of short circuits
- Wider operation temperatures
- Better system control

No noise.

- no fans or pumps
- improves user experience

But they have their limitations...

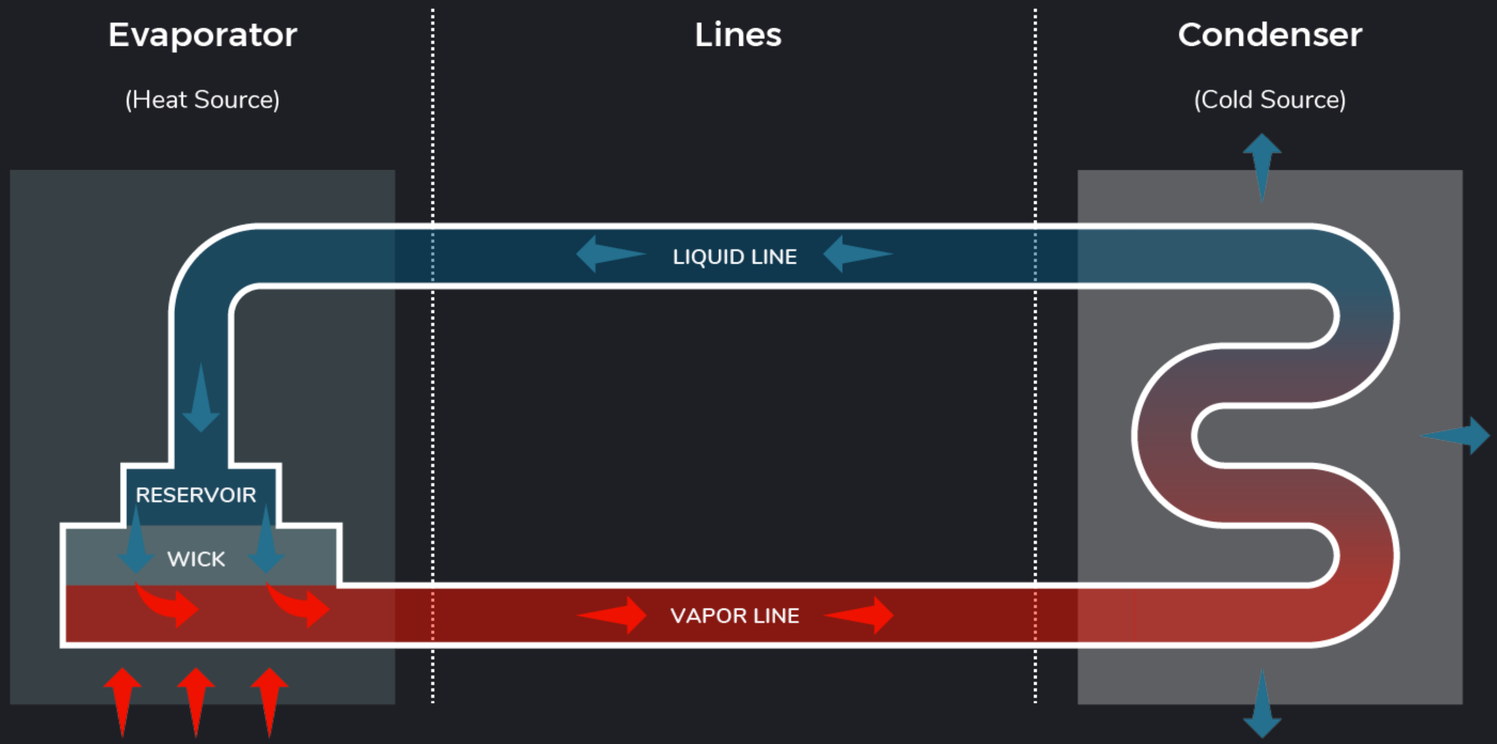
Orientation.

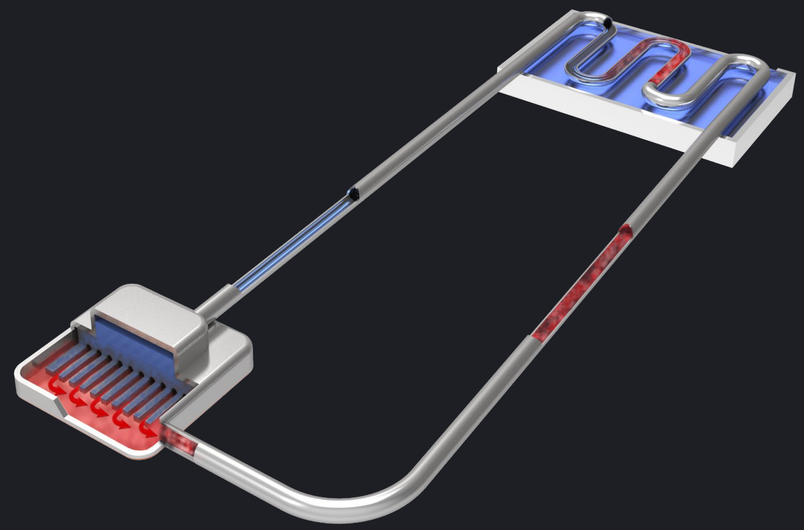
Integration.

Transportation.

Performance.

Loop Heat Pipe





The same passive principle, but with improved flexibility and performance.

LHP Benefits

Orientation.

- Operate against acceleration (Gravity!)
- Any specific orientation

Integration.

- Low profile evaporators
- Multi-evaporator architectures
- Any number or type of sources

Transportation.

- Thin lines over long distances
- Navigating environments
- Any position of sources.

Performance.

- Flat evaporator improves conduction
- Reduced friction because of separate lines
- Wick concentrated on heat source

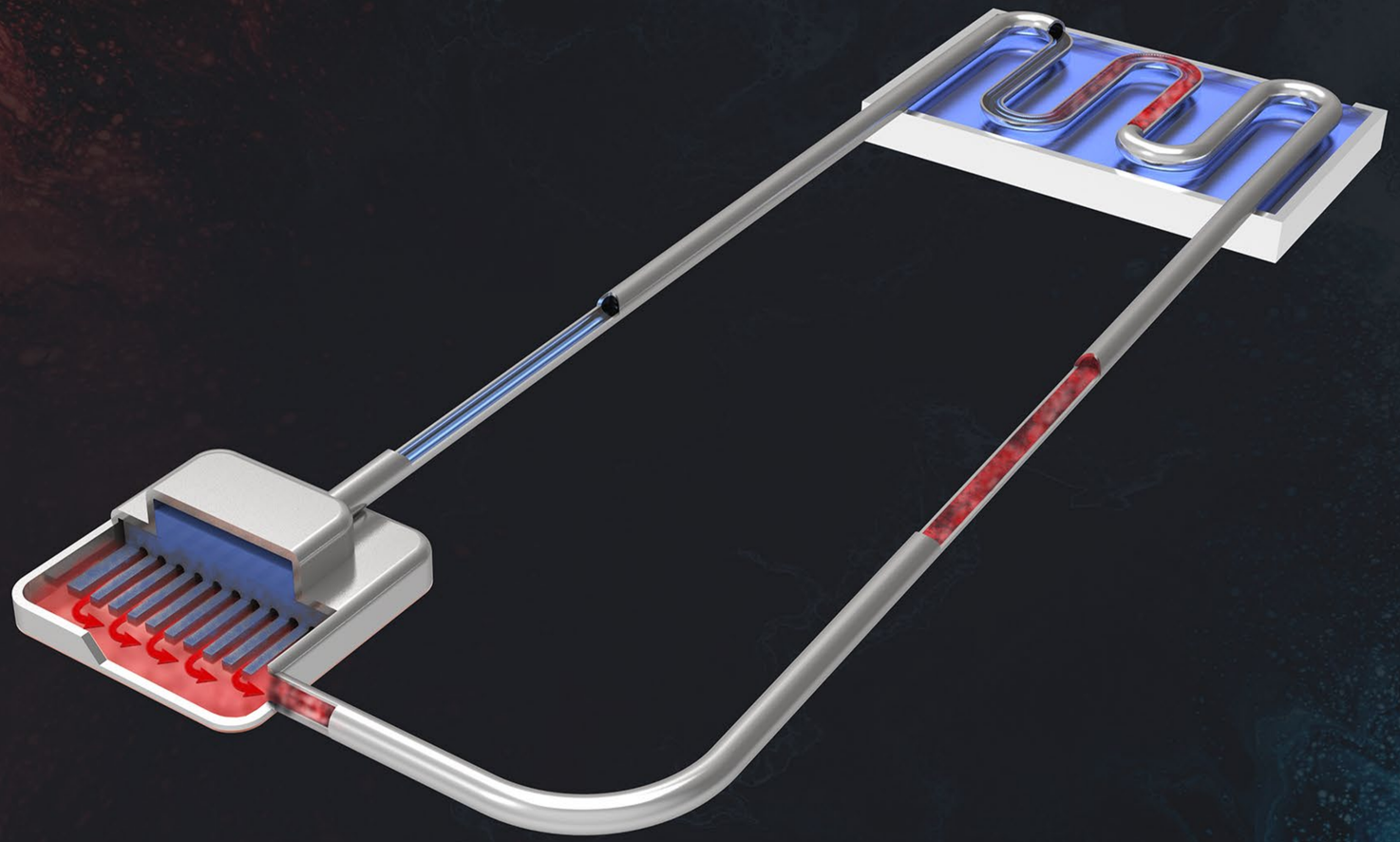
Solving the limitations, retaining the benefits.

No Power.

No maintenance.

No water.

No noise.

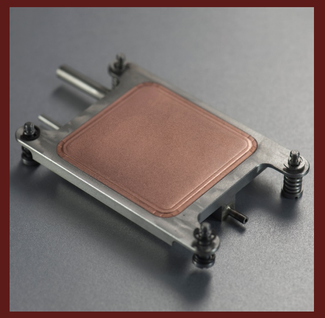


Loop Heat Pipes,
the **passive** answer to **liquid cooling**.

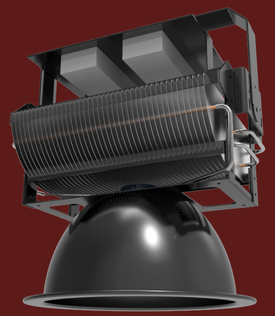
So, how do we put them into practice?

Source Interoperability

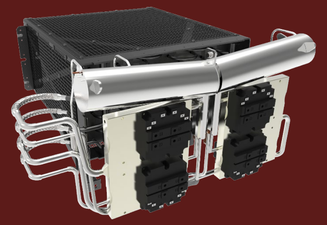
Heat Source’s



Typical
Evaporator

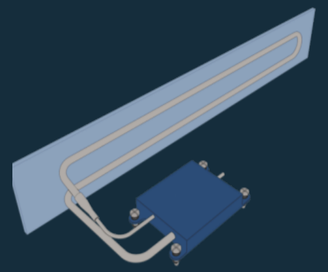


Area = 8cm²
Power = 300W

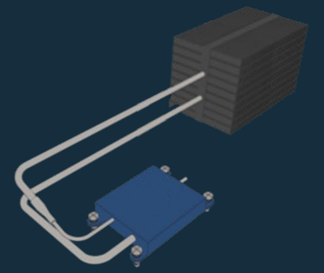


Area = 8x 150cm²
Power = 20kW

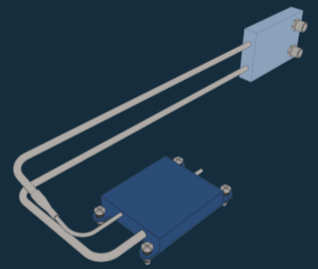
Cold Source’s



Conductive Plate



Air Exchanger
(Forced & Natural)



Liquid Exchanger

Integrate the technology with any type/size of heat/cold source.

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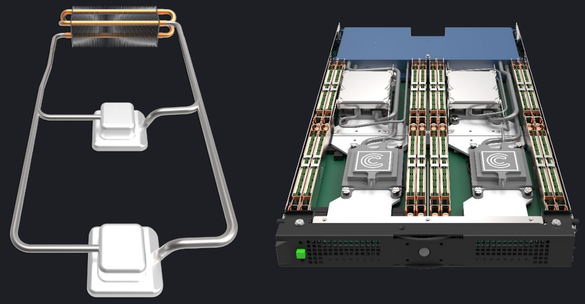
Scalable Architecture

Classic

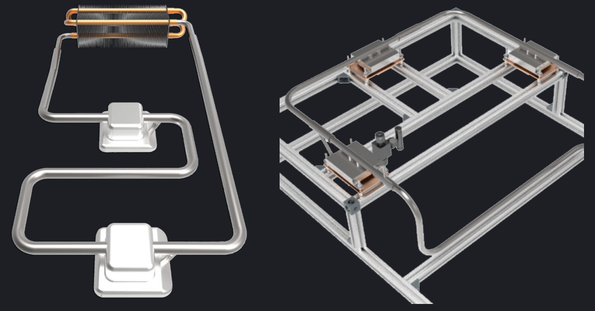
1x Evaporator

Parallel



4x Evaporators

Series

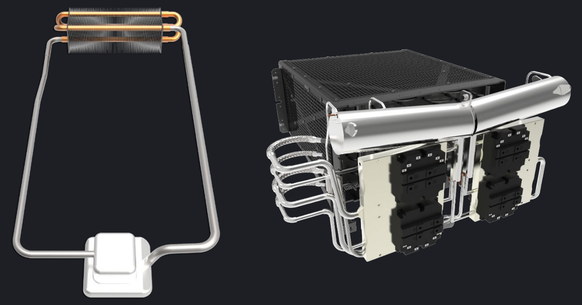


3x Evaporators

Scale the system based on your application, moving the heat where you please.

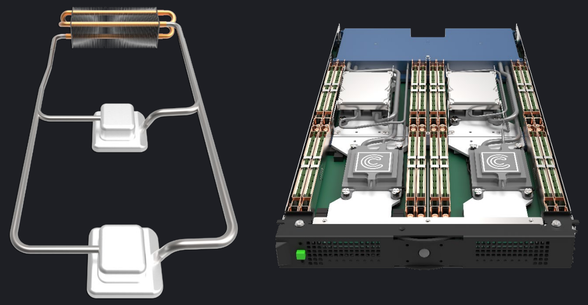
Scalable Architecture

Combined



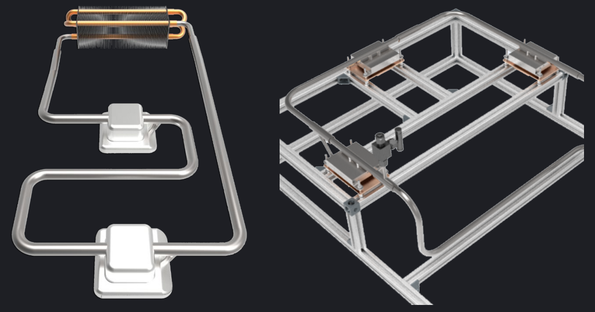
8x Evaporator

Parallel



4x Evaporators

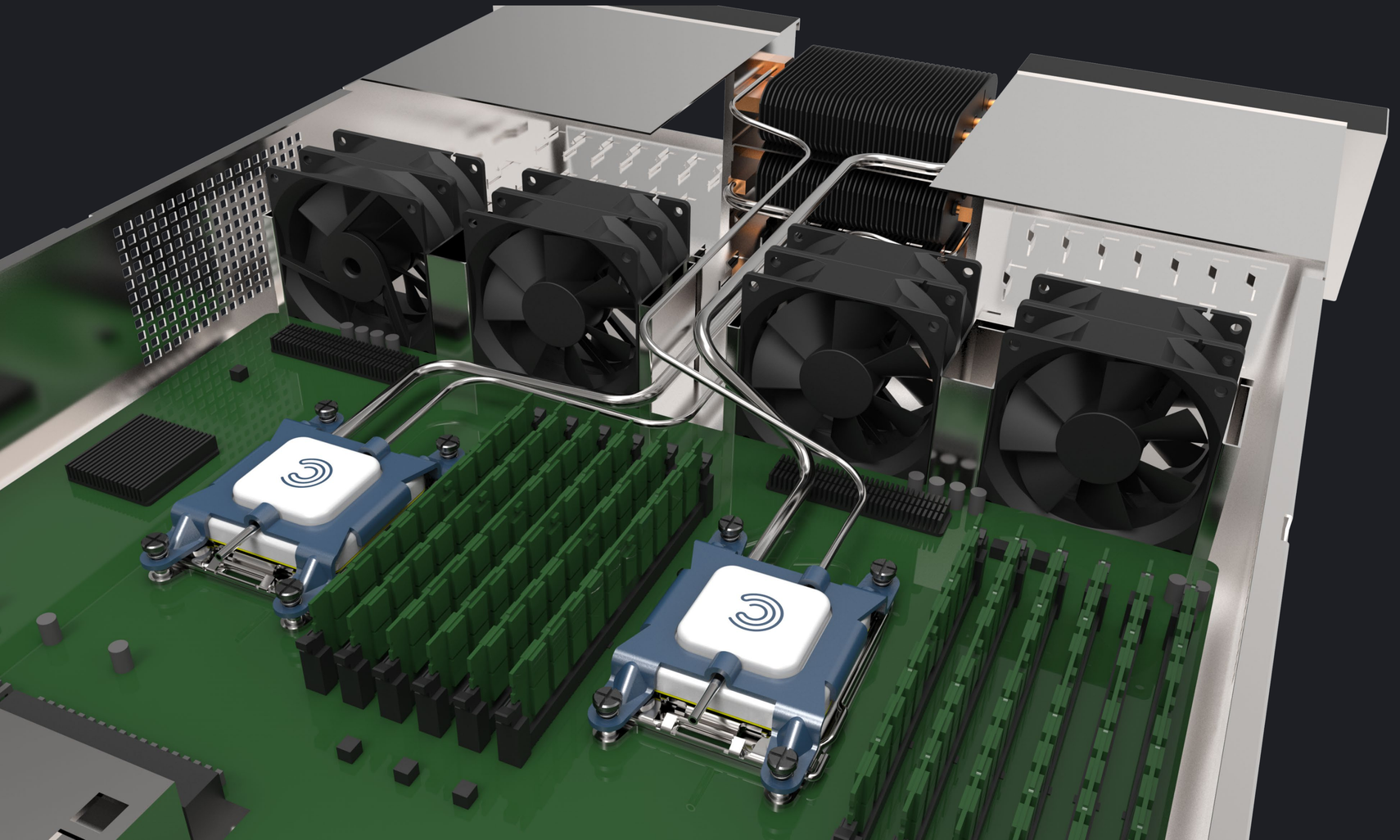
Series



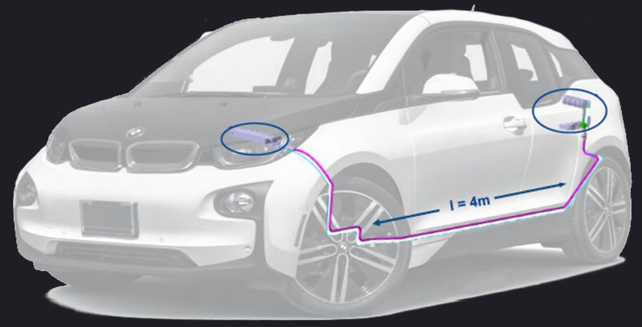
3x Evaporators

Combine series & parallel architectures.

Transportability



Navigate complex environments and transport the heat wherever you desire.



Inverter Automotive Application
4m Transport Distance

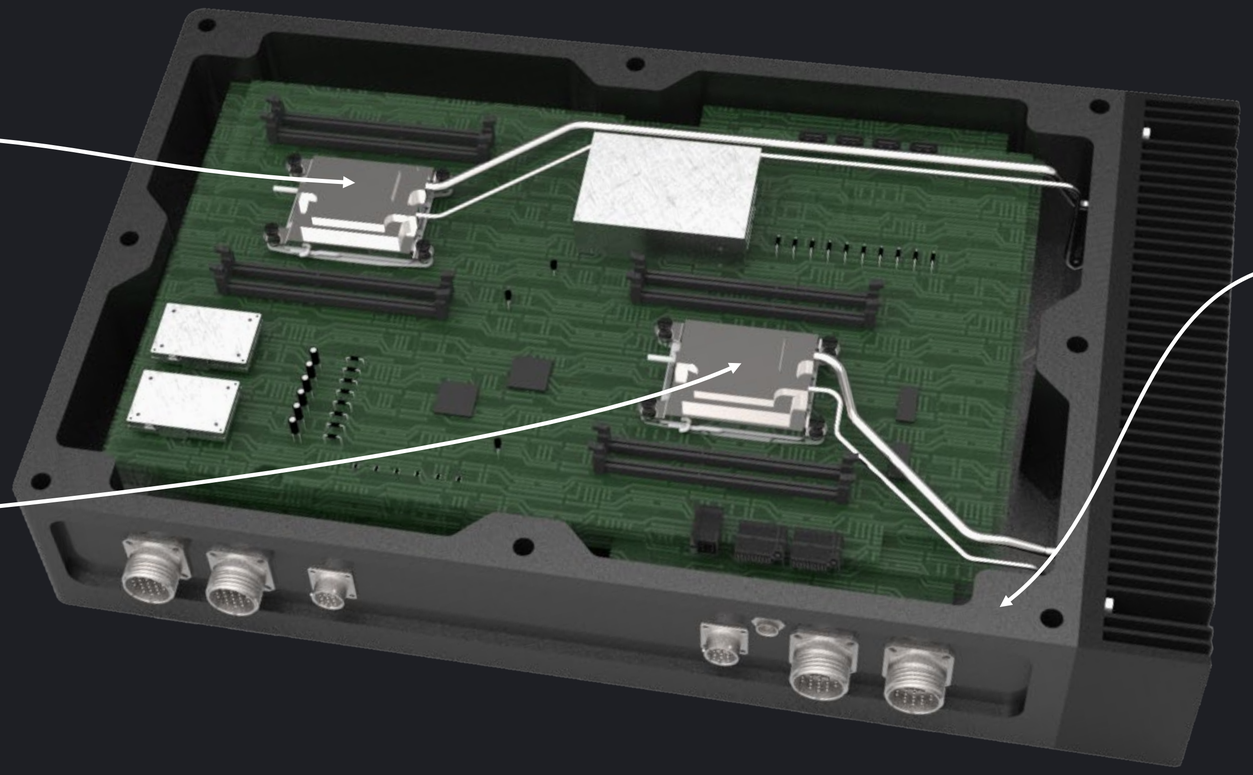
CALYOS

Fluid & Seals

Fluid R1233zd*.

- GWP = 1
- Dielectric (no short circuits)
- 18˚C Boiling Point
- Nonflammable

*Alternative fluids available on request.



Lines.

- Flexible option to ease installation and maintenance
- Custom designs
- Under 8mm Diameter

Hermetic Seal.

- Helium Tested Loop
- Design for **IP Ratings**
- Passed **Vibration** & **Acceleration** Testing for Military, Aero & Space

Ideal for all types of enclosures, easily passing stringent testing.

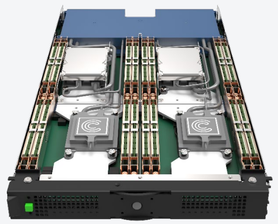
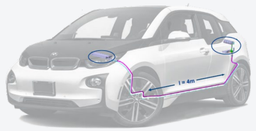
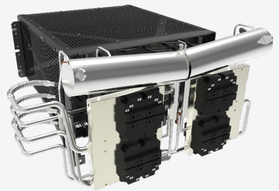
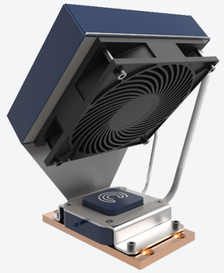
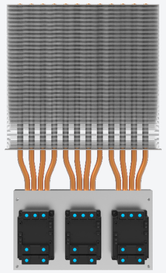
Performance Comparison

	Calyos Loop Heat Pipe	Heat Pipe Heat Sink	Water Cold Plate
Pump	**No**	No	Yes
Fluid	**R1233zd**	Water	Water
Heat density	**Very High (<320W/cm²)**	Average (<60W/cm²)	High (<100W/cm²)
Operating temp	**-40˚C to +120˚C**	0˚C to +100˚C	0˚C to +100˚C
Source distance	**Metres**	Centimetres	Metres
Reliability	**Very Good**	Good (Water Oxidise)	Average (Pump)
Integration	**Flexible & Low Volume**	Restrictive	Flexible
Lifetime	**Long (>20 years)**	Short	Mid

Where have we applied the technology?

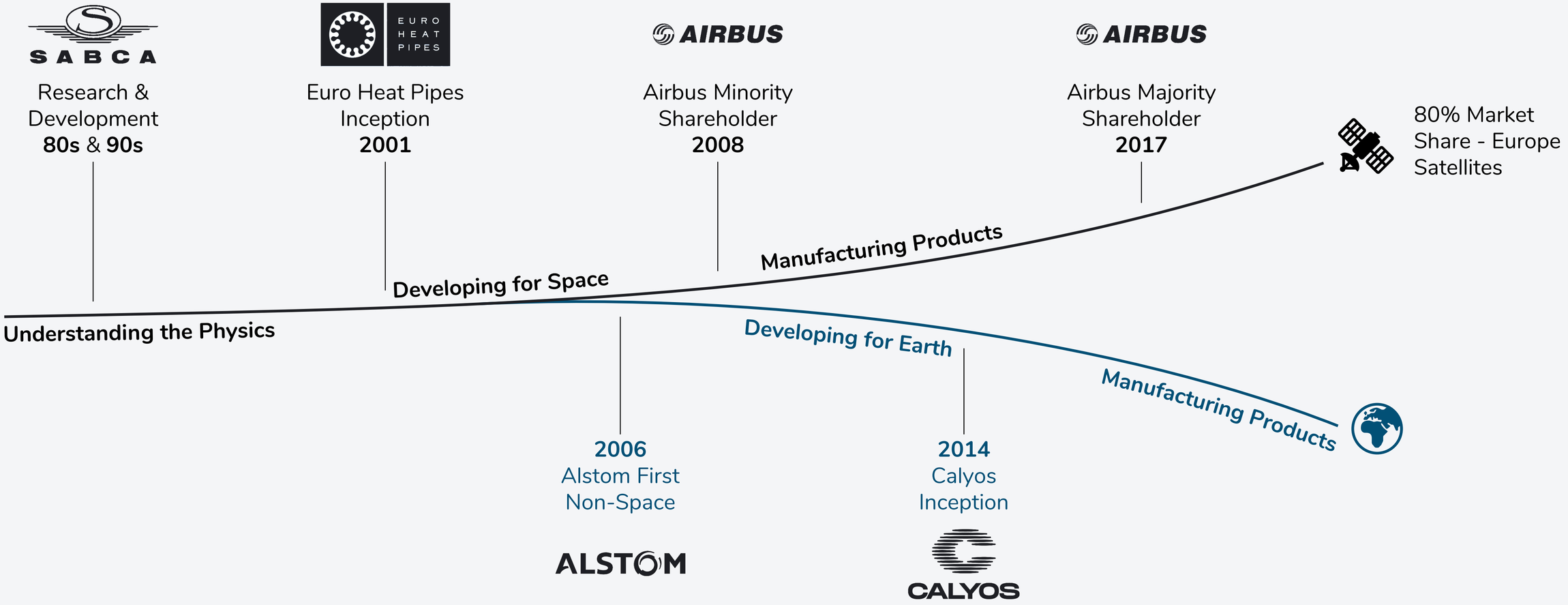
APPLICATIONS

Sectors

IT & Data Centers	Electric Vehicles	Rail	Defense	Medical	Energy	Aviation	Photonics	Space
LDA Tech (Others Confidential)	**Valeo** (Others Confidential)	**Alstom**	**John Cockerill** (Others Confidential)	All Confidential	All Confidential	**Clean Sky**	All Confidential	Sister Company: Euro Heat Pipes
Processors Data Centers	Power Electronics Energy Storage e-Motor	Traction Inverters Auxiliary Converters Sub Stations	Power Electronics Energy Storage Enclosures	Power Electronics Semiconductors Enclosures	Power Electronics Energy Storage Enclosures	Power Electronics Energy Storage Enclosures	Semiconductors Enclosures	Satellites Spacecraft
						Clean Sky		EURO HEAT PIPES
Link	Link	Link	Link	Link	Link	Link	Link	Link

Lastly, what is Calyos' story?

Our Story


SABCA
Research & Development
80s & 90s
EURO HEAT PIPES
Euro Heat Pipes Inception
2001
AIRBUS
Airbus Minority Shareholder
2008
AIRBUS
Airbus Majority Shareholder
2017
80% Market Share - Europe Satellites
Manufacturing Products
Developing for Space
Understanding the Physics
Developing for Earth
Manufacturing Products
2006
Alstom First Non-Space
ALSTOM
2014
Calyos Inception
CALYOS

Why Calyos LHP’s?

Choice of Fluids.

World experts in the use of **dielectric green refrigerants** as opposed to dangerous fluids like ammonia or methanol.

Capillary Structure.

Averaging 30% **better performance** thanks to our patented evaporator design bridging the cost vs performance gap.

System Architecture.

Patented ability to implement series and parallel systems supporting applications where there are **multiple heat/cold sources**.

No Pumps.

Competitors often use pumps to improve performance. We remain **totally passive** throughout the whole loop heat pipe.

Patent Partnership

CALYOS

Non-space

20+

Shared Patents

AIRBUS

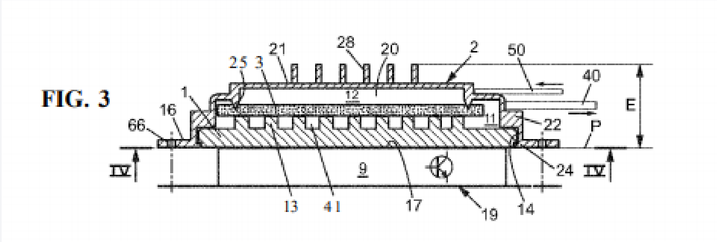
EURO HEAT PIPES

Space

We continue to research and develop our technologies together.

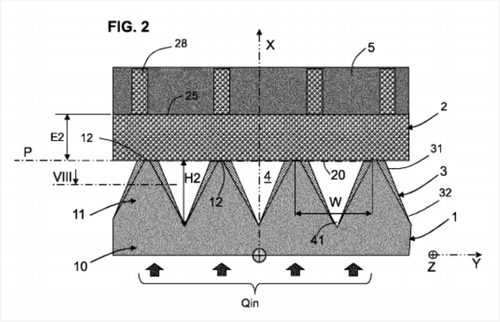
Key Patents

WO2015014929A1



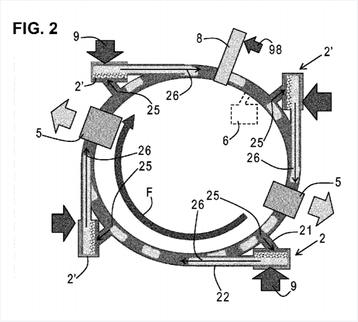
Low cost, **low profile** evaporator which avoids vapor penetration inside the wick at startup. Also ensures capillary tightness at low cost.

WO2018192839A1



Capillary structure to **maximize** LHP evaporator **performance**, ensuring the vaporized fluid exits down the vapor line.

WO2016119921A1



Multi-evaporator **series system design** with core loop. Using vapor momentum from localized LHPs to move fluid in core loop.

Why Calyos?

Great Physics
enabling change.

Great Engineers
easing integration.

Great Products
unlocking potential.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#PLAY IT COOL
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