



INDUSTRIAL MACHINERY MARKET OUTLOOK

WINNERS ARE GREEN, SMART, AND DIGITAL

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IN VIRTUALLY EVERY CORNER of the world where they operate, machinery and industrial automation (MIA) companies today are grappling with a period of instability and transition caused by disruptive social and commercial phenomena. To explore these challenges and the strategies of the companies that are navigating them best, BCG conducted an in-depth analysis of the MIA industry—its current performance and its future prospects. Our goal was to identify which MIA segments were doing well and why, and which were likely to lead the industry in the coming years as products, customer needs, and technologies shift and advance. We also examined the impact of the COVID-19 pandemic on MIA companies and produced the first forecasts of how the virus outbreak will affect sector gains over the next few years.

Our analysis uncovers a two-sided picture of the industry. One side is struggling to maintain a competitive and profitable position, innovating and embracing digitization too slowly and facing a difficult period of change and volatility. The other side is rap-

idly finding its footing and augmenting its products with breakthrough digital features, in many cases leading customers to real and unanticipated performance improvements. These bright spots in a somewhat stressed industry hint at a path to future growth that other MIA companies could emulate.

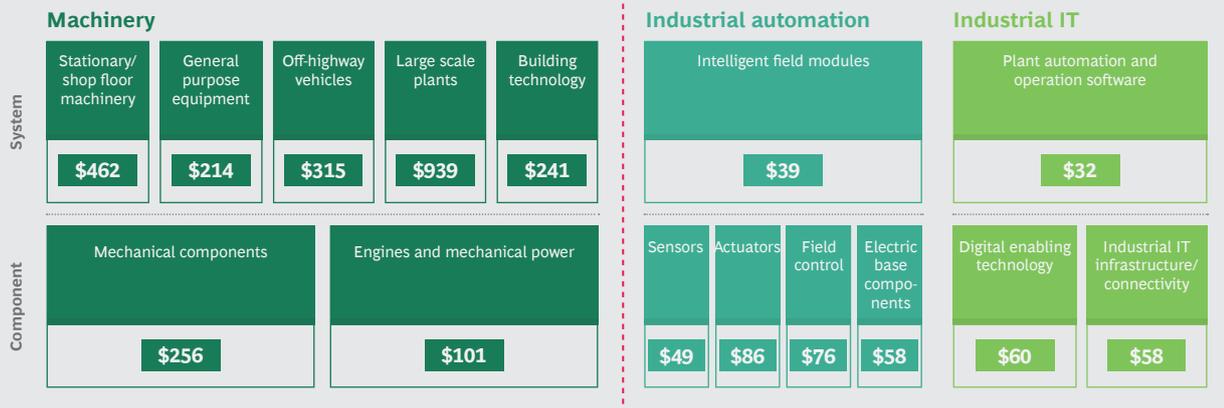
An MIA Roadmap

Machinery and industrial automation is a \$2 trillion-plus industry comprising three sectors—machinery, industrial automation, and industrial IT—and 15 subsectors. (See Exhibit 1.) Although the industrial automation sector is not new, more recently it has been enhanced by new digitally focused developments in industrial IT, and together these two sectors are now commonly viewed as the innovative advanced automation space. Each of the MIA subsectors encompasses a large number of segments.

Indeed, the MIA industry overall is extremely heterogenous and extensive, with products, applications, and niches varying

EXHIBIT 1 | MIA Represents a \$2 Trillion-Plus Market Across 15 Subsectors

\$ = billions



Source: BCG analysis.

from relatively basic (for instance, power tools and bending equipment) to state of the art (machines with artificial intelligence and virtual reality capabilities). This diversity offers existing MIA companies as well as new entrants an enormous range of market possibilities and opportunities to expand into new regions, product lines, and customer groups.

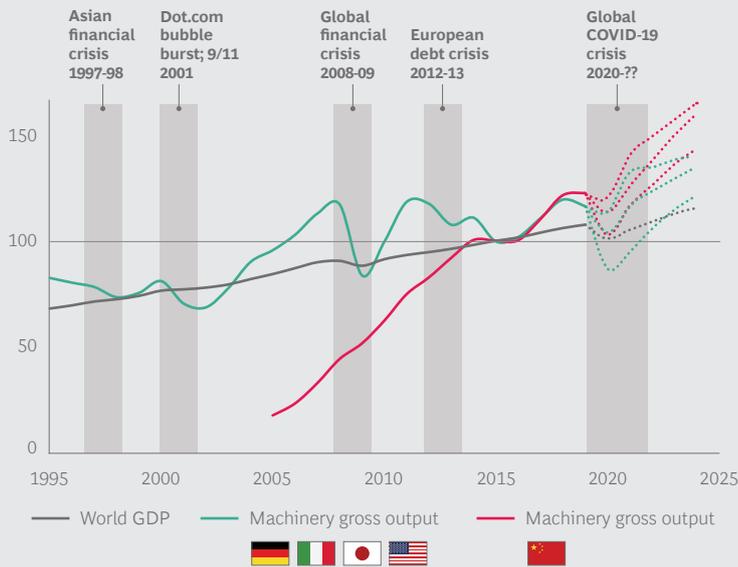
But despite the industry's advantages, success for MIA companies is anything but guaranteed. Overall, MIA lags other industries in adopting new technologies and embracing digital advances, even though MIA companies serve some of the most influential and indispensable industries in the world—everything from automotive manufacturing to mining, agriculture, high-tech, and health care. This shortcoming is somewhat perplexing since a sizable percentage of MIA companies make equipment for plant automation and devices that contain sensors, actuators, complex operational software, and connectivity capabilities. Even as these technologies play an increasingly visible role in MIA products, the industry has fallen behind digitally, in large part because its innovation cycle is very long compared with other industries. And this cycle could slow down even further as hardware and software (both traditional and more advanced involving, for instance, the Internet of Things) become increasingly integrated. In that environ-

ment, technology upgrades will have to be more exhaustive, synchronized across product lines.

In the past, customer expectations have played a big role in slowing the innovation cycle. Many of the industries that MIA companies sell to have long investment horizons for their large and expensive equipment purchases—as many as 15 years for automotive factory machine tools, but it could be as much as 40 years if it's a small-business, individual-assembly operation (in an assembly line, the equipment's life would typically be somewhat shorter than that). Even with computer- and software-controlled industrial equipment, such as computer numerical control software or programmable logic controller (PLC) systems, innovation has plodded along with breakthroughs only every 30 years or so. For instance, the first wave of PLC equipment occurred in the 1960s when Siemens introduced its SIMATIC control units. But the second wave wasn't until the 1990s, when Beckhoff debuted its industrial PC products. The third wave is only now under way—with the launch of Bosch Rexroth's fully software-based advanced ctrlX Automation architecture.

That multidecade innovation cycle is a far cry from what we see in, for instance, consumer electronics, where fundamentally new products—from iPods to smartphones

EXHIBIT 2 | MIA Long-Term Growth Trend



Sources: Oxford Economics; BCG analysis.
Note: Indexed, 2015 = 100.

- Machinery sales tied to development of GDP and industrial production, but with strong cyclical fluctuation.
- Emerging Chinese market skyrocketing since 2005 (in terms of volume and value).
- Drop from COVID-19 pandemic projected based on 2008-2009 experience.
- Long-term recovery toward historic growth trend expected.

to tablets to audiophile equipment—are developed and advanced with dizzying speed. Of course, MIA products must meet much higher safety standards than an audio or video device, but even in more deliberate design and manufacturing environments, slow and incremental product modernization is not a viable approach anymore.

At least in part, this innovation shortfall bears some blame for the generally lackluster growth of the MIA industry for well over a decade. While global GDP has trended slowly upward—with a few significant hiccups like the 2008 recession—since before 2005 global machinery sales (except in China) have ridden large fluctuating waves. (See Exhibit 2.) And although the COVID-19 pandemic has worsened prospects for the MIA industry, even before the virus shuttered economies around the world, MIA revenue was slumping. In fact, 2018’s sales upswing had reversed itself pretty dramatically by the following year.

The Impact of Megatrends

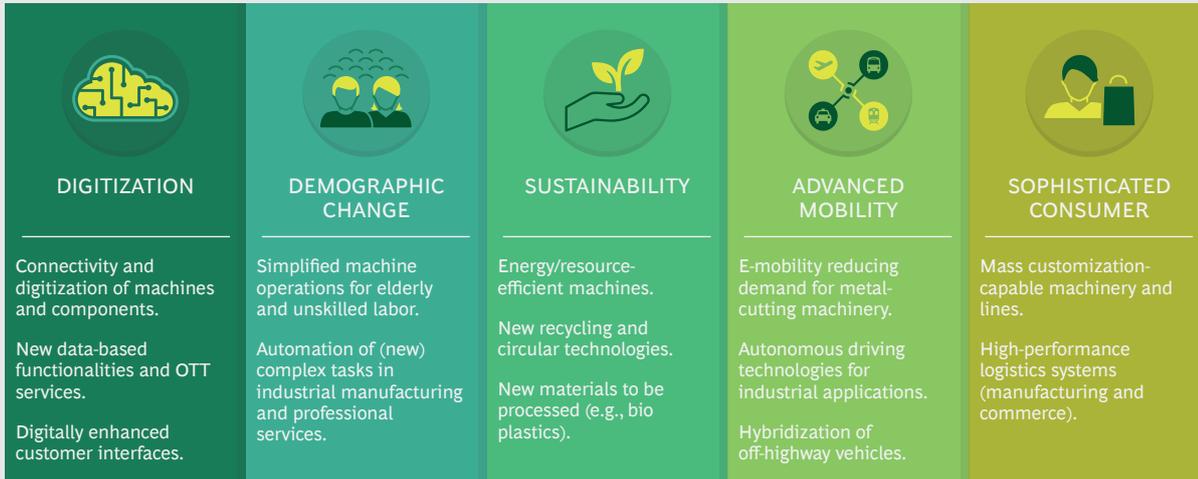
We can trace to some degree the pre-COVID downturn among machinery companies to five global megatrends that are influencing the direction of global manu-

facturing and changing MIA customer requirements and expectations. Combined with COVID-19, these powerful megatrends, whose impact will outlast the virus, form a daunting headwind for MIA companies. Yet, at the same time, these megatrends are a beneficial wake-up call for the machinery industry—and a catalyst for MIA companies to develop a better comfort level around digitization more quickly, enhance their products with technology advances, improve their relationships with customers, and develop new profit pools.

Viewing these megatrends in the context of the outlook for the MIA industry, it is apparent that they will affect a broad array of operational and product design possibilities. (See Exhibit 3.) For example:

1. **Digitization.** This megatrend has the greatest impact on the machinery industry, affecting product connectivity, cloud computing and Big Data functions—features and capabilities that are necessary for MIA products to be on the cutting edge. Customers, facing their own digital disruptions, expect and require accelerated improvements in digital features. Digital enhancements, including machine intelligence, sensors,

EXHIBIT 3 | The Impact of Five Megatrends on the MIA Industry



Source: BCG analysis.

equipment self-monitoring, robotic capabilities, autonomous systems and sophisticated data analysis, can allow equipment owners to replace rule-based production in favor of much more efficient and creative goal-based production.

Rule-based manufacturing is driven by a programmed series of operational guidelines that attempt to anticipate all real-world factory situations that may crop up. When something unexpected occurs, however, the system is unable to deal with it, and failure or slowdown often follows. By contrast, goal-based production processes, built on artificial intelligence and advanced analytics, concentrate on achieving specific manufacturing metrics, using computing and communications technology to reach these goals and flexibly navigate unpredicted situations.

Digitization affects virtually all MIA industry sectors. But it is particularly relevant in the two advanced automation sectors: industrial IT and operational technology breakthroughs are increasingly being integrated into more traditional automation architectures. That is spurring the development of intelligent field modules, currently more as an overlay than true digital

convergence. We anticipate that these advances will accelerate in the next decade.

- 2. Demographic Change.** As the global population ages, manufacturing is losing older, experienced workers and struggling to replace them with experienced and skilled operators who want to work in factories among the younger population. As a result, there will be a growing demand for intelligent machines that can collaborate with human workers. Among other things, this equipment can automate difficult tasks; detect production anomalies and propose resolution steps; use sensors to surveil production speed and quality while helping to maintain predetermined standards; and maximize the impact of machine connectivity in the factory and, through the cloud, to external facilities. For the MIA industry, addressing demographic change will be critical in the more traditional machinery/systems segments, such as stationary shop floor equipment and building technology.
- 3. Sustainability.** As ecological concerns, policies, and requirements expand in every industry, addressing climate change, protecting resources, implementing low-waste circular economy

concepts and replacing fossil fuels with renewable energy sources are priorities. For MIA companies, this translates into the urgent need for new classes of machinery that are energy- and resource-efficient, such as electric waste-sorting robots or pumps that are not simply switched on or off but rather able to measure and perform to precise power or output needs. In addition, new equipment should be developed that are suited to manage environmentally safer, more lightweight and efficient materials, such as bioplastics. Among MIA segments, sustainability trends will strongly increase the market for new off-highway vehicles—for instance, mining, construction, and agriculture machines—that run on electric or hybrid power and, to a lesser degree, components for electronic equipment and building technology. The market for traditional engines and power equipment, however, will be hurt by the preference for more environmentally-sound machinery.

- 4. Advanced Mobility.** An offshoot of the sustainability megatrend, this category primarily covers new developments in autonomous driving, shared mobility, and the slow but steady shift from internal combustion engine vehicles to electric vehicles. Beyond improving demand for off-highway vehicles (both electric and self-driving) and electronic components, advanced mobility will also propel interest in autonomous driving equipment, such as sensors. On the negative side, it will crimp sales of traditional metal cutting machinery, which will play a lesser role in next-generation automobile factories since electric vehicles lack combustion engines and power transmission systems that are primarily trimmed and forged with metal shaping equipment.
- 5. Sophisticated Consumer.** Consumer preferences are shifting markedly, on the one hand, toward more individualized items purchased online using smart mobile devices and, on the other, toward new types of products, particu-

larly in the health and wellness area, such as home diagnostic and exercise monitoring equipment. To satisfy this new consumer landscape, MIA customers are increasingly in the market for machinery that can be used for mass product customization and that offers seamless digital integration of product configuration, order intake, production planning, and production. They also seek high-performance logistics systems suitable for e-commerce channels. MIA companies have a huge opportunity in this accelerating change in consumer attitudes, especially in designing for their customers digital equipment to enhance multiple product changeovers and automated orders handling.

MIA Market Outlook

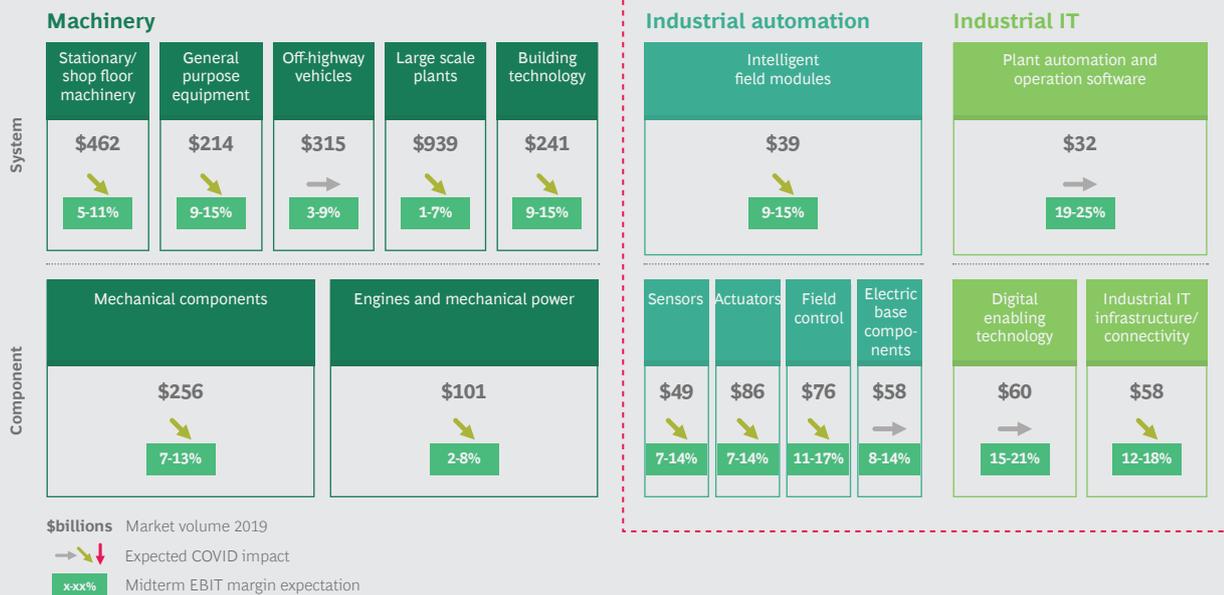
Taking into account the impact of these megatrends, BCG's MIA sector and subsector forecasts suggest that the industry is becoming more and more stratified. Essentially, it is divided between companies that have embraced digitization and other pronounced shifts in society and consumer behavior—and, hence, have prospects for significant revenue and profit gains—and companies growing more slowly because they have thus far failed to take advantage of these megatrends.

For instance, the MIA subsectors that are poised to enjoy the best earnings before interest and taxes (EBIT) margins generally provide equipment top-heavy with digital features or technologically advanced tools for next-generation mobility, factory of the future, and sophisticated logistics applications, to name just a few. These subsectors are expected to emerge relatively unscathed by the pandemic. (See Exhibit 4.) They include industrial IT companies that provide digital enabling technology, industrial IT infrastructure and connectivity, and plant automation and operation software.

A word of caution, however: our forecasts do not take into account the full impact of the COVID-19 pandemic on these sectors. The outbreak and the subsequent global economic shutdowns are wild cards that

EXHIBIT 4 | MIA Market Outlook 2019-2023

Sales growth and profitability = \$billions



Sources: BCG market model; BCG analysis.
 Note: EBIT=earnings before interest and taxes.

are impossible to make clear-eyed guesses about just yet. Our preliminary analyses of the pandemic’s impact on compounded annual growth rates (CAGR) through 2023, however, doesn’t anticipate high profit margin subsectors like digital enabling technology and plant automation and operation software to be sustainably hurt by COVID-19. Indeed, they may actually have greater sales growth than anticipated: as the virus alters industrial workplaces in the short run, the need for automation and machine intelligence to take on, or at least share, factory tasks with humans will likely accelerate.

By contrast, companies in the more traditional side of the MIA industry—such as the stationary machinery and large-scale plants subsectors—can expect much worse margins. This is not a good sign for the industry overall since the machinery sector makes up about 85% of total sales. Viewing the MIA industry as a whole, we estimate that about two-thirds of its sales lie in low- or no-growth segments. Companies that rely primarily on these segments have no choice but to reinvent their business mod-

els and reposition themselves to take advantage of MIA industry areas that show more promise.

It is worth noting that viewing the MIA industry through its subsectors, while valuable in providing a general sense of trends and directions, does not paint the whole picture. Growth varies a great deal among the many segments included in the subsectors. For instance, we forecast that the stationary/shop floor machinery subsector will expand at a relatively slow 2.7% CAGR through 2023 (not including the impact of the coronavirus) and will take a moderate hit from COVID-related economic conditions. But among the segments in this category is manufacturing equipment for photovoltaic (PV) panels—and more than likely it will be an outlier. With interest in solar energy widening, PV manufacturing equipment sales should rise more than 15% each year and barely feel the pinch of COVID-19.

Even so, PV panel prices will be under pressure. Solar installation companies and utilities are finding homeowners and commercial users skeptical about switching to

solar power without short term returns on investment, which depends among other things on low-cost PV panels. As a result, profit margins for PV manufacturing equipment are likely to remain below 6%.

Our forecasts for automated material handling, a segment in the general purpose equipment subsector, are even more bullish. Although pre-pandemic CAGR estimates for this subsector come in at about 7.3%, the explosion in e-commerce could increase profit margins in this segment up to 14% on average.

The Top Five Performers

With a wide range of variables simultaneously affecting MIA companies—megatrends, COVID-19, consumer attitudes, and digital advances, just for starters—we concluded that perhaps the most useful analysis of the industry today and going forward would come from determining which segments are performing best in this unique environment, and why. Such a scorecard could be a valuable guide for MIA compa-

nies in segments that are struggling, providing clues about the product and market decisions that are most likely to yield success and improve their prospects.

After analyzing all 85 MIA segments for characteristics common to companies expected to perform best over the next few years, we came up with six traits: (1) their sales growth will top 7% per year; (2) during that time, average EBIT margins will also be north of 7%; (3) they are relatively unaffected by the COVID-19 crisis or may even benefit from it; (4) their best business opportunities result from multiple megatrends; (5) they have scaled up to critical mass; and (6) their start and ramp up phases are behind them.

Only 14 segments meet most of those criteria. Of them, the top five are waste and recycling technology; machine vision; smart sensor modules; automated material handling, including automated guided vehicles (AGVs); and industrial and collaborative robots. (See Exhibit 5.) Here’s why these segments outpace the rest of the MIA industry:

EXHIBIT 5 | Top Five (Plus One) MIA Segments at a Glance

	Market size	Pre-COVID growth	COVID impact	Midterm profitability expectation	Megatrend impact	Sample companies	Rationale
Waste and recycling technology	\$24	+7.0%	→	15-24%	■	Tomra Andritz Alba Group	Manifold new business opportunities opening up from sustainability needs and environmental laws
Machine vision	\$13	+10.0	→	15-24	■	Basler Isra Vision Keyence	Fast-growing enabler technology for flexible machine and system concepts
Smart sensor modules	\$7	+15.9	↘	7-14	■	Ifm electronic Sick Omron	Integrated HW/SW business in the “heart” of IIoT
Automated material handling, including AGVs	\$30	+7.3	→	7-14	■	Daifuku Swisslog Vanderlande	Sustainable growth driven by e-commerce and demographic changes
Industrial and collaborative robots ¹	\$20	+13.8	↘	7-14	■	Kuka Universal Robots Schunk	Advanced robots and rising breakevens for investments extending field of applications
+							
AA/AI/ML ²	\$15	+31.1	→	25+	■	Groove Jones Amazon Web Services Siemens	Key cross-industry enabler for intelligent digital functionalities and use cases

\$xx billion Market volume 2019 +xx% Pre-COVID CAGR 2019-23 →↘↙ Expected COVID impact x-xx% Midterm EBIT margin expectation

Sources: BCG market model; BCG analysis.

¹Includes conventional robots, lightweight/collaborative robots, and end-effectors.

²AA/AI/ML = advanced analytics, artificial intelligence, and machine learning.

- **Waste and Recycling Technology.** Of the top five, this segment has the best profit potential, with projected margins as high as 25%. The segment has many new business opportunities emerging from sustainability needs and environmental laws. Growth is impeded a bit by this segment's fragmented niche markets due to many individual recycling solutions broken down by material type.
- **Machine Vision.** Profit margins in this segment are expected to reach upwards of 25% as equipment with artificial intelligence enjoy robust growth over the next few years. For robotic, intelligent equipment, machine vision is the critical technology for location and guidance, object recognition and identification, as well as quality control and documentation.
- **Smart Sensor Modules.** Pre-COVID growth of about 16% is forecast for this segment, which is the pivotal technology for sensing and capturing data, the prerequisite for automating industrial processes and the heart of the IIoT (the Industrial Internet of Things). However, depending on how long the effects of the virus are felt, this segment could be harmed by factory and construction slowdowns.
- **Automated Material Handling, Including AGVs.** This segment is already a big market with over \$30 billion in annual sales. But the accelerating emergence of online shopping—which has exploded during the pandemic as consumers prefer the safety of ordering products from home—should propel sales for equipment that reduces the need for human workers in warehouses and production.
- **Industrial and Collaborative Robots.** Strong sales growth of as much as 14% is expected for this segment, which has been growing steadily for the past decade as factories have increasingly embraced automation. Aging workforces and the difficulty in finding sufficient

numbers of skilled workers for assembly activities have amplified this trend. In the coming years, collaborative robots will be used for cost-efficient individualized production and alleviating workforce reductions in a world that could be at risk of rolling pandemics. However, post-Covid economic sluggishness could impede sales in this segment.

Taking a slightly broader perspective, advanced analytics, artificial intelligence, and machine learning—a standalone segment that also plays a critical role in each of the top five segments—should be highlighted as the sixth-best performing segment. Our forecast projects more than 30% sales growth per year and EBIT margins of 25%-plus. This uber segment is the base software technology enabling all advanced applications and solutions in machinery and industrial automation, and it both influences and is influenced by the five megatrends.

How to Climb into the Top Five

Companies that are not active in one of the top five segments are not necessarily out of luck. They simply need to discover how to leverage today's megatrends better to their benefit and how to reposition themselves to take advantage of the bright spots in the MIA landscape. This will differ across segments. Some segments not currently in the top five are actually well situated for the future. For instance, mobile machines for big construction projects and agriculture could improve by quantum leaps as digital advances improve their performance and agility and autonomous driving technology is perfected. Self-driving improvements will be easier to safely introduce in protected, pre-mapped settings where mobile machines operate than on less predictable urban and suburban streets.

Other segments—such as power tools and pumps—do not stand to gain from megatrends but won't be negatively impacted either. Companies in these segments need to be mindful of continuing to produce high quality products with the latest features to stave off competition, particularly among more flexible startups or spinoffs

from other more successful MIA companies. A small number of segments will definitely be disrupted and weakened by at least one megatrend. This group includes machine tools, conventional power generation and pulp, paper, and print machinery. Digitization, environmental sustainability, and even shifting consumer preferences are already beginning to slow sales growth for these types of equipment, and companies in these shrinking markets must begin to switch their core focus toward new businesses in other, more promising segments.

But whatever the impact of megatrends on your company—that is, whether you have to differentiate your products and accrue competitive advantages in a rapidly shifting landscape or, less desirably, hold your position in a challenging environment—we believe that three business principles offer MIA companies the best chance for success:

1. Provide solutions, not products.

Solutions can have a couple of primary dimensions. First, in the customer's production process as an end-to-end system that enhances performance and improves value. Second, across the equipment's life cycle; examples of this include proactive equipment maintenance and service programs automatically triggered by machine sensors or complementary consulting packages to help in developing applications.

For instance, one German auto supplier sells individual robots to customers but also offers to install completely automated work cells that handle a specific production process with no human intercession, potentially lowering costs and improving plant safety. Similarly, some providers of waste recycling equipment market entire waste removal systems, from cradle to grave, rather than just individual recycling stations that have to be hauled away by other companies.

2. Sell hardware via software. Virtually all of the new value in MIA equipment today lies in the software, where significant features and functions

reside. In its simplest implementation, software links together individual machines to create a fully productive system, such as an assembly line, and helps maintain maximum productivity or overall equipment efficiency from each facet of the machine network. A more advanced application would include cloud-based support for local equipment. For instance, a tissue machinery producer provides a cloud-based add-on to its products that automates much of the assembly line in, say, toilet paper factories. This application uses AI and machine learning to optimize production by improving process parameters aimed at increasing output. In the past, many of these factories failed to live up to performance expectations because of insufficiently skilled operators. And while some software increases automation, other programs serve as the backbone of the user interface, which ultimately determines how well a piece of equipment can be operated by people at high degrees of efficiency. All of these facets of software are essential to any advanced and digitized machine/equipment offering.

Many companies involved in advanced automation sectors—such as builders of equipment with machine vision or smart sensor modules—design and develop their products from the software end first and add hardware components as physical adjuncts to the software as needed. Traditional machine builders go about it in an opposite, less effective way: they initially focus on the electro-mechanical components of their equipment, then provide some automation (basic elements like sensors and drive control units), and lastly consider what software suite could provide additional functionality and user access. This approach often results in equipment that is not especially user friendly or useful as an end-to-end networked solution; instead, the machines tend to be segregated from each other in silos and often fail to meet customer expectations.

3. **Establish an agile working style and culture.** This is a huge undertaking for many companies, and every company has to determine for itself how much it needs to change its work style to meet its market needs. But viewed broadly, it is imperative for MIA companies to adopt high levels of team collaboration, more efficient and speedier approaches to product design and development, and an innovative spirit that encourages and rewards workers to use their creativity to improve product features and designs. The overall goal is to speed up development of the highly volatile and feature-rich software part of the product offering and to be open to integrating third-party technology solutions, which will accelerate the development process even more. In addition, agile cultures are quicker to identify new features that customers want or can get from competitors and incorporate these functions into their companies' products. Perhaps most importantly, they create solutions from the user's perspective, rather than purely focusing on implementing the latest technology, whether it is relevant for a particular product or not. Of course, to undertake such a significant culture shift, the company's technology design engineers have to see their jobs in a new light. Rather than focusing on technical quantum leaps, they must be motivated to develop customer-centric solutions (which ultimately may have more commercial traction) in shorter and faster cycles than before.

MIA companies in software-heavy segments like machine vision or advanced analytics/artificial intelligence have come a long way in adopting agile work styles. By contrast, companies in automated material handling or other automated equipment segments are moving rapidly toward changing their design and development cultures because their products depend heavily on rapid technological advances—but most of them have not yet improved sufficiently. Often the first step for a company to embrace agile methods and

techniques involves establishing a separate team to incubate digital solutions quickly. The team's workforce would virtually by definition need to be familiar with and enthusiastic about accelerated software design approaches based on trial-and-error and test-and-fix and be willing to eschew traditional long-cycle software development campaigns.

While these three business principles are essential for MIA companies to adopt, there are other things to consider as well, depending on the company's circumstances, markets, and prospects of growth that could provide opportunities. For instance, legislation involving environmental protection, construction, manufacturing and land use policies, and waste removal may open up channels for new products in certain regions. Moreover, reducing outmoded legacy products that are declining in popularity might release funds for developing more innovative products that are better suited to the MIA markets now.

THERE IS NO doubt that the MIA industry has become bifurcated. Some companies are in the perfect position to profit handily from the speed with which the market is moving toward digitization, although to be successful they will have to keep their feet firmly on the pedal. They are better situated, though, than many of their counterparts in the long-established machinery sector. In that part of the industry, the products are increasingly out of step with the market's tilt toward technology improvements, more digital automation, the Internet of Things, and efficiency gains. Only the very best and most agile of machinery sector companies will survive this period of disruption.

Broadly speaking, successful MIA companies during the coming years will have acknowledged the need for change in the types of products they offer and how they manufacture them, as well as in the digital and software-based features they provide. They must be willing to concede that the traditional legacy engineering mindset is

not viable anymore and that company management and culture must support new ways of thinking, developing products, and conducting customer relationships.

unambiguous: the changes we have already seen in many MIA segments are nothing compared with what is about to come in the next few years. For that, all MIA companies need to be prepared.

While our MIA outlook portrays an industry with many uncertainties, one result is

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