THINK ACT

BEYOND MAINSTREAM

INTERVIEW WITH SACHIN LAWANDE, PRESIDENT AND CEO OF VISTEON CORPORATION

CONSOLIDATION IN VEHICLE ELECTRONIC ARCHITECTURES

The master key to unlocking value in the next generation of "smart cars"

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Roland Berger
Strategy Consultants

THE BIG 3

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Electronics costs are growing out of control and limiting user experiences – Electronics consolidation is key to growth and value capture.

Linda wakes up to an alert from her smartphone that it's snowing and her smart car estimates she needs to leave early to make her morning meeting. She's video conferencing while she enters her car and the conversation transitions to the car's infotainment system (IVI). Since the IVI is already in use, her car confirms her route on the cluster (speedometer and other information display) and begins driving in automated mode. While the car uses sensors to drive, Linda dictates responses to emails being read to her.

While this scenario is fictitious, consumers will soon be expecting this level of comfort and seamless commuting, and OEMs are not ready to provide it. Commuting in this fashion will require cars with multiple screens that have intensive graphics capabilities, multiple operating systems, in-vehicle and cellular communication networks, and numerous external sensors. Behind the scenes, a tremendous amount of graphics intensive, "mission critical," well-coordinated processing power will be required to efficiently operate all of these systems error free.

Today's mainstream solution to the increasing electronics requirements in vehicles is to add an additional electronics control unit (ECU) every time a new feature requires processing capabilities. These ECUs then communicate with each other over multiple slow communication networks.

While this strategy has been effective to date, it has a number of limitations and downsides as the number of ECUs in a vehicle grows. Every additional ECU adds direct costs to the vehicle – sometimes hundreds of dollars per ECU. Additionally, as ECUs increasingly need to communicate with each other, internal communication networks are becoming "crowded," slowing down and complicating information sharing.

This continuously increasing cost and added complexity is unsustainable, from both a functional and economic perspective. The solution: a completely reworked electronics architecture that consolidates ECUs using modern multicore processors to operate multiple modules on a single domain controller. By reducing the number of ECUs in the vehicle – cost, complexity, and weight are all simultaneously reduced as well – and these are only some of the advantages of module consolidation.

In total, these advantages represent an eye-opening USD 175 total cost of ownership savings per vehicle from the perspective of an OEM when consolidating a group of mid-range cockpit ECUs, presenting a tremendous opportunity. However, there are also challenges OEMs must overcome, including changes to their supplier pools and organizational issues, in order to adopt module consolidation.

This being said, automotive consumers like Linda are basing their expectations – both for price and for quality – on their consumer electronics. This is setting a high bar and fast expected pace of innovation for the automotive industry.

1 **The tipping point –** Due to functional limitations and increasing costs, today's patchwork approach of adding ECUs for each new feature is no longer sustainable.

Automotive consumers expect the latest and greatest in electronics and safety, regardless if they are buying a BMW 7 Series or a Honda Civic. Whether it's an instrument cluster with a graphics rich, fully reconfigurable display or a lane departure warning system, a tremendous amount of processing power and electronic communication is required to operate today's vehicles. These features add complexity to vehicle's network architectures and proliferate the number of ECUs in each vehicle. The quantity and complexity of these systems is only expected to increase as all major automotive trends are largely enabled by advanced electronics systems A.

This proliferation is the result of the ad-hoc approach OEMs are taking to designing their electronic architectures. Instead of thinking about what a modern electronics solution would look like if it was designed from scratch, they are simply adding a new ECU every time a new vehicle feature requires processing power. This has resulted in vehicles with as many as 100 ECUs and over 100 m lines of code B.

This approach has brought the industry to a tipping point for two fundamental reasons. First, continually adding ECUs is no longer economical. For example, upgrading a cluster from an analog display to a fully reconfigurable screen with the processor required to run it can add USD 150 to a vehicle. In total, advanced versions of the major ECUs in today's cockpit (IVI, telematics unit, cluster and radio) can add up to over USD 800. Premium car customers might be willing to accept these added costs, but more and more mainstream vehicle buyers expect advanced electronics at a more economical price point.

Second, patchwork electronic architectures are reaching a point where they are becoming too complex to deliver the experience consumers expect. Adding ECUs increases development complexity, which slows the development process and adds unnecessary costs.

Additionally, adding ECUs increases traffic and slows communication on vehicles' already burdened electronics networks. This can impact the seamlessness of the customer's experience and doesn't allow for certain operations to be processed quickly enough to enable features that require fast, reliable input from multiple ECUs.

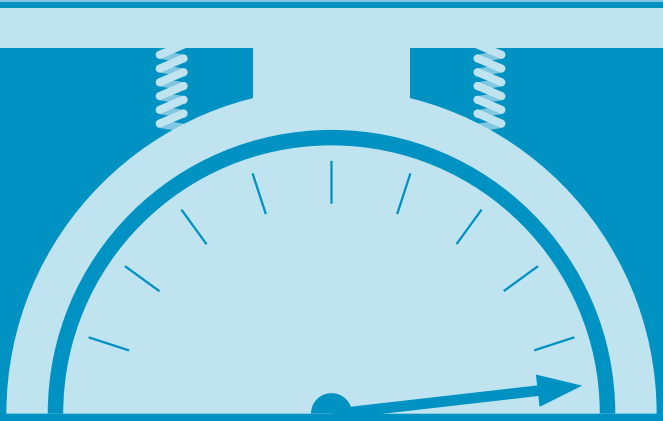
The end result are electronics experiences in vehicles that are inferior to the latest consumer electronics, which has caused brand perception issues, damaging OEMs' reputations. Additionally, these systems can be too slow and unreliable to perform the level of processing required for automated and connected driving.

A

AUTOMOTIVE TRENDS

IMPACT ON ECU PROLIFERATION AND INCREASED COMPLEXITY

More, bigger, higher quality screens e.g., reconfigurable clusters	✓	✓	
Improved HMI e.g., touchpads, gesture control	✓	✓	
Greater content requirements e.g., IVIs running multiple OSs		✓	
Increased inter-ECU communication e.g., navigation information simultaneously displayed on the IVI, cluster and HUD			✓
Increasing ADAS assist penetration e.g., lane departure warning	✓		
New Active ADAS features e.g., active lane departure avoidance	✓	✓	✓
New demands on telematics units e.g., WiFi, OTA updates	✓		✓
Higher emissions and fuel economy standards e.g., manage additional sensory input and provide system control		✓	✓



LESS ECUS, PROCESSING POWER REQUIRED, AND E/E ARCHITECTURE COMPLEXITY

MORE ECUS, PROCESSING POWER REQUIRED, AND E/E ARCHITECTURE COMPLEXITY

More ECUs | Increased processing power requirements | Increased E/E architecture complexity

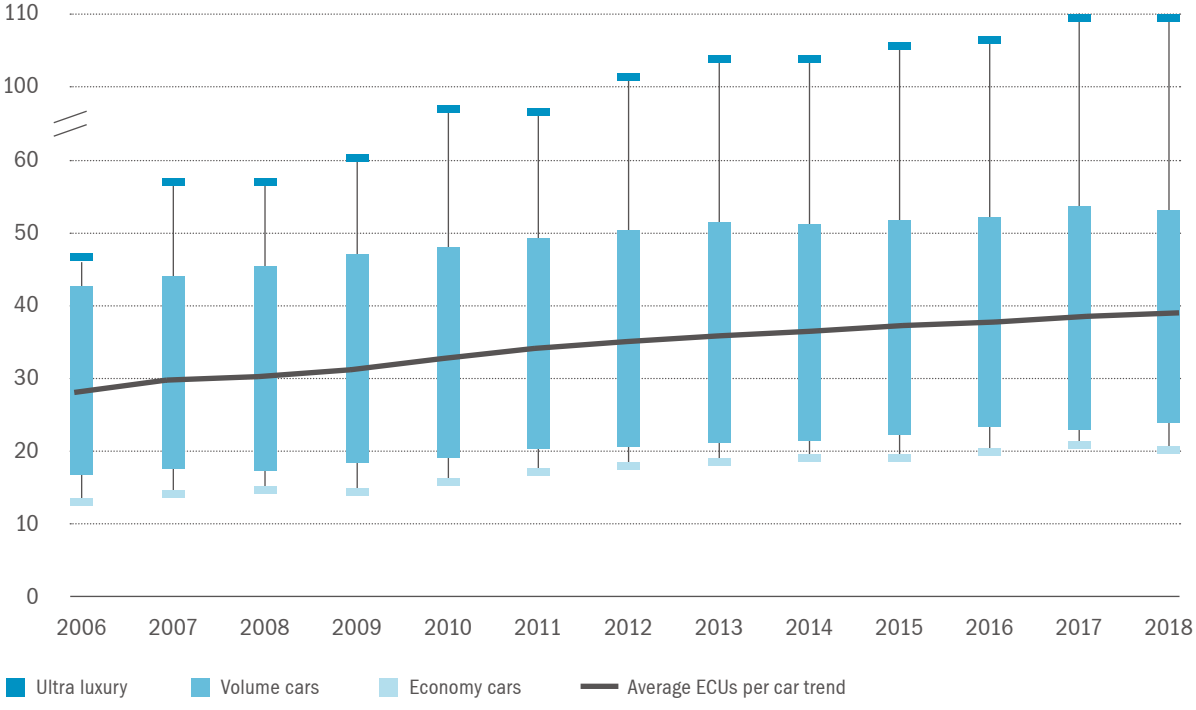
Source: Roland Berger

B

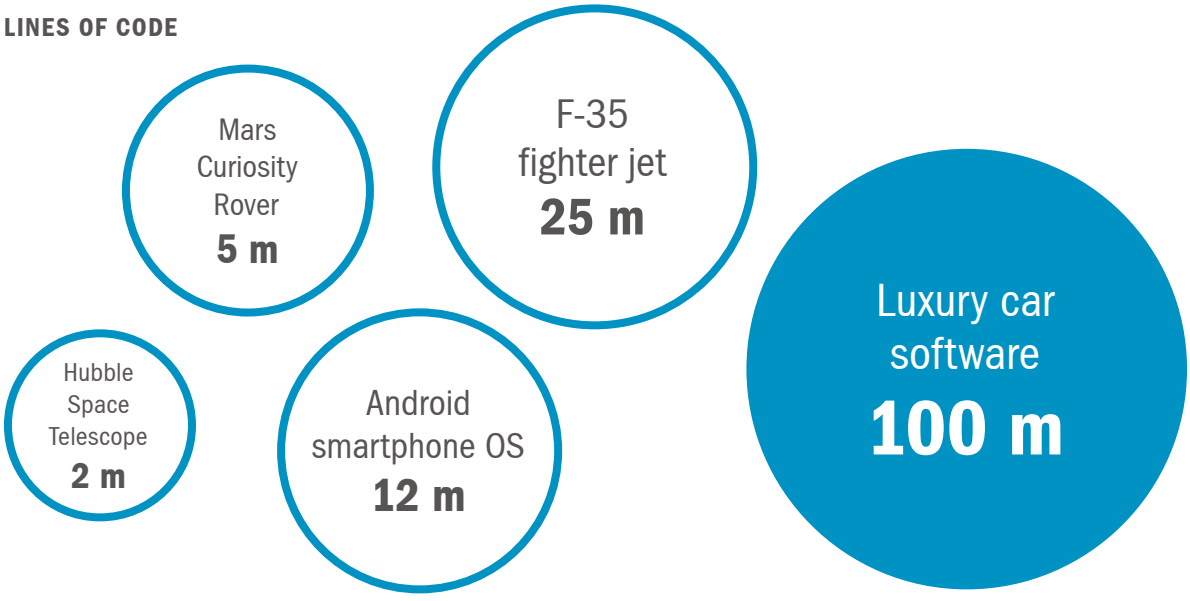
COMPLEXITY

INCREASING ECUs AND LINES OF CODE PER VEHICLE

AVERAGE ECUs PER CAR



LINES OF CODE



Source: Wall Street Journal, Strategy Analytics, Information Is Beautiful, Roland Berger

The blank sheet approach – Module consolidation is the modern solution to problems with today's electronic architectures.

Module consolidation is a technical solution leveraging modern, multicore processing technology to operate multiple ECUs which all traditionally had their own processors. In a multicore solution, these ECUs retain dedicated processing space, usually in the form of their own core in the processor.

However, a number of redundant components are eliminated, including housings, power supplies, wire mounts and harnesses, as well as the processors themselves, all saving cost. Instead of ECUs communicating over a communication network such as the CAN bus, they are able to communicate within the processor itself, which increases speed and reduces complexity. The result is an electronic architecture that is faster and more capable while being less complex and less expensive.

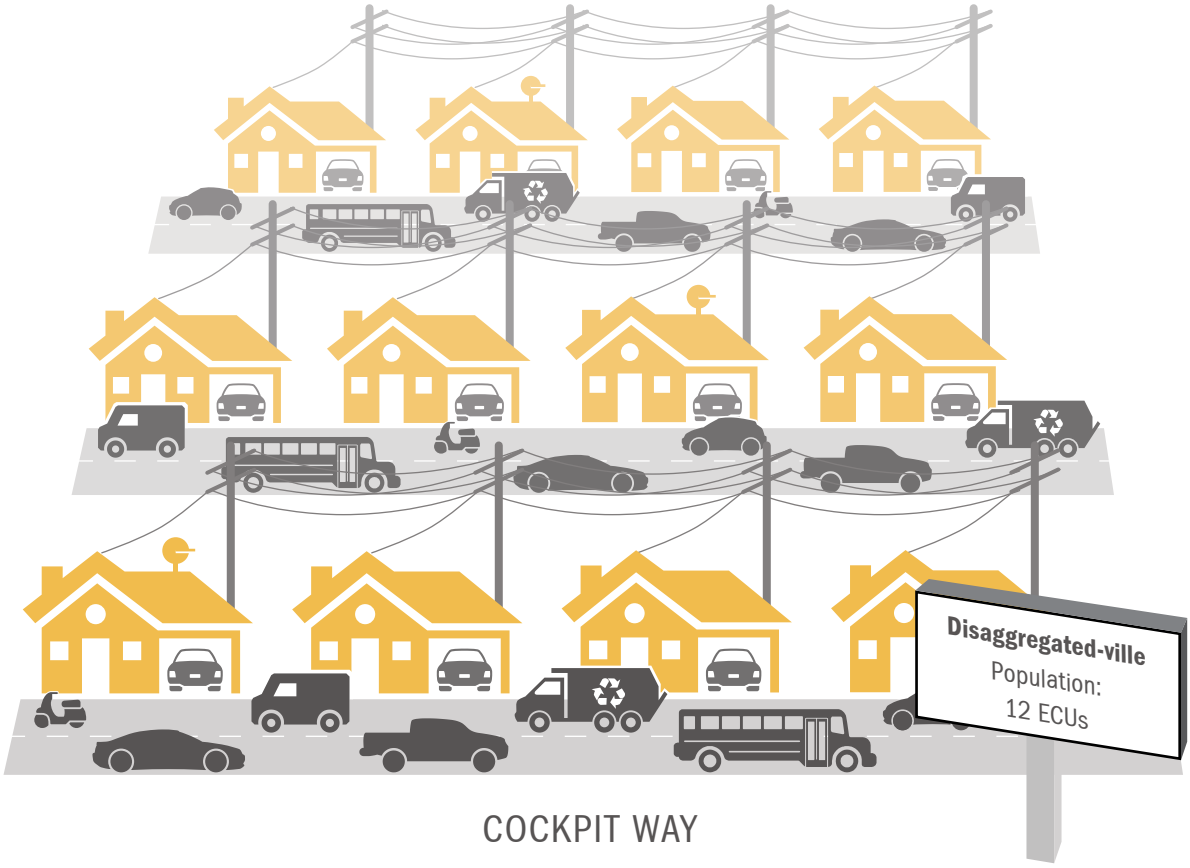
The advantages of an electronic architecture with consolidated modules can be illustrated by thinking about different urban planning solutions C D.

The result of module consolidation is an electronic architecture that is faster and more capable while being less complex and less expensive.

C

DISAGGREGATED-VILLE

THE TOPOLOGIES OF MOST OF TODAY'S ELECTRONIC ARCHITECTURES LOOK LIKE SPRAWLING SUBURBAN COMMUNITIES



COCKPIT WAY

DISAGGREGATED-VILLE
Population: 12 ECUs

Depicted as suburban "Disaggregated-ville" in the accompanying diagram, each ECU is represented by a single family home. Suburbia does have its advantages: households can easily be built and modified independently of each other, and a disaster such as a burst pipe will likely only impact a single home. However, suburbia has many more disadvantages.

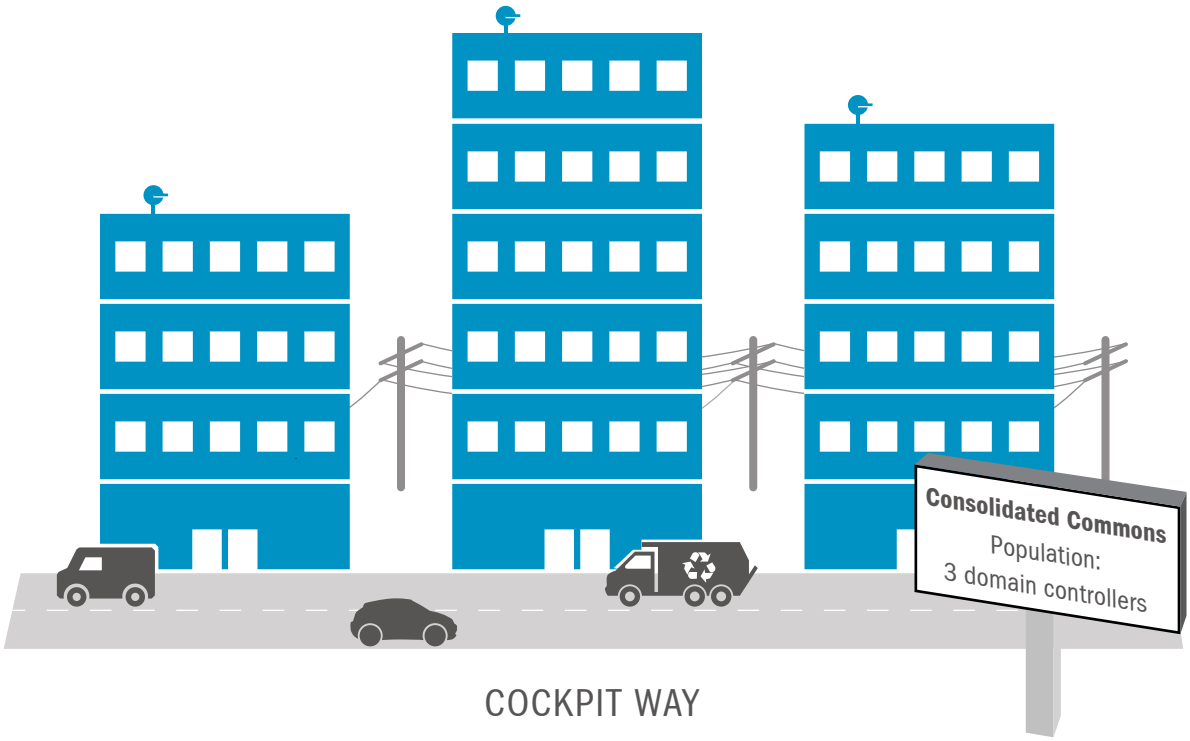
- Efficiency lost due to redundancies such as independent amenities required for each household
- Efficiency lost due to the delivery of services such as mail, garbage, water, gas and electricity to independent households
- Costs to develop the infrastructure necessary to deliver services
- Significantly larger space requirements than consolidated housing options
- Infrastructure become strained and congested as the community grows

Source: Roland Berger

D

CONSOLIDATED COMMONS

HOWEVER, IF A "CLEAN SHEET" APPROACH WAS TAKEN TO DESIGNING A VEHICLE'S ELECTRONIC ARCHITECTURE, ITS TOPOLOGY WOULD LOOK MUCH MORE LIKE A MULTI-FAMILY BUILDING



COCKPIT WAY

CONSOLIDATED COMMONS
Population: 3 domain controllers

Depicted as urban "Consolidated Commons" in the accompanying diagram, each ECU is represented by its own apartment unit, consolidated into a single building, or "domain controller." Multi-family buildings have a number of advantages.

- \+ Shared amenities such as power within each building
- \+ Shared infrastructure to deliver services like power and water within each building
- \+ Efficient delivery of services such as garbage and mail
- \+ Space is conserved

Source: Roland Berger

2 **The value iceberg –** Piece price savings are just the tip. TCO advantage of USD 175 per vehicle is realistic.

Thinking about module consolidation in terms of urban planning principles would suggest that combining multiple ECUs and their housings into a single unit would result in significant cost savings. In an industry where every cent matters, this sounds like a no-brainer. However, intuition alone isn't enough.

For this reason, we conducted a detailed total cost of ownership (TCO) analysis from the perspective of an OEM to model the financial advantages of a single domain controller over a disaggregated set of ECUs. The results of this analysis added up to more than a few cents in savings – a USD 175 advantage per vehicle for a group of "mid-range" cockpit ECUs E.

This analysis first considers the direct piece price savings, or first order system cost savings that can be achieved by consolidating disaggregated ECUs into a domain controller. The individual costs of four mid-range cockpit ECUs (an IVI, cluster, TCU and a radio), can total ~USD 800. Due to the removal of unnecessary, redundant hardware and electronics, a consolidated domain controller would cost just USD 690, which includes the cost of the domain controller and the "dummy displays" which no longer have dedicated ECUs, but are still required to complete the system.

The result is a piece price savings of USD 110. However, piece price savings are just the "tip of the iceberg," as additional TCO advantages, or second order benefits, have also been quantified. These include reduced weight, reduced assembly complexity, and improved upgradeability. These total savings of USD 65 per vehicle. We took a conservative approach when quantifying these additional benefits, carefully only selecting benefits that we could confidently apply a sound methodology to translate them into a dollar figure advantage. Therefore, there are even more benefits, such as the design flexibility freed-up packaging space in the cockpit offers, that are even "further below the surface."

E

THE VALUE ICEBERG

Per vehicle advantage of consolidation

Source: Roland Berger

The second order benefits quantified include:

> Reduction in system weight of ~three pounds from eliminating redundant housings, processors, connections, etc., which was translated into a fuel economy benefit (USD 8/unit)
> Reduction in systems costs, primarily based on a reduction in wiring (USD 13/unit)
> The ability for OEMs to streamline operations including procurement, development and testing due to reduced supplier coordination requirements and less communication/complexity on vehicle communications networks (USD 6/unit)
> Reduced assembly plant complexity due to fewer part numbers and fewer physical ECUs (USD 8/unit)
> Improved upgradeability – a single module can more easily be packaged in a location conducive to interchangeability (e.g. in a glove box) than multiple modules, and interchanging one module can update/upgrade the entire cockpit (USD 30/unit)

While this analysis provides a baseline value of the advantages of consolidation, it is imperative that every OEM conducts their own TCO analysis on a platform by platform basis as advantages of module consolidation will vary widely from OEM to OEM.

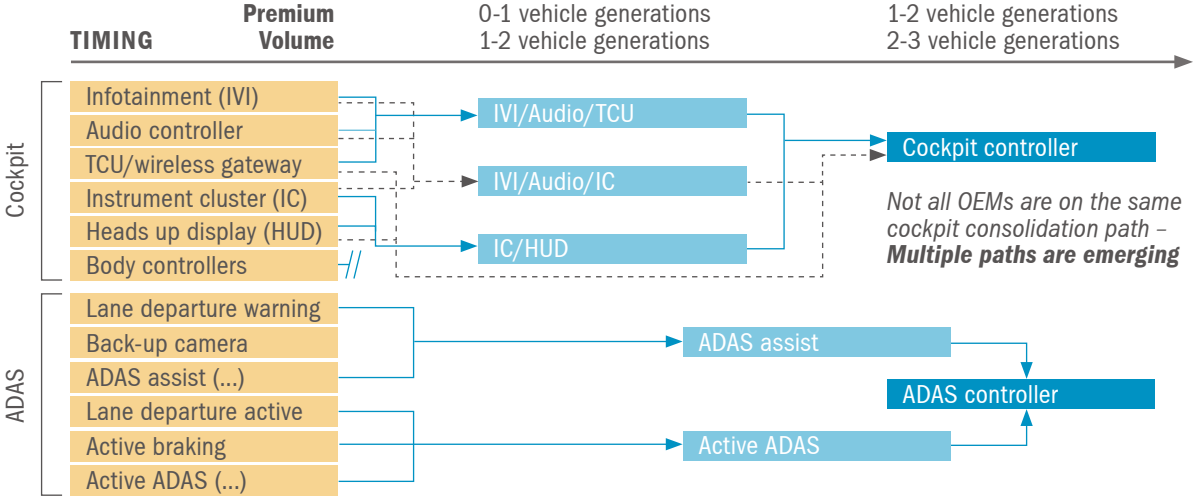
ECU consolidation roadmap

Although the advantages of module consolidation are clear, the path OEMs will take to consolidate modules isn't. Even though the path will vary from OEM to OEM, there are some generalizations about the expected paths OEMs will take towards full system domain controllers. It is clear that ECU consolidation will take place in stages, with differing groups of ECUs being consolidated, then being further consolidated into full system domain controllers. However, the exact groups of ECUs that will be consolidated will vary by OEM. Also, there will likely be a clear divide between the consolidation of ADAS related ECUs and cockpit ECUs, due to safety and security concerns (e.g. so a hack of the IVI can't control the chassis system). Finally, it is also clear that Premium OEMs are leading the charge towards consolidation, and given their existing level of infotainment systems and ADAS, have already begun consolidation F.

F

ECU CONSOLIDATION ROADMAP

Consolidation timelines will differ – Cockpit and ADAS consolidation will occur independently



Source: Roland Berger

The time is now – Solutions exist to OEMs' hesitations. The industry can start adopting module consolidation.

Despite the clear advantages of ECU consolidation, the amount of urgency OEMs are showing to consolidate modules varies widely. In fact, while some OEMs are already starting to use domain controllers in production vehicles, most are just beginning to consider consolidation and haven't yet established roadmaps detailing their consolidation strategies. The hesitation most OEMs are showing to adopt module consolidation is linked to a number of risks and roadblocks – some real and some largely perceived.

⚠ **OEM HESITATION:** One of the largest perceived risks OEMs face is mixing functions with different safety requirements (i.e. ASIL levels). For example, an IVI system that mainly provides driver entertainment does not have the same safety requirements as an instrument cluster, which displays regulated information on the speedometer and odometer. The implications of different safety levels are different development timelines and costs, as well as a risk of one impacting the function of the other if they are combined within the same ECU.

⚠ **OEM HESITATION:** Security is also a major concern, and OEMs therefore try to avoid mixing safety relevant functions with "consumer electronics" functions, which are exposed to a certain level of intrusion risk from the outside world.

⚠ **OEM HESITATION:** OEMs are use to sourcing standalone ECUs from separate suppliers – whereas a consolidated module may be sourced from a single supplier depending on the technology execution. This risks OEMs putting their "eggs in one basket" in case there are issues with that supplier, as well as potentially reducing their bargaining power.

💡 **SUPPLIER SOLUTION/RISK MITIGATION:** In response to these concerns, suppliers have developed technical solutions, primarily in the form of hardware virtualization, which fully segregates different modules running on the same chip into their own processor cores. This solution allows modules to be developed and operate independently while taking advantage of the consolidation. While many OEM hesitations are legitimate, suppliers have responded with solutions that address these concerns and allow for consolidation to happen now.

⚠ **OEM HESITATION:** Some OEMs also see an uphill battle in restructuring their organizations from the current state with dedicated teams for each ECU to a single team responsible for the entire consolidated system. To many OEMs, this is the biggest hurdle they will face moving towards a more layered and centralized E/E architecture.

💡 **SUPPLIER SOLUTION/RISK MITIGATION:** However, to a large degree, this actually presents an opportunity to OEMs who already outsource much of this development, allowing them to consolidate and more efficiently work with these service providers.

3 **The race is on –** Players are moving, but too slowly. First movers can capture the most value before commoditization hits.

The trend towards module consolidation is largely being pushed by the supplier community, including the "high-tech" Tier 1s, chip manufacturers and software providers. Although every OEM and supplier is at their own stage of accepting and adopting ECU consolidation, we've generalized where the various players stand G.

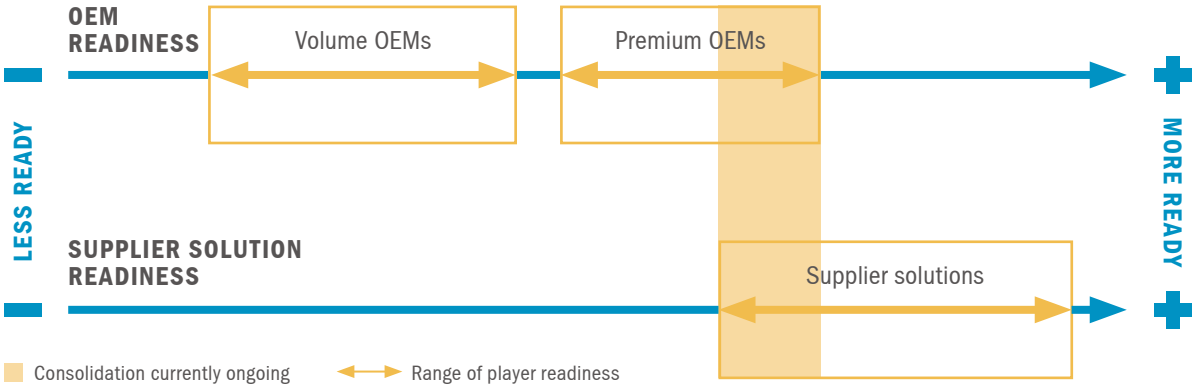
PREMIUM OEMs: Premium vehicles with fully digital and reconfigurable clusters, IVI systems with large touchscreens, connectivity systems, and HUDs are the most ideal for consolidation due to the soaring costs of these modules and functions. Unsurprisingly, Premium OEMs are leading the charge in module consolidation as they need to offer advanced electronics throughout their lineups to remain competitive, and they are more adept at introducing new technologies than their volume peers.

VOLUME OEMs: Vehicles with analog clusters, dot pixel displays, and no connectivity features may not benefit from consolidation. However, these vehicles won't be around for long in developed markets due to changing consumer preferences and regulations requiring connectivity. Volume OEMs also have large organizations that are slower to adopt new

G

RELATIVE PLAYER READINESS SPECTRUM

Supplier, Premium OEM and Volume OEM readiness for ECU consolidation



Source: Roland Berger

technologies, and they contend with scalability issues as lower segment vehicles do not have as much processing or graphics demand. For these reasons, they are lagging behind their premium counterparts when it comes to module consolidation.

TIER 1s: Tier 1 suppliers are largely pushing the transition towards module consolidation, having developed the key technologies to implement these solutions. These suppliers have been pushing these solutions into the industry and, as they start to go into production, will develop use-case examples proving the associated cost savings and benefits.

CHIP MANUFACTURERS: Chip manufacturers' importance in the automotive industry has increased substantially as the number and processing requirements of ECUs has grown. Currently, the market is largely controlled by automotive-focused suppliers. However, traditional chip powerhouses are finding an increasing role in the market as well.

SOFTWARE PROVIDERS: Software providers are capturing an increasing amount of value as the amount of software in a vehicle continues to increase substantially. Additionally, these suppliers are able to protect their margins better than many component suppliers, as it is harder for OEMs to "reverse engineer" their products to identify what their true cost is. Software providers have an opportunity to play an extremely important role in module consolidation as they can act as the primary "integrators," combining the functions of multiple ECUs into a single controller.

Although OEMs are at various stages of adoption and even acceptance, it is clear that module consolidation is coming. It is also clear that just as OEMs will have to restructure their electronic architectures, the entire industry is going to have to restructure to provide consolidated solutions.

This natural restructuring will create new value within the ecosystem, and allow for value to be transferred between players. However, players need to act now to take advantage of this window of opportunity. If they don’t, they risk letting module consolidation become the norm, missing out on the value created as the industry adopts this technology, and not being well positioned for when the solution eventually becomes commoditized.

While OEMs have an opportunity to capture new value by providing better products to their customers by being the first to adopt consolidated modules, the stakes are particularly high for traditional Tier 1 ECU suppliers. Yes, there is an opportunity to develop innovative and market leading products, potentially attracting new customers and gaining market share.

However, they will be competing in a market that is actually decreasing in addressable size, as a reduction in piece price to the OEM translates to a reduction in sales and profits for suppliers.

At the same time, Tier 1s face increasing pressure from Tier 2 semiconductor manufacturers moving up the value chain to offer systems on chips, as well as software providers looking to capture value from the new ECU integration stage of the value chain. OEMs are also increasingly working directly with Tier 2s to specify and direct-source components. The net result to Tier 1s is even greater margin pressure and a squeezed position in the value chain.

To capture value, Tier 1s need to aggressively market and sell their solutions, as there are now new opportunities to develop market leadership positions. At the same time, they need to work on strategies to fend off, or even replicate the services of Tier 2s who are moving up the value chain and already control some of the highest value-add aspects of these solutions.

Conversely, Tier 2s can capture value by encroaching on Tier 1's domain, such as full system on chip solutions and acting as system integrators. To do this they need to develop their own relationships with OEMs, and make sure they fully understand the requirements and challenges of working in the automotive industry.

Insights from an industry thought leader

We spoke with SACHIN LAWANDE, President and CEO of Visteon Corporation regarding positioning Visteon as a leader in bridging the consumer-focused technology and automotive worlds.

Mr. Lawande, electronics in vehicles are changing rapidly and in big ways. What is your view on the trends occurring in today's vehicle electronics? SACHIN LAWANDE: You have to look beyond automotive and think about how people's lives and expectations are changing, especially with respect to how their portable devices have become important parts of their lives and their always connected lifestyle. People expect to have the same level of experience in their cars, which puts a lot of pressure on the automotive ecosystem to respond at an aggressive pace similar to consumer electronics. It's important for the incumbent supplier community to build bridges to bring technology innovation into automotive as part of our product offering to OEMs.

What impact does this have on ECUs and vehicle e-architectures? As ECUs grow and as more devices within the vehicle become managed by ECUs, the number has gone from 5 to 50 to sometimes 100. They add cost, complexity, take up space, draw power and add weight. With a highly distributed set of ECUs you have to apply the appropriate hardware resources to each ECU because it operates independently – which can be expensive. There is a lot of computing horsepower that sits idle until it's needed.

Based on these trends, what role do you see ECU consolidation playing in future vehicle E/E architectures? You can consolidate what were previously discrete ECUs into one module that takes advantage of new multicore system on chip solutions. That's what our SmartCore™ solution does, which also enables an architecture and platform that are easier to manage, a security platform that governs multiple domains that would traditionally be independent security schemes in independent ECUs, and provides update capability in a closely coupled environment – allowing OEMs to better utilize connectivity to make changes over the air.

From your perspective, what are the key advantages of ECU consolidation? If you aggregate domains into more centralized controllers, you're able to apply a more cost-effective set of computing resources, processor, memory, etc., and be able to provide security and

prioritization to understand what's mission-critical and what's not mission-critical. You're able to future-proof the car because you have additional computing horsepower available, making the user experience more updateable. By running SmartCore™ in one ECU powering multiple displays you can generate compelling new experiences in vehicles that for the first time can compare to what people are used to from their smartphones, yet in an integrated and less distracting way.

How far do you believe ECU consolidation will go? Will we see one Central Vehicle Control Unit in the future? I suppose that is possible, but doubtful for the foreseeable future. However, the next generation of platforms will be more software based than hardware, with hardware layers abstracted to allow for the pervasiveness of the software platform. That allows for the reuse of components, and for the quality that can be achieved instead of using silo-ed hardware platforms. For example, a multi-gigabyte infotainment platform built for one vehicle platform for just one OEM is a model that will not scale into the future. Open architecture, common use of objects within the vehicle, with some of those objects' functions being accomplished in the cloud with connectivity will be part of how every vehicle is operated in the future.

What do you believe is the timeframe for consolidation to occur? The sensibility of individual ECUs likely has a shelf-life within the industry. Compelling user experiences can't be generated, it's not cost-effective and it's arguably less-secure. We're already delivering SmartCore™ to the market for the 2018 calendar year and we see this trend growing. We're working with each OEM to develop a path that best suits its market needs and is in line with its core DNA.

You joined Visteon as CEO on June 29, 2015, in the midst of this period of significant change for automotive electronics. What attracted you to Visteon? Electronics and software are more important to the automotive industry than ever before, and the newly transformed Visteon is in an ideal position to emerge as the innovation and technology leader in this space to continue to deliver value for customers and shareholders. I am excited about the opportunity to build on the company's momentum and lead Visteon into the next phase of its growth as a premier provider of driver information systems and infotainment that form the backbone of the connected car.

Let's jump up a level – Visteon is consequently focusing on electronics and has divested all of its other businesses. Why put everything in one basket? Visteon established a focus for the purpose of excelling in this space – and is transforming to have technology DNA, shifting from a traditional fragmented Tier 1 business to a software-driven, platform-based business. Electronics are at the heart of where consumer expectations are generated, where the opportunity exists and where the massive change is expected within automotive in the next few years.

What is Visteon doing to respond to the changes in today's vehicle electronics? We work with our OEM and ecosystem partners to enable the user experience that is expected by today's consumers. In addition to Visteon's advanced engineering capabilities, Visteon can provide value by building the bridge between the key innovation areas in consumer electronics, mobility and Silicon Valley to the safety and reliability requirements in the automotive industry.

How will Visteon's business model change in this environment? Is Visteon becoming a software company? More and more every day. We are already majority focused on software solutions and moving forward as this is where the growth is. But we can't lose sight of the fact that these are user experience solutions, so creating market leading software solutions that allow for adaptability, reuse and scalability across market segments is key.

How is Visteon responding to new competitors moving into the auto industry? Do you see a threat from let's say software companies? The role of the traditional Tier 1 is changing. Visteon is embracing this change and actively seeking out alliances and cooperation with companies who have technologies or ecosystem experience that can make our solutions better. However, these new players are changing the mentality in automotive, where it's traditional to load a very well-tested, deeply embedded set of very efficiently running software onto an ECU and forget about it. In the consumer world, the expectation is that software will be updated all the time; you'll download apps, you'll personalize and you'll download fixes. It's a very different mentality. We provide the technology and business model bridges that most of these highly innovative companies need when attempting to enter the automotive ecosystem.

Coming back to ECU consolidation. Even though there is a clear TCO advantage, we're not seeing big adoption yet. What do you see as the main roadblocks on the way to ECU consolidation? Some automotive industry processes and organizations emphasize the structured sourcing/buying process as a strategic lever and advantage, but it's one of the biggest limitations. If this is abstracted at least one layer, you can aggregate modules and see tangible sourcing benefits. Even advanced R&D can see new use-cases emerging that would be impossible in a loosely coupled set of ECUs trying to do the same things. Consolidated ECUs are a disruptive technology that is all for the good.

How do you see OEMs and suppliers as an automotive community responding to these roadblocks? All the OEMs with whom we are working appreciate these constraints and are responding to take advantage of the benefits. Sourcing impacts need to be understood at a generally broader level, and product development seeking to use platforms need standardization and modularity – SmartCore™ makes a lot of sense. Advanced R&D can use the tightly coupled network of processing power, yet distributable, fire-walled and multi-tenant in a way that creates new use cases; the most relevant information in the most relevant display to the driver at the most relevant time is nirvana with respect to HMI in a vehicle.

Sachin Lawande *is President and CEO of Visteon Corporation.*

Module consolidation is a certainty – If they haven't already, all industry players need to think:act now.

All major trends in the automotive industry are increasing the number and complexity of ECUs – the industry is now at a tipping point, where adding ECUs is no longer sustainable, both economically and functionally. Module consolidation, the use of a single domain controller as a replacement for an independent processing unit for each ECU, is a solution already being made available to address the complexity issues arising from these trends.

Domain controllers have a number of advantages over traditional disaggregated ECUs, including systems cost savings, reduced weight and wiring complexity, reduced development costs, increased upgradeability, easier packaging and reduced plant-level assembly costs. Most of these advantages can clearly be quantified, and represent a USD 175 differential versus a disaggregated solution for a standard set of cockpit modules.

Despite these clear advantages, many OEMs have been slow to adopt consolidated modules. These OEMs risk losing the ability to stay competitive against not only incumbent competitors, but also disruptive market entrants like Google and Apple. Regardless of their current level of adoption, all industry players need to act now to ensure they are positioned to fend off these risks and are able to deliver the user experience consumers demand at the price they expect.

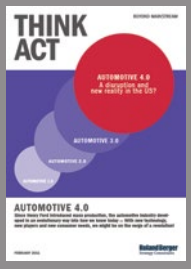
◆ *Authors: Thomas F. Wendt, Wolfgang Bernhart, Jiten Behl, Dagan Mishoulam, Ethan Goldsmith*

ABOUT US

Roland Berger Strategy Consultants

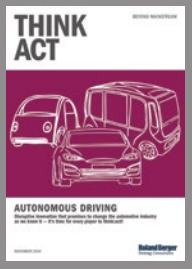
Roland Berger Strategy Consultants, founded in 1967, is the only leading global consultancy of German heritage and European origin. With 2,400 employees working from 36 countries, we have successful operations in all major international markets. Our 50 offices are located in the key global business hubs. The consultancy is an independent partnership owned exclusively by 220 Partners. **WWW.ROLANDBERGER.COM**

Further reading



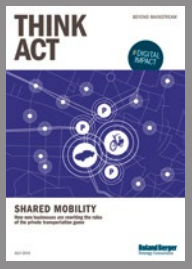
AUTOMOTIVE 4.0

The news is full of transformative technology innovations and business models like advanced connectivity systems, innovative shared mobility concepts, and of course, self-driving cars being showcased and introduced around the world. We've seen this type of fundamental change recently in industries including brick and mortar retailing, cell phone manufacturing and computer manufacturing. The numerous trends impacting the automotive industry require the industry to respond – but it's the confluence of connectivity, shared mobility and automated driving that we believe will truly put the industry as it's known today to the test.



AUTONOMOUS DRIVING

Autonomous driving has the potential to fundamentally transform the automotive industry in the coming years – be it through innovative software technologies and vehicle models or new ways of using cars, such as "Mobility on Demand." The expectation is that cars will be able to drive completely autonomously from 2030 onward, without the driver taking an active role. The market potential for the automotive industry is huge.



SHARED MOBILITY

Shared mobility: where vehicles are shared and mobility offerings are used jointly will see rising revenues and growing customer numbers in the period through 2020. We anticipate annual growth rates of up to 35 percent in the new business fields around car, bike and ride sharing and shared parking. In a clear sign that this market trend is taking off, the number of market players in the segment is growing. Besides innovative start-ups, greater quantities of established companies like auto makers, transportation and logistics firms and airlines are entering the fray.

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ROLAND BERGER
STRATEGY CONSULTANTS LLC
71 S. Wacker Drive
Suite 1840
Chicago, Illinois 60606 USA
www.rolandberger.us

Authors

THOMAS F. WENDT, WOLFGANG BERNHART, JITEN BEHL, DAGAN MISHOULAM, ETHAN GOLDSMITH

Marketing and Public Relations

LINDA SALIBA
linda.saliba@rolandberger.com

Contact information

THOMAS F. WENDT
Partner
thomas.wendt@rolandberger.com

WOLFGANG BERNHART
Partner
wolfgang.bernhart@rolandberger.com

MARC WINTERHOFF
Partner
marc.winterhoff@rolandberger.com

STEPHAN KEESE
Partner
stephan.keese@rolandberger.com