

Zonal Architecture vs. Domain Architecture: Modular Automotive Infrastructure Face Off

Emerging vehicle functionality is pushing traditional domain architecture to its limit. Learn how the transportation industry is embracing zonal architecture to improve vehicle simplicity, efficiency, maintenance and manufacturing.

In the rapidly evolving world of automotive manufacturing, a transformation is underway from the ECU-laden vehicles of the past to the streamlined and data-centric vehicles of the future. The concept of zonal architecture is redefining everything from vehicle design to on-road performance, maintenance and manufacturing processes.

The transportation industry is in a transformative era, where the integration of zonal architecture promises to raise vehicle design to new levels of efficiency and connectivity. This revolutionary strategy streamlines the overly complex systems of the past and sets the benchmark for vehicle electronics.

What are Domain and Zonal Architectures?

Domain and zonal architectures are two design approaches to a vehicle's electrical infrastructure. Although domain architecture has long been the traditional method to provide increasing vehicle functionality, automotive performance and consumer demands are forcing a pivotal shift towards a more agile zonal architecture. But the massive design changeover required demands careful and thoughtful approaches at every step of development—and at every level of infrastructure.

What is Domain Architecture?

Domain architecture is an approach to a vehicle's electrical infrastructure constructing wiring by function to provide control for the entire vehicle. Each functional element features its own domain controller, whether for powertrain, safety systems or infotainment.

But over decades, the wiring inside vehicles has accumulated as new systems and features have been added. Repeated connections from power source to electronic control unit



(ECU) to device have led to redundant and crowded cabling. This gradual accrual of wiring is considered a flat architecture and faces extreme scaling limitations.

Domain architecture has been an effort to depart from flat layouts toward more adaptability. Most manufacturers have now moved to a domain-oriented design but are now facing new limitations. A single domain can span an entire vehicle — in fact, most do — and each device requires its own unique connection to the controller. This complex web of vehicle-spanning domains requires an incredible amount of cabling, adding weight and decreasing efficiency.

Vehicles with traditional or domain architectures are burdened with between 100 to 150 electronic control units (ECUs), each demanding its own dedicated wiring, contributing to an immensely complex and space-consuming cable harness system. Remarkably, as the rest of automotive systems have moved to automated or robotic assembly, these harnesses still require customization and hand assembly for each vehicle model.

Although domain architecture is an improvement over the traditional flat wiring systems, it represents only an intermediate step toward a fully modular, adaptable approach.

What is Zonal Architecture?

[Zonal architecture](#) is a decentralization of electric controllers to several modular zones, or hardware gateways, located at

points throughout the vehicle. Devices of various functions attach to the closest gateway, rather than with its [domain grouping](#). Zonal architecture reimagines the entire approach to vehicle electronics by assigning each cluster of electrical features to a dedicated [zonal controller](#). This strategic placement of controllers significantly shortens wiring lengths, simplifies power and signal transmission and frees up more space, setting the stage for vehicles that are [data centers on wheels](#).

The Benefits of Zonal Architecture

Structuring devices and computer controls into isolated hubs provides the scalability needed to accommodate high-speed data and a wide range of electronic systems. And zonal architecture also brings automakers several new advantages in terms of efficiency, safety, maintenance and production.

1. Shed the Weight of Copper

The use of extensive copper cabling in traditional vehicle designs contributes significantly to vehicle weight, which is detrimental to efficiency and performance. Some harness configurations contain up to [5 kilometers](#) (3 miles) of wire. Domain system wiring accounts for an average of [45 to 55 kilograms](#) (100 to 120 pounds) of vehicle weight, with a maximum of around 68 kilograms, or 150 pounds.

Automotive lines experimenting with zonal architectures, such as Tesla for the Model 3, considerably reduced cabling length ([3 km to 1.5 km](#)) and dropped overall harness weight by 85%.

By decreasing heavy cabling, zonal designs result in dramatically lighter vehicles. This is especially beneficial for electric vehicles (EVs), where every kilogram saved translates to an increase in range and a boost in performance. This weight savings is further improved as vehicles migrate from 12V to 48V electrical systems that can deliver the same power at lower currents, reducing the thickness and corresponding weight of wires. With thinner wires and simpler routing, designers also free up more space for other systems.

2. Increase Durability for Data and Power Reliability

Traditional vehicle systems are often at the mercy of the operational environment, with connectors particularly vulnerable to the frequent shocks and vibrations inherent in daily vehicle use. The centralized layouts of domain architecture are more susceptible to comprehensive failure — where one error can bring down the entire electrical network — and increase the risk of safety issues.

However, the durability of zonal systems is enhanced by more advanced, rugged connectors. These interconnects are engineered to withstand life on the road — such as extreme temperatures, ingress and vibration — to ensure uninterrupted power and high-speed data transfer. Within zones, failsafe protocols keep malfunctions isolated,

preventing widespread electrical failure. This added durability is essential for the safety and functionality of advanced driver assistance systems (ADAS) and the emerging autonomous vehicle sector.

3. Simplify Maintenance and Updates

Traditional electrical systems can lead to time-consuming maintenance tasks. Mechanics must understand the nuanced wiring of each complex system, making even simple access, repair and updates a labor-intensive process that often requires specialized skills and equipment. This complexity also increases the risk that a repair action to one feature will disrupt the functioning of others.

With the universal and modular approach of zonal, vehicles can be easily improved or repaired, significantly reducing downtime and costs. Isolated zones make access, diagnosis and troubleshooting far simpler and within reach of the average technician.

Software updates can also be deployed remotely, such as over Wi-Fi or 5G, keeping vehicles current with the latest features, updates and safety patches without the need for a technician and manual involvement.

4. Improve Manufacturing and Assembly Efficiency

Producing vehicles that integrate domain architecture has traditionally been labor-intensive, especially when crafting individual harnesses. Each harness is uniquely tailored to the specific product. Assembly lines are encumbered by the meticulous process of taping and attaching wires at each station, for every feature.

The manufacturing process is on the brink of a revolution with the adoption of the zonal paradigm. The standardized and modular design of zonal architecture facilitates streamlined assembly lines featuring pre-assembled harnesses and plug-and-play interconnects. These advances lead to greater flexibility, easier automation, fewer errors and drastically reduced manufacturing costs for electrical subsystems.

This surge in efficiency is not just a win for manufacturers, but also for consumers as it can potentially lead to more affordable vehicles.

Explore the Era of Zonal Architecture with Molex

The adoption of zonal architecture into vehicle design marks a pivotal shift in the transportation industry. It addresses the major challenges of complexity, weight, durability, maintenance and assembly that have long plagued vehicle manufacturers.

As the transportation sector continues to innovate with ADAS, electrification and shared mobility models, zonal architecture emerges as the new foundation upon which the

future of transportation will be built.

Molex is at the forefront of this change, harnessing its extensive engineering expertise to develop connectors and systems that ensure the vehicles of tomorrow are not only more advanced but also reliable, efficient and adaptable. For example, our [MX-DaSH Hybrid Inline and Wire-to-Board Connectors](#) are designed with zonal in mind by combining traditional power and signal with high-speed data in a single compact connector system.

[Download our whitepaper](#) for deeper insights into the benefits and capabilities of zonal architecture.



[zonal-architecture-vs-domain-architecture](#)