VENTIVA™

Zoned Cooling™

Unlocking a New Era of System Design Freedom

Himanshu Pokharna, CTO
Christian Schlachte, Director of Product Management

Executive Summary

The premium thin-and-light category is becoming the mainstream for "do everything" notebooks: work, creation, and now on-device AI. These systems need to deliver sustained SoC performance, higher-end graphics, and AI workloads in chassis that stay thin, light, and quiet.

Conventional fan-based thermal solutions are now one of the main constraints for AI-first premium thin-and-light notebook design. Fan cutouts consume valuable board area and shared airflow paths couple SoC temperature, skin temperature, and acoustics in ways that limit design freedom. By comparison, Ventiva ionic cooling technology is solid-state, totally silent even during the most demanding thermal loads, and more layout-friendly than conventional fans (being a thin, rectangular profile, rather than a large, irregular semi-circle).

Ventiva has translated these unique advantages of ionic cooling into a notebook architecture that replaces fans with ionic air propulsion and delivers up to 20% more usable PCB space back to the motherboard for notebook design innovation, all while cooling a demanding 28 W TDP load (44 W system power) in the premium thin-and-light envelope.

The breakthrough advancement that enables a totally silent 28 W system with thousands of mm^2 more PCB and battery space is Ventiva's Zoned Cooling™ design architecture that divides the notebook into three distinct rectangular zones: a cooling zone, a compute zone (the full PCBA), and the battery zone.

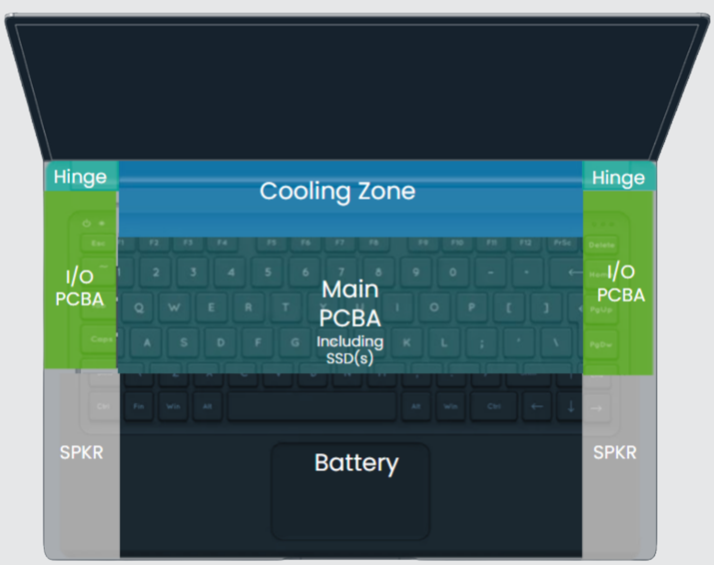


Figure 1. An overview of the three primary cooling zones

This white paper outlines the problems facing the thin-and-light category of notebooks in the age of demanding AI workloads, explains the benefits and implementation of a Zoned Cooling design, and outlines Ventiva's 28 W AI-ready laptop reference design built around the Zoned Cooling concept.

Introduction: The Problems Faced by Premium Thin-and-Light Notebook Designs

The 28 W premium thin-and-light category creates very specific system design constraints that push the limits of balancing performance with reducing weight and system bulk. This category is currently characterized by:

- Requiring higher sustained performance than 15 W SoC ultrabooks without having the sustained thermal requirements of 45 W+ workhorse systems
- Aggressive chassis thinness, typically less than 16 mm
- The need for a balanced design considering acoustics that maintains close-to-silence operation (<28 dBA)
- The presence of broader and higher-end feature sets that demand additional cooling
- Use of premium materials for refined look and feel

With these characteristics and the need to enable all day productivity at up to 28 W SoC performance, the mainboard footprint ends up severely constrained: impacted by both battery and cooling space demands. This is especially true for current fan-based thermal management approaches that chew up valuable space and complicate system design with large motherboard fan cutouts needed to maintain the low targeted acoustic levels (n.b., to minimize acoustic impact, fans must grow in footprint and spin more slowly). Figure 2 helps illustrate the common system design impacts created by large fan hole cutouts—including increased trace length, routing pinch points, and far less board area for feature and component placement.

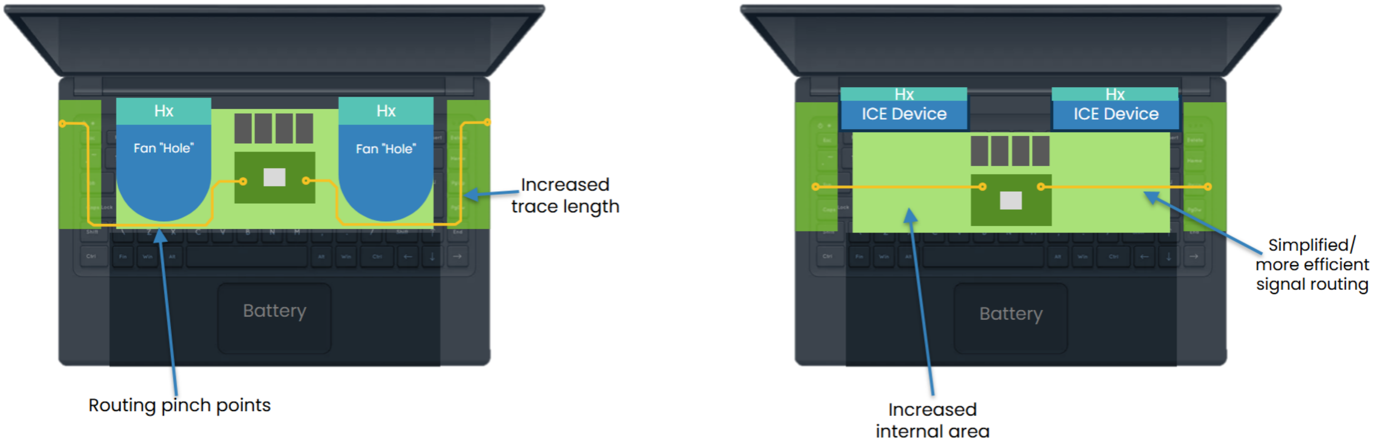


Figure 2. The board layout "fan tax" that results from accommodating fan cutouts

Ventiva's Zoned Cooling architecture, shown on the right-hand side of Figure 2, helps systems break free of the fan-based board-space tax. This new design approach delivers up to 20% more space back to the motherboard, unlocking space for system design innovation and differentiation.

The benefits of this approach and how to design your own system using a Zoned Cooling design are outlined in the following section.

Key Benefits of the Zoned Cooling Architecture for Premium and AI Notebooks

1. More Space and Simplified System Design for Differentiation

Zoned Cooling design reclaims space from fan holes by eliminating the need for large circular fan cutouts, freeing up contiguous PCB area that can be used for compute components with fewer mechanical and layout constraints. The high-speed RAM that AI-first computing requires can be placed closer to the SoC, and shorter, more direct routing supports higher data rates and improved signal margins.

The larger usable board footprint also enables larger SSDs, allowing space for full-length M.2 space (including multiple 2280s) without inefficient routing around fan holes which results in longer trace lengths and often increased PCB layer count. This supports higher storage capacities and more flexible SSD options in the same footprint.

At the same time, reduced thermal module volume enables a larger battery, as the pack can grow in length/width or support additional cells. This enables higher battery capacity in the same ID, which is increasingly important as average power requirements rise to feed AI and graphics requirements.

2. Improved Cost Structure/Margins

The same Zoned Cooling design approach that frees up space and simplifies layouts also helps your bottom line. With predictable rectangular shapes, the platform layout allows the core PCB to be scaled across multiple SKUs. For example, motherboards can more easily be treated as shared modules across a family of products, directly supporting reduced time to market. Standardized cooling building blocks reduce rework around fan geometry for each new ID, and shorter mechanical and thermal validation loops further accelerate platform development.

Additionally, moving from “swiss-cheese” boards to more rectangular outlines improves PCB panelization, saving manufacturing cost. Simplified routing with no detours around fan openings shortens trace length, reduces motherboard complexity, and can reduce layer count, boosting yield and lowering BOM cost.

Zoned Cooling design also drives reduced inventory carry costs. By creating PCBs that are scalable across entire product lines with minimal changes, your team has fewer unique SKUs to qualify, stock, and manage. Common ionic cooling modules further simplify the supply chain.

3. Better User Experience

The benefits discussed above, like extended battery life and more premium features, ultimately show up in the user experience.

Moreover, the Zoned Cooling design enabled by Ventiva ionic cooling technology delivers a truly unique user experience benefit—utterly silent computing: <15 dBA Operator Position noise, inaudible to the human ear. Ionic cooling technology is solid-state and unlike fans, systems remain completely silent under even the most demanding operating conditions. Next, a cleaner internal layout empowered by the modular Ventiva assembly simplifies disassembly, part replacement, and user-driven upgrades, making it easy to access each part of the system for maintenance and repair. This also matters for commercial and education deployments where service time results in greater costs.

Lastly, systems based on an effective Zoned Cooling design lower skin temperature and reduce hot spots to make the device feel even more premium.

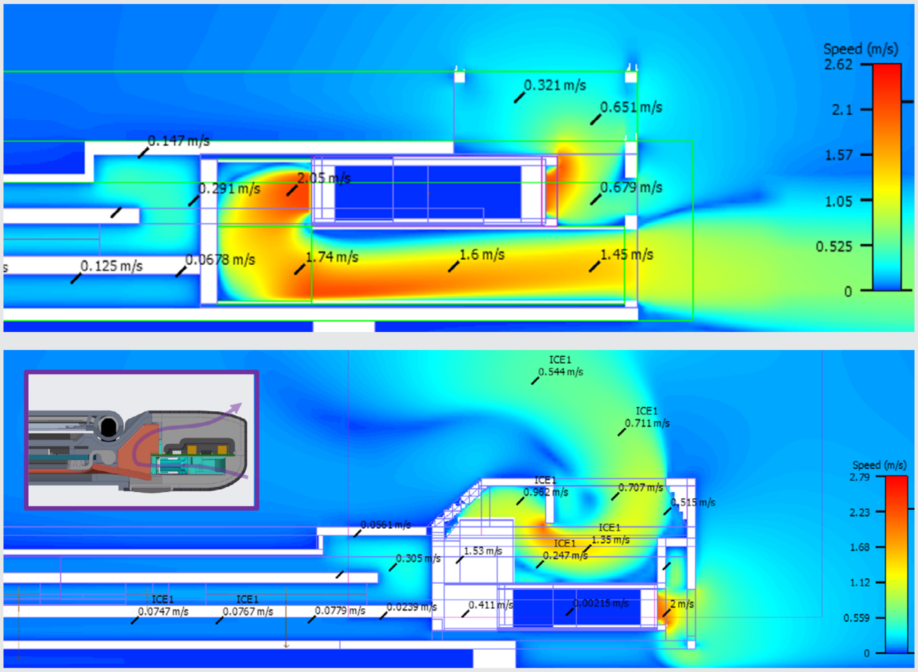
How to Implement a Zoned Cooling Design: Enabling Flexible and Best-in Class Thermal Cooling for Increased System Performance and Reliability

Zoned Cooling design leverages the form factor of Ventiva ionic cooling solutions to decouple airflow paths and reduce system airflow impedance and maximize cooling efficiency. This section outlines the key design principles for implementing Zoned Cooling design in notebook platforms.

1. Design for Lower System Impedance

A core objective with Zoned Cooling design is to minimize total airflow impedance to maximize cooling the SoC (Tj) and skins. To minimize impedance, first, minimize turns, constrictions, and recirculation regions between inlet, the Ventiva devices, and heat exchanger. Second, decouple heat exchanger flow from the system airflow that cools the skins so that no single air mover is required to drive both system-side flow and heat exchanger flow. Lastly, focus on a heat exchanger design that optimizes for low impedance, reducing internal pressure losses.

Figure 3. Demonstrations of U-shaped ingress and exit for airflow that minimizes turns and recirculation



In a Zoned Cooling design, skin cooling and CPU cooling function most efficiently when they behave like independent flow channels, enabling predictable airflow over the primary HX while allowing skins to be cooled separately.

2. Create Ionic Cooling-Centric Airflow Pathways and Push Cooling Rearward

The rear-biased architecture of Zoned Cooling consolidates exhaust at the back edge, reducing internal hot air impingement on the keyboard and palm rest, simplifying the inlet strategy, and directing flow away from the user. This rear-focused path is enabled by the Ventiva device's ability to drive airflow with a side-in, side-out pattern without requiring any inlet plenum as needed by a traditional fan. To best take advantage of this flow pattern, provide short, well-defined channels feeding directly into the device's intake and exhausting to the rear or opposite side.

The use of baffles and ducting allows cooling air to be driven rearward while preventing recirculation into the device inlet. Similarly, aligning vent perforations with the device flow field rather than for purely aesthetic considerations ensures the cooling zone operates efficiently with minimum impedance.

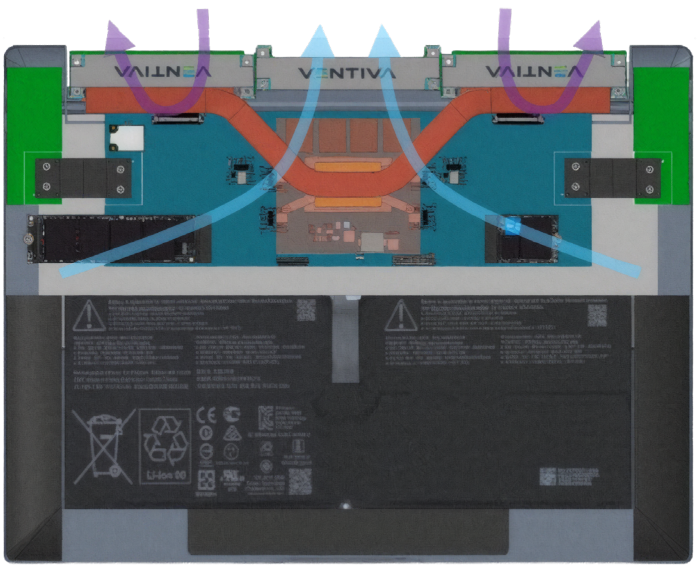
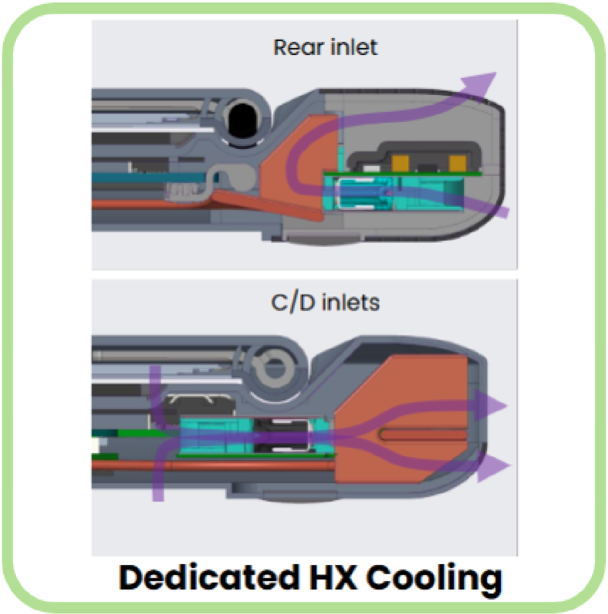


Figure 4. Pushing cooling rearwards through decoupled flow channels allows designs to maximize board space while achieving optimal airflow

3. Separate Heat Exchanger Cooling from Skin Cooling

As noted in Figure 4, one of the simplest ways to create ionic cooling-centric cooling pathways and design for low system impedance is to decouple heat exchanger cooling from skin temperature cooling. This is achieved by employing different airflow pathways for different ionic coolers. For example, in the 28 W SoC reference system, two Ventiva devices use a very short, high-flow, low-impedance path through the heat exchangers which are dedicated to SoC cooling. The third device uses a separate low-impedance path to manage keyboard, palm rest, and bottom-cover temperatures.



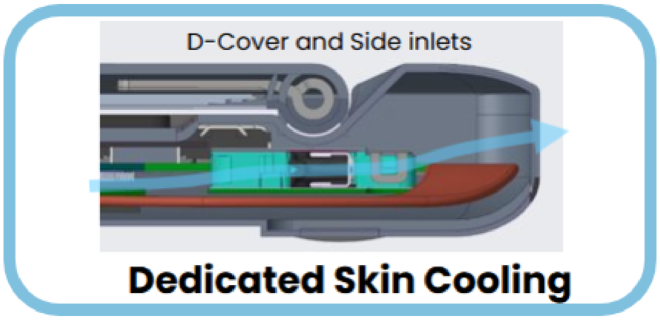


Figure 5. Creating different pathways to each device by separating airflow pathways allows some devices to focus on CPU (HX) cooling while others focus exclusively on skin cooling

This separation avoids compromising needed compute-zone airflow to manage Tj limits while also lowering impedance for dedicated skin cooling to meet touch-temperature requirements.

4. Leverage and Scale with Stacking

Traditional top-in, side-out fans require a plenum above the impeller, consuming Z-height and constraining the layout under under the keyboard. The ionic cooling device's side-in, side-out, low z-height profile eliminates this requirement. As such, air can be drawn directly from side, bottom, or top surfaces anywhere near the inlet to the Ventiva devices and vertical space that was previously reserved for a plenum can be reallocated to reduce system z-height or improve overall design performance and ID.

Moreover, because the Ventiva device is side-in, side-out and requires no plenum, multiple units can be stacked or arranged in parallel resulting in higher flow. This stacking approach could be leveraged in the future to meet even more demanding heat loads (e.g., 45 W+ TDPs found in gaming and workstation notebooks).

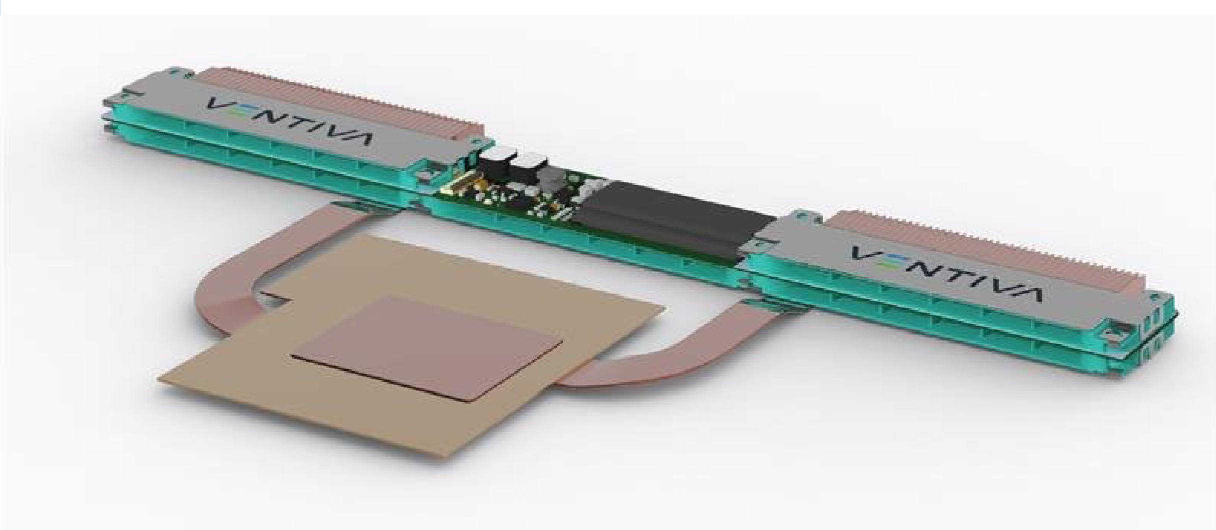


Figure 6. The devices' side-in, side-out flow direction allows them to be stacked together to achieve additional cooling

5. Embrace Modular Board Design and Battery Improvements

Zoned Cooling design empowers modular board architectures with clearly defined core zones: the battery zone, the compute zone (your main, large PCBA), and a significantly smaller cooling zone. By collapsing the thermal module footprint to the rear of the system, your cooling hardware no longer competes directly with the main board area. In a typical 14” chassis, this can free as much as 7,200 mm² of additional PCB area, enabling richer feature sets without increasing system footprint.

The compute zone becomes a large, contiguous PCB region that can host the SoC, discrete GPU or accelerator, power delivery, and a greater population of high-speed memory than is found in traditional system designs. The straighter, less constrained routing enabled by a larger board area simplifies signal integrity for high-speed interfaces and supports more aggressive local AI workloads (e.g., additional memory channels) while still maintaining robust thermal control via the adjacent cooling zone. The battery zone benefits from this modularity as well. Without fan cavities, more of the system’s volume can be allocated to battery cells.

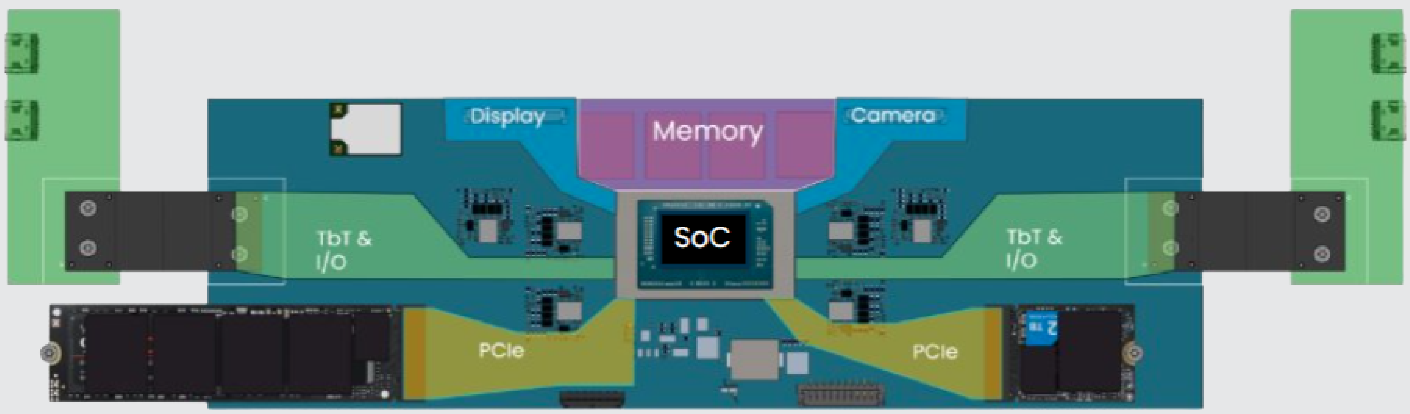


Figure 7. A larger, rectangular board provides additional space which allows for more feature-rich motherboards, fully optimized for maximum signal integrity

The net effect is a cleaner, three-zone system layout that simultaneously increases available motherboard area, improves routing and integration options, and preserves or enlarges the battery, rather than making sacrifices across the board to meet thermal performance targets.

Design Principles → Practice: Ventiva's AI-Ready Notebook Reference Design

In this section, we explain how Ventiva translated the principles of Zoned Cooling design into a concrete, manufacturable example: a 28 W TDP AI-ready notebook reference design. The reference system is a 14" thin-and-light platform in a <16 mm chassis, built around our fully modular architecture with three Ventiva ionic cooling devices, each with 62 mm of active width for driving airflow. The system is organized into three clear zones (battery, compute, and cooling), with the ionic cooling devices forming the compact cooling zone at the rear of the system with decoupled heat exchanger and skin cooling capabilities.

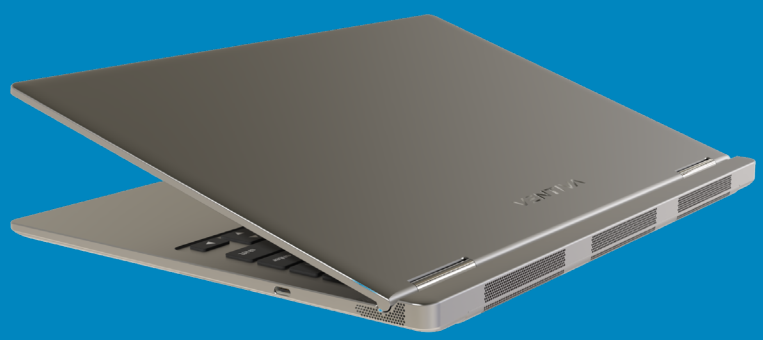


Figure 8. Ventiva's 28 W TDP AI-Ready Laptop reference design

Within this minimal envelope, the design fully supports a 28 W CPU TDP and 44.3 W total platform power, up to a 77 W hr battery, 64 GB of memory, a full 2280 SSD, and is Microsoft Co-Pilot+ ready—demonstrating that AI-first client workloads can be supported without increasing the thickness of the notebook, sacrificing battery, or requiring noisy cooling solutions.

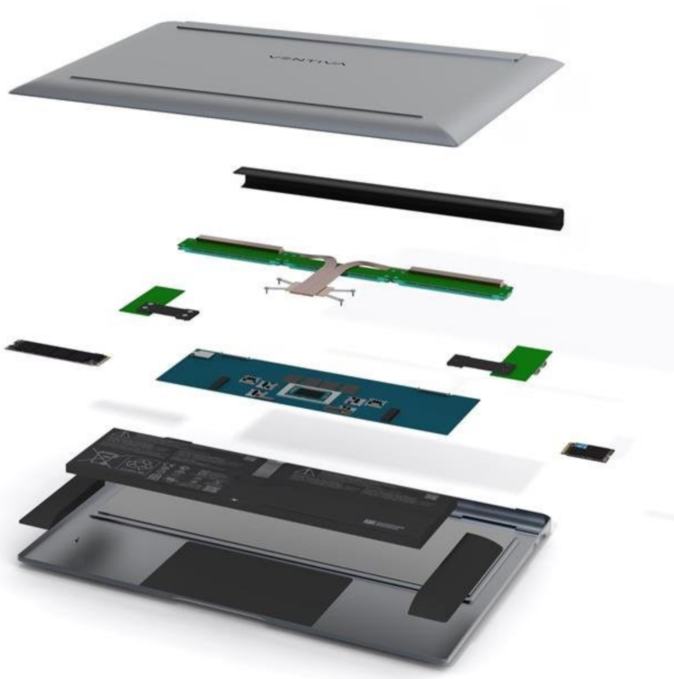


Figure 9. Configuration of the reference system demonstrating distinct cooling, compute, and battery zones

Thermal simulation results validate the Zoned Cooling approach. Under the targeted 28 W CPU TDP and 44.3 W platform power, the CPU package stabilizes at approximately 82°C. User-facing surfaces remain controlled, with maximum bottom and top skin temperatures of 44°C and 45°C, respectively. Total device flow is 2.13 CFM, intentionally partitioned into 1.43 CFM of HX-focused flow and 0.69 CFM of skin-focused flow. This explicit separation of airflow paths is the practical manifestation of Zoned Cooling design: the primary heat exchanger receives a high-efficiency, low-impedance flow channel, while a distinct, independent path is used to manage skin temperature cooling and eliminate hot spots. Importantly, because the heat load is also split between these parallel paths, these flow rates are more than adequate to cool the entire system and the exhaust flow temperatures from each individual unit are approximately equal at about 61°C.

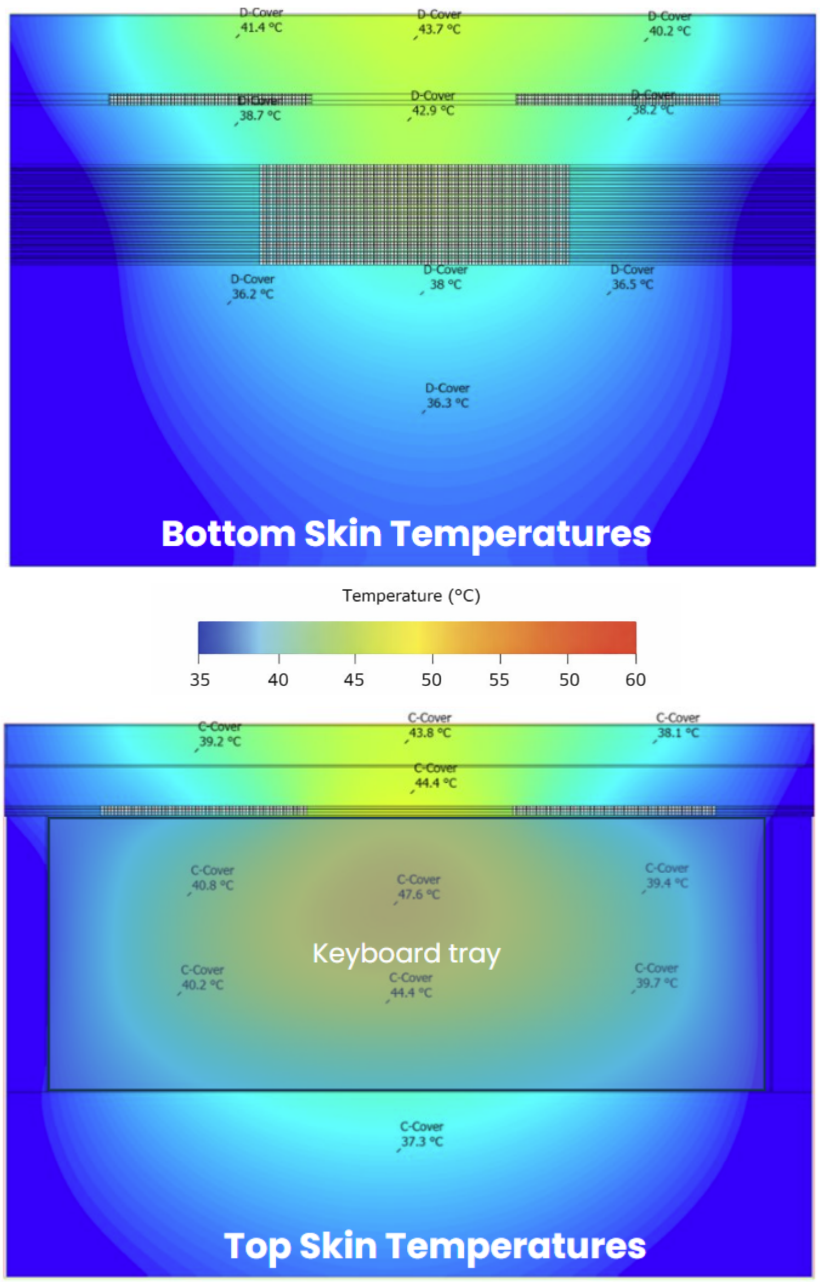


Figure 10. Thermal simulation results demonstrating hotspot temps <48°C

Critically, the entire system is designed to be modular. The computing zone is treated as a self-contained assembly that can be reused, scaled, or adapted across multiple SKUs, while the cooling zone and battery zone retain similar rectangular shapes that could be swapped easily depending on system needs. The result is a reference design that not only proves the thermal and performance benefits of Zoned Cooling design in a 14”, <16 mm chassis, but also provides a clear blueprint for OEMs and ODMs to adopt: a Co-Pilot+ capable, AI-forward platform with excellent thermal performance, large battery capacity, and a layout that is straightforward to scale and productize.

Conclusion

Zoned Cooling design with Ventiva ionic cooling technology is designed to slot into the same AI-first thin-and-light envelope OEMs are already targeting, but without frustrating tradeoffs. Zoned Cooling designs deliver:

- Larger board area by reclaiming space back from fan cutouts
- Cleaner, more modular board layouts
- Lower system impedance with separated HX and skin paths
- Fewer expensive accommodations: reduced layer count on PCBs, reduced retimer use, etc.
- Silent operation and better use of reclaimed volume: increased battery, larger SSDs, more and better high-speed memory

For premium and AI-ready laptops, this translates into more design freedom, a richer feature set, higher sustained performance, and a better overall user experience. All of this with a path to improved margins through simpler, more modular platform design.

Ventiva's 14" 28W AI-ready notebook reference design is just a starting point. The same building blocks and Zoned Cooling approach can be scaled across SKUs and categories where thin, silent, and AI-capable systems are no longer optional but expected by today's consumers.