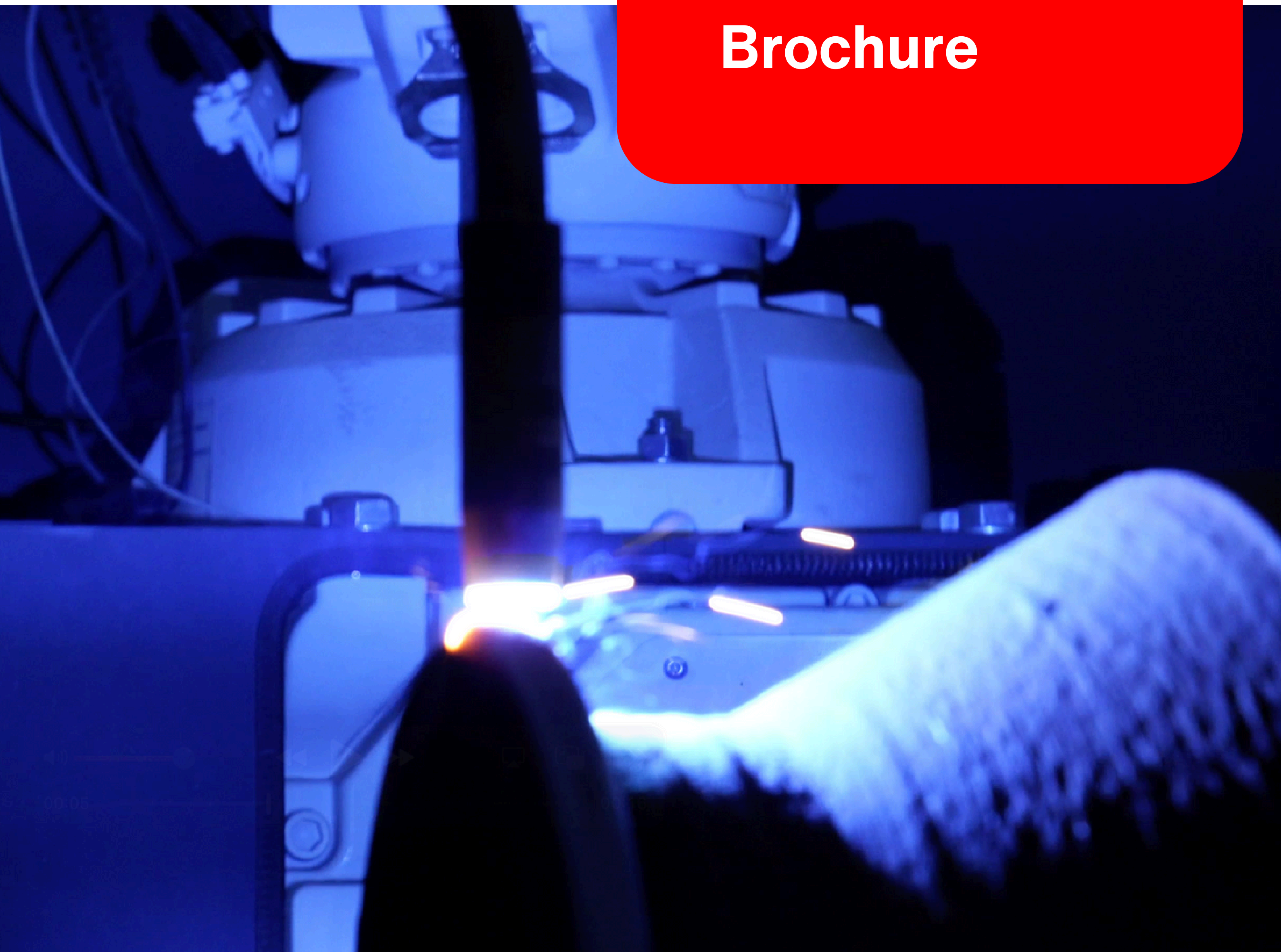
Pioneer

Funded by the European Union

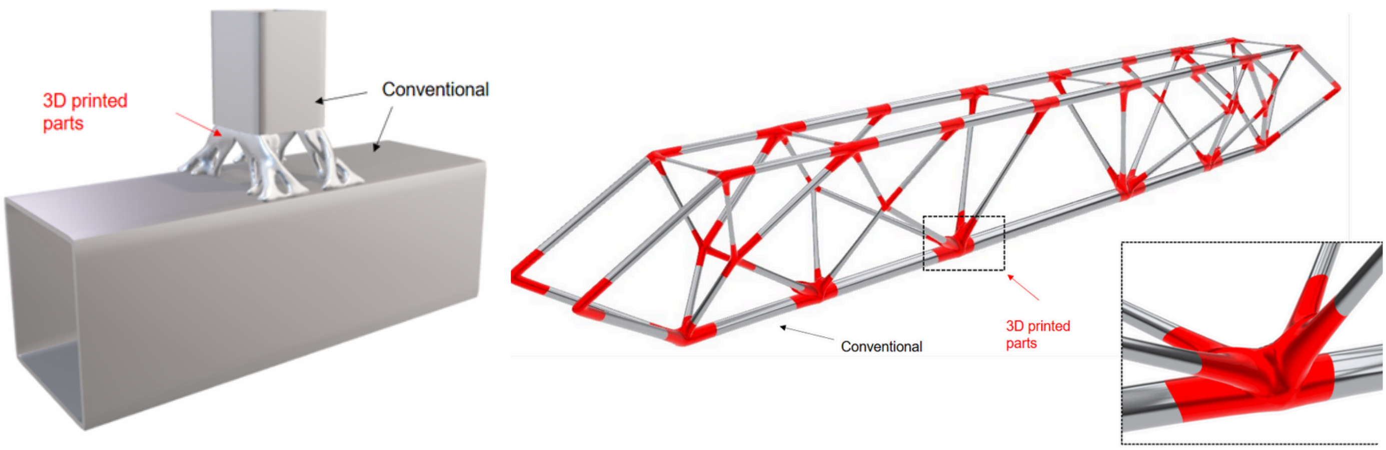
Open Innovation Platform for Optimising Production Systems by Combining Product Development, Virtual Engineering Workflows and Production Data.

Pilots Brochure



ABOUT THE MX3D PILOT

The MX3D pilot line demonstrates a novel hybrid manufacturing approach that integrates traditional rolled steelwork with additive manufacturing, specifically Wire Arc Additive Manufacturing (WAAM), to produce highly efficient steel structures. By embedding WAAM-specific design principles early in the design process, the pilot line enables end-to-end manufacturability and optimised use of materials. The central focus lies in the use of fast-running topology optimisation tools to generate structurally efficient components—such as beams, frames, and trusses—while dramatically reducing material consumption. These tools are enhanced by interoperable material characterisation data and process-aware layout optimisation, ensuring that printed joints and geometries are both mechanically sound and production-ready. WAAM is used strategically to reinforce conventional profiles, such as I-sections or hollow sections, achieving up to 85% increases in load-bearing capacity with only 16% more material. The result is a substantial reduction in embodied carbon and steel usage—by as much as 50–75% in some applications—without compromising structural performance.
The pilot line integrates a digital workflow with real-time re-optimisation, linking design, simulation and manufacturing execution. In-process monitoring and thermal modelling drive dynamic path planning to ensure dimensional accuracy and defect-free prints. This data-driven approach guarantees structural compliance and supports replicability across sectors, offering a scalable, resource-efficient manufacturing solution.



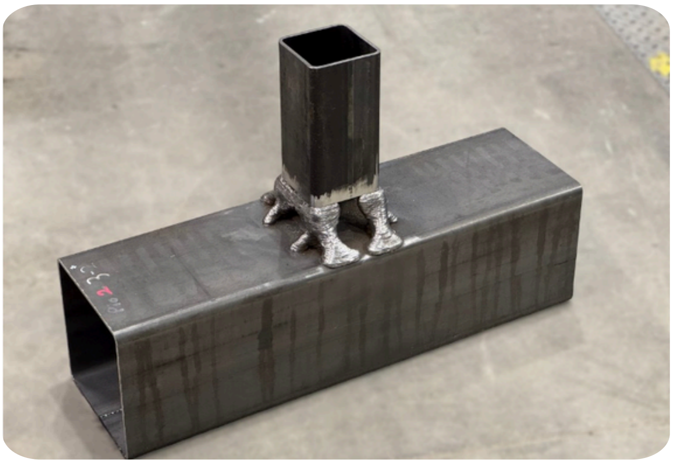
TARGET COMPONENT

The target components developed within the pilot line focus on hybrid structural elements that exploit the complementary strengths of conventional steel profiles and WAAM-enabled geometric freedom. One target application concerns hybrid joints, where WAAM-fabricated interface features are additively deposited directly onto standard square hollow section (SHS) profiles to enable efficient load transfer to perpendicularly connected SHS members, with the objective of achieving substantial increases in joint stiffness and capacity relative to material addition. A second target component addresses the strengthening of conventional I-section beams through the selective deposition of WAAM material at structurally critical locations, aiming to significantly enhance load-carrying capacity while limiting the associated increase in mass. Finally, the pilot line targets the fabrication of a full-scale, 10-metre-long three-dimensional hybrid truss, in which standard circular hollow section (CHS) members are connected through optimised WAAM-printed nodes designed to enable first-time-right assembly, high structural efficiency and suitability for load-bearing construction applications.

EXPECTATIONS AND SUCCESS

The pilot line was expected to demonstrate a fully integrated, industrial-grade hybrid manufacturing approach for optimised steel structures, enabled by the seamless integration of complementary solutions developed by the project partners. Central expectations included the validation of a digital end-to-end workflow that combines structural optimisation algorithms, thermal and distortion-aware simulation, and WAAM manufacturing within a single operational framework. Inline monitoring and closed-loop control were expected to ensure process stability and right-first-time production, while digital twins and AR/VR-based tools were foreseen to support quality assurance, operator training, and process maintenance across the pilot line. Operating under low-volume, high-mix conditions, the pilot aimed to reach TRL7 through full-scale demonstrators and generate robust performance, sustainability, and cost benchmarking data to support certification, replicability, and future industrial deployment.

These expectations were met and exceeded through the successful deployment of the MX3D pilot line, where the tight coupling of partner-developed simulation, optimisation, and control solutions enabled a fully operational digital workflow for zero-defect manufacturing of high-mix, low-volume WAAM components. Thermal and distortion simulations were directly linked with real-time process monitoring and inline control, allowing early detection and mitigation of anomalies during fabrication, while AR/VR tools supported seamless quality assurance procedures and improved operator interaction with complex hybrid components. As a result, hybrid joints achieved an average 300% increase in load-carrying capacity with 100% additional material, and WAAM-strengthened I-section beams demonstrated load-carrying capacity increases between 35% and 84% for only 5% to 16% added mass. In total, 22 WAAM-printed structural nodes were manufactured first-time-right and assembled into a load-bearing hybrid beam, confirming the robustness, repeatability and industrial relevance of the integrated pilot line approach.

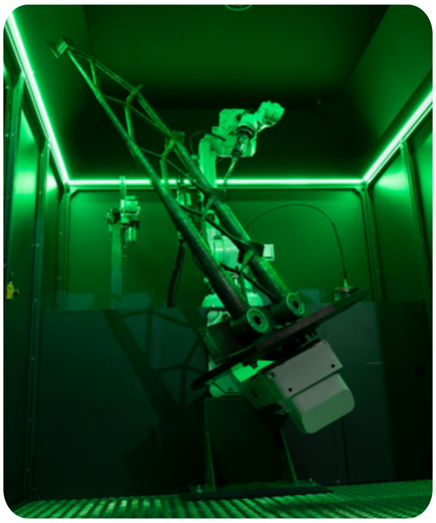


MAIN CHARACTERISTICS AND ADVANCES

- A fully deployed novel digital workflow for zero-defect manufacturing of high-mix low-volume WAAM components.
- An inline monitoring & control system capable of in-line anomaly detection and mitigation.
- For hybrid joints, an average of 300% capacity gain is achieved with 100% additional material.
- Between 35% and 84% increases in load-carrying capacity for between 5% and 16% increases in mass in the case of the WAAM strengthened I-section beams.
- A total of 22 first-time-right WAAM printed nodes for the construction of the 10m long hybrid 3D truss.

ABOUT MX3D

MX3D is a pioneering Dutch scale-up that develops advanced solutions for robotic Wire Arc Additive Manufacturing (WAAM). Founded in 2015 following groundbreaking research into large-scale metal 3D printing, the company enables the production of complex, certified metal components through industrial-grade robotic systems. MX3D offers both turnkey WAAM production services and integrated hardware–software platforms that allow partners to implement WAAM in-house.



MX3D's technology combines multi-axis robotic control, real-time sensor feedback, and proprietary software to achieve high-performance additive manufacturing at scale. A strong emphasis is placed on process monitoring, repeatability, and qualification, enabling WAAM to be deployed in regulated and safety-critical environments.

Applications span sectors including energy, aerospace, maritime, infrastructure, and heavy industry—where reducing lead times, material use, and design constraints is critical. MX3D is best known for high-profile projects such as the world's first 3D printed stainless steel bridge in Amsterdam, and continues to drive innovation through applied R&D, industrial collaborations, and EU-funded projects focused on scaling WAAM from experimental use to reliable industrial production.

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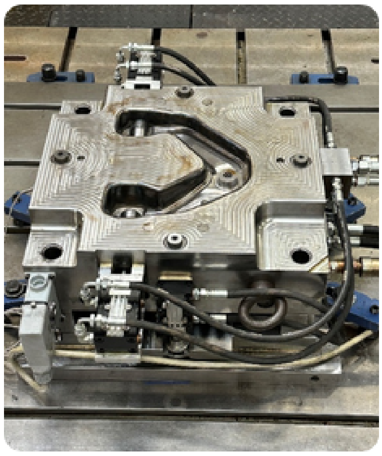
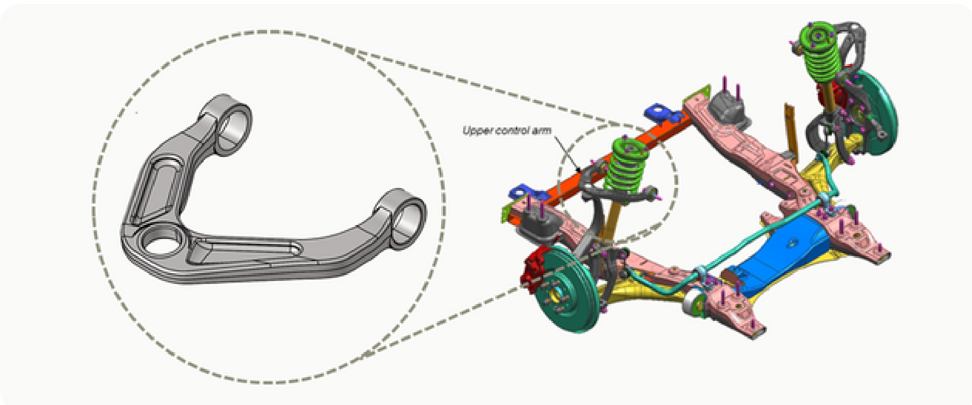
ABOUT THE MARELLI PILOT

Turin's R&D headquarters are equipped with a 1500-ton Sheet Molding Compression (SMC) press (table size 2500 × 1800 mm), enabling in-house design, production, and validation of structural suspension components. The SMC process supports the manufacture of complex, high-strength composite parts, and the site's high vertical integration allows material development, component manufacturing, and testing to be performed in one location. This streamlined workflow accelerates development from concept through validation while enhancing efficiency and innovation.

The pilot deployed for demonstration at the company showcases a complete and digitally integrated workflow for composite part manufacturing using SMC technology. It combines product and process definition, real-time data acquisition from production equipment through embedded sensors and OPC UA interfaces, and the deployment of a digital infrastructure based on the Open Innovation Platform (OIP). The pilot enables traceability from material and design parameters to manufacturing execution and data-driven validation of produced parts, illustrating the practical application of PIONEER methodologies in a real industrial environment.





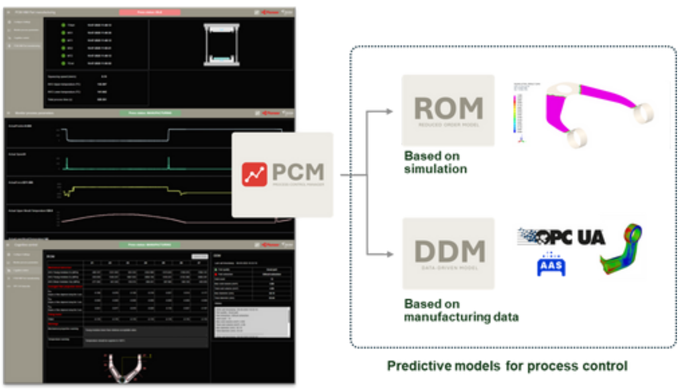
TARGET COMPONENT

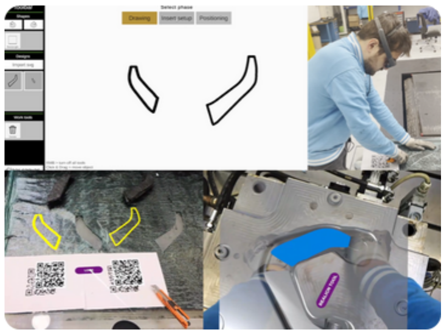
Within the PIONEER project, Marelli developed, manufactured, and tested an upper suspension control arm for front suspension systems. The component provides structural support, linking moving parts (wheel, knuckle) to fixed vehicle structures (body, subframe, cradle). Control arm configurations vary with suspension architecture; in independent systems, the classical double-wishbone layout uses two transverse arms per wheel, with the upper arm integrating two bushings and a ball joint—typically pressed-in or molded in-place—for attachment to the subframe and steering knuckle. While state-of-the-art solutions are predominantly metallic, Marelli's new lightweight control arm is produced using a Sheet Molding Compound (SMC) with vinyl ester resin reinforced with 50% carbon fiber, achieving about 30% mass reduction relative to conventional metal counterparts.

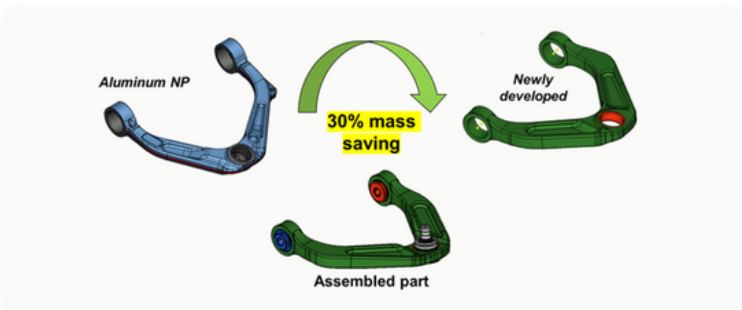
EXPECTATIONS AND SUCCESSES

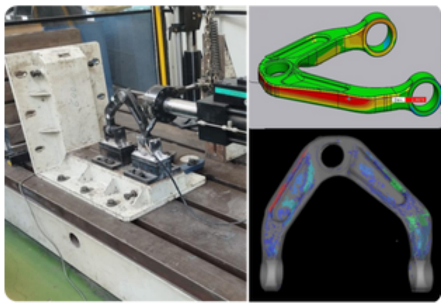
Within the PIONEER project, this use case aimed to enable the accurate prediction of the mechanical behaviour of complex SMC components by accounting for fibre orientation effects, leveraging a virtual process chain to reduce development time and costs, and establishing a strong correlation between material characterisation data and final product quality.

As a result, Marelli developed, manufactured, and tested a composite upper suspension control arm using Sheet Molding Compound (SMC). The complete design and production workflow was enhanced through digital tools: a Digital Thread ensured traceability across material, simulation, and manufacturing stages; Process simulation and a visual Reduced Order Model (ROM) accelerated process engineering tasks by enabling rapid evaluation of parameter effects; a cognitive Process Control Manager (PCM) integrated quality-predictive models derived from simulation and experimental data; and an AR interface supported the operator in preparing and positioning charge materials. Together, these technologies established a digitally enabled, data-driven composite manufacturing process.



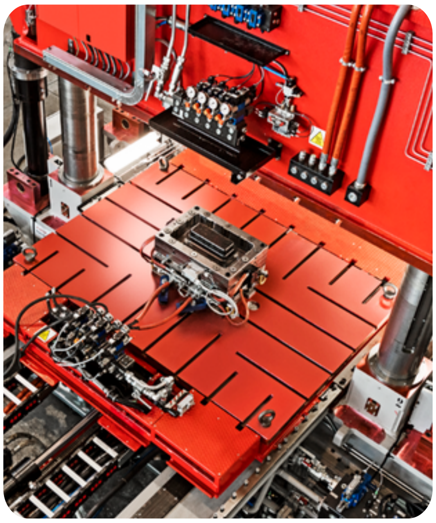






MAIN CHARACTERISTICS AND ADVANCES

- The resulting SMC upper control arm, reinforced with 50% carbon fiber, demonstrated about 30% mass reduction relative to typical metal counterparts, contributing to lower fuel consumption for ICE vehicles and extended driving range for BEVs.
- The digital workflow delivered measurable gains in quality and production efficiency: interpretable ROM/DDM models and the PCM reduced defective parts through predictive adjustments; Visual ROM shortened engineering lead time; AR support reduced preparation time for charge cutting and placement; and full lifecycle traceability enabled improved monitoring and documentation.
- Collectively, these outputs support Marelli’s goals of innovation, sustainability, and enhanced customer value.



ABOUT MARELLI

Marelli Ride Dynamics is one of the business units within Marelli, operating as an automotive Tier-1 supplier specialized in advanced vehicle motion control solutions.

The company designs, manufactures, and distributes suspension components—such as shock absorbers, suspension modules, and ride control systems—for passenger cars and light commercial vehicles. With a focus on innovation, safety, and performance, Marelli Ride Dynamics leverages engineering expertise, cutting-edge research, and close collaboration with global automotive manufacturers to enhance driving comfort and handling.

Within Product Development, the Advanced Material Application team leads several projects focused on metal replacement with composite materials to deliver extremely lightweight solutions for structural suspension components, drawing on Marelli RD's extensive experience in this field.

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Funded by the European Union

This project has received funding from the European Union's Horizon Europe Research and Innovation programme under the grant agreement no. 101091449.