REDESIGNING AUTOMOTIVE MANUFACTURING

How manufacturers can utilise advanced techniques to overcome the industry's toughest challenges

AUTODESK.

Image courtesy of BAC Ltd./Monty Rakusen

INTRODUCTION

Why advanced manufacturing is necessary right now

Automotive manufacturers are in the midst of tremendous industry-wide change. Consumer preferences are rapidly evolving, the global regulatory environment is tightening, product development cycles are shrinking, and virtually all of the technologies involved in design and manufacturing are seeing rapid-fire innovations.

In response, many manufacturers are taking steps toward a more advanced manufacturing environment, one that is characterised by connectivity, driven by data, and open to new modes of working. But advanced manufacturing itself is an emerging concept made up of fast-moving and complex techniques for both design and production. And there is no one right way to bring advanced manufacturing to life.

In this ebook, we'll take a closer look at the industry trends creating the need for advanced manufacturing, explore the new technologies automakers can employ in future factories, and show how forward-thinking manufacturers are benefiting from some of these techniques today.

INDUSTRY DRIVERS

Six trends that are transforming the automotive industry

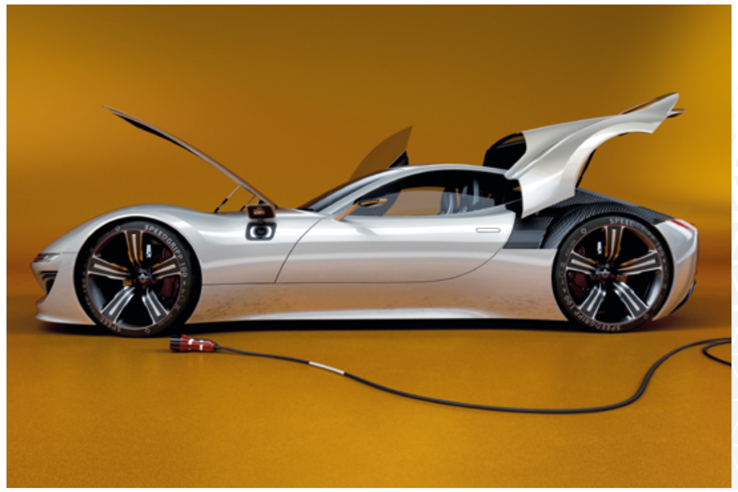
The pace of change in automotive manufacturing is accelerating due to multiple simultaneous trends. Each of these alone could reshape the industry. Together, they contribute to an unprecedented moment of transformation–one manufacturers must prepare to withstand.

01. ELECTRIFICATION

Urgent environmental concerns are elevating the prominence of electrification, which includes efforts to develop hybrid and fully electric vehicles. Electrification offers a wide range of environmental benefits, including reduced emissions and greater overall energy efficiency. As global environmental goals get translated into enforceable regulatory frameworks, electrification will give auto makers a proven way to achieve compliance.

Increasingly stringent requirements for greenhouse gas emissions are just one example. Current regulations in Europe allow 130g/km of CO_2 emissions but this will drop sharply to 95g/km by 2020[1] and long-term targets will be even more aggressive. U.S. emissions targets continue to tighten as well. China, which is focused on reducing air pollution, recently introduced an emission standard for heavy-duty vehicles that exceeds its European counterpart. In addition, nine countries around the world have committed to banning internal combustion engines.

All of which means electric vehicles will represent a growing percentage of global fleets. According to a 2017 report, battery electric vehicles (BEV) will make up 15% of all vehicles on the road in Europe while plug-in hybrid electric vehicles (PHEV) will account for another 9%, while diesel and gasoline vehicles will decrease by 13% and 11% respectively[1]. Electric vehicles are expected to make up 35% of the total fleet sold in the U.S. by 2025 and 22% in China[1].



1. “Automation and electrification to overhaul global automotive industry,” Consultancy.uk, 2017. https://www.consultancy.uk/news/13269/automation-and-electrification-to-overhaul-global-automotive-industry

02. SUSTAINABILITY

Beyond immediate environmental concerns, the industry is seeking to make all of its processes more sustainable as a lower-carbon or decarbonised future approaches. Sustainability is a complex and multifaceted endeavor that affects virtually every part of the automotive industry.

On the production side, sustainability goals include balancing economic growth with regulatory compliance, investing in the digitisation of production lines, cutting costs, and developing a more efficient and dynamic supply chain. Automakers are also addressing the sustainability of employment practices, including increased training and education, closing the gender pay gap and dealing with an aging workforce.

Vehicle usage is another pillar of sustainability, which is seeing manufacturers start developing the technologies necessary—including alternative fuel vehicles and connected and autonomous vehicles—to reinvent the industry as a cleaner part of the global transportation mix.

Finally, manufacturers are examining end-of-life principles, requiring that more and more of each vehicle's total weight be recoverable at this stage, increasing the use of recycled plastic, and finding ways to further increase other recycled content while meeting safety and quality benchmarks.

03. MASS CUSTOMISATION

Mass customisation involves personalising vehicles for specific customers at scale, a longtime and historically intractable industry challenge. While traditional mass customisation was confined to the manufacturing process, new approaches combine advanced design and manufacturing techniques to personalise aspects of the vehicle where they add the most value.

The future result may combine a virtual build-to-order experience for customers with vehicle designs that themselves allow for greater upstream reconfiguration and manufacturing systems that are designed for greater flexibility. Manufacturers that find the "sweet spot" for mass customisation stand to gain a significant competitive advantage.

Image courtesy of Mackevision

04. LIGHTWEIGHTING

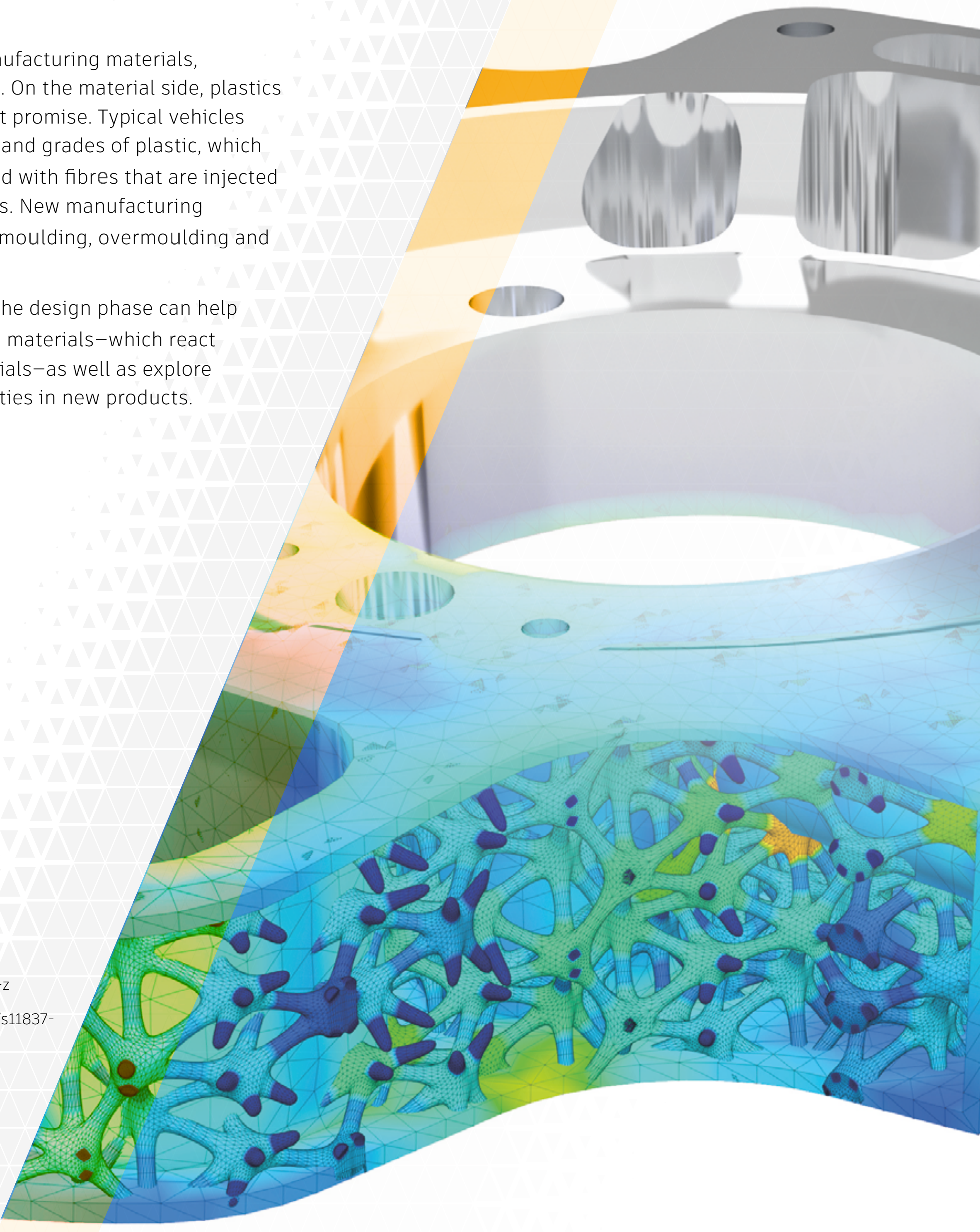
Vehicle lightweighting gives automotive manufacturers a proven way to improve fuel economy by replacing components with a variety of lightweight materials, including aluminum, magnesium, high-strength steel, plastics, and carbon fiber. Reducing the weight of a vehicle by 10% typically delivers a 6 to 7% increase in overall fuel economy[2]. This is an important consideration given how quickly fuel economy and emissions standards are ramping up.

Lightweighting involves new manufacturing materials, processes and design techniques. On the material side, plastics and composites offer the greatest promise. Typical vehicles already use more than 100 types and grades of plastic, which can be strengthened and stiffened with fibres that are injected during the manufacturing process. New manufacturing techniques include compression moulding, overmoulding and microcellular injection.

Finally, simulation tools used in the design phase can help manufacturers analyse advanced materials—which react differently than traditional materials—as well as explore various lightweighting opportunities in new products.

2. Joost, W.J. JOM (2012) 64: 1032.
https://doi.org/10.1007/s11837-012-0424-z

https://link.springer.com/article/10.1007/s11837-012-0424-z



05. SKILLS GAP

The skills gap refers to the difference between the jobs in automotive manufacturing that need to be filled and the available skilled talent to fill them. Hiring skilled talent is a huge issue for all global manufacturers, but especially in the U.S. This is due to prolonged economic expansion creating more jobs, including up to nearly two million new manufacturing jobs by 2028 according to a Deloitte study[3]. At the same time, nearly three million baby boomers are expected to retire from manufacturing in the next decade.

For automakers, these retirees are taking with them a great deal of institutional knowledge that has not been passed down to the workers replacing them. In addition, just as auto manufacturers need to incorporate more advanced technologies than ever before, those positions are becoming the most difficult to fill.

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06. INDUSTRY 4.0

The "4.0" in Industry 4.0 refers to the fourth revolution in manufacturing, after the advent of mechanisation through water and steam power, the development of mass production driven by electricity, and the use of computers and automation. The fourth revolution is one of information and will be driven by a wide range of connected, autonomous and data-driven systems as well as machine learning and artificial intelligence (AI). It is also known as the combination of the Internet of Things (IoT) and the Internet of Systems in smart factories.

All of these concepts are still emerging. But possible applications include manufacturing lines that can sense or predict when they need maintenance, supply chains that automatically adjust to changes in demand or even the weather, and autonomous factory equipment.

3. Deloitte Insights, "The jobs are here, but where are the people?" November 2018.

https://www2.deloitte.com/insights/us/en/industry/manufacturing/manufacturing-skills-gap-study.html

Image courtesy of BAC Ltd./Monty Rakusen

ADVANCED MANUFACTURING

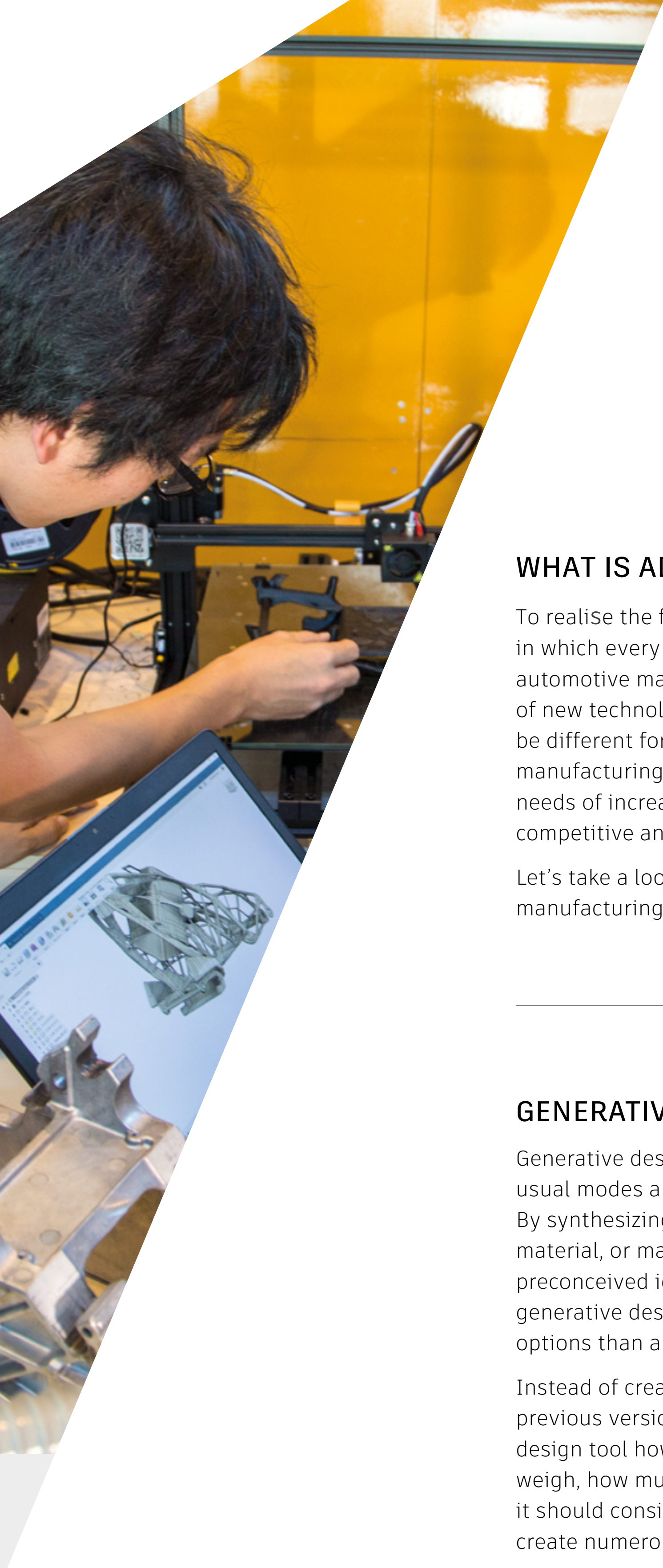
Exploring the technologies that are redefining automotive design and manufacturing

If there is one theme that emerges from all of the trends the automotive industry is weathering at the moment, it's connectivity. To solve big, complex problems, manufacturing concerns will need to move away from traditional departmental silos and begin to build a more seamlessly connected enterprise that can coordinate itself more rapidly and adjust to change more efficiently.

Nowhere is this more apparent than in the convergence of design and manufacturing. In the past, the handoff between the two has been colourfully referred to as the "throw it over the wall" approach. In the future, a more highly connected and automated manufacturing process will require the studio and the shop floor to collaborate more closely to reduce iterations, minimise errors, and create more innovative products more quickly.

What manufacturers should envision is an environment in which product designers use technology not to document a pre-determined outcome but rather to define the range of possible ideas and narrow them down according to functional parameters rather than geometry. Engineers will spend less time defining the shape of each part and more time analysing tradeoffs among performance, cost, and materials. AI will augment these experiences, learning from each iteration to eventually eliminate the need for engineers to repeat common tasks.

As designs move into production, the manufacturing systems themselves will provide suggestions about the impact of specific process adjustments or insight into where failures might occur. Data gleaned from production will be used to enhance simulations of components and systems further upstream in the pipeline, compressing the development cycle and quickening time to market.



WHAT IS ADVANCED MANUFACTURING?

To realise the full potential of advanced manufacturing, one in which every step in the process is connected to the next, automotive manufacturers will need to integrate a wide range of new technologies and techniques. The specific mix will be different for every manufacturer. But overall, advanced manufacturing will give automakers the ability to meet the needs of increasingly demanding customers in a highly competitive and tightly regulated market.

Let's take a look at some of the solutions advanced manufacturing is likely to involve in the automotive industry.

GENERATIVE DESIGN

Generative design tools enable engineers to surpass the usual modes and limitations of traditional design thinking. By synthesizing forms based on inputs about performance, material, or manufacturing characteristics—as opposed to a preconceived idea of how a part should look and behave—generative design can deliver more (and more unusual) design options than any team could come up with on their own.

Instead of creating an automotive component based on the previous version of a similar one, engineers tell the generative design tool how strong the part should be, how much it should weigh, how much force it must withstand, and what material it should consist of. Generative design leverages AI to rapidly create numerous variants, "learning" from each iteration.

The potential benefits of this are significant. Engineers can start with more design options, including novel approaches. Plus, because the part's parameters are established from the get-go, generative design can resolve conflicting design requirements more easily, allowing engineers to choose a direction and follow it more efficiently.

ROBOTICS

Robots are essentially hardware and software systems. The software tells the hardware what to do. The challenge with these machines, however, is programming them to do unique tasks in an efficient way. Robots are common in automotive manufacturing, and if a robot will make the same weld repeatedly for many years, any programming time can be viewed as a good investment. But in an advanced manufacturing environment, robots may need to do more complex or unique jobs. This is why the emphasis on robotics is human-robot collaboration, empowering the two to achieve a common goal that neither could accomplish independently.

One potential application for robotics is industrial polishing, a cornerstone of manufacturing that involves manually creating matte, gloss, shiny, flat or effected surfaces on any part with sandpaper or a laser. To polish surfaces, robots will need to move through many points of motion, adapting to various methods, angles of approach, and forces for each part. This is easy for humans but less so for machines that need numerical values to understand whether a surface is "shiny" or not.

Bringing this application to life will likely involve algorithmic programming driven by machine learning, surface metrology and systems of sensors. Eventually robots could perform up to 80% of all finishing work and complete the remainder under human supervision. The benefits include repeatability that improves quality assurance as well as the ability to handle parts and tools that are too large or heavy for humans to lift.

TOOL & DIE

The typical car has thousands of parts, many of which are made from moulds. With an emphasis on lightweighting and part consolidation through generative design, future vehicles may include even more plastic parts with even more complex moulds. This is why precision mould making will likely be an important part of advanced manufacturing.

New CAM software makes it simpler to create toolpaths that maximise the capabilities of CNC machines, allowing automakers to produce complicated moulds efficiently and achieve desired levels of quality. These applications allow CNC machines to run "lights out" (unattended) 24 hours a day, ensuring moulds and dies are ready for production on time. They typically include modeling and preparation tools for electrodes and mould and die surface runoff, simulate toolpaths to minimise collision risk and generate optimised toolpaths, and incorporate on-machine verification to confirm mould and die quality while avoiding costly errors.

SIMULATION

Simulation gives automakers a critical way to shorten time to market for new products. By enabling engineers to predict, validate and optimise components with accurate analyses, simulation tools promote confident decision-making earlier in the development process, eliminate iterations and reduce the risk of late-breaking errors that can cascade throughout a subsystem—or vehicle platform—and throw off the entire schedule.

Examples of simulation tools include finite element analysis (FEA) software, which can predict part performance using linear, nonlinear, thermal, and dynamic analyses, as well as optimise designs and validate part behaviour prior to manufacturing. Computational fluid dynamics covers thermal management and airflow analysis. Plastic injection moulding software helps optimise part design, mould design, and manufacturing processes to maximise quality and avoid defects. Simulation software can also help engineers design laminates and reduce the weight of composites.

CNC AUTOMATION

Automated CAM software applies many of the same principles to the milling process, enabling automotive manufacturers to load a CAD model and have the CAM software not only determine the best way to mill it but also automatically program the CNC machine. This process is currently only available for certain kinds of parts, but could soon extend to more parts in a future advanced manufacturing environment.

The core capability is called automatic feature recognition and it uses the solid model to understand the part's shape, eliminating the need for users to spend hours defining part geometry, creating boundaries and specifying cutting operations. Typical 2D parts can be programmed in a few minutes instead of an hour or more with this method. After the features are defined, they can be sorted for machining efficiency and machined with a strategy that aligns with the properties of each feature. For example, an open pocket may be machined differently than a closed pocket, or shallow bosses milled differently than tall ones.

ADDITIVE MANUFACTURING

3D printing cars may sound far-fetched, but interesting case studies have already been done. In 2015, Local Motors introduced the Strati roadster, an electric two-seater made in just 44 hours featuring 75% 3D-printed parts. In 2016, Divergent 3D created the Blade, a 700-horsepower “supercar” with a 3D-printed body and chassis. In 2017, Italian startup XEV began making the LSEV, a small electric car the company claims is the world’s first mass-producible 3D-printed vehicle.

Also known as additive manufacturing, 3D printing creates a physical object by layering materials one by one according to a digital model. The term encompasses a wide variety of processes, each with different hardware, material requirements and applications, including vat photopolymerization, binder jetting, material jetting, material extrusion, powder bed fusion, sheet lamination and directed energy deposition.

Additive manufacturing helps automakers address a number of trends. Depending on the vehicle, 3D printing can be used to produce lightweight components, personalised components for mass customisation and on-demand prototypes for generatively designed parts.

HYBRID MANUFACTURING

Metal additive fabrication often requires subtractive CNC finishing. In an advanced manufacturing environment, successful “hybrid” processes will require careful planning during design as well as accommodations during 3D printing. This approach can get quite complex, combining 5-axis additive and 5-axis subtractive machining. Ultimately, however, hybrid manufacturing enables automakers to produce parts that can’t be made through traditional means.

INSPECTION

Part inspection in a smart factory creates opportunities to boost productivity and generate important data that be fed back to inform the design and development processes. New software applications can reduce inspection programming time by importing pre-defined measurement points, creating and using copies of probed features when the geometry or form is replicated, reusing measured data to avoid duplication of effort, and using datums to report features for assemblies.

DIGITAL TWIN

In a data-driven manufacturing environment, data from across the enterprise is used throughout the product life cycle to build faster, cost-effective, high-quality products. One important interface of the real and digital worlds is called a digital twin, which pairs the virtual and physical worlds, allowing automakers to analyse data, monitor systems and detect issues before they occur.

Blending the IoT, 3D simulation tools and predictive analytics, the digital twin creates opportunities to improve vehicle development and manufacturing.

In vehicle concepting, the digital twin can integrate all data from previous generations of the vehicle platform and the current concept, enabling better communication among stakeholders. It can improve repeatability and accuracy of models and simulations to discover potential issues earlier.

In manufacturing, the digital twin sets the stage for flexible-cell manufacturing, connecting data sets for machines, tools and automated guided vehicles (AGVs). Using augmented reality, the digital twin can provide visual guidance for assembling products and operating machinery. With real-time sensor data, the digital twin can predict machine failures and optimise maintenance schedules. It can even monitor the movement of employees and equipment to help prevent workplace injuries.

CASE STUDIES

Real-world examples of automakers pursuing advanced manufacturing

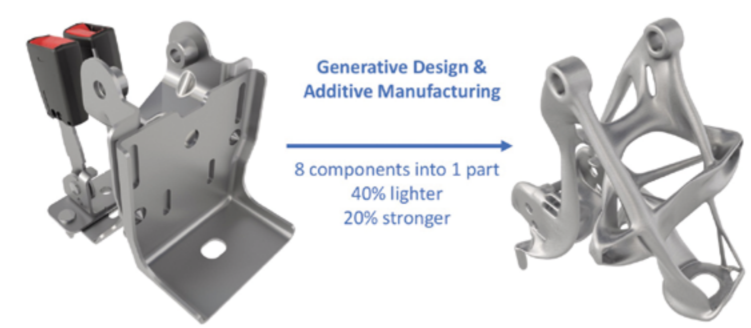
While comprehensive advanced manufacturing remains a long-term goal, many automotive manufacturers are already putting these technologies into practice. Here are just three examples.

GENERAL MOTORS AND GENERATIVE DESIGN

It's not just specialty automotive manufacturers that are starting to take advantage of advanced technologies. Right now, GM is using generative design to promote lightweighting and supply chain simplification to reduce the cost of making electric and autonomous vehicles.

In a recent collaboration with Autodesk, GM engineers designed a new, functionally optimised seat bracket. This standard auto part, which secures seat-belt fasteners to seats and seats to floors, typically features a boxy design made up of eight separate pieces. Using generative design software, GM came up with more than 150 alternatives. The one the team chose is made from a single piece of stainless steel, and is 40% lighter and 20% stronger than its predecessor.

By consolidating eight parts into one, GM can optimise for mass while simultaneously reducing all of the supply chain costs associated with eight separate suppliers providing eight pieces that have to be joined together. Applying this concept across hundreds or thousands of parts can go a long way toward making vehicles less expensive, lighter and more fuel-efficient.



Images courtesy of General Motors

Image Courtesy of BAC Ltd./Monty Rakusen

BAC MONO AND MASS CUSTOMISATION

Lifelong motorsports enthusiasts Ian and Neill Briggs started the Briggs Automotive Company (BAC) in 2009 to build their "dream car," one that would be unconstrained by manufacturing logistics, financial considerations or even conventional design principles. What they came up with is the futuristic Mono, a car that prioritizes performance and handling—and offers a custom fit for individual drivers, so they can feel and respond to the road in unprecedented ways.

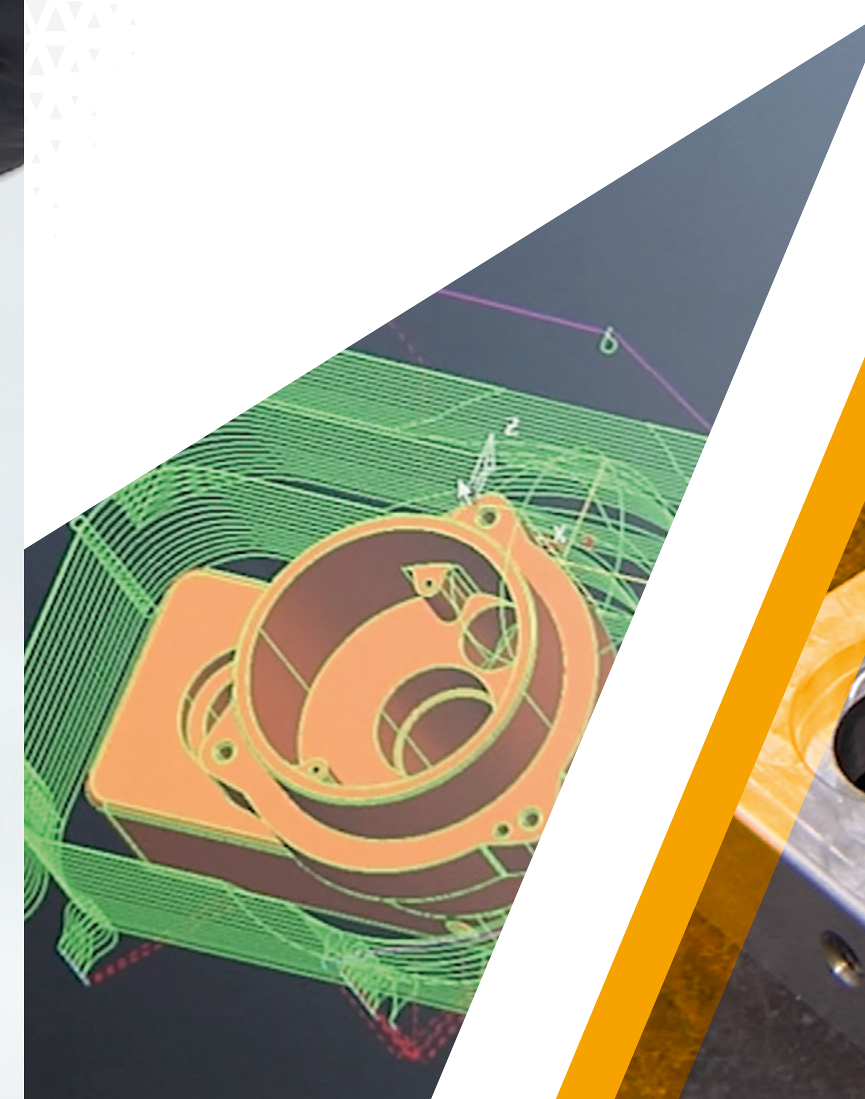
The Mono not only features a raised spine, sleek aesthetic, a longitudinally mounted engine and exposed rear components. It also offers a custom-fitted steering wheel, pedal reach and seat.

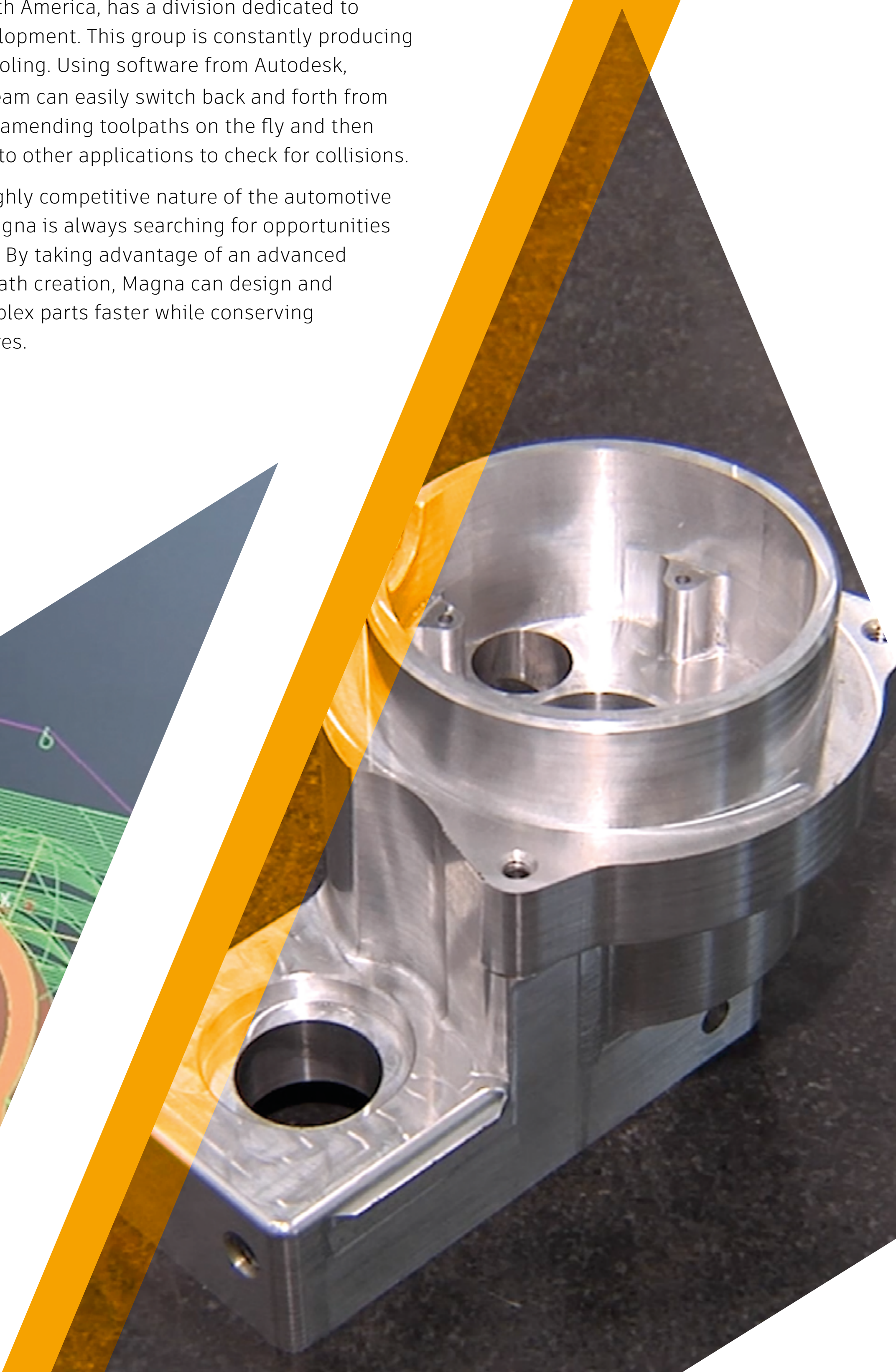
To develop each Mono around the dimensions of the driver, the BAC team starts with a core set of specifications and incorporates the driver's exact measurements into the design. Each driver has the opportunity to select special features and paint colours. And at every step, the driver can experience and approve changes via 3D visualisation and simulation software. This approach indicates how other manufacturers can take advantage of mass customisation, using technology that can configure a variety of features into a truly personalised design.

MAGNA AND TOOL AND DIE

Magna Automotive, one of the largest automotive parts companies in North America, has a division dedicated to new product development. This group is constantly producing prototypes and tooling. Using software from Autodesk, this specialised team can easily switch back and forth from prototype to tool, amending toolpaths on the fly and then exporting the file to other applications to check for collisions.

Because of the highly competitive nature of the automotive parts industry, Magna is always searching for opportunities to conserve costs. By taking advantage of an advanced approach to toolpath creation, Magna can design and manufacture complex parts faster while conserving capital expenditures.





CONCLUSION

Looking ahead and setting priorities

Advanced manufacturing in the automotive industry does not have one set path. Implementations will vary from company to company as each organisation chooses investments that will provide the greatest competitive advantage. The list of technologies involved is longer than this ebook has room to explore, and new opportunities arise regularly.

One decision that will be important no matter what path companies choose, however, is selecting the right technology partner. Because connectivity is so fundamental to advanced manufacturing, it will be critical to select providers that can deliver a complete portfolio of software applications that are specifically designed to work together and that touch on multiple aspects of design and production.

GET STARTED

Call us or complete the contact form to speak with us about our full portfolio of automotive manufacturing solutions.

Call **+44 (0)203 893 2211**

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