

# Fon Mag

READ AM | Application stories, interviews, news  
and insights about Additive Manufacturing

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Bucking the trend through specialised  
machines and proprietary technology

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Strong research expertise powering  
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# We are standing in the foothills of the singularity.

Demis Hassabis is a British computer scientist, neuroscientist and AI researcher, and the co-founder and CEO of Google DeepMind

The statement refers to the development of Artificial General Intelligence and whether it can perform cognitive tasks at or above human level.

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Cover: BMW Group

**D**ear Readers, whenever I talk to companies from around the world these days, I keep encountering the same question: How can we future-proof our production? Although there is no easy answer to this, one thing is clear: The demands on our industry have changed fundamentally.

Resilient supply chains, technological autonomy, sustainable production and the intelligent use of new technologies have long since ceased to be issues for the future. They dictate how we act today.

And this is precisely why Additive Manufacturing has become a key technology in recent years. It allows us to develop products faster, manufacture components right where they are needed and make production processes much more flexible. What was seen as an exciting new development just a few years ago is rapidly becoming an integral part of modern industrial value creation.

We see this trend every year at Formnext. Our trade show is much more than just a platform for new machinery or materials. It's a place where ideas are born, partnerships flourish and innovations make the leap into real-world industrial applications. And that's exactly what makes Formnext so special.

With this year's Formnext Defence Summit, we are deliberately shifting our focus to a new area. The changes in security policy over recent years have shown that resilience today is also a matter of technological capability. Additive Manufacturing can play an important part in this – by supporting decentralised production, digital spare parts warehouses or the rapid manufacture of complex components right where they are needed.

And this doesn't only apply to the defence sector. These same technologies can also boost the competitiveness of companies in the aerospace, mechanical engineering, medical technology, energy and automotive sectors. If you want to make supply chains more resilient, use resources more efficiently and respond more quickly to change, you can benefit from the same innovative approaches.

Formnext has always reflected the latest developments in our industry. It brings people together who don't just talk about the future but actively shape it. This aspiration is also what drives us as organisers. We aim to provide guidance, foster dialogue and address issues that have a lasting impact on our industry.

I am firmly convinced that we can only overcome the challenges of our time by working together with openness, a spirit of innovation and the courage to break new ground. That is exactly what Formnext stands for.

I hope you enjoy reading these articles filled with exciting new perspectives and look forward to seeing you in person at Formnext 2026 in Frankfurt.

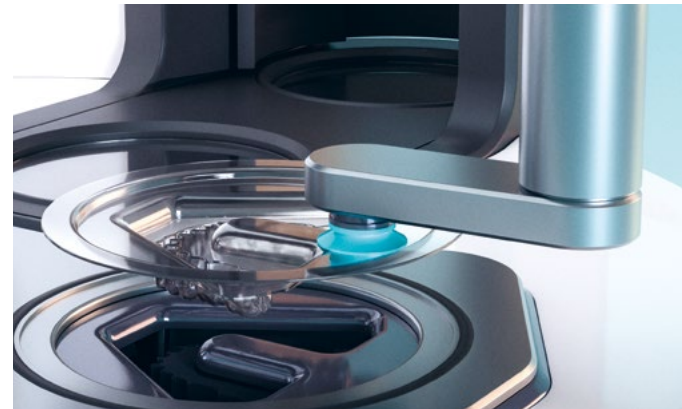
Sincerely, **Sascha F. Wenzler**  
Vice President Formnext



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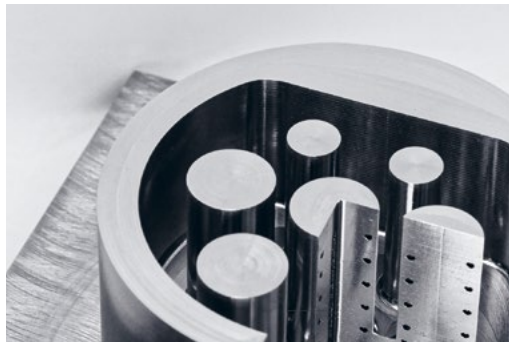


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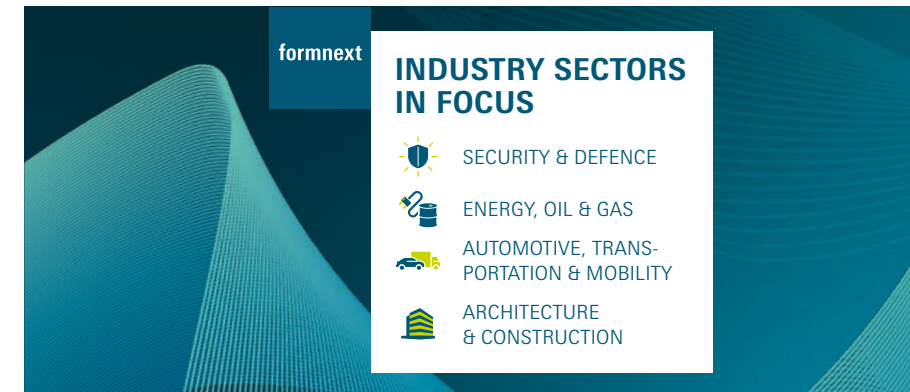
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A new spirit of innovation

## FORMNEXT CONTINUES TO INCREASE ITS INVOLVEMENT IN KEY END-USER INDUSTRIES



Formnext's AM4U newsletter at [formnext.com/getindustryinsights](https://formnext.com/getindustryinsights). This will provide you with regular updates on the year-round programme as well as important news and highlights relating to Formnext 2026.

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Across numerous industries, Additive Manufacturing has evolved from a promising technology into an integral part of industrial value creation. A growing number of companies in medical technology, aerospace, energy and automotive manufacturing are using Additive Manufacturing to bring innovations to market faster, make supply chains more resilient and tap into new business opportunities. Meanwhile, dynamic growth markets such as the defence sector are generating numerous new application areas that are driving the technology's growth.

With this in mind, Formnext 2026 is stepping up its focus on concrete applications, successful implementations and verifiable business cases across the entire value chain. The goal is to make the added value of Additive Manufacturing even more tangible and to offer users practical guidance for their own investment and production decisions.

To this end, Formnext is systematically expanding its lineup for various user industries. Real-world use cases, innovative business models and successful industrial products will be presented and discussed, both within the framework of the year-round programme and at the trade show itself. This year, the defence, energy, oil and gas, automotive, transportation and mobility, and construction and architecture sectors will receive special attention.

Formnext's offerings range from industry-specific technology talks to

white papers that shed light on current developments and best practices. Formnext Magazine regularly features articles on successful application examples and the key trends in end-user industries. During the trade show, specific use cases and their economic potential will be presented on the stages. In addition, the established special exhibitions on architecture and construction as well as mechanical and plant engineering offer in-depth insights into innovative AM solutions drawn from real-world practice.

The topic of defence will feature prominently on the agenda in 2026. At a summit organised specifically for this purpose, Formnext will examine the growing range of applications for Additive Manufacturing in the defence sector and provide a platform at the trade show for sharing ideas on current applications, requirements and future prospects.

Formnext will also feature a greater emphasis on an area that is becoming increasingly critical to the industrial success of additively manufactured components: post-processing. For the first time, there will be a dedicated special exhibition devoted to this topic, where visitors can learn all about the latest technologies, processes and solutions for post-processing additively manufactured components. Guided tours will also be available, offering a brief overview of the main innovations and suppliers.

To stay informed about the latest developments, you can subscribe to



**Cover**  
3D-printed sand cores at BMW's Landshut foundry for optimising engine performance. »Manufactured as a single piece and optimised for improved flow characteristics, they enhance cylinder-head cooling, which our customers experience through cleaner, high-performance engines. Producing many hundreds of thousands of parts each year is a remarkable achievement,« says Stefanus Bosch, Head of AM Predevelopment at the BMW Group. BMW uses additive manufacturing in three areas: series production, production aids and prototype development.

Find out more in the free Formnext white paper »3D Printing for Automotive, Transport and Mobility«.

HOLOGRAPHIC 3D PRINTING IN A SINGLE EXPOSURE

Researchers at the University of Utah have developed a novel holographic manufacturing process that creates microscopic 3D structures in a single exposure rather than building them layer by layer. Instead of relying on a conventional laser scan, the system uses a nanostructured mask to shape the laser light into a holographic pattern, selectively curing the material. This enables parts to be produced in around 20 seconds, offering a significant speed advantage over conventional laser-based manufacturing processes.

The research was led by Rajesh Menon, a professor in the Department of Electrical & Computer Engineering at the Price College of Engineering. Among other achievements, the team successfully fabricated tubular microstructures with diameters as small as six micrometres. Initial testing demonstrated high mechanical robustness as well as the ability to transport liquids through capillary action.

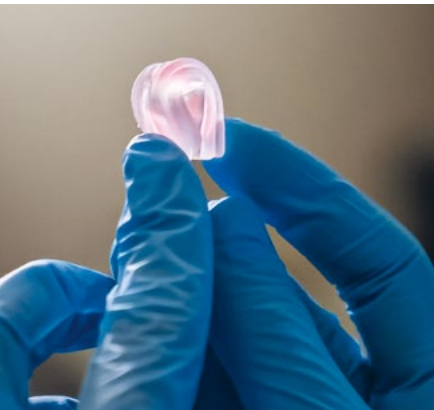


According to the researchers, potential applications include microfluidics, medical technology, and optical and micromechanical components.

At present, the process is primarily suited to the production of microstructured components. In the long term, however, the researchers aim to extend the technology to more complex three-dimensional geometries and enable continuous manufacturing processes.

EXCEPTIONALLY TOUGH AND DURABLE

In 2024, the Soft Materials Laboratory (SMaL) at the EPFL School of Engineering introduced double network granular elastomers (DNGEs) – rubber-like materials made of microscopic elastomer particles connected by a softer elastomer network. Originally, DNGEs were developed as 3D Printing »inks« for components with precisely tailored mechanical properties.



In a follow-up study, the research team has now demonstrated an unexpected additional advantage of this material architecture: superior resistance to both fracture and material fatigue. While the initial goal was to improve the processability of the material, the team has now discovered that these materials are also exceptionally tough. According to Esther Amstad, Head of the Soft Materials Lab-



oratory, this toughness comes from repeated energy dissipation mechanisms: the material can absorb energy over and over without suffering permanent damage.

The two networks – one consisting of granular elastomer particles and the other of a soft elastomer – share the mechanical load, according to Amstad. This makes the material more robust overall. In experiments, optimised DNGEs achieved fracture toughness values up to 15 times higher than conventional elastomers and fatigue resistance values up to 3 times higher.

The research team is exploring potential applications in areas such as soft robotics systems, flexible electronics and biomedical devices, where components are subjected to repeated mechanical stresses over long periods. DNGE materials could help extend the service life of these systems.

Images: Dan Hixson, 2026 SMaL EPFL, CC BY-SA

HIP INVESTMENT TO OPEN NEW MARKETS AND APPLICATIONS

Hiperbaric will supply TTT Group with the first Hot Isostatic Pressing (HIP) system fully developed and marketed in Spain. The industrial Hiperbaric HIP 107 system will be used in post-processing to enhance the mechanical properties of metallic components destined for applications in the aerospace, defence and energy industries.

The system operates at pressures of up to 2,000 bar (200 MPa) and temperatures of up to 1,400 °C, with the option to reach 2,000 °C. Thanks to the integrated



Fast Cooling technology, heat treatment and material densification can be combined into a single step, which, according to Hiperbaric, can help reduce energy consumption and processing times.

For TTT Group, the investment represents an important expansion of its service portfolio. The company has been providing heat treatments, surface treatments and coatings for the European automotive and aerospace industries for more than 65 years. With the new system, TTT Group will also target additional markets such as oil and gas.

»This acquisition represents the largest investment in our 65-year history,« explains Xabier Berasategi, CEO of the northern Spanish TTT Group. »The integration of Hiperbaric’s HIP technology aligns with a clear strategy of diversification and high added value, with a particular focus on the aerospace sector. It also opens the door to other markets and future technologies such as Additive Manufacturing and Near Net Shape processes (PM-HIP).«

During the HIP process, components are exposed to high pressure and elevated temperature simultaneously to eliminate



porosity and internal defects, increase fatigue resistance and improve mechanical properties. According to Hiperbaric, the company is the only manufacturer of HIP systems in Spain and operates Southern Europe’s first HIP Innovation Center, where new materials and applications are developed and tested.

SIMULATING ENTIRE BUILD VOLUMES

A study supported by the Air Force Research Laboratory (AFRL) has evaluated PanOptimization’s PanX thermomechanical simulation software for creating digital twins of entire build volumes in metal Additive Manu-



Images: Hiperbaric, PanOptimization

facturing. According to the study, the software can accurately predict thermal histories and mechanical distortions throughout the build process.

As Additive Manufacturing continues to move in the direction of industrial-scale production, the demand for advanced simulation tools is growing, according to Pennsylvania-based PanOptimization. In highly regulated industries such as aerospace, defence and energy, digital twins could help assess builds before production, predict part distortion and reduce the effort required for qualification and certification.

According to PanOptimization, PanX can simulate entire build volumes while accounting for the thermal and mechanical interactions between multiple parts on the build plate. At the same time,

however, the study notes that the predictive accuracy could be improved even further. The evaluation did not include actual machine process timing or layer-by-layer energy input, both of which influence the simulation results. The authors suggest that incorporating these process parameters would further enhance the accuracy of predictions.

According to PanOptimization, physics-based simulation models are becoming a key enabling technology for industrial-scale Additive Manufacturing. By identifying potential issues before a build begins, they can potentially reduce the need for costly trial builds and improve the reliability of production processes.

# TWO PROCESSES, ONE MACHINE

Additive Manufacturing (AM) is often benchmarked against its subtractive cousins on speed, finish, materials and cost. But the two can also come together to make a system worth more than the sum of its parts.

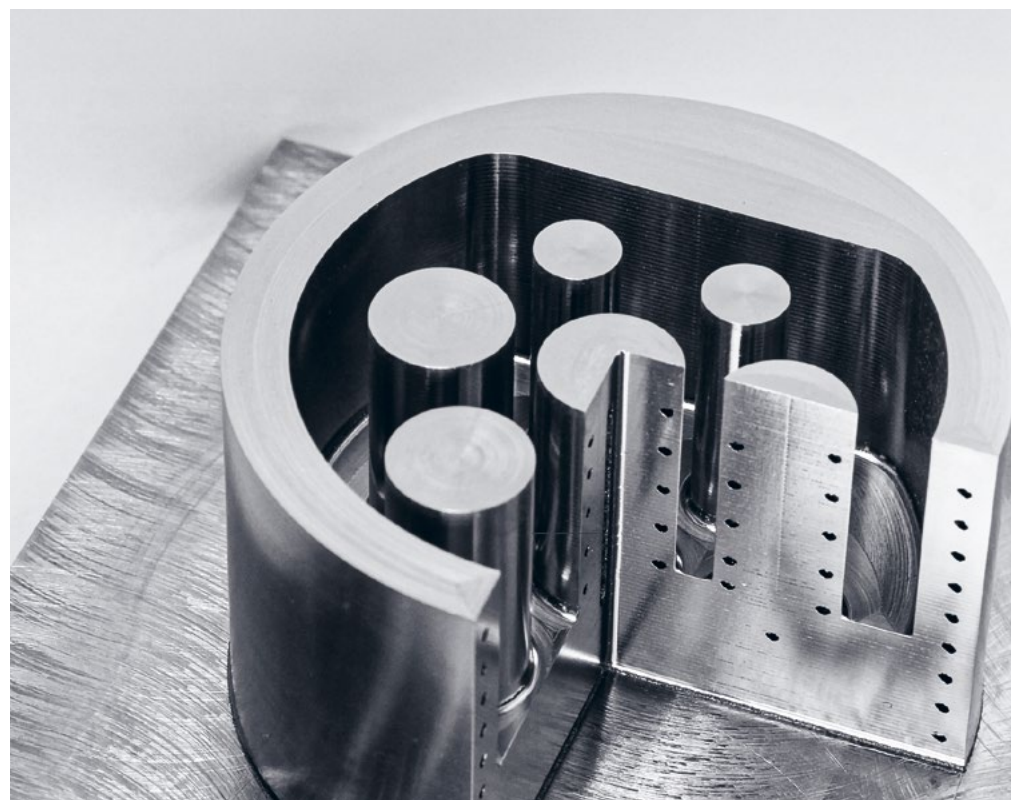
**A**M gives designers geometric freedom, but parts rarely arrive ready to use off the machine. As-built surfaces are rough, and tolerances often fall short of true precision work, especially on larger parts. Machining delivers that finish and precision but can't reach the internal channels or organic forms AM is prized for. Hybrid AM/CNC machines put both processes inside one setup, so a component can be built, machined and finished in one place, including internal features only accessible mid-build, without ever being unclamped.

This single-setup logic is what makes hybrid interesting for production, and even more so for repair. Several distinct families of hybrid system have now reached the market.

## THE LARGE-FORMAT WORKHORSES

Many industrial hybrids marry directed energy deposition (DED) to a multi-axis machine tool. DMG Mori's Lasertec DED Hybrid line is the reference point. The second-generation Lasertec 65 DED Hybrid, launched at the start of 2026, combines laser deposition, 5-axis milling, turning, grinding, preheating and 3D scanning into a single platform with integrated melt-pool and process monitoring. Mazak, Okuma and WFL offer comparable turn-mill machines with deposition heads.

DED is the natural additive partner here because it deposits quickly and at scale but loses the dimensional accuracy of powder bed systems in doing so. The machine tool then supplies the tolerances



and finish on the critical geometries. The pay-off is greatest in repair and feature addition. Worn turbine blades, injection tooling and large castings can be scanned, rebuilt and finish-machined in one pass, extending the life of high-value components that would otherwise be scrapped. For aerospace and energy maintenance, where originals are forged or cast and replacements punishingly expensive, that is a compelling economic case.

This mould tool for an EV charging connector demonstrates the surface finish required for injection moulding and the 2mm channels used for conformal cooling.

## FINE FEATURES AND TOOLING

A second family builds on powder bed fusion (PBF), for example Matsuura's Lumex Avance which brings together laser powder bed fusion with a 45,000 rpm milling spindle. Internal walls and features are milled as the part builds layer by layer, reaching surfaces a finished part could never expose to a cutter. Sodick's OPM series works on the same principle.

The standout application is injection-mould tooling with conformal cooling channels that follow the cavity rather than being drilled in straight lines. Better cooling shortens moulding cycles, by up to 50% on Matsuura's own figures, while improving part quality and trimming EDM steps. Beyond tooling, the fine-feature accuracy suits small, complex aerospace and medical components. For mould and die shops, this remains hybrid's clearest commercial case today.

## LOWERING THE BARRIER

Not every shop needs a six-figure turnkey machine, and the fastest-growing corner of the market reflects that. Hybrid Manufacturing Technologies' Ambit heads slot a deposition, inspection or other process tool into the spindle of an existing CNC, converting a machine a shop already owns into a hybrid cell. Meltio, founded in Linares, Spain in 2019, takes a related route. Its wire laser deposition engine integrates with lathes, machining centres and robot arms, and feeds standard welding wire, which is cleaner to handle and cheaper to stock than powder. Phillips packages that engine onto Haas machines as an off-the-shelf hybrid, with early adopters running multi-machine fleets for aerospace, energy and general subcontract work.

This retrofit approach lowers the barrier to entry, taking hybrid out of the aerospace primes and into the job shops that make up the bulk of the industry.

## GOING LARGE IN POLYMER

Not every hybrid works in metal. The most mature polymer route is Large-Format Additive Manufacturing (LFAM), where a pellet extruder lays down thermoplastic or fibre-filled composite at high throughput and a CNC head machines it to final tolerance on the same platform. The part is printed slightly oversized, then trimmed to net shape. A printed-and-trimmed composite mould can reach the shop floor in days rather than weeks, which is why the approach dominates big tooling, moulds, patterns and fixtures for aerospace, automotive and marine work.

Thermwood, a long-established CNC router maker, pairs a polymer print head with a 5-axis trim head on its LSAM machines, with build lengths reaching 100 feet. Ingersoll's MasterPrint runs an extruder rated up to 500 lb per hour, which swaps automatically for a 5-axis milling head, and has printed a functional »



The Lumex Avance-25 pairs powder bed fusion with in-process high-speed milling. Matsuura pioneered the hybrid metal approach in 2002.

Text: James Woodcock

Images: D. Sommer et al., Materials 2021, 14, 5753, CC BY 4.0., Matsuura, Belotti Spa

boat hull. Europe is well represented. The Netherlands' CEAD builds the robotic Flexbot and the Flexcube, shown at Formnext 2024 with integrated milling. Italy's Belotti drops a CEAD extruder into its 5-axis BEAD machining centre, printing from 12 to 80 kg per hour and finishing to within hundredths of a millimetre. The retrofit idea carries over too, with Hybrid Manufacturing Technologies' pellet-fed Ambit Xtrude head bringing large-format polymer work to an existing CNC.

#### A DIFFERENT KIND OF HYBRID

One process sidesteps melting altogether. Fabrisonic's Ultrasonic Additive Manufacturing (UAM) welds thin metal foils together with high-frequency vibration at low temperature, and its Sonic-Layer machines interleave that deposition with CNC milling to cut features between layers. With no melt pool, UAM

joins dissimilar metals such as aluminum to titanium without brittle intermetallics, and can embed sensors, electronics or cooling channels inside otherwise solid metal. Fabrisonic has even worked with NASA on shrinking the process for use in space. It occupies a niche, but it does things melt-based hybrids cannot.

#### WHERE THE RESEARCH IS HEADING

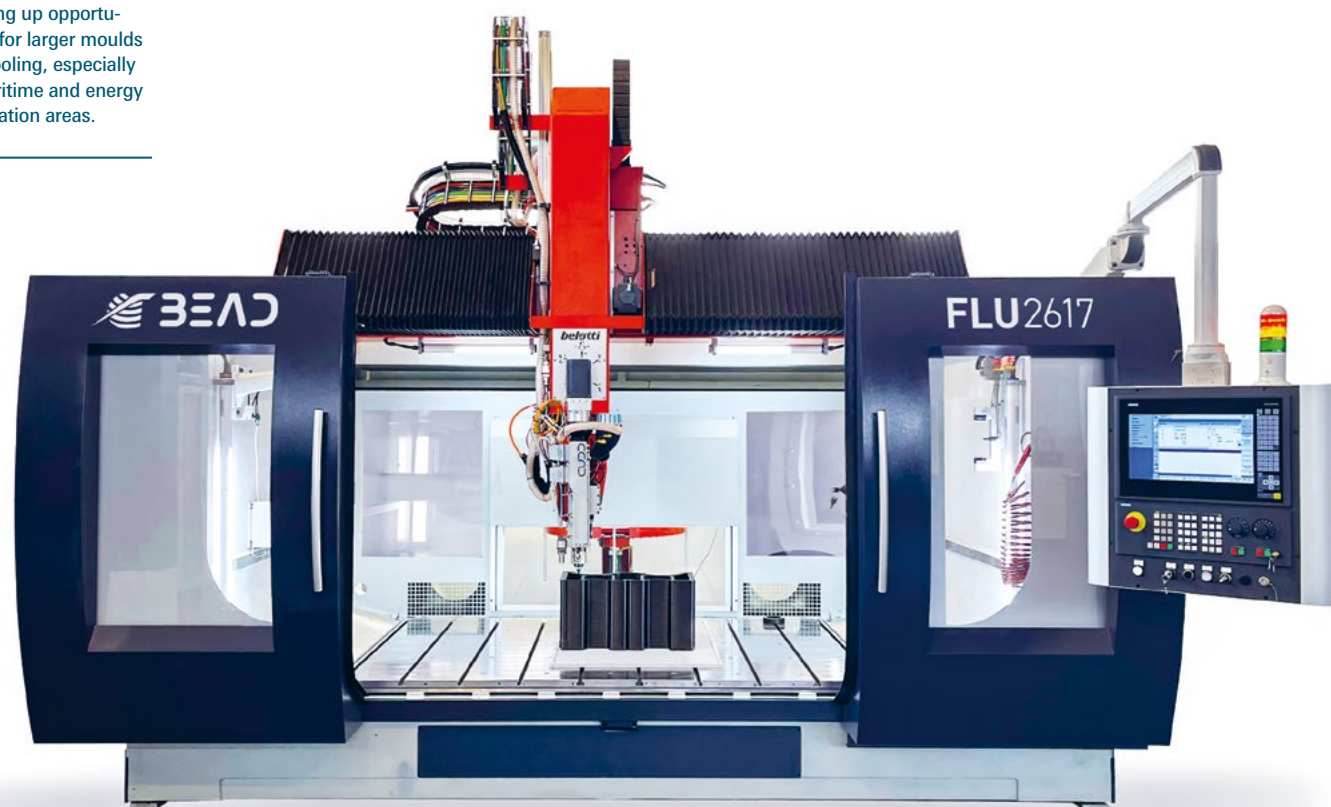
The frontier is control and moving towards closed-loop hybrids that monitor every deposited layer and correct on the fly, pushing toward zero-defect, autonomous builds. DMG Mori's process monitoring and easyAM controls already gesture at this. Academic work on cold-spray additive-subtractive cells, using in-situ laser profiling and adaptive toolpaths to repair defects without manual programming, extends the same idea into fully automated repair. The harder problem is

fusing several sensor streams so a machine can decide for itself, mid-build, whether a flaw needs correcting, re-depositing or machining away.

Beyond process control, expect richer multi-material parts, machine learning-driven process planning and tighter digital thread traceability. At Formnext 2025 in Frankfurt, DMG Mori argued that hybrid is evolving from a niche technology into the new standard for flexible, efficient production. Based on current industry developments, that appears to be a fair assessment, with additive and subtractive manufacturing increasingly converging into a single workflow.

**+ FURTHER INFORMATION:**  
» [formnext.com/fonmag](https://formnext.com/fonmag)

Hybrid AM for polymers and composites is opening up opportunities for larger moulds and tooling, especially in maritime and energy application areas.



Text: Thomas Masuch

Images: Liqtra

## FINDING THE RIGHT NICHE

Hamburg-based company Liqtra uses its own extrusion technologies in its specialised machines for additive series production



The automotive industry may be going through a tough time, particularly in Europe, but the sector remains an attractive market for Liqtra's additive solutions for series production: »Things are going very well for us right now,« reports co-founder and technical manager Joscha Krieglsteiner. »Bucking the general trend, we've grown steadily in recent years thanks to projects in the automotive industry and still have numerous new projects in the pipeline,« he says happily. Today, the company – founded in 2019 – employs 14 people, most of whom work in technical roles.

The automotive sector is Liqtra's most important market. Here, high-volume production with a high material through-

put is found to an extent rarely seen elsewhere. »The projects for Additive Manufacturing – especially in series production – are there; often, the only thing missing is the technical expertise to implement them,« says Krieglsteiner. Customers are typically Tier 1 suppliers with the freedom to decide whether to implement innovations.

#### TECHNOLOGY PROVIDER AND ENGINEERING FIRM

The company's successful growth is also down to the founders' determination to remain flexible. »We started with a technical idea for high-productivity material extrusion and turned it into machines,« Krieglsteiner recalls. »However, even »

A pellet 3D Printing system was developed to 3D-print a metre-high structural component for the Tier 1 supplier AFT Automotive.

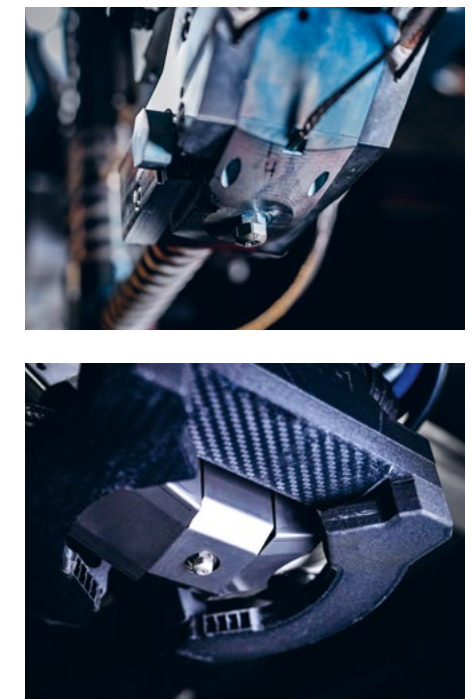
four years ago, it was already becoming clear that off-the-shelf 3D printers in the filament sector were a difficult business,« primarily due to price competition with Chinese suppliers. »That's why you have to look for niches that are harder for companies from China to reach.« For Liqtra, this niche involves being both a technology provider and a creative engineering firm for Additive Manufacturing: »We are a partner for the development of technically sophisticated custom solutions.« Given its flexible growth trajectory, the young company also benefited from having founders who have always been self-directed and free from external influences, such as the requirements of venture capital investors. This has allowed them to hold on to the freedom they need to develop their business model in line with market conditions. »Given the economic circumstances, that was also the right approach,« says

Krieglsteiner. After all, the days when versatility was a key selling point for 3D printers are over. »With the increasing maturity of mass production applications, the topic of customisation has come to the fore in recent years. Mass production does not require great versatility but benefits from the performance gains and cost advantages achieved through the application-specific optimisation of a machine.«

### SHIFTING THE ECONOMICALLY VIABLE PRODUCTION VOLUME

When developing special purpose machines, Liqtra always starts with a specific application. »We need a use case – ideally involving large parts and high production volumes,« explains Krieglsteiner. New machines are then built for each suitable application, with core technologies and components from the fields of extrusion and software being reused across

*Photo left: Standard systems from the FX Series for filament processing (FFF) and the PX Series for pellet processing (FGF). The VPX-1 print head, equipped with patented valve-nozzle technology, is optimised for FGF and offers the same design freedom as FFF. Bottom right: standard cooled print head. Top right: customised solution with two print heads integrated into a single end effector.*



## Industrial 3D Printing for the Core Manufacturing of the Future

The demands on industrial core manufacturing are constantly increasing: Foundries worldwide expect higher productivity, maximum process reliability, and cost-effective mass production. Centered around the **L3D-200** 3D printer, Laempe Mössner Sinto GmbH has developed a new binder jetting platform specifically designed for the industrial production of sand cores and sand molds.

The modular system combines high printing speed with an open material platform and scalable automation. Users



can flexibly adapt the printer to their production requirements and expand it as demand grows. At the same time, the open material compatibility allows for the use of existing sand and binder systems. Developed based on experience gained from large-scale industrial projects, the **L3D-200** meets the requirements for availability, robustness, and cost-effectiveness in everyday foundry operations.

### Award-Winning Technology for Industrial Series Production

The system's performance was recognized in 2025 with the prestigious (R)Evolution Award at Formnext. The award honored a highly automated binder jetting solution for the series production of sand cores, which is already being successfully used by the BMW Group. With a throughput of more than 1,100 sand cores per day, the system ranks among the most productive industrial 3D printing systems worldwide. It covers the entire process chain—from material preparation and the printing process to automated desanding, cleaning, and visual quality control.

With the official unveiling of the **L3D-200** during Open Week 2026 in June, Laempe underscores its commitment to consistently advancing additive core manufacturing toward industrial mass production.

Visit Laempe at Formnext 2026: Hall 12.0 | Booth B.17

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Laempe Mössner Sinto GmbH  
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the board. However, features from the field of traditional mechanical engineering – such as the build volume, the number of print heads, the installation of additional axes, and process automation – are customised. The custom machines (or production modules) are then integrated into existing production lines.

In addition to its customised options, Liqtra also offers standard machines: the FX Series (filament printing) and the PX Series (pellet printing). »For mass production applications, these typically serve as a foundation for optimising components and processes in collaboration with the customer and deriving specifications for the custom-built system for mass production,« says Krieglsteiner. Pre-series production and qualification begin on these machines. »In this case, our standard machines serve as enablers. However, making the leap to a custom machine for series production only makes sense for very high production volumes.« Custom machine design for series production then involves, for example, scaling kinematic axes or integrating multiple printing systems into a single machine. »This allows us to increase productivity and reduce component costs with relatively

little effort. With this approach, we're pushing the upper limit of production volumes at which 3D Printing makes economic sense even higher.« Even though some projects require more than a year of development work, Krieglsteiner says the effort often pays off even if it results in just a 10 percent reduction in component costs.

### MASS PRODUCTION FOR THE AUTOMOTIVE INDUSTRY

At Liqtra, pellet printing is generally used for high-volume production of large-format components, where plastic pellets have clear cost advantages over traditional FDM filament. This made it possible for Liqtra to carry out a project that made headlines in the automotive industry: a pellet 3D Printing system was developed to 3D-print a metre-high structural component for the Tier 1 supplier AFT Automotive. A number of benefits have already been achieved: for example, cost savings due to the reduced assembly effort required for the additive monolithic construction and the lightweight construction achieved by eliminating fasteners.

Krieglsteiner explains that the project required a specialised system and could

not be implemented with an off-the-shelf 3D printer due to the technical peculiarities of pellet printing: »As a rule, pellet printers cannot cleanly interrupt the print process, for example, to move over open spaces. This usually results in stringing.« This shortcoming is often circumvented by printing in spiral patterns so that the printer does not have to stop. Liqtra has solved this problem with a special patented nozzle that, according to Krieglsteiner, can cleanly stop and resume printing. As a result, Liqtra's granulate-based processes are not limited to spiral vases or continuous extrusion but offer a degree of freedom that was previously only possible in filament-based processes. Ultimately, this means material savings of up to 30 percent for customers' applications.

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# FROM NETWORKING TO INDUSTRIAL APPLICATION

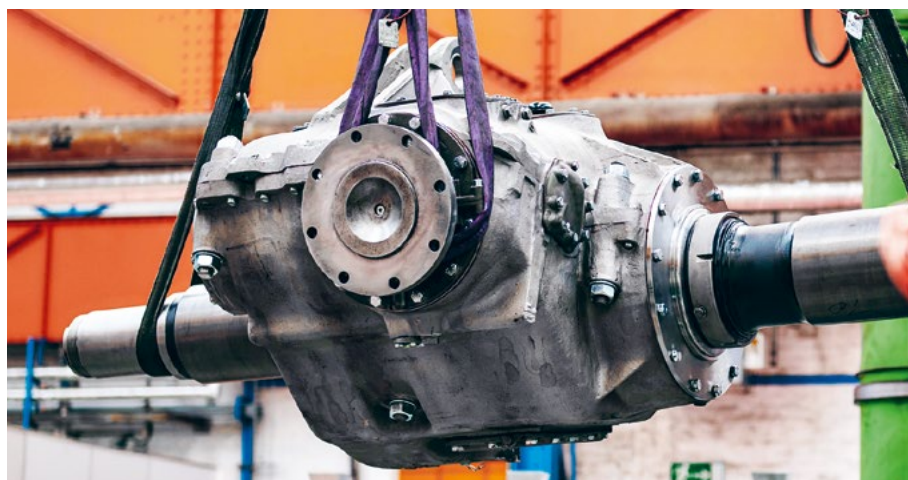


Photo above:  
Using 3D-printed sand  
moulds to manufacture  
engine components  
reduced lead times by  
eight months.

Photo below:  
Stefanie Brickwede,  
Managing Director of  
MGA, heads Additive  
Manufacturing at  
Deutsche Bahn.

When the Mobility goes Additive (MGA) Network was founded ten years ago, one question stood out above all others: How can 3D Printing make the transition from individual pilot projects to everyday industrial practice?

Ten years later, the network provides concrete answers – ranging from new standards and approval procedures to more than 200,000 additively manufactured components in the rail sector. For Managing Director Stefanie Brickwede, the focus has shifted from technological feasibility to promoting industrial applications.

When MGA launched in 2016 with nine founding members, the initial focus was on connecting companies in the railway sector. Stefanie Brickwede, who was already head of Additive Manufacturing at Deutsche Bahn at the time, was looking for solutions to obsolescence and the long-term supply of replacement parts, since – due to the long service life of trains – many replacement parts were either no longer available or very costly to procure. »We quickly recognised the potential that AM offers here – but only if manufacturers, suppliers, service providers, research institutions and certification bodies collaborate with end users.«



The network now has around 140 members and has expanded its activities far beyond the mobility sector. In addition to rail, dedicated working groups now focus on areas such as aerospace, construction, lifestyle and medical technology and defence. This is accompanied by international collaborations, political advocacy, and events and technology programmes that foster exchange among users, manufacturers and research institutions.

For Brickwede, however, growth is not an end in itself. What is far more important is that the network's members can learn from different perspectives as well as the common ground they share. The development of standards plays an important role in this. »As the industry matures, these standards become increasingly important,« she says.

One example is DIN 52920, which emerged from collaboration within the network and defines criteria for the qualification of additively manufactured components. Especially in regulated industries such as rail transport, standards are an essential prerequisite for approving components and putting the technology to use in industry. MGA therefore not only supports the work of various DIN and ISO committees but also intends to contribute financially to DIN's activities in the future.

Text: Thomas Masuch

Images: MGA, Deutsche Bahn AG/Susanne Tost/Dominic Dupont/Uwe Miethe

In addition, the network organised a »round-robin« test, in which, for example, the quality of additively manufactured aluminium components from various service providers and users was compared. The goal of these tests is to demonstrate the reproducibility of manufacturing processes and thereby further strengthen confidence in industrial AM processes.

Just how far the transition from pilot applications to industrial use has come is particularly evident at Deutsche Bahn, the initiator and sponsor of MGA. There, more than 200,000 components have already been additively manufactured and over 1,000 different applications have been implemented. Both replacement parts and production and operational equipment are being printed – ranging from drilling templates to flame-retardant plastic components for passenger compartments. Twelve different AM processes are used, with metal components primarily manufactured in collaboration with specialist service providers.

Brickwede sees particular potential in the digital supply of replacement parts. Deutsche Bahn alone keeps replacement parts worth around 1.8 billion euros in stock. According to MGA's estimates, about 10 percent of these components could be produced as needed using Additive Manufacturing. Many of these parts are rarely needed, are no longer available from the original manufacturer, or have previously had to be procured in minimum quantities that are economically unfeasible. Digital spare parts warehouses and on-demand manufacturing

could reduce storage costs while simultaneously increasing availability.

This trend is also reflected in new procurement strategies. For example, procurement contracts with Deutsche Bahn and Dutch State Railways now include requirements stipulating that it must be possible to produce a portion of the components using Additive Manufacturing. The goal is not to print as many parts as possible, but to utilise Additive Manufacturing where the technology offers economic or logistical advantages.

»There is also significant untapped potential in applying this to related industries, such as local public transit, since the framework conditions are very similar to those in rail transport,« explains Stefanie Brickwede. The associated MGA working group is set to meet during Formnext to provide public transit companies – many of which have only recently become involved in the AM sector – with comprehensive insights and opportunities for adaptation.

While MGA initially focused primarily on public transit and rail transport, its focus is now expanding to include other industries. For example, the network regularly hosts the European Healthcare Forum for Additive Manufacturing (EHFAM) and established a defence working group three years ago. Together with other initiatives, such as the Resilience Technology Campus in Berlin, the goal is to further expand networking between defence companies and the AM industry. Brickwede notes that geopolitical developments have indeed increased the pressure to innovate. Nevertheless, this

must not lead to a neglect of established certification and quality requirements. »We can't throw everything overboard – we still have regulations that must be followed.«

Ten years on, Brickwede therefore sees the network as being at a different stage than when it first began. While the focus was initially on identifying where Additive Manufacturing could be used at all, the emphasis today is increasingly on reliably scaling the technology. In her view, standards, certification and collaboration across the entire value chain will be crucial to ensuring that successful individual projects become an integral part of industrial production and supply chains.

**Additional Formnext specials focusing on AM in automotive, transportation and mobility:**

- » Formnext Technology Talk, 23 September, 3:00 p.m. CEST, with Stefanie Brickwede and other industry leaders
- » Free whitepaper featuring application examples from Deutsche Bahn, Daimler Truck & Buses, Siemens Mobility, Sakuu, and BMW Group

at [formnext.com/mobility](https://formnext.com/mobility)

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- » [formnext.com/fonmag](https://formnext.com/fonmag)
- » [mga-net.com](https://mga-net.com)

The yaw damper mounting bracket is a substantial metal component in the bogie assembly of an ICE train. Traditionally produced as a casting, this safety-critical part is essential for operation. By 3D printing the 27 kg stainless steel replacement component, the downtime of a damaged ICE 2 train was reduced from ten months to four.



# A REMARKABLE INDUSTRY WITH IMMENSE POTENTIAL

The defence sector is arguably one of the primary drivers of the global Additive Manufacturing (AM) industry today. Yet this unique sector is difficult to compare with other end-user industries. It remains a relatively insular community shaped by a complex web of national and international interests. The applications and requirements involved could hardly be more diverse, ranging from spare parts for tanks and shipboard equipment to highly sophisticated components for aircraft and missiles, as well as the production of drones in combat zones.

In this special feature, we summarise current developments in the defence sector and examine applications for land, air and naval forces, alongside the opportunities and challenges facing Additive Manufacturing as a whole. In the following section, we offer deeper, exclusive insights by highlighting two key European players: Rheinmetall UK, which is using AM to advance its tank technology, and the Spanish company Novaindef, which supplies spare parts to the Spanish military and is expanding its production capacity to meet future defence requirements.

## FROM SECURITY OF SUPPLY TO A «GATED COMMUNITY»

As the CEO of a major AM company told us confidently, «The defence industry is something of a «gated community». Gaining access can take a long time and requires considerable persistence, but once the door opens, collaboration tends to be far more rewarding than in many other sectors.»

This positive working relationship is reflected in what many describe as «realistic expectations», stemming partly from the fact that technological advancement in certain areas of the military has not yet reached the same level as in other industries. There is also a marked financial difference compared with sectors such as the automotive industry. In the defence sector, «there is no haggling over the tiniest contractual details». It is not only

price and technical component specifications that matter; the military sector imposes a host of additional requirements on suppliers, including security clearances, export controls, long-term supply security, safety protocols and ownership structures.

There are specific reasons why the industry remains relatively insular, particularly in Europe, despite becoming somewhat more open in terms of public perception. Russia's war in Ukraine is unfolding on Europe's doorstep, involving vast quantities of equipment and weaponry manufactured by European companies and their suppliers, often in collaboration with Ukrainian firms. The reality of the threat environment has been underscored by numerous acts of sabotage across Europe, ranging from the discovery of an explosive-laden drone at Leipzig Airport to alleged plots targeting Rheinmetall CEO Armin Papperger. Sabotage carried out by activist groups in the UK has also prompted some Additive Manufacturing companies to stop publicly highlighting their defence-related activities, choosing instead to discuss them only within closed networks.

This insular nature creates unique challenges for sales and marketing within AM companies, leading to an increasing number of former military personnel taking on leadership roles. A case in point is Australian WAAM system manufacturer AML3D. The board of its US subsidiary receives guidance from retired US Navy

Rear Admiral David Goggins and Larissa Smith, the former Director of Additive Manufacturing for the US Navy.

## MARKET, BUSINESS AND OUTLOOK: «NOT JUST PRINTING MORE PARTS»

Defence budgets have grown significantly in recent years, driven in particular by the wars in Ukraine and the Middle East. The US National Defense Authorization Act (NDAA) for 2026 authorises defence spending of more than \$900 billion. While it is difficult to estimate exactly how much of this funding is allocated to Additive Manufacturing, the share continues to rise.

According to data from 360iResearch, the AM market in the defence sector is valued at \$2.16 billion. Forecasts suggest it will reach \$2.48 billion in the near term and grow to \$5.99 billion by 2032, representing a compound annual growth rate of approximately 15.7%. A rapidly expanding segment of this market is drone manufacturing. According to AM Research, this segment is expected to grow from \$140 million in 2025 to \$900 million in 2034.

Overall, Hamid Zarringhalam, CEO and General Manager of Nikon Advanced Manufacturing, anticipates that AM will become increasingly important, particularly for propulsion systems, aerospace structures, maritime components, sustainment and repair. «However, widespread adoption will be heavily reliant upon the industry's creation of a resilient manufacturing ecosystem built around qualified pro-

cesses, shared datasets, workforce development and secure regional production. The future of defence manufacturing is not simply printing more parts; it is building repeatable and reliable industrial capability that can be deployed efficiently, where and when it is needed.»

Notable examples of the growing adoption of AM in the defence sector include Beehive Industries and Velo3D, the latter having secured a significant proportion of its orders from the aerospace and defence markets. Velo3D opened Forge 1, a campus with space for more than 40 large-scale metal AM systems. Beehive Industries has been manufacturing engines for the US Air Force since 2020. Six years later, the company employs 400 people across four sites with a combined footprint of 30,000 m<sup>2</sup>, roughly equivalent to four football pitches.

In June 2026, Beehive invested \$50 million in 30 additional EOS M4 Onyx printers, marking the largest single order ever publicly announced by EOS. This expanded its installed base to 50 systems, which are expected to produce more than 8,000 engines annually. What sets Beehive apart is that its turbines are designed for Additive Manufacturing from the outset. Rather than consisting of over 600 components, they comprise around 50.

Companies offering specialised AM solutions for the defence sector are also attracting investor interest. The four-year-old US company Firestorm Labs has raised more than \$150 million through various financing rounds since 2023. Firestorm Labs' xCell is a mobile microfactory housed in one or two 20-foot ISO contain-

ers and designed specifically for decentralised production of drones and military spare parts. The system incorporates HP Multi Jet Fusion printers, assembly and post-processing capabilities, as well as testing and quality assurance systems.

## NAVAL

AM is also playing an increasingly important role in the naval sector. Ships are increasingly being equipped with AM systems that enable defective components to be replaced at sea without requiring a return to port. A significant milestone was reached during the international RIMPAC exercise in July 2026, when the 257-metre USS Essex and the aircraft carrier USS Theodore Roosevelt, among others, were equipped with various AM systems and, in some cases, CNC equipment for post-processing. According to Firestorm Labs, more than 1,000 AM parts were produced using an xCell unit aboard the Essex, while Squall FPV drones were also printed and assembled. In addition, a certified, 3D-printed metal component was installed for the first time on an operational Virginia-class submarine.

At the same time, entire boats are also being produced using 3D Printing, increasingly for military applications. Florida-based Haddy recently manufactured its TF-179 drone boat using a large-format 3D Printing system from CEAD utilising robotic arms.

To further advance AM in the naval sector, Phillips Corporation, Federal Division (Phillips Federal), headquartered in Hanover, Maryland, has equipped the

US Navy's training centre in Danville, Virginia, with twelve hybrid metal AM machines. The investment also includes twelve Markforged X7 systems for composite materials, providing sailors with hands-on experience in hybrid metal manufacturing, composite AM and production-ready workflows. The Phillips hybrid machines are based on Haas TM-1P machining centres incorporating DED technology from Meltio.

## AEROSPACE

A particularly advanced application was recently announced by Pratt & Whitney and GKN Aerospace. The two companies are developing a 3D-printed casing for the F135 engine used in the F-35 Lightning II. Certification is targeted for 2028. GKN Aerospace will manufacture the full-scale demonstrator in Norway using Laser Directed Energy Deposition, with the first demonstrator expected in 2027.

AM also plays an important role among suppliers, not only in manufacturing but also in product development. Stratasys, for example, reports that 3E Elektro Optik Sistemler San. ve Tic. A.Ş., a Turkish specialist in electro-optical components, uses durable materials such as Somos WeatherX to test its latest models under operational conditions.

## DRONES

AM now plays a crucial role in the drone sector. The airframes of smaller quadcopters, as well as mounts and structural components, are frequently 3D-printed. Demand is enormous. Ukraine plans to produce 19,000 drones per day in »

Text: Thomas Masuch

Images: GKN Aerospace, Dan Linehan, Elmet

Pratt & Whitney and GKN Aerospace are developing a 3D-printed casing for the F135 engine used in the F-35 Lightning II. GKN Aerospace will manufacture the full-scale demonstrator in Norway using Laser Directed Energy Deposition



Photo left:  
An xCell mobile  
microfactory deployed  
during an exercise at  
McMillan Airfield.

Photo right:  
Elmet Technologies  
plans to 3D print large  
heat exchangers for  
future hypersonic  
missile programmes.



2026, including reconnaissance, combat and FPV drones, making a significant contribution to the country's defence capabilities. Some of these are manufactured in print farms, often at undisclosed locations, while others are produced using desktop printers and are frequently redesigned and improved within very short development cycles.

Taga, a manufacturing company specialising in industrial design, demonstrates how this process can work in practice. The company developed a safety feature for UAVs designed to improve rotor durability. To determine the optimum level of flexibility, it was able to combine rigid and flexible materials on a Stratasys J35 Pro PolyJet system. Taga's customer was then able to use the resulting prototypes to test and select the appropriate design.

The high demand for drones presents opportunities not only for printer and material manufacturers, but also for companies specialising in post-processing. DyeMansion, for example, highlights the value of post-processing technologies such as vapour smoothing for UAV applications. Benefits include increased strength and durability, improved environmental resistance and aerodynamics, and a more professional finish.

## MISSILES

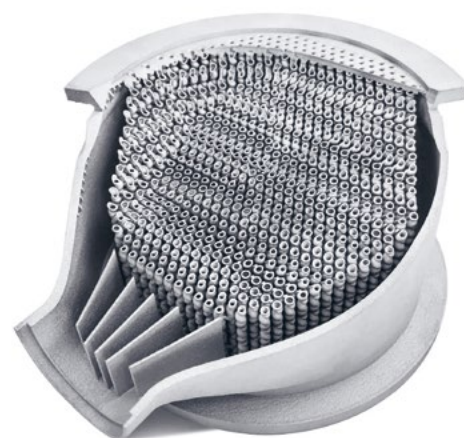
Missiles are currently among the most sought-after military products, particularly Patriot interceptor missiles, which have been used by Ukraine and others to defend against ballistic missile attacks. Stockpiles have been significantly depleted, while

manufacturers are working to increase production capacity, a challenging task given the complexity and precision required.

The successful use of AM for numerous missile components and propulsion systems has already been demonstrated for many years in the civilian sector. Consequently, military missile manufacturers are increasingly turning to Additive Manufacturing to accelerate development and production.

European defence company MBDA, which is jointly owned by Airbus, BAE Systems and Leonardo, has also been using Additive Manufacturing for more than a decade. In October 2025, MBDA announced that it had printed a structural component for a next-generation missile, significantly improving thermal management. According to the company, the use of a double-skin structure reduced temperature increases by up to 70%. MBDA produced more than 50 prototypes and subjected them to extensive testing to validate fatigue resistance, thermomechanical stability and firing performance. Among the company's latest developments is the SPEAR mini cruise missile, scheduled for delivery from 2027.

Elmet Technologies plans to use its 3D Systems DMP Flex 350 Triple metal 3D Printing system (PBF-LB) to manufacture large heat exchangers for hypersonic missiles in the future. The company intends to qualify and certify the system using the niobium-based high-performance alloy C103 before commencing series production. Hypersonic



missiles travel at speeds exceeding five times the speed of sound (around 6,000 km/h), generating extreme loads and temperatures due to aerodynamic friction alone.

AM is also opening up new possibilities in propulsion technology. Firehawk Aerospace has additively manufactured solid propellant for Javelin- and Sting-er-class rocket motors and successfully tested it in flight. The key advantage lies in shorter production times and the ability to tailor thrust characteristics through the geometry of the propellant itself.

## LAND FORCES

Numerous projects are underway, particularly in the field of larger military platforms such as tanks and armoured personnel carriers, to explore how AM can best be used to supply spare parts. Given the relatively low production volumes of these systems and their long service lives, Additive Manufacturing offers significant advantages over conventional manufacturing methods.

The exclusive articles on Rheinmetall UK and the Spanish company Novaindef over the following pages examine this topic in greater detail.

**+ FURTHER INFORMATION:**  
» [formnext.com/fonmag](https://formnext.com/fonmag)

Text: Thomas Masuch

# EASING OBSOLESCENCE-DRIVEN SHORTAGES FOR DEFENCE SYSTEMS

Spanish startup Novaindef offers a compelling illustration of the use of Additive Manufacturing in the defence sector. Founded in 2024 and headquartered in Linares, southern Spain, the company employs both traditional tools and methods and a wide range of AM. In close collaboration with defence OEMs, it not only supplies obsolete and unavailable spare parts to the Spanish Armed Forces and other military organisations but also develops production capabilities to address future military challenges. To support this effort, several advanced manufacturing centres have already been established across Spain.

Part of the Spanish Sicnova Group, Novaindef was founded to consolidate and further develop a collaboration spanning more than a decade with the Spanish Ministry of Defence in the field of AM under a single organisation. To support this mission, the company has built substantial industrial capacity at its headquarters in Linares. Its facilities include more than 30 AM systems for metals (PBF and DED), polymers and composites, sourced from various manufacturers. These are complemented by several CNC machining centres, advanced inspection technologies such as X-ray inspection and computed tomography, and post-processing equipment for heat treatment and surface finishing.

Despite Novaindef's extensive AM capabilities, Fernando Lasagni, CTO of the company, views 3D Printing not as an isolated technology but as part of a wider Advanced Manufacturing ecosystem: »Our goal is not to use a specific technology, but to identify the most suitable manufacturing solution for each challenge.«

The partnership with the Spanish Ministry of Defence also aims to establish a network of advanced manufacturing centres for the armed forces. These include three CESFARE centres (for manufactur-

ing and repair) serving the Air and Space Forces in Albacete, the Army in Córdoba and the Navy in Rota. The network is further supported by CEDAEC, a 3D technology centre for military and defence-sector certification located at Novaindef's headquarters in Linares.

»In addition to their extensive manufacturing capabilities, these centres also offer a complete ecosystem for development, qualification, design, testing and certification. This includes training, technology transfer, digital warehouses and the ability to validate materials, processes and components,« explains Lasagni.

## ADDRESSING SHORTAGES OF OBSOLETE SPARE PARTS FOR DECADES-OLD SYSTEMS

Novaindef's development is closely linked to the history of the Sicnova Group. Founded in 2007, Sicnova initially operated as a distributor of 3D printers. Today, the Group offers engineering solutions, manufacturing services and industrial AM technologies.

Lasagni sees the supply of replacement parts as one of the most critical areas of the Additive Manufacturing business, since military platforms often remain in service for decades, while suppliers, production lines or sometimes



Fernando Lasagni, Novaindef CTO: »3D printing should not be viewed as an isolated technology«

Images: Novaindef

even manufacturers disappear. As part of the collaboration with the Spanish Ministry of Defence, obsolete components are therefore identified, digitised, redesigned if necessary, and then manufactured.

In general, Lasagni recommends following a gradual approach: starting with non-structural components, progressing to structural parts of increasing criticality and, finally, addressing highly demanding applications where dynamic performance must also be validated.

For security reasons, Novaindef does not disclose specific applications. However, Lasagni explains: »We often replace components that were originally cast and whose quality level is lower than that achieved with other production methods. Here, we also use AM to improve the structure and quality. That's a triple win.«

In addition to the traditional advantages of on-demand production with a digital warehouse, the collaboration with the Spanish Ministry of Defence also calls for the development of modern production capacities. »In times of war, you need the ability to produce quickly and at scale,« explains Lasagni.

#### MOBILE MANUFACTURING FOR DEPLOYED OPERATIONS

Another focus is mobile manufacturing solutions. Together with the Spanish Ministry of Defence and under the leadership of the Spanish Air and Space Forces, Novaindef developed the FAMU (Forward Advanced Manufacturing Unit) system, which was deployed during the Pacific Skies 2024 mission in Alaska. This is a container-based solution which houses

various technological systems for producing spare parts at the point of use: a DED-AM system, a 5-axis machining centre, heat treatment capabilities, and testing and quality assurance equipment.

Despite the growing importance of advanced manufacturing, Lasagni warns against oversimplifying its implementation. In the defence sector in particular, rigorous inspection, certification and process control are essential. »Additive Manufacturing must always be backed by robust inspection, testing and certification processes that reflect the criticality of the component.«

#### A SUCCESSFUL COMBINATION

Lasagni attributes the development of this advanced manufacturing ecosystem, in which Spain plays a pioneering international role, to a combination of strategic vision, technical expertise within the Ministry of Defence and a supportive national regulatory environment. »The Engineering Corps of the Spanish Armed Forces has been working with advanced manufacturing technologies for many years, which has been instrumental in driving this strategy,« he says. At the same time, Lasagni emphasises the importance of efficient regulation. »In some countries, bureaucracy and excessive regulation can be major barriers to innovation.«

#### + FURTHER INFORMATION:

» [formnext.com/fonmag](https://formnext.com/fonmag)

» [novaindef.com](https://novaindef.com)

In collaboration with the Spanish Ministry of Defence, Novaindef is establishing a network of advanced manufacturing centres for the Spanish military. The network is supported by CEDAEC, a 3D technology centre for military and defence-sector certification, located at Novaindef's headquarters in Linares.



## OVERCOMING BARRIERS

The mission of the Additive Manufacturing Defence Network (AMDefNet) is to overcome barriers and foster collaboration to accelerate the strategic adoption of Additive Manufacturing (AM) across Europe's security and defence sector. Established in Frankfurt am Main in February 2026, the European network currently comprises 50 members and sees itself as the face and voice of Additive Manufacturing for the defence and security community. The association aims to strengthen collaboration and knowledge exchange among industry, research organisations, military stakeholders, institutions and policymakers, contributing to the development of a long-term European AM strategy.

As AMDefNet co-founder and chair Martin Huber explains, »The objective of an AM strategy must be to support and promote all areas that are relevant to Europe's industrial autonomy and independence«. A key element of this mission, he argues, is challenging entrenched perceptions and removing barriers to adoption, both within the public sector and the manufacturing industry itself, where companies often »prefer to rely on conventional, time-tested manufacturing methods«. AMDefNet is therefore driven by both technological and strategic priorities. Rather than being simply another manufacturing process, Additive Manufacturing should be viewed as a cornerstone for decentralised, demand-driven production, resilient supply chains and Europe's technological sovereignty.

For more insights, visit the [Formnext Defence Summit on 17 November 2026](https://formnext.com/defencesummit), being hosted in partnership with the AMDefNet.

#### + FURTHER INFORMATION:

» [amdefnet.eu](https://amdefnet.eu)

» [formnext.com/defencesummit](https://formnext.com/defencesummit)

Text: Thomas Masuch

# HUGE OPPORTUNITIES – BUT NO HYPE

At Rheinmetall UK, Additive Manufacturing has been on the agenda for many years. Today, 3D-printed components are increasingly being incorporated into the company's military vehicle programmes. Alongside an increasing number of metal components, the ducting for the crew temperature control system used in the new Challenger 3 main battle tank is additively manufactured, helping to streamline the product development process.



3D-printed components are also used in the latest Challenger 3 battle tanks.

According to Julian Wright, Technology Programmes Manager at Rheinmetall BAE Systems Land (RBSL), a division of Rheinmetall UK, the potential of AM extends far beyond individual components. He recalls a 2014 study suggesting that, in theory, around 30–40% of the parts in a main battle tank could be additively manufactured. »And the technology has advanced enormously since then,« he says.

For Wright, however, this is no reason to get carried away by the hype. While AM offers significant advantages for a defence company such as Rheinmetall UK, he is equally aware of the challenges that continue to slow the wider adoption of the technology.

Nevertheless, AM has become an important part of Rheinmetall's strategy, supporting the development and produc-

tion of modern military vehicles as well as the long-term supply of spare parts.

#### OPPORTUNITIES FOR AM

Rheinmetall UK's key defence programmes are centred on the modernisation of the British Army. These include the Challenger 3 programme, under which 148 Challenger 2 main battle tanks are being upgraded to the Challenger 3 standard. Valued at more than €900 million, the programme covers the development, manufacture and final assembly of the vehicles at Rheinmetall UK's facility in Telford.

In parallel, Rheinmetall UK is manufacturing several hundred Boxer 8x8 armoured vehicles together with KNDS UK. The company is also responsible for through-life support and spare parts provision and is expected to play a key role

in the UK Ministry of Defence's future Land Integrated Operating Service (LIOS) programme.

Compared with many other industries, the relatively low production volumes of military vehicles are often an advantage for AM. »In many applications, AM can make strong commercial sense. It can eliminate the need for expensive tooling and minimum order quantities while facilitating on-demand production; reducing inventory requirements and warehousing costs while improving cash flow,« Wright explains. AM can also accelerate product development and sometimes enable part consolidation by replacing complex multi-component assemblies with a single component. »But it's not always the case, it depends on the application and the AM production process selected. For example, with the polymer ducting for Challenger 3, »

Images: RBSL



Prototype Land Rover brake peddle printed in 4 sections with Metal Paste Deposition in 17-4PH Stainless Steel and TIG welded together to optimise production cost and time.

we've split the parts into multiple sections, increasing overall part count. By minimising the amount of support structure that must be printed, we can enhance productivity and reduce costs.»

Wright also sees significant opportunities for Additive Manufacturing with polymers. Replacing metal components with polymer parts can significantly reduce vehicle weight while lowering manufacturing costs. »For example, as part of the work Rheinmetall UK is doing for Project Tampa, we are demonstrating how we could replace steel parts with polymer alternatives, reducing mass by 80–90% without losing functionality,« Wright reports. »However, this also requires a change in mindset,« he says. »Many components in military vehicles have traditionally been manufactured from steel or aluminium, partly because low production volumes rarely justify the cost of injection moulding tooling. At the same time, there remains a widespread percep-

tion that polymers are not sufficiently robust for demanding military applications.«

Another major application for AM in military vehicles is the production of spare parts and the faster availability of components. Since armoured vehicles typically remain in service for several decades, replacement parts must be available throughout their operational life. »The challenge is that these legacy components are not designed and certified for AM,« Wright explains. »Creating certified digital assets is one of the key challenges ahead.«

The long service life of armoured land vehicles raises another question regarding the use of polymer components produced using AM. In tanks, durability is a key factor. As Wright advises, »With many AM materials, there is often no data available on how they will perform after several years under military operating conditions.«

#### SOURCING COMPONENTS

Rheinmetall UK has established its own in-house Additive Manufacturing capability, while also sourcing components from external service providers when internal capacity is fully utilised or when specialised AM processes are required that are not available in-house. Where commercially viable, however, Wright and his team prefer to manufacture parts themselves. »There are many advantages to doing so,« he explains. »It makes us more agile and allows us to build our own expertise.« As the company's AM experience continues to grow, it is increasingly being considered for end-use parts.

At the same time, Wright cautions against overestimating the capabilities of the technology or oversimplifying the realities of 3D Printing. »You have to look at the entire manufacturing process. Printing is only one part of the overall production chain. Oversimplifying the process does little to advance the industry.«

Due to a favourable return on investment, Wright and his team have now established high temperature polymer and metal AM production facilities in-house. The team are the first in the UK to adopt Metal Paste Deposition technology from Rapidia Inc, and Wright is more than

convinced of this approach. »It is highly cost-competitive and can, in some cases, offer a more economical route to production than conventional manufacturing methods. It's safe to integrate into the site since there's no loose powder in the process, and it requires relatively little post-processing; for example, supports can be removed by hand.« The equipment's compact footprint and mobility also lend themselves to production of spares at the point of need. »We're anticipating that systems could be positioned closer to the front line than currently imagined for other metal AM systems. It also overcomes the challenge that military users have by not needing skilled personnel to deploy with the equipment enabling the capability to be distributed more widely across the battlespace.«

#### LOOKING AHEAD

While the current Challenger 3 programme already incorporates additively manufactured components, Wright expects future vehicle upgrades and next-generation vehicles to contain significantly more AM-produced components.

In his view, AM will play an important role in lightweighting vehicles while at the same time helping to reduce development costs and timescales. Furthermore, deployed AM will change the way we repair vehicles, enabling parts to be produced on demand, enhancing fleet availability.

Nevertheless, heavy armoured vehicles weighing over 40 tonnes will not disappear from the battlefield, according to Wright. »This will not change despite lessons learned from the effective use of drones in Ukraine. While tanks remain vital for holding ground and assaulting defended positions, they must be integrated into a broader force package and equipped with robust counter-drone systems, just like any other land asset.«

**+ FURTHER INFORMATION:**  
» [formnext.com/fonmag](https://formnext.com/fonmag)  
» [rbsl.com](https://rbsl.com)

The University of Nottingham is one of Europe's leading universities for Additive Manufacturing and industrial 3D printing technology.

## TURNING RESEARCH INTO GROWTH

As the partner country for Formnext 2026, the United Kingdom brings a strong lineup of innovative exhibitors plus valuable industry expertise for the supporting programme. The UK has many of the ingredients required to become a leading Additive Manufacturing nation. Its universities, research centres and manufacturers have built a strong base of academic and technical knowledge and generated a significant share of the global intellectual property associated with the technology. The challenge for the UK is converting that work into products, production capacity and profitable businesses.



The global AM market was valued at approximately \$21.9 billion in 2024 (Wohlers Report 2025), with the UK market estimated to be worth between \$650 million and \$940 million, representing 3% to 4.3% of global activity for that same period. This is below the UK's estimated 6.9% share in 2015 and suggests that other countries have adopted and expanded their capabilities at a much faster rate.

UK organisations in general have faced a difficult trading environment over the last few years. High inflation, interest rates and energy prices coupled with poor access to skills and uncertainty over our supply chain and trading relationship with the EU following Brexit have created a lot of uncertainty, which in turn has affected demand in capital investment, with AM machinery suppliers reporting particularly challenging conditions. There were signs of a recovery at the start of 2026, but rebuilding the UK's position will require sustained effort and investment and a clearer route from research to industrial adoption.

However, despite the tough operating and economic environment, research and development is one of the UK's current strengths, with over £650 million of public funding being spent over the last decade to establish a strong base. The UK ranks fourth globally for AM-related intellectual property generation and has main-

tained a share of around 4% of worldwide patent family applications in recent years. However, the pipeline underpinning future innovation has weakened considerably in recent times. UK public research and development funding for Additive Manufacturing for the period from September 2024 to August 2025 was only £17 million, compared to £81 million for the period from September 2023 to August 2024. This huge reduction will have a significant impact on the level of intellectual property generated in the UK in the area of Additive Manufacturing.

This reduction comes as other countries, including the United States and China, are supporting the industrial deployment of the technology as part of wider manufacturing strategies. Currently, 17% of UK organisations use Additive Manufacturing technology as part of their processes. For many smaller companies, the initial cost, uncertainty over returns and lack of in-house knowledge make it difficult to move beyond a first trial. Businesses also struggle to qualify components, find relevant technical support or obtain funding for the later stages of development and deployment.

These barriers matter because Additive Manufacturing is relevant to sectors in which the UK already has industrial strengths. Aerospace, defence, automotive, healthcare, energy and specialist engineering can all benefit from compo-

nents that are lighter, more specialised or produced in lower volumes. The defence sector has generated more positive demand, while the ability to manufacture parts domestically could help companies reduce exposure to fragile international supply chains.

The next stage should therefore focus on industrialisation: moving technology from research projects and prototypes into qualified, repeatable production. AMUK has identified five areas of work covering commercialisation and intellectual property, adoption and scale-up, supply-chain resilience, exports and skills. Its proposals include better support for development at technology readiness levels six to eight, straightforward adoption grants for early trials, clearer access to Catapult capabilities and stronger help for companies seeking to protect and commercialise their ideas.

There is a substantial prize at stake here. If the UK can recover a global market share of around 7%, its Additive Manufacturing sector could be worth nearly \$6 billion by 2030. Reaching that point will depend less on proving the technology and more on helping manufacturers use it at scale.

**Additive Manufacturing UK (AMUK)**  
at Formnext 2026: Hall 12.0, Booth F139

Joshua Dugdale,  
Head of Technology  
& Skills at the  
Manufacturing  
Technologies Association, the British  
trade association  
for manufacturing  
companies.



Image page 23: iStock/Ruben Minjauw, Image: AMUK

## THREE DECADES OF EXPERIENCE DEVELOPING SOFTWARE ENGINES



MachineWorks' libraries are used in a range of leading additive and subtractive software.

MachineWorks Ltd is a British software company founded in 1994 and based in Sheffield. The company was acquired by Heidenhain GmbH in 2014 but continues to operate as an independent subsidiary.

Since its foundation, MachineWorks has focused on providing component technology – software libraries designed to be embedded as »engines« into applications developed by other companies. MachineWorks is a CNC simulation engine used in a wide range of leading CAM systems, while Polygonica is an engine for mesh operations.

The libraries are used in a range of leading additive and subtractive software.

MachineWorks is used as the CNC simulation engine inside Dassault Systèmes CATIA, Autodesk Fusion, OpenMind hyperMILL and leading CAM solutions from Hexagon, including NCSimul. Polygonica is embedded in Oqton's 3DXpert, 3D Systems 3DSprint, Stratasys GrabCAD Print, Hexagon AM Studio, Ansys Discovery SpaceClaim and Hexagon's Geomagic Suite. Other clients include industrial manufacturers such as Vulcan Forms, manufacturing service providers such as Xometry, and topology optimisation specialists such as Novineer.

The company has recently added GPU acceleration to the MachineWorks libraries, cutting the time needed to compute

results for long simulations from tens of minutes to tens of seconds. As well as planning to integrate GPU operations into Polygonica, the company is working on a new reverse engineering solution for automatically converting meshes created by topology optimisation into editable parametric CAD BREP. The initial version is expected in time for Formnext 2026.

**MachineWorks at Formnext 2026:**  
Hall 11.0, Booth C02

Images: MachineWorks

## WHEN THOUSANDS OF PINS FORM ALIGNERS

Dental appliance manufacturing relies on 3D Printing more than almost any other industry. Standard practice for retainers and aligners starts with a digital scan of the mouth. A resin model is then printed, washed and cured, ready to pressure form the appliance. It's estimated this industry produces 1.1 million resin models per day\*, most of which end up in landfill.

UK startup Fyous's novel approach uses thousands of reconfigurable pins instead of resin to produce the same thermoformed appliances without producing any model waste. The system is called Ghost and will make its live debut at Formnext 2026.

Fyous's proprietary technology, PolyMorphic Moulding, digitally controls the position of thousands of pins to form temporary shapes in minutes. Ghost makes one fundamental change to the existing workflow for dental appliances by skipping the printing, processing and discarding of the model. According to Fyous, the rest remains largely unchanged.

The process starts with an STL or OBJ file, which is processed by Fyous's Pin-Point control software. This converts the file into F-code, which then configures the pins into a negative version of the patient's arch that acts as a temporary model for the pressure forming step that follows. A standard PETG, EVA or PU thermoform blank is then heated and pressure formed over the pins before the appliance is stored for collection. The pins then reset and the process automatically starts on the next file in the batch.

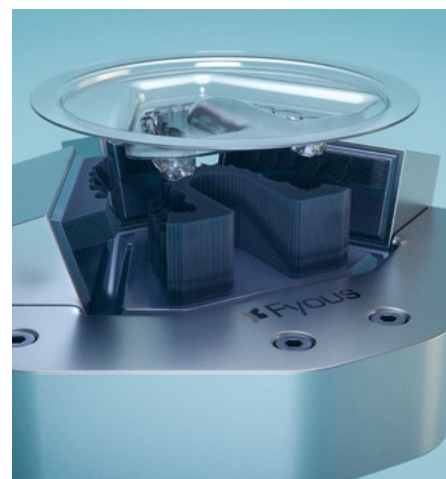
The multi-axis pin array consists of 20,000 individual pins, each 300 microns in diameter, with positions accurate to within 100 microns. This produces appliances that are dimensionally equivalent to or better than those formed over a 3D-printed model. As there is no physical model, quality control is verified digitally against the source file. The full cycle time is approximately 5 minutes including pin configuration and forming. A single machine will produce up to 180 appliances per batch, with an annual

capacity of around 60,000 appliances, taking changeover times and servicing into account.

Fyous has raised over £3.5 million in investment so far and is backed by former Envisiontec CEO Al Siblani and Stratasys co-founder Scott Crump. The company reports that it has secured £1 million in pre-orders for Ghost. Josh Shires, CEO & Co-Founder: »We've spent 6 years in R&D with PolyMorphic Moulding. Ghost is the culmination of that work.«

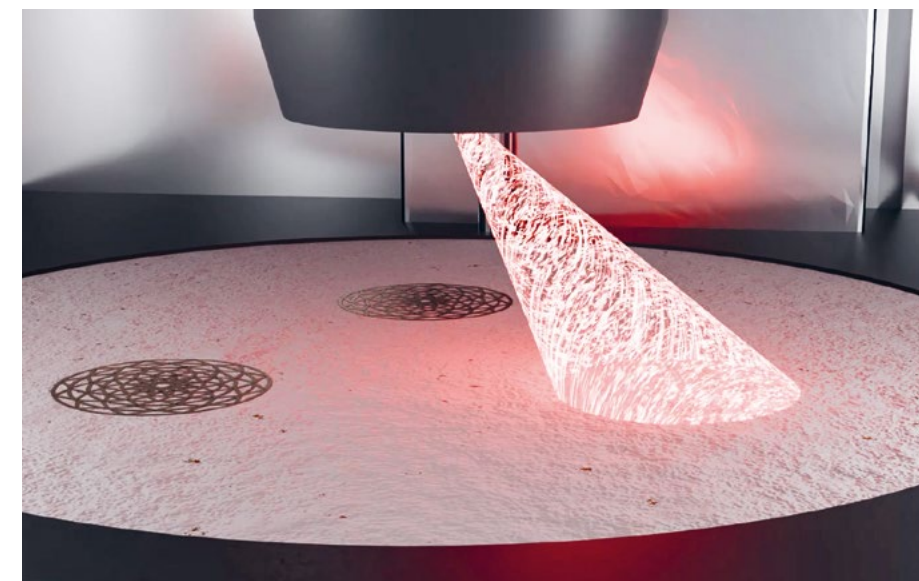
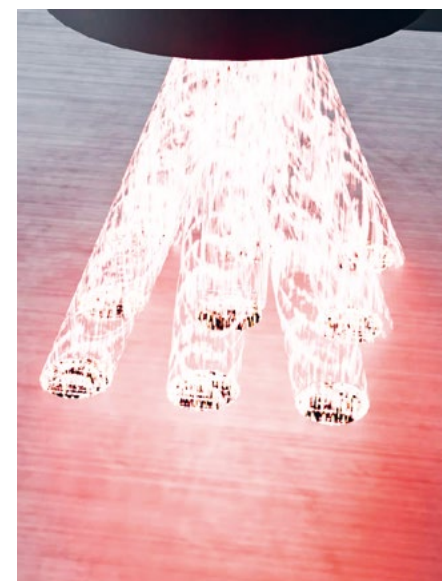
**Fyous at Formnext 2026:**  
Hall 11.0, Booth F22

\*Estimated from ~4.5 million annual clear aligner case starts (Straumann, 2021) and a median 47 aligner stages per arch including refinement (Meade et al., Journal of Orthodontics, 2023); cross-checked against Align Technology's disclosed 2025 case volume.



Images: Fyous

Images: Santec, NexusAM



## PROGRAMMABLE BEAM SHAPING FOR METAL AM

Santec Group has introduced the SLM-310, a spatial light modulator (SLM) that enables programmable beam shaping for industrial laser systems with power levels of up to 1 kW. The technology allows laser beam geometry and energy distribution to be adjusted in software during the manufacturing process.

For metal AM, the system can generate not only conventional beam profiles such as flat-top or ring-shaped beams, but also multi-spot configurations and freely defined patterns. According to Santec, initial tests with prototype systems have demonstrated reduced spatter formation, lower porosity and increased processing

speeds. The SLM-310 is designed as an integration component for AM machine manufacturers and laser system providers.

**Santec at Formnext 2026:**  
Hall 12.1, Booth G128

## A NEURAL-NETWORK CT SURROGATE

London-based startup NexusAM, founded in 2024, wants to make every metal AM part tell its own quality story in real time during the build. The Imperial College spin-out, working with partners including Rolls-Royce, BAE Systems and GKN Aerospace, combines machine learning-based defect detection with the familiar language of statistical process control with the aim of compressing part qualification from months to weeks and giving serial AM production the process confidence that conventional manufacturing takes for granted.

The Nexus platform is software that fuses in-process sensor data – from optical and thermal cameras, photodiodes, pyrometers and other sensing systems – and feeds it through machine learning (ML) models built specifically for the physics of the AM process. The company

describes its patent-pending core technology as a neural-network CT surrogate: layer by layer, the platform registers multi-sensor data and laser path information into a common 3D coordinate system and builds a digital twin of the printed component, with defect location, estimated size and confidence.

Under the hood sits a physics-informed neural network trained on several trillion individual measurements, including a validation dataset of more than 10,000 intentionally seeded defects built following ISO/ASTM guidance for benchmarking AM inspection capability. The architecture matters.

The platform is deliberately machine- and sensor-agnostic, making it suitable for use with all major LPBF machine manufacturers. After a year of early-stage testing with its first customers, NexusAM

is now signing up beta partners, with a full commercial launch planned for 2027.

**NexusAM at Formnext 2026:**  
Hall 11.0, Booth F121



# COMPONENTS FOR LOCOMOTIVES, ROLLING STOCK AND METROS

The British company DB ESG specialises in engineering solutions for the railway sector and handles certifications and upgrades for new high-speed trains as well as repairs to older railway vehicles on the UK rail network and London Underground. AM is playing an increasingly important role in this.

In 2018, DB ESG began its journey into Additive Manufacturing (AM) through a collaboration with the rolling stock leasing company Angel Trains aimed at extending the service life of older trains affected by obsolescence. »For a whole range of replacement parts, the moulds and tools were no longer available. Sometimes, the manufacturer had even gone out of business,« recalls Martin Stevens, who has worked in the British railway industry for 25 years in Derby, the UK's railway hub, and is now Chief Engineer at DB ESG. The solution typically involved reverse-engineering the components to be repaired by scanning them, converting them into printable data and 3D Printing them.

DB ESG is a leading specialist provider of rolling stock engineering solutions for the UK rail industry. Founded in 1995, DB ESG is part of Deutsche Bahn and currently employs 65 people. Among other things, the company assists OEMs with quality control for trains as well as approval and certification. DB ESG also supplies spare parts for trains in service and customises trains to meet operators' specific requirements. Extensive modifications are a key business area for the company, one example being the refurbishment of part of the underframe on one of London Underground's fleets, including design, engineering and installation support. »Alongside this, however,

we also have hundreds of smaller projects involving the replacement or addition of minor components,« explains Martin.

Like its counterparts in many other European countries, the British railway system is characterised by a number of historically developed peculiarities. As a result of privatisation in the mid-1990s, the rail network, trains and train operations are each owned by different entities. The trains belong to »rolling stock companies« such as Angel Trains, Porterbrook or Beacon Rail and, until now, have been leased to private operating companies. Since 2024, the British government has been working to gradually transfer operations back to a new state-owned company, Great British Railways (GBR).

The British model also shares significant similarities with almost all other rail systems worldwide: »In general, the railway industry is a sector that adopts innovations rather slowly, partly due to high safety standards,« says Martin. »At the same time, there are truly large-scale projects in the industry, for example, new train procurement contracts worth over a billion euros or more. A contract of this size, however, would deliver just 70 trains, so the component batches are almost always quite small.« Manufacturing injection moulds specifically for such short production runs is usually not eco-

nomical. And this is where Additive Manufacturing almost automatically comes into play.

DB ESG produces an extensive range of 3D-printed components ranging from switches on driver consoles to various handles, armrests and brackets as well as the housing for a train phone (on the London Underground), which was optimised for increased durability. Even on

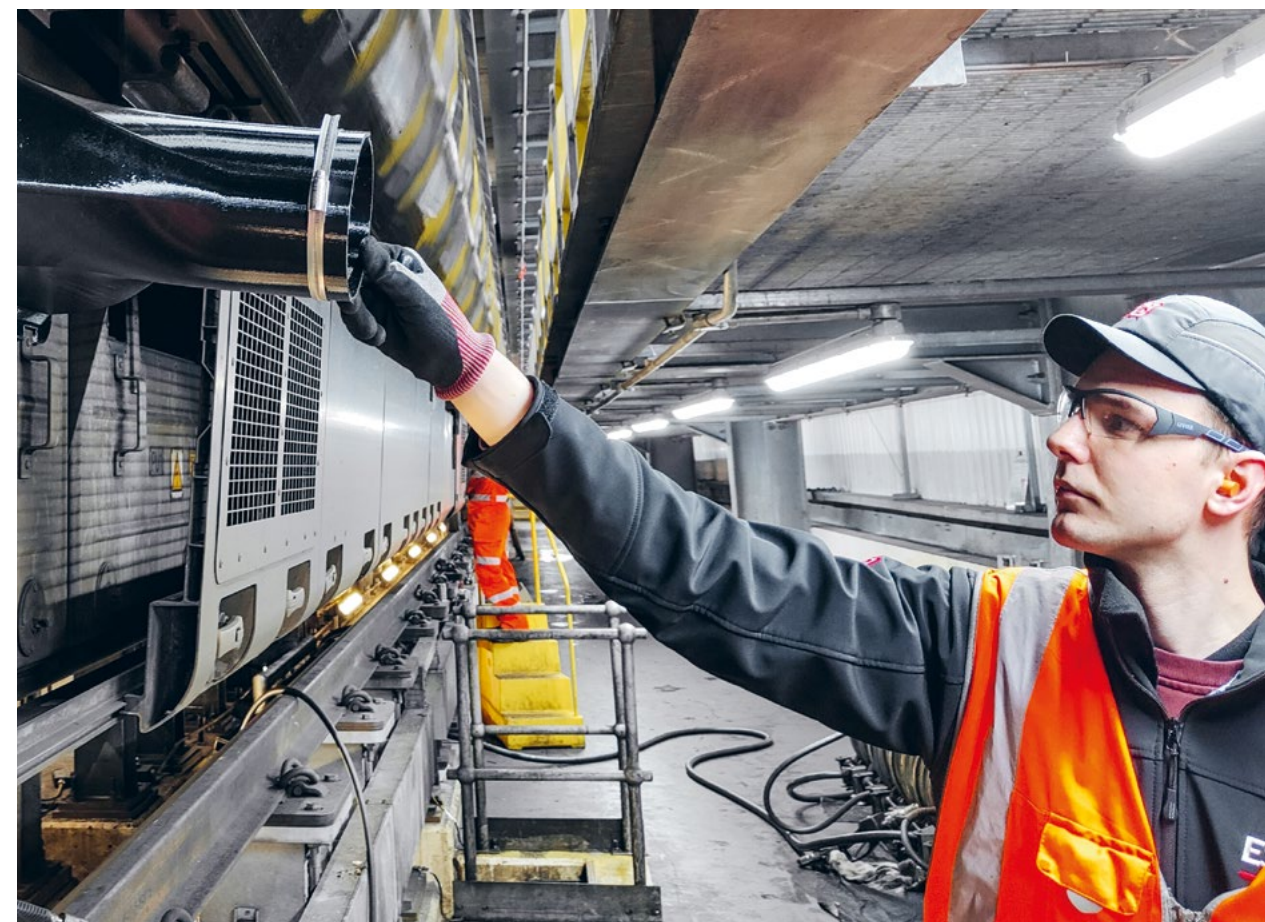
A selection of components developed and manufactured by DB ESG, some in-house and some via suppliers.



Text: Thomas Masuch

Images: DB ESG

Thanks to the 3D-printed tool, maintenance personnel are able to clean some components directly on the train with no need for removal, saving hours of labour.



new trains, adjustments are often necessary. In one new train, for example, bright sunlight made it difficult to see whether some buttons in the driver's cab were illuminated. The solution in this case was a custom-made cover. Certification for non-structural components like these is rarely a major problem, provided a fire-retardant material compliant with railway standards is used. The situation is different for larger metal components such as a 22-kg cast iron yaw damper mounting bracket. In this case, the component was indirectly 3D-printed using rapid casting and then cast using traditional methods. The advantage of this method is that the new components do not need to be recertified. DB ESG has also developed numerous labour and time-saving tools for repairs and cleaning.

Many of the required components (prototypes, most tools and some end-use parts) are manufactured in-house using six FFF systems. DB ESG also col-

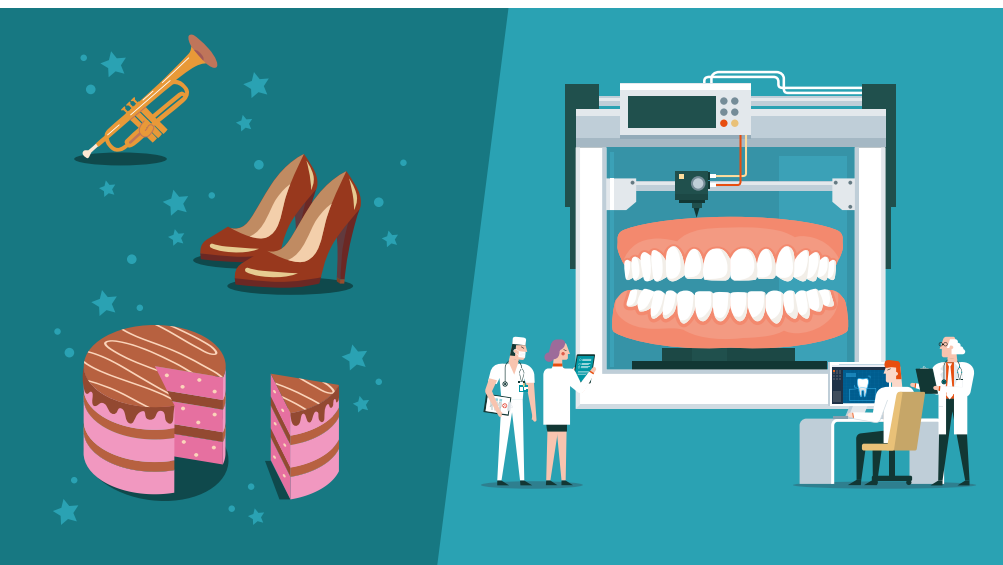
laborates with various service providers, including those specialising in SLS components or specialised metal materials. According to Martin, the company's own printers run 70 percent of the day, demonstrating how Additive Manufacturing now covers a significant portion of DB ESG's overall parts requirements and »is now well integrated into the company. All our engineers are familiar with AM and the benefits of the technology.« 3D-printed components are also frequently used in marketing to emphasise that DB ESG is »one of the most innovative British engineering firms in the railway sector.«

Martin is keen to expand the scope of Additive Manufacturing even further within his area of work. Finding the right applications, however, is no easy task, »because, after all, it's not us who have a problem with the train, but our customers and partners.« That's why DB ESG has been holding »lunch-and-learn sessions«

for the past four years to increase awareness of the benefits of AM technology among its partners' employees as well. »Our goal is to find one or two enthusiastic champions in every department who will drive AM forward.« Martin has found that younger members of middle management (fleet performance managers and obsolescence managers) tend to be more enthusiastic about new technologies than experienced engineers who are more set in their ways or top managers who are under intense pressure to get trains back on track quickly. »Because even though AM offers many advantages, you have to be willing to put in a little extra work now and then at the beginning.«

**+ FURTHER INFORMATION:**  
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# SPARE PARTS INSTEAD OF DISRUPTIVE PARTIES



When you look back at the world of AM a little over a decade ago, it is hard to believe it was the same industry. There were huge product launches, some featuring more than ten new products at once, live bands playing 3D-printed instruments and 3D-printed cakes served for dessert. To make those cakes possible, 3D Systems developed the ChefJet, a printer capable of producing intricate creations from sugar and chocolate. Among the celebrity guests at these high-profile events was Will.i.am of the Black Eyed Peas, who in 2014 was named Chief Creative Officer at 3D Systems. Other well-known artists, including Björk and Katy Perry, showcased 3D-printed headpieces and masks created by Stratasys during their performances.

At the same time, 3D Printing seemed destined to transform countless other industries. Buildings, pizzas, shoes and much more were all predicted to be produced primarily through Additive Manufacturing in the near future. In 2014, AM really was the hottest thing in the tech world. Investors appeared to pour money into the sector blindly, paying little atten-

tion to company figures. The focus was on disruption or creative destruction, and somehow everyone wanted to be part of it, driven by the fear of missing out on the next big thing after the internet.

What followed next is well documented. Turning that vision of disruption into reality proved far more difficult than anticipated. At the time, 3D printers were slow, available materials were limited and often not optimised for Additive Manufacturing, and printed components could be brittle, rough and inconsistent in quality. In many cases, they were also prohibitively expensive. Producing eye-catching cakes was relatively straightforward; building a profitable business around 3D Printing was not.

Since then, the AM landscape has changed profoundly. In time, the ChefJet disappeared from the product line, Will.i.am faded from 3D Systems' marketing spotlight and the share prices of what were then the largest AM companies began a dramatic decline after the highs of 2014.

So where is today's tech-defining news coming from? Artificial intelligence and robotics have unmistakably taken

centre stage, surpassing 3D Printing not only in commercial impact but also in spectacle. In China, humanoid robots compete in exhibition matches resembling mixed martial arts contests, creating scenes that would not be out of place in a Terminator movie. AI-powered machines patrol entrances, provide security, promote products and offer information to visitors. Occasionally, they overstep their role: in Macao, for example, a passer-by reportedly felt harassed by a Unitree G1 robot, which was subsequently escorted away by a (human) police officer. During testing, some AI models exhibited unexpected behaviour, attacking other businesses in a reality resembling the Matrix, and even resorting to blackmailing employees. Meanwhile, Anthropic pursued a very different approach through Project Panama, acquiring second-hand books in large quantities and scanning them using automated processes. Unfortunately, many of the physical books were destroyed afterwards and discarded. It is all undeniably revolutionary and, in some cases, disruptive in the most literal sense, yet it does not always inspire confidence about the future. The world could emerge a little poorer from these developments, and not only because of the loss of old books.

And what is AM doing in the meantime? The industry continues to grow steadily, producing spare parts for trams, tanks, automobiles, aircraft, oil platforms, industrial equipment and dental applications. Companies are qualifying new materials, validating production processes and developing software that reduces the need for support structures. It may no longer sound quite as revolutionary as it once did, but it is encouraging nonetheless: much is being improved and genuinely useful products are being created, all without destroying anything in the process.

Text: Thomas Masuch

Illustration: feedbackmedia.de, iStock/elenabs, invincible\_bulldog, luplupme, Magnilion, sorbetto

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70178 Stuttgart, Germany  
Phone +49 711 61946-0  
[info@mesago.com](mailto:info@mesago.com)  
[mesago.com](https://mesago.com)

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PROJECT COORDINATION  
Nina Schwarzer  
Phone +49 711 61946-566  
[Nina.Schwarzer@mesago.com](mailto:Nina.Schwarzer@mesago.com)

EDITED BY  
ZIKOMM – Thomas Masuch  
[thomas.masuch@zikomm.de](mailto:thomas.masuch@zikomm.de)

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