INTEL FOCUSES ANEW ON THE AUTOMOTIVE MARKET FOR STRATEGIC GROWTH

INTRODUCTION

Automobiles are undergoing radical technological change, motivated by forces inside and outside the automotive industry. Advanced driver assistance systems (ADAS) make our vehicles safer and easier to use, and over time they will help usher in the era of self-driving cars. Environmental and economic concerns have led to many advances in fuel efficiency and the use of alternative fuels, hybrids, and electric vehicles (EVs). Better wireless connectivity options are transforming the latest cars into broadband hubs on wheels. This connectivity enables new information and entertainment options, which suits the tastes of younger generations of car buyers who have come of age accessing sophisticated apps on the screens all around them. And probably the greatest technological shift of our age—artificial intelligence—is being put to work (or soon will be) in many different aspects of vehicles, just as it is in the rest of our technology.

Beyond these forces is the stark reality that the technology architecture of our automobiles must change because the current architecture is not sustainable technically or economically. This creates large challenges for the automotive industry as it evolves away from traditional ways of operating. In terms of the tech devices used inside vehicles, this implies a necessary shift from having hundreds of electronic control units (ECUs) connected by a (literal) mile of copper wire to a software-defined vehicle with a modern, unified technology platform.

On an operational level, the shift applies to long-running industry behaviors around developing new electronic components. The predominant model has been for a car maker to provide a high-level set of requirements to a tier-one supplier that makes all the technical decisions and delivers a “black box” meeting those requirements. Such components are built to perform only their own function, not fit into a flexible open platform that can take full advantage of the latest technologies in the most efficient ways. More than that, development cycles for the highest-performance compute sockets often run five years or more—multiple times as long as the more adaptive cycles of IT hardware and software. This is a model that must change to accommodate the forces described above and deliver the technologies that consumers want.

Intel wants to take advantage of these shifts. Legendary former Intel CEO Andrew Grove once said, "Market share is gained and lost at times of technology breaks."[1] Intel applied that thinking during the dramatic early years of the PC market and applied it again when the Internet mushroomed. Current CEO Pat Gelsinger was heavily involved in both of those transitions, and now he and his team are following this guideline again in the automotive business.

The company sees the shifts outlined above as playing into its strengths in everything from platform-wide compute architecture to energy management to Intel's manufacturing footprint and global supply chain. Intel also needs new areas for growth; according to the head of its automotive business, Jack Weast, the company has identified automotive as its single best growth opportunity. Gelsinger himself has predicted that the share of chips in the total bill of materials for a premium car will reach 20% by 2030—a five-fold increase from 4% in 2019.[2]

However, Intel's current automotive strategy represents a significant pivot in its approach to this market. The new strategy does not rely on well-built individual components, which is how Intel has mostly operated in the automotive space in the past, but rather takes a whole-vehicle platform approach to address and solve the industry's biggest challenges. The strategy also represents a significant change from the ADAS and autonomy play that Intel attempted with its $15 billion acquisition of Mobileye in 2017 and its much-publicized spinoff of that company in 2022.

Intel knows that it must convince the auto industry—where companies tend to have long memories—that it is committed to its new strategy for the long haul. This is especially important because Intel has at times shown a tendency to get into and out of niches within this market (including, but not limited to, ADAS). That said, Moor Insights & Strategy believes that Intel has the capabilities and resources—and the organizational commitment—required to address the large challenges explained here and become a significant force in automotive technology.

THE CURRENT STATE OF TECHNOLOGY IN THE AUTOMOTIVE MARKET

The auto industry has a long history of embracing new technologies for safety, comfort, and environmental impact, albeit sometimes slowly. Radios, for example, were first

[1] Andrew S. Grove, "Los Angeles Times 3rd Annual Investment Strategies Conference," Los Angeles, California, Intel, May 22, 1999.
[2] "Intel CEO Predicts Chips Will Be More than 20% of Premium Vehicle BOM by 2030," Intel, September 7, 2021.

installed in cars—as a very expensive extra—in the 1920s. By the 1960s, most new cars included radios as standard equipment. Anti-lock brakes were adopted more quickly: Developed in the early 1970s, they were standard on many new vehicles 20 years later (and required by U.S. law beginning in 2012). And almost every car on the road today relies on hundreds of electronic components to improve everything from airbag deployment to the efficiency of fuel injection.

Without casting aspersions on the car makers, it is a simple fact that the rate of technology evolution in the automotive business is much slower than the pace of IT innovation. Contrast the five-year development cycles mentioned earlier to common IT development cycles of less than a year for new software releases and 18 to 24 months for hardware. To be fair, car makers have traditionally faced very different economic forces than IT providers, and they have created design and manufacturing procedures that have proven effective across many decades for building huge numbers of cars and trucks at a high standard of quality.

Now, however, the auto industry faces a pivotal period, and the industry will inevitably undergo great change during the 2020s and beyond because of the technological and market forces in play. As already mentioned, the prevailing tech architecture inside today's vehicles is not sustainable. From a technical perspective, it operates as a collection of boxes—not a cohesive platform. Historically, plenty of these components have been 8- or 16-bit devices that perform a single function, with no reuse among the designs. Many of the components also cannot talk to each other, which inhibits functionality and efficiency. That does not match the best practices of integration and streamlining common within IT.

Given these constraints, it is no coincidence that these platforms evolve much more slowly and do not perform as well as they could with a more flexible architecture. Car designers are also running into the physical limits of the current structure; in some cases, there is literally nowhere else to put an additional ECU or add to the mile-plus of copper wire found in many vehicles.

The example of copper wiring underscores that the current architecture is not viable from an economic perspective as well. Copper is an expensive commodity that a unified IT-style architecture will not need so much of. But there is also the opportunity cost of doing things the old way. Inhibited functionality, limited efficiency, a lack of flexibility to respond to consumer demands—all of these are costing auto makers too much money. And all of them will be addressed by shifting cars' tech architecture from fixed-function to flexible-use.

Traditional auto makers are also under pressure from a new generation of tech-centered competitors, with Tesla at the head of the list. Sustainability concerns connected to internal combustion are not going away, and it is reasonable to project that the widespread adoption of EVs will accelerate, especially as higher numbers of EVs on the road improve the economics of—and reinforce the need for—better battery technology and more extensive charging infrastructure.

Tesla has opened the Pandora's box of what technology can do in a car, and what consumers expect of the technology in their cars. Tesla and other new-look manufacturers have laid the groundwork for a future in which a vehicle's compute architecture looks more like a PC, smartphone, or datacenter rack—as it must, if it is going to meet growing consumer expectations for in-vehicle technology and support the advanced technologies that are already being delivered.

The hype around fully autonomous cars has died down lately, but the growth of ADAS certainly has not. These systems are increasingly ubiquitous, not because everyone is going to shift to self-driving cars overnight, but because ADAS is already making cars safer and better with functions such as automatic emergency braking, pedestrian detection, automatic parking, and driver attention monitoring. These systems will continue to improve, especially given new developments in sensor technology, connectivity, and AI.

Connectivity and AI will affect many other areas of future vehicles, too. We can expect new cars to ship with increasingly sophisticated (and AI-enhanced) entertainment options that will take advantage of better cellular bandwidth. For example, back-seat passengers will play connected, graphics-intensive video games on the car's built-in screens, and businesspeople will carry on real-time video conferencing within their vehicles. As with ADAS and other onboard systems, entertainment options like this will naturally require more raw computing power and, increasingly, AI support from the car's central compute module. Given the recent radical growth in the power and practicality of AI, the only sensible projection is that AI could influence virtually every software-driven function of new cars—likely sooner than later.

To fulfill this vision for future automobiles, Intel is banking on the industry to shift its technology and organizational practices to embrace the software-defined vehicle. As noted above, this implies a shift to a flexible, unified hardware platform that allows workloads to be managed more intelligently. (Examples of this are provided below in the section on Intel's automotive strategy.)

Adopting such a platform, powered by Intel's silicon or someone else's, will inevitably imply making hard decisions about using open-source versus proprietary software and about building components in-house versus having them custom-built versus buying standard parts off the shelf. It will also require a revision of many time-honored production and management practices that may be hard for some auto makers to give up. Regardless, this is where Intel wants to help the automotive industry go—and where we agree it should go.

Intel's History in the Automotive Market

Intel has a long history of delivering semiconductors for automotive uses, tracing back to 1976 when it began making engine controllers. This period required Intel to work closely with the car companies to build chips for their specific needs. For some years, Intel learned its way around the industry by taking on smaller projects, but in the 1980s it became a major supplier for Ford. In 1990, Intel became the first chip maker to receive Ford's Total Quality Award.

Unfortunately, early wins like that one segued into a period that Weast openly admits was characterized by a "very public, confused commitment to the automotive industry."[3] He cites the examples of Intel entering and then exiting the market for brake controllers in the 1990s, then doing the same thing again a little later with chips for other functions. More recently, Intel put most of its automotive focus on Mobileye—even to a fault, considering that it was still making chips for infotainment and other functions all the while. These days, Mobileye is publicly traded on Nasdaq, although Intel retains voting control over the company.

Weast says that he learned a lot from his time working with Mobileye. He admires how well Mobileye understands its strengths, holds firm to a vision for the industry, and excludes distractions or anything extraneous to the strategy. Intel is trying to follow that paradigm with its new approach to the software-defined vehicle. Rather than focusing on ADAS—which represents only a small fraction of the total silicon opportunity in a car—Intel has doubled down on its corporate strengths. At the top of the list is designing for open ecosystems that include compute, graphics, media, AI, and plenty of third-party software. As Weast puts it, "We're not an algorithm company. We're a platform company." He also notes that Intel's platform-centric approach to this has been thoroughly validated across decades of success in the PC and the datacenter.

[3] Here and elsewhere, Weast's comments are drawn from private analyst calls and follow-up correspondence.

INTEL'S NEW AUTOMOTIVE STRATEGY

Intel's newfound clarity in the automotive context goes hand in hand with its corporate strategy under Gelsinger, who returned to helm Intel in 2021 after several years leading other companies. Gelsinger, who was the architect of the original x86 microprocessor at Intel in the 1980s, has been resolute about restoring Intel's reputation as an execution powerhouse, able to push the envelope of technical capabilities and hit the tightest production schedules.

Although the turnaround remains a work in progress, 2023 did see significant advances for this overarching strategy, which we believe is gaining real traction for Intel in its global manufacturing operations, core IP, and distributed architectures—and with its customers. Here we review the larger corporate strategy before analyzing how it particularly applies to the automotive market.

BRINGING THE OLD INTEL BACK TO LIFE

Intel's renaissance over the past three years has refocused the company on executing against an ambitious product and manufacturing roadmap on a brisk cadence. Intel has built on its traditional strengths to address five major technological forces that are disrupting various industries, including automotive: AI, cloud-to-edge infrastructure, compute, pervasive connectivity, and sensing. It is easy to see that all five of those areas apply very well to software-defined vehicles.

The company is working to reestablish product leadership with a chiplet-based architecture to deliver its flagship x86 CPUs alongside other processor types. We believe this disaggregated architecture is a clear path forward for many types of chip making. In it, multiple IP blocks called chiplets (or tiles) are combined on a single piece of silicon. This allows chips to be configured with exactly the right mix of functions. For example, SoCs optimized for AI workloads can include CPU cores for general-purpose compute, GPUs for computationally intensive AI tasks, NPUs to handle longer-running jobs efficiently, and FPGAs and ASICs for more specialized tasks.

When Intel has been at its best, it has combined high-performing designs with exquisite manufacturing acumen at immense scale. Today, the company is well underway on the "IDM 2.0" plan that Gelsinger announced in March 2021, just a month after he rejoined the company. This big step forward for Intel's integrated device manufacturing model includes a major buildout of production, packaging, and distribution capacity across a globally resilient supply chain that puts key manufacturing resources close to customers. When the plan was announced, manufacturers worldwide—auto makers prominent among them—were suffering significant shortfalls of the chips they needed to produce their goods. Intel saw the opportunity to address not only the concerns of that moment during the Covid pandemic but the longer-term sensitivity of tech-heavy products (including, increasingly, cars) to disruptions in supply.

FIGURE 1: INTEL INVESTMENTS

Intel is supporting its corporate renaissance with major investments in its manufacturing capabilities and supply chain.

Source: Intel

The $70 billion to $80 billion that Intel is investing in new chip fabs over the next three or four years[4] is not simply an expensive volume play. It also backs Gelsinger's intention to enable the production of even more advanced devices by implementing five new process nodes in four years. Given that a typical semiconductor process node takes two years to deliver, Intel's current implementation schedule—which it is meeting so far—is compelling. The new process nodes are tied closely to the advances in chiplet-based products that Intel is introducing, plus they enable the expansion of Intel Foundry Services, through which Intel manufactures chips on behalf of other chip design companies (including auto makers).

[4] For more on Intel's investments in its manufacturing facilities and supply chain, see "Global Manufacturing at Intel."

Intel's strategy also relies on its commitment to building hardware and software based on open industry standards. According to Arun Gupta, VP and General Manager for Open Ecosystem at Intel, "Intel's culture is built around contributing to open source because our customers care about it. ...That's why Intel contributes to more than 300 community-managed projects."[5]

On the software side, the company is a founding member of the Linux Foundation, the top corporate contributor to the Linux kernel for more than 15 years, and a top-10 contributor to both Kubernetes and OpenJDK. On the hardware side, Intel is involved in the development of many open standards, for example by chairing the UCIe group concerned with setting standards for chiplets.

This openness makes it easier for customers to leverage the breadth of Intel's silicon IP, software tools, and foundry capabilities. For many years, the company has also cultivated connections with software developers and others from independent software vendors, system integrators, startups, the open-source community, and academia. We believe these connections—and Intel's sincere support of open standards—will pay dividends in its automotive endeavors.

Applying Intel's New Strategy to the Automotive Business

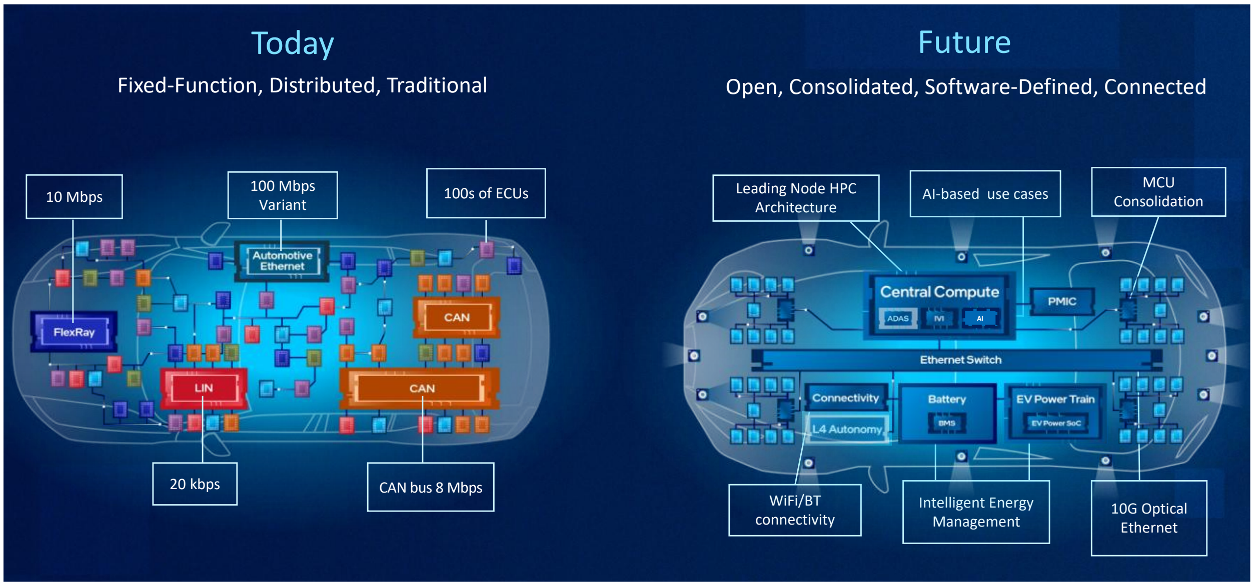
All aspects of the broader Intel renovation strategy extend directly to its new approach to the automotive market. The company intends to win long-term business among car makers by applying its strengths in chiplet-based architecture, open hardware and software platforms, and global manufacturing at the largest scale. Now we will consider the major areas of its automotive strategy one by one.

Architecture Wall

At the heart of Intel's automotive approach is the move to software-defined vehicles, which centers on what Intel calls the architecture wall. The slide below captures the essential elements of this shift.

[5] Arun Gupta and Joe Curley, "Open Source at Intel," July 17, 2023, *Test and Code* (now *Python Test*) podcast, hosted by Brian Okken; partial transcript at Intel, "How Intel Supports Open Source from the Inside Out."

FIGURE 2: INTEL'S VISION OF "THE AUTOMOTIVE ARCHITECTURAL SHIFT"



Source: Intel

The "Today" image on the left represents the status quo of vehicle technology architecture. It is a classic example of a system that is grown, not made. In other words, its current configuration is a product of many separate choices and development processes over time rather than any unifying central design that applies to all the parts.

The contrast to the "Future" image on the right is immediately clear. That image looks much more like the insides of a server in a datacenter—a unified technology platform that applies consistent principles of integrated design. This approach streamlines and simplifies key aspects of the platform, for example by reducing the number of ECUs by more than half. More than that, the whole platform is built—and often co-designed with customers and other suppliers—around a high-performing backbone that enables much easier integration of new high-performance components.

Rome was not built in a day, and the transition from "Today" to "Future" will not happen immediately. Intel's starting point for this transition is in-vehicle infotainment— "IVI" in the Central Compute part of the right-hand image—where it already has relationships with car makers. From there, through its chiplet architecture, it is easy to see a path for Intel to embrace an open ecosystem approach to handle all of central compute.

In this context, it is interesting to note how thinking has changed in recent years for Intel and others in the automotive industry. Back when Intel focused its automotive strategy on Mobileye, the predominant view was that ADAS would drive the major architectural shift for high-performance central compute. This was connected to an industrywide emphasis on autonomous vehicles.

Over time, however, two important things happened. First, the industry figured out that the level of compute required for every vehicle to be fully autonomous is not viable commercially (or at least not yet). Second, ADAS functions such as lane control or adaptive cruise control are already being efficiently implemented in purpose-built solutions such as those from Mobileye and are increasingly becoming commodity features expected in any new vehicle. Thus, even though ADAS remains important, it is not the motive force for change to the whole vehicle architecture that auto industry technologists thought it would be.

By contrast, in-vehicle infotainment experiences present far more opportunity for OEM brand differentiation and value creation, especially when we consider the connected services that vehicles can now support. (More on that below.) That is what makes IVI a locus of value creation and a sensible foundation for the "Future" vehicle architecture.

From that foundation, Intel plans to expand soon to other parts of the architecture. One key example of this is the consolidation of microcontrollers, in which Intel has a long legacy. Some of Intel's key automotive innovations in the 1980s grew out of its expertise in microcontrollers, and today the company is a market leader in microcontrollers for key areas of functionality in PCs such as Wi-Fi and Bluetooth. In this way, Intel plans to move from strength to strength in open hardware platforms, rather than trying to deliver complete vertical solutions as it did during the Mobileye years.

Intel’s hardware production plans are ambitious. As announced at CES 2024, Intel has debuted a new roadmap of AI-enhanced automotive SoCs designed for the software-defined vehicle. Intel has made it clear that the multiple offerings on this roadmap reflect its commitment to delivering power, performance, and cost scalability to meet the needs of the entire automotive market. Over time, these devices will progressively deliver more compute, more AI functionality, better graphics for more displays, and support for more cameras, with plenty of room for further expansion.

Intel is also deploying hardware virtualization technologies (Intel VT-x) such as single-root I/O virtualization (SR-IOV), which have been proven in use for decades in the datacenter. Combined with chiplet-based architecture, these technologies further aid automakers in handling mixed-criticality workloads—an absolute must for central compute within a vehicle. As central compute devices become more sophisticated and deal with a multitude of separate workloads, it is essential for both safety and efficiency that those workloads can be treated differently. Critical safety features such as an instrument cluster indicator light receive high priority, even when they may not require very much computational power. Meanwhile, low-priority features such as video display for back-seat passengers are not treated as critical to the operation of the car.

Intel's silicon-based virtualization technologies can support this separation within the SoC. Alternatively, a chiplet-based design can enable physical separation of functions, for instance by incorporating an ADAS subsystem on a chiplet of its own. So, for example, if the video game being played in the back seat gets stuck in a loop that locks up one of the graphics cores, the hardware-based virtualization will ensure that it has no effect on the digital instrument cluster running on other graphics cores or the ADAS functions implemented on an independent chiplet.

Finally, this vision of the architecture wall allows auto makers to use their own IP or third-party IP alongside Intel cores. So, if a given auto maker or one of its key suppliers has designed a specific piece of silicon that differentiates their vehicles, it can be folded in alongside Intel CPUs, GPUs, and so on in whatever configuration strikes the right balance of performance and cost. And thanks to both the chiplet architecture and the flexibility of Intel's foundry-style manufacturing (more on that below), Intel can easily produce chips like this at volume.

Autonomy

Although Mobileye is no longer part of Intel, Intel did learn important lessons from that venture. Intel itself does not have a freestanding ADAS offering today because that lies outside the company's areas of strength. That said, the company of course recognizes the ongoing and growing importance of autonomy functions in vehicles and the possible opportunity for future integration of ADAS within central compute devices.

In support of this, and in line with its commitment to open platforms, Intel is ADAS-agnostic in its automotive strategy. This enables automakers to choose their preferred ADAS solution—complete with multiple integration options at the platform or chiplet level (or both)—courtesy of the open-platform architecture. Integration matters a lot here, so we expect that Intel will announce close collaborations with ADAS providers.

Cloud-Based Vehicle Services

Enhanced connectivity, flexibility, and performance—including AI performance—will enable the "Future" architecture to support many more cloud-based services to enhance drivers' and passengers' in-vehicle experience. In the past, many motorists have used services like these through satellite radio or roadside assistance applications, but these kinds of services will soon become common across many other domains such as video games. This will enable new business models and revenue streams for auto makers and their suppliers—an opportunity that Intel is keen to support.

Intel has a built-in advantage in this area because so many existing cloud-based services are designed to operate on the x86 microarchitecture, whether on x86-based client devices or in an x86-based cloud environment. This means that a car maker or third party can deploy anything already tailored for x86 from the cloud to the car without needing to validate on a new microarchitecture. That said, in line with its open platform approach, Intel will also happily accommodate any other microarchitecture(s) for specific chiplets as needed.

Electrification

The “Today” architecture within vehicles is full of inefficiencies. As one easy example, standard procedure for most ECUs is to operate at full power for the entire time a car’s engine is running. By contrast, in the software-defined vehicle, coordination among different subsystems will enable the car to power down any components that are not needed at the moment, with corresponding reductions in battery drain for hybrids and EVs. For instance, the high-performance 8K screens in the back seat that are ideal for video gaming could be automatically powered down completely when sensors in the car detect that there are no passengers in the back seat.

Intel is particularly well-situated to help auto makers optimize for this because it has decades of experience in battery power management. Weast draws the parallel to the work that Intel was doing on portable computers when he started with the company in the 1990s. All the default settings for the components inside a PC were established on desktop platforms that stayed plugged into the wall all the time, so concepts such as advanced power management and dynamic variable voltage delivery were never even considered. All of that changed when laptops became more popular; before long, Intel had helped to create open industry standards to enable advanced power management techniques to enable significantly greater battery life—from a much smaller battery.

Weast is eager to apply Intel’s experience in this area to EVs, for which batteries are the most expensive and heaviest component. As he puts it, the challenge is answered by treating the vehicle platform like a laptop or a datacenter rack and power-managing everything. In the bigger picture, EVs should benefit even more than other vehicles from the platform-based, software-defined approach. And in line with its commitment to open standards, Intel is chairing the committee developing the new SAE J3311 standard for vehicle platform power management.

Supply Chain and Production

As it has ramped up investment in its global manufacturing footprint and supply chain, Intel has focused on situating production capacity close to the customers that need it most. Knowing the importance of the automotive sector, Intel has strategically placed fabs in Germany and Ohio, close to the factories of the major German and American auto makers. On the simplest level, this should make it easier for Intel to be more responsive to these customers because of proximity—and even more so because Intel routinely puts engineering teams near its customers to support local customization, market by market. But the placement of fabs has the extra advantage of limiting the carbon footprint of a car maker's supply chain, which is important in the European Union today and becoming more important elsewhere.

Intel already enjoys massive economies of scale in production—an advantage that will be even more pronounced once its new fabrication, packaging, and distribution facilities come online. This, combined with the flexibility of the chiplet architecture, stands to save auto makers a bundle. As discussed in the section on the architecture wall above, car makers or their key suppliers sometimes want to include their own silicon IP in a vehicle's electronics. Intel's approach allows these companies to design a chiplet at a cost of tens of millions of dollars, rather than needing to produce an entire monolithic chip for ten times that.

Clearly this makes customization of chips easier, more affordable, and more scalable. But a more subtle advantage is that the chiplet approach allows Intel to dial up or dial down functionality of one chiplet independently of others on the same chip. This is unlike the monolithic approach, which requires many strict decisions to be made in advance about what level of performance is needed for each aspect of the product. Unfortunately, that is an expensive guessing game—and one that usually goes wrong because the time between locking in the design and encountering the real-world workloads that matter is always measured in years. Using chiplets, by contrast, allows some of these decisions to be made very late in the game—much closer to their deployment in vehicles—and then adapted over the course of a platform's lifespan.

Intel's automotive strategy is not about making it a better supplier of widgets. Intel believes—and we agree—that the inescapable requirement, and crucial opportunity, for the industry is to rearchitect the whole vehicle to be software-defined with a unified but open hardware and software platform. This approach gives auto makers more choice so they can adopt and adapt the specific technologies that suit them best. Weast offers a hypothetical example in which an auto maker could put its own IP into a chiplet that would interact with the SoC's open-standard UCIe interface, using an open-source PCIe driver to provide access to the customer IP all the way up the stack to the Android environment. This means, for example, that the auto maker could develop its own Android app to access the cameras on the car via its proprietary ADAS chiplet.

This strategy also enables a hardware/software co-design approach—another principle that Weast and Intel learned from Mobileye. Through this approach, nothing is built in a vacuum: All the parts are designed with the others in mind to produce the best results for the vehicle platform as a whole. This squeezes out waste and duplication while optimizing cost, performance, and power consumption. Intel is strategically partnering with auto makers to achieve precisely these collaborative outcomes, and we believe this outlook is serving them well.

Hurdles to Overcome

While Intel's automotive strategy is logical, disciplined, and aligned with the company's strengths, that is no guarantee of success. Below we address four significant areas where there are potential pitfalls. Intel must successfully navigate all of these if it wants to achieve its aims in the automotive market.

Messaging and Legacy — Intel's long history in the auto industry means that its technology is in more than 50 million cars today. Yet its leaders know that the company has not done a great job of talking about its strengths in automotive, and it must overcome understandable doubts from car makers about its commitment to the industry.

In our conversations with Intel leaders, they have been forthright in talking about how the company has been misaligned with the auto industry in the past—and how they believe that Intel's IDM 2.0 strategy is now aligned well with the industry's needs. Beyond that, Gelsinger and his lieutenants are fond of pointing out that the enormous budget of Intel's current construction spree, combined with the company's targeting of automotive as its number-one growth market, mean that it now has 80 billion reasons to stay in the industry.

The Mobileye Experience — Intel now acknowledges that when it bought Mobileye, it talked about its automotive strategy as though it was all Mobileye, even though Intel kept shipping products at growing volumes in the infotainment space. Our perspective on this is that misjudgments happen, and sometimes they are not evident until later.

And to be fair, Moor Insights & Strategy's contemporaneous coverage of the deal acknowledged the challenges Intel would face but summarized the acquisition as "a sound strategy"—as it seemed at the time.

Intel is now older and wiser, which means that it must stay the course. If Intel is going to sell its automotive play as a natural, perfect-fit extension of its overarching strategy, it must prove that in practice—and do it over and over and over—with understandably skeptical carmakers. In other words, Intel must keep executing against this strategy at a high level for many years running to achieve the real potential of its opportunity in this market.

Entrenched Practices in the Automotive Industry — Auto makers employ plenty of smart engineers and engineering leaders who see the need for open platforms, better integration, shorter development cycles, and the like. That said, the auto industry as a whole has a cultural lack of familiarity with things like open-source software that are perfectly routine for a stalwart of Silicon Valley such as Intel.

Even when all parties are operating with maximum goodwill, we can expect friction as these huge auto manufacturers move toward a model that challenges many of their long-held beliefs about what the insides of a vehicle should look like, how long product development should take, or how collaboration should work across previously siloed operations. Enlightened efforts at co-design should help, but it is going to take a long time and a lot of work for Intel to see the auto industry transformed into an IT(-driven) industry like it wants.

Stiff Competition — There are many chip makers serving the automotive space, but a few stand out as key competitors for Intel. NVIDIA made a splash nearly 15 years ago when it entered the market focused on the dashboard. From there, it moved into safety systems and autonomous driving, where it remains highly active. Its efforts in autonomy are backed by its industry-leading position in AI chips. NVIDIA is well-entrenched in its automotive niches; it says it works with "several hundred" companies in the automotive market, ranging from car makers and tier-one suppliers to AI startups.

When Qualcomm came into the market, it ultimately won a sizable amount of the dashboard business that had previously been with Intel and NVIDIA. Qualcomm now competes across the digital cockpit, ADAS (including more recently full autonomy), and of course connectivity. Its strengths in connectivity make it a particularly important competitor for anyone trying to enable connected in-vehicle experiences for motorists. In fact, its roots in this area are quite deep, given that it provided the connectivity solution for General Motors' OnStar service starting decades ago. It is also worth mentioning that Qualcomm has decades of experience in power management just like Intel does; the difference is that Qualcomm's products embedded in mobile devices have needed to manage even finer increments of power than Intel's products for PCs and servers, so it will be interesting to see how that plays out in vehicles.

Although Qualcomm and NVIDIA reported $1.87 billion and $903 million in automotive revenue, respectively, for their most recent fiscal years, both companies have also said that their backlog of automotive orders runs into the tens of billions of dollars across the 2020s and beyond. Thus, Intel faces entrenched competition from both of them.

And these companies are hardly the only ones to recognize the opportunities for growth presented by the automotive market. That is why other chip makers have made significant investments to position themselves competitively in the automotive space. A prime example is Intel's historic archrival AMD, which completed its acquisition of Xilinx in 2022; Xilinx had already been active in ADAS and other automotive functions for many years by that point.

Moor Insights & Strategy Assessment of Intel's Automotive Strategy

Over the past three years, Intel has done an impressive job regaining some of its old identity as the dominant player in its market. That said, there is still much work for the company to do. We believe that its approach to the automotive industry will prove to be an important part of that work. Here are five key insights that support our view:

- **Intel seems like *Intel* again.** Gelsinger's reorganization properly took hold in 2023, and it seems clear that the company is now returning to its traditional metronome-like cadence of implementing new technologies, building word-class production facilities, and delivering products at volume.
- **Intel's automotive strategy aligns with inescapable forces affecting auto makers.** Having a vehicle with 100+ ECUs running at full power all the time is not a sustainable approach in a world with Tesla and other disruptors in it, let alone when Millennials and Gen Z are the ones buying so many of the cars. This period *will* represent a sea change for the auto industry, and Intel is well-positioned to make the most of it.
- **Open standards and open platforms make a lot of sense.** In the history of modern technology, most big transformations have been fostered by high degrees of openness—in the open standards underlying the Internet, for

example. Yes, there are exceptions such as Apple that thrive with closed standards, but not many. In the automotive business as elsewhere, open standards make it easier for participants to develop complementary new technologies. And car makers desperately need that kind of innovation as they move to software-defined platforms.

- **Intel appears well-positioned to deal with key competitive forces.** As noted above, Intel is waging battle on multiple fronts against chip makers including NVIDIA, Qualcomm, and AMD. But that kind of multifaceted competition against smart, well-funded opponents is hardly a new development for any of these companies. In the auto business, Intel will also face some car makers that want to develop their own silicon. In all of this, Intel will benefit from its expanded manufacturing capacity, renewed engineering vigor, and ability to sell customers on the appeal of open standards when some of its competitors would require them to lock into proprietary approaches. And if an auto maker wants to design its own chips like Tesla has, Intel can manufacture the chips for them through its foundry services.
- **Now it comes down to execution.** At its industry-leading best, Intel has been one of the best *execution* companies ever built, in any sector. If Gelsinger and his lieutenants succeed in getting Intel back to that place and keeping it there, we believe it could return to its dominance in general—and claim a newfound role as a bellwether for technology companies working in the automotive sector.

CONCLUSION

For auto makers and tech companies in the automotive industry, we are indeed in an axial period—one of the "times of technology breaks" that Andy Grove said are ripe with opportunity. While the automotive industry certainly has had upheavals over time, many of the legacy car makers and their ways of doing business have been stable for decades. Given that stability, it could be tempting for them to think that the auto industry will continue to operate as it has—for example by maintaining the five-year development cycles discussed above rather than shifting to new, more flexible ways of operating.

By contrast, the history of the IT industry is quite different, marked by plenty of instability and endless emphasis on rapid change to avoid becoming obsolete. Anyone dealing with automotive technology should be ready for rapid upheaval of that type, because the technical and economic logic of moving from the status quo to a software-defined vehicle—Intel's version or someone else's—is inescapable. In other words, auto makers should expect at least this part of their industry going forward to work a lot more like IT and a lot less like the traditional automotive business.

At its best, the automotive industry has combined great design and a great understanding of customers under fine leadership. The car makers that take advantage of the opportunities created during this period of transition will need each of those qualities more than ever. And they will need the right technology partners to help them bridge the gap between their traditional ways of operating and the vehicles of the future. We believe that Intel thoroughly understands the forces at play and has the technical know-how and depth of leadership needed to facilitate auto makers' transition into the new era of tech-centric vehicles.

Important Information About This Paper

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