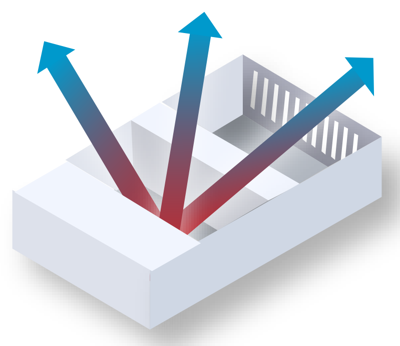
Which Cooling Method is Best for AI Transportables?

With the latest high-performance GPUs and CPUs reaching TDP's of greater than 500W, innovative cooling solutions are needed to bring maximum performance to the harshest environments. While some cooling methods are acceptable for datacenters, the size, weight, temperature, power, noise, and vibration constraints of vehicles introduce new challenges.

Conduction (Natural Convection)

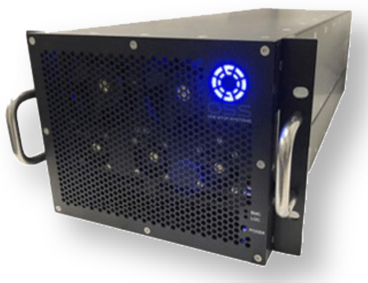
Heat moves from heat generating components to the case of the system via conduction through a combination of thermal interface materials and heat pipes. The enclosure then dissipates heat to the surrounding environment - often through fins built into the chassis.

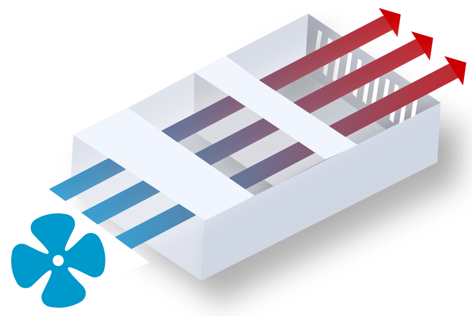


Key Factors	Pros	Cons
• Heat dissipated through system enclosure • Heat moves through system via contact with thermal interface materials or heat pipes	• High shock/vibration tolerance • Passive cooling - no added power consumption to cool	• Limited cooling capacity • Limited system performance • Thermal interface limits repairability

Forced Convection (Air/Fans)

Heat is conducted from components to heatsinks, transferred to air provided by fans, then exhausted out of the enclosure. Fan quantity, size, and electrical properties dictate the effectiveness and supported temperature range of the system.

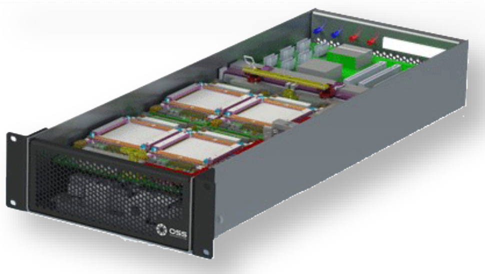


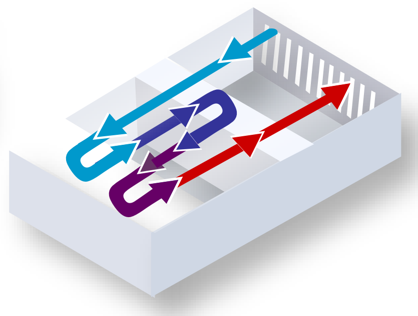


Key Factors	Pros	Cons
• Trade-offs between size, noise, power, and cooling capacity • Uses environment air - no external heat exchanger required	• Wide range of supported heat loads and environmental conditions • Low cost per performance makes good candidate for medium heat requirements	• High noise output • Fan serviceability challenges • Not effective for high heat output components

Direct-to-Chip Liquid Cooling

Heat is transferred to a fluid being pumped through a coldplate and cooling loop which touches the primary heat sources within a system. The hot fluid exits the system and is cooled by an external heat exchanger before recirculating into the system. All-in-one systems cool the liquid through an integrated radiator within or attached to the system.

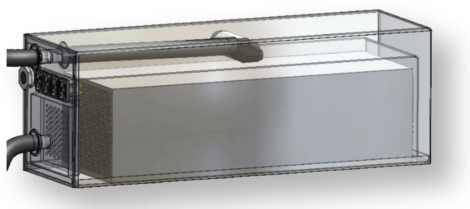


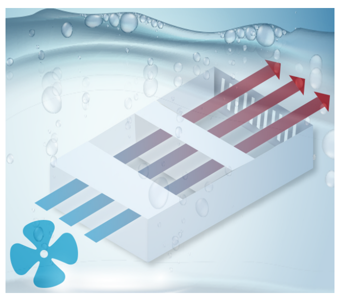


Key Factors	Pros	Cons
• Fluid properties and flow rate dictate performance • Industrial grade components limit risk of leaks • Variety of fluids to fit different applications and heat loads	• Low noise output • Improved thermal efficiency over air cooling • Supports high heat output components	• Limited effectiveness in extreme ambient temperatures • Dependent on heat exchanger to cool fluid

Single-phase Immersion Cooling

The system is immersed in a non-conductive fluid. Heat is transfered to the fluid from the heat generating components, then the fluid exits the system and is cooled by an external heat exchanger before recirculating into the system. The fluid is often directed across the primary heat sources by pumps to improve cooling capacity and efficiency.

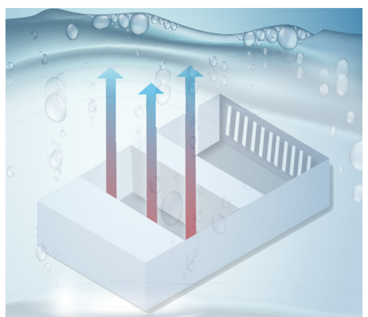




Key Factors	Pros	Cons
• Fluid properties and system design dictate performance • High mass density of fluid changes SWaP profile considerably	• High thermal efficiency enables high ambient temperature applications • Can dampen impact of vibration based on system design	• Additional weight limits transportable applications • Limited field serviceability • Dependent on heat exchanger to cool fluid

Two-phase Immersion Cooling

The system is immersed in a non-conductive fluid which has a boiling point near the target operating point of a key heat generating component. Once the fluid reaches its boiling point, the fluid changes phases to a gaseous state and rises to the surface of the system, pulling heat out of the fluid. The gas is then cooled and recondenses on a condensing coil to recirculate within the system.



Key Factors	Pros	Cons
• Latent heat property of fluid dictate performance • High thermal efficiency enables extreme environmental applications	• Supports highest ambient temperature of all methods • Small power overhead to enable cooling cycle	• Engineered fluids expensive and application specific • Fluid property variations at altitude limit aerospace applications

Website: onestopsystems.com • Email: sales@onestopsystems.com • Toll Free: (877) 438-2724 • Local: (760) 745-9883