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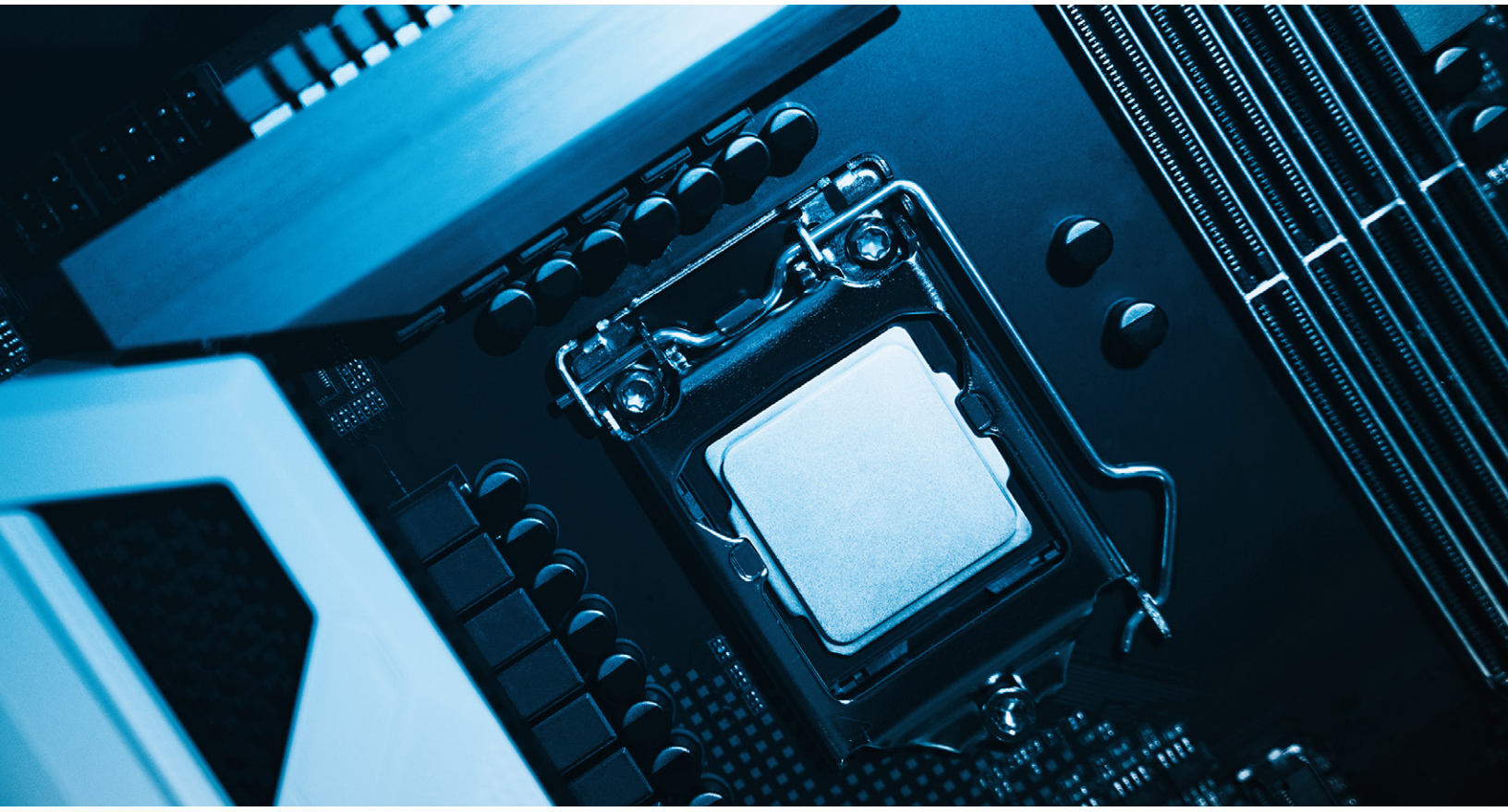
Semiconductors Practice

Semiconductor shortage: How the automotive industry can succeed

As the semiconductor shortage persists, the automotive industry will likely benefit from new sourcing models and stronger bonds between OEMs, Tier 1 suppliers, and semiconductor suppliers.

by Ondrej Burkacky, Johannes Deichmann, Philipp Pfingstag, and Julia Werra



June 2022

During the earliest days of the COVID-19 crisis, automotive headlines focused on the huge drop in vehicle demand. But for more than a year now, concerns have shifted to the supply side. Although vehicle orders have surged to unexpected heights, a shortage of automotive semiconductors is forcing OEMs to close production lines or remove some popular features, such as heated seats, from their offerings.

We first explored the automotive chip shortage in a May 2021 article, noting that a quick fix was likely impossible.[1] The situation has worsened since then, and the recent drop in automotive revenues is largely occurring because OEMs and Tier 1 suppliers cannot procure sufficient quantities of chips and must delay vehicle production. While manufacturers of laptops, white goods, and other devices have also cut production because of semiconductor shortages, the repercussions in the automotive industry have been more severe. Some premium OEMs were able to safeguard profits with selective manufacturing and sales strategies designed to optimize margins. This strategy, however, may result in a shortage of lower-margin vehicles and could cause extreme fluctuations in demand for automotive chips.

Russia's invasion of Ukraine has introduced further uncertainties to both the semiconductor supply chain and automotive demand. For instance, Ukraine supplies 25 to 35 percent of the world's purified neon gas, and Russia supplies 25 to 30 percent of palladium, a rare metal used for semiconductors.[2] Another wrinkle: many semiconductors are transported by air, but transport costs have significantly increased while available shipping volume has dropped. And yet another problem: OEMs have been unable to obtain critical vehicle components, such as wiring harnesses, and have reduced their production volumes in response, which has added even more uncertainty by decreasing demand for some semiconductor-based components.

Given the ongoing instabilities in the semiconductor supply chain, the automotive industry should consider refining its strategy. Companies can start by focusing on the implications of three critical activities that form the foundation for strategic shortage management: the creation of strong technology maps, reliable short-term demand planning, and guidance for long-term demand planning.

Factors behind the escalating challenges in semiconductor supply

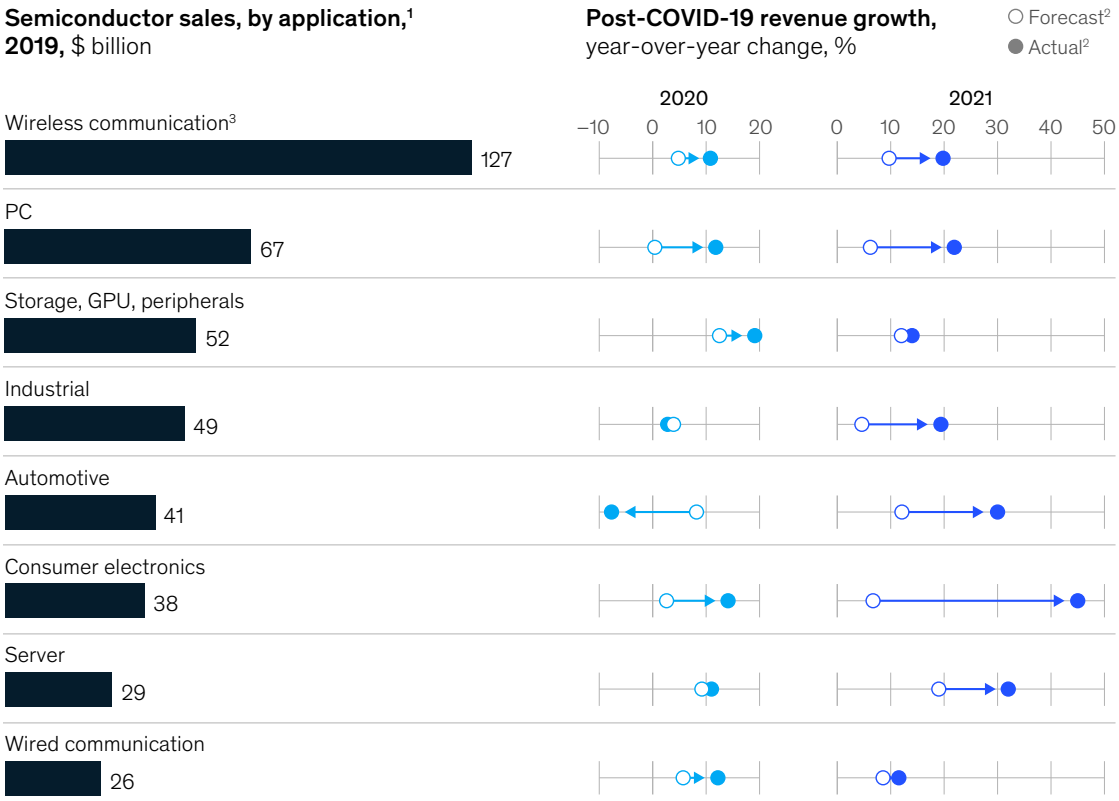
More than two years into the pandemic, the gap between chip supply and demand has widened across all semiconductor-enabled products. While sales of all consumer goods plummeted in the first half of 2020, and automotive sales dropped precipitously—up to 80 percent in some locations—demand rebounded more than expected later in the year, continued to grow in 2021, and remains strong today. The high-tech sector, in particular, has seen sales volumes increase, partly because of changes wrought by the COVID-19 pandemic. The growth in working from home, for instance, has contributed to a greater demand for wireless connectivity and PCs. These market shifts have rippled back to affect demand for semiconductors and other components. Across almost all industries, the demand for semiconductors in 2020 and 2021 exceeded prepandemic forecasts (Exhibit 1). And this means automotive OEMs and Tier 1 suppliers are increasingly competing with companies in other industries for chips.

Although the chip shortage is affecting many industries, the automotive sector has some unique characteristics that exacerbate the problem. For instance, many OEMs and Tier 1 suppliers follow a "just in time" manufacturing strategy in which they order semiconductors and other vehicle components close to production to optimize inventory costs. When vehicle sales fell in early 2020, OEMs and Tier 1 suppliers decreased their chip orders, leaving them low on inventory when

[1] Ondrej Burkacky, Stephanie Lingemann, and Klaus Pototzky, "Coping with the auto-semiconductor shortage: Strategies for success," McKinsey, May 27, 2021.
[2] Peter Hobson, "London market greenlights Russia's palladium while blocking its gold," Mining.com, March 8, 2022; Karvi Rana, "The Russian invasion of Ukraine to further cripple the semiconductor industry," Logistics Insider, February 16, 2022.

Exhibit 1

Overall demand for semiconductors continues to increase.



[1]Products include memory, microcomponents, logic, analog, discrete, optoelectronic, and sensors/actuators.
[2]The estimate for 2020 was calculated using a 2019 baseline and percentages have been rounded. For 2020–21 rate, backward corrections from IHS might be included in 2020 data. Forecast for 2020 as of Q4 2019; forecast for 2021 as of Q4 2020.
[3]Includes Chinese inventory effect; growth rate without this effect expected to be –4% to –8%.
Source: Omdia Semiconductor Silicon Demand Forecast Tool; McKinsey analysis

demand began to recover. Companies in industries that do not follow a just-in-time ordering approach were in a better position, especially since some had secured extra capacity when automotive players canceled or reduced their orders.

On the demand side, automotive companies have much more complex and personalized products than companies in many other industries. In consequence, they may have more difficulty predicting their semiconductor needs, and demand may fluctuate. On top of this, the automotive industry must follow stringent safety requirements that necessitate the use of specifically validated semiconductors and defined production facilities along the complete value chain.

Amid all the uncertainty, demand for automotive chips is growing steadily as vehicle electrification, advanced driver-assistance systems (ADAS), and connected-car features become more popular.

The growing chip shortage is prompting the automotive industry to order surplus semiconductors—about 10 to 20 percent more than needed—to ensure inventory and safeguard production. This “bullwhip effect” has been documented across various industries for many

years. In 2022, for instance, OEMs and Tier 1 suppliers are expected to place orders for enough automotive chips to outfit about 120 million new cars, but annual vehicle sales are forecast to be about 83 million.[3] Companies across industries are also placing more ad hoc orders, often at an unusually high average sales price. The new ordering trends do not provide immediate relief, given the long production times for chips, and they introduce additional uncertainty into the semiconductor supply chain.

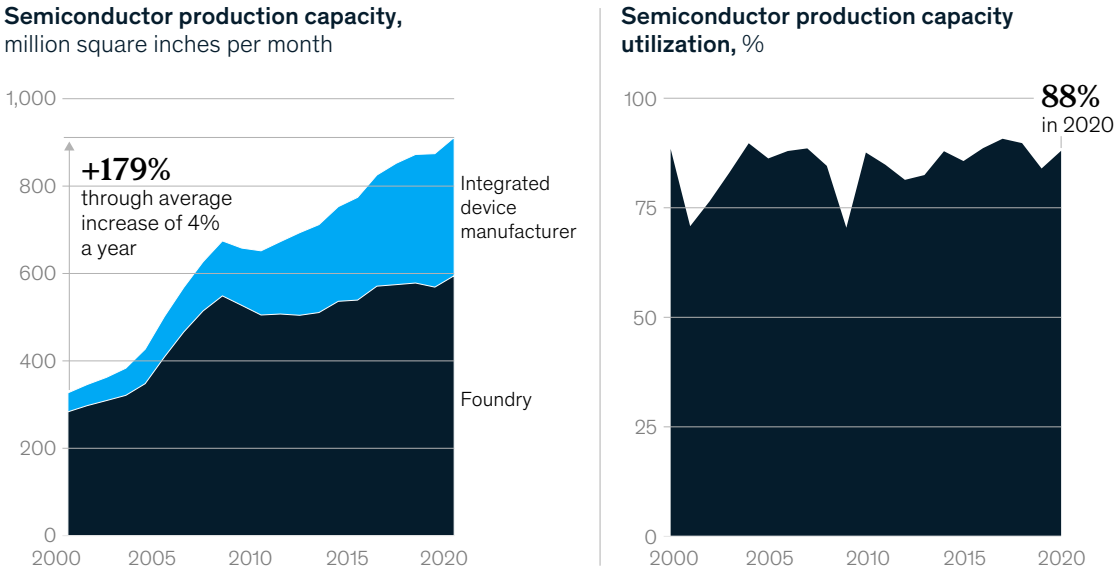
The need for solutions

As we noted in our earlier article, no short-term solutions exist for the automotive semiconductor crisis. The lead times for chip manufacture average a minimum of four months if capacity is available and no expansion is required; otherwise, it will likely take a minimum of 18 months (Exhibit 2). Increasing production might seem like the obvious answer, but it takes more than three years to build a new fab and ramp up wafer production. Lead times for manufacturing equipment have also increased over the past two years because COVID-19 complicated supply chains, making expansion even more difficult.

The semiconductor supply chain was already under stress before the pandemic. COVID-19, combined with recent challenges related to power outages, natural disasters, and geopolitical uncertainties, has only intensified the problem. After closely examining the industry, including these recent supply and demand trends, we have concluded that the semiconductor shortage will likely persist in selected technology nodes for at least the next three to five years. The ongoing shortage is partly a result of long-standing structural factors, such as insufficient capacity, but the recent behavior of automotive companies—overordering and increasing stock levels—is also contributing to the problem (Exhibit 3).

Exhibit 2

Lead times for semiconductor production can exceed four months.

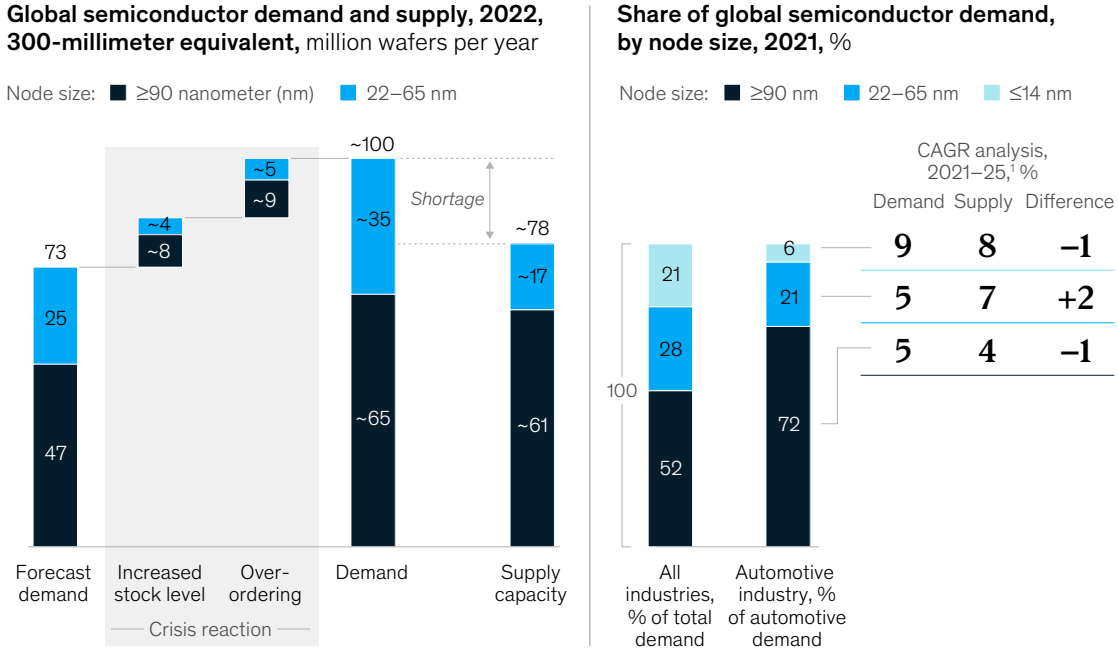


Source: IHS-Omdia; McKinsey analysis

[3] Alternative propulsion forecast, IHS Markit, January 2022.

Exhibit 3

A combination of structural issues and crisis reactions has led to semiconductor shortages.



Note: Figures may not sum, because of rounding.
[1]Supply is installed capacity in million 300-millimeter-equivalent wafers; demand foundation is conversion of million square inches into million 300-millimeter-equivalent wafers.
Source: Omdia Semiconductor Silicon Demand Forecast Tool (Q1 2022); SEMI WFF (Mar 2022); McKinsey analysis

For nodes greater than 90 nanometers (nm), which are in high demand in the automotive industry, the shortage is likely to persist for two reasons. First, the semiconductor industry is unlikely to address the structural reasons for this shortage, because mature nodes have low profit margins. Second, some end customers appreciate the attractive price point of mature nodes and have a limited incentive to migrate to lower node sizes, because of the additional development and qualification costs, as well as the limited availability of R&D staff.

For wafers from 22 to 65 nm, the shortage will not fully resolve over the short- to midterm, but it may lessen if semiconductor companies increase their supply, as expected. Overall, however, it is difficult to predict the size of the demand–supply gap for specific products in this group, given the high heterogeneity of device types and technologies.

An updated approach: Sustainable control rooms and an intensified long-term strategy

As companies contemplate the semiconductor shortage, they are considering both their short- to medium-term needs, as well as their long-term resiliency and survival. Our previous article described some strategies that are appropriate for both periods, and we have refined them to reflect recent experience.

Many OEMs and automotive Tier 1 suppliers have already established control rooms that combine staff from procurement, supply chain management, and sales to help ensure that they have a sufficient supply of semiconductors. While these teams have developed some effective solutions to manage the immediate supply–demand shortage, they often lack the required tools, skills, or capacity to manage it over the midterm and develop strategic solutions. To remedy the most common problems, companies can undertake several actions (Exhibit 4).

Stronger technology road maps

In many cases, companies create unclear technology road maps that do not truly define their semiconductor needs. For instance, the road maps may contain limited insights about the semiconductor content in next-generation products or fail to account for all factors affecting semiconductor supply and demand, such as the impact of custom-vehicle orders.

Creating stronger technology road maps will allow Tier 1 suppliers (or potentially OEMs in the case of certain components, such as central computers) to increase transparency, allowing the companies to steer their product development more strategically. They may decide to reengineer chips, hold discussions jointly with the OEMs to identify opportunities for drop-in components, or collaborate with OEMs to reduce variations in

Exhibit 4

Several factors may complicate the creation of a technology road map and planning, but solutions exist.

	Technology road map	Short-term demand planning	Long-term demand planning
Typical challenges	Unclear technology road maps, making it difficult to predict development of **semiconductor content for next-generation products**	OEMs frequently making changes that affect semiconductor demand, **even after production has begun** for their order Semiconductor suppliers **requiring commitment** on product mix and allowing little flexibility	Limited ability of OEMs to determine their **custom orders** that largely affect demand for specific semiconductors Semiconductor suppliers requiring guidance to decide on **long-term capacity investments**
Best-practice solution	Tier 1 suppliers—and in certain circumstances, OEMs—**develop strong technology road maps**	**Share information on demand and supply** through the full value chain based on: • Commonly agreed-upon nomenclature • Increased accuracy through data-driven forecast algorithms	**Extend demand planning** to 3–5 years
Strategic management levers	**Strategic product development:** • Identification of re-engineering needs for chips • Identification of potential for drop-in components • Reduction of semiconductor variance across products to reduce the fluctuations in demand resulting from custom-vehicle orders	**Trusted partnerships:** Resulting from increased transparency **Binding orders:** Potential commitment to the integrated device manufacturer (and even the foundry) by the Tier 1 supplier, and to the Tier 1 supplier by the OEM, on volumes **Improved inventory management:** Midterm inventory strategy based on demand–supply matching	**Strategic investments:** • Assessment of co-development opportunities • Strategic coinvestment in nodes in short supply

If one supplier appears to be having difficulty getting the components necessary for its products, the manufacturers know that this delay will ripple back to affect them.

the large-volume discrete and analog devices across different vehicle components (thereby decreasing variations in demand resulting from custom-vehicle orders).

Improved short-term demand planning

In addition to strategically designing products, OEMs and Tier 1 suppliers can provide greater transparency about short-term automotive chip demand to semiconductor suppliers. In other industries, such as electronic equipment, manufacturers and suppliers share information about demand and supply across the full supply chain, which helps surface potential problems before they escalate. If one supplier appears to be having difficulty getting the components necessary for its products, the manufacturers know that this delay will ripple back to affect them. Historically, the automotive industry has not required this end-to-end transparency, because of its market power and steady growth, and OEMs and Tier 1 suppliers have not yet achieved this. To attain the desired level of insight, OEMs and suppliers can use a commonly agreed upon nomenclature, such as a shared definition of chip families and technology nodes, in demand forecasts.

OEMs and Tier 1 suppliers that invest in data-driven processes and automated tools will improve the quality of their end-to-end planning process. Some have already taken steps in this direction by providing ready-to-use dashboards for tracking products along the supply chain, but many more opportunities remain across functions. Sales, for example, could use advanced analytics to forecast required demand. And manufacturing could use digital tools that help allocate semiconductors to the right areas, rather than making ad hoc decisions, to keep vehicle production on track. Teams can also use risk cockpits to reduce the chance of unexpected semiconductor shortages. These steps can help address many issues that now interfere with chip supply, such as a lack of insight about the semiconductor content of next-generation products.

Better end-to-end planning along the supply chain, combined with greater use of data-driven processes, will make OEMs and Tier 1 suppliers within the automotive industry more reliable and potentially preferred partners. These actions will also enable strategic contractual levers, such as long-term take-or-pay commitments by Tier 1 suppliers, that will increase the chances for strategic partnerships between semiconductor suppliers and automotive players.

Better short-term planning will also help OEMs and Tier 1 suppliers form more strategic relationships. As they work together, OEMs should remember that demand estimates may be inaccurate and take steps to mitigate risks or share the burden with their Tier 1 suppliers. For instance, a contract might state that an OEM will commit to using a specific chip

technology 18 months in advance. It would offer the OEM some limited flexibility to modify the order and the option of switching to a different technology until six months prior to shipment. To make such arrangements work, OEMs must specify the exact components needed (rather than the vehicles being manufactured), since this directly translates into demand for semiconductors.

Improved transparency along the complete supply chain, including supply–demand matching, is a prerequisite for having OEMs and Tier 1 suppliers implement midterm inventory-management strategies that will reduce risk. This inventory management can allow Tier 1 and semiconductor suppliers to confirm that they can fill orders because the supply–demand analysis gives them more transparency and allows them to allocate chips to potential customers earlier.

Improved long-term demand planning

Besides short-term demand planning, OEMs and suppliers could build a long-term perspective on demand. This will allow them to consider jointly investing in projects involving mature nodes. Alternatively, both groups may codevelop semiconductors in advanced or leading-edge nodes. These strategies will allow them to share the financial burden while improving the supply of low-margin or highly innovative technologies.

Even after OEMs and Tier 1 suppliers improve their strategy, control rooms may become semipermanent features in the automotive industry until the semiconductor crisis is resolved; companies should therefore develop some long-term talent strategies for staffing them. Many employees have been juggling multiple priorities and dealing with unexpected challenges since the pandemic began, and asking them to serve on a control room team might seem overwhelming in these circumstances. To reduce the burden, automotive companies can create efficient control room processes and tools that streamline tasks. They can also ensure a stable inflow of talent by asking different employees—either current staff or new hires—to participate on the team, allowing other employees to rotate out.

OEMs and Tier 1 suppliers have quickly moved into firefighting mode to deal with the short-term chip shortage, but even more decisive action is necessary, especially since the situation is likely to persist far into 2023. Taking a hard look at internal processes, contract conventions, and product features will go a long way, as will greater transparency and cooperation with semiconductor suppliers. Those OEMs and Tier 1 suppliers that are willing to experiment and investigate creative solutions may gain the greatest advantages.

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The authors wish to thank Stefan Burghadt, Justin Peters, Larissa Rott, and Fabian Steiner for their contributions to this article.

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