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ROBOTIC 3D METAL PRINTING

THE ROI OF WAAM

WHITEPAPER 2026



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From Technical Feasibility to Competitive ROI

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Wire Arc Additive Manufacturing (WAAM) has matured into a proven production technology for large, load-bearing metal components in sectors such as **nuclear**, **maritime**, **oil & gas**, and **defense**. Today, the key question is no longer whether WAAM works technically, but whether it delivers a competitive return on investment (ROI).



For industrial users, after determining technical feasibility, ROI is driven by a small number of core questions:

- What is the lead time reduction versus traditional manufacturing?
- What are the production costs versus traditional manufacturing?
- Can WAAM reduce supply chain risk and strengthen strategic autonomy?

Rather than relying on abstract cost models, this white paper takes a business-driven approach, grounded in hundreds of man-years of real production, to answer these questions. It provides a clear framework for understanding how lead time reduction, production realities, and strategic autonomy can influence the ROI.



About the author

Filippo Gilardi, R&D Manager at **MX3D**, has been instrumental to the company's growth since its founding in 2014. With an M.Sc. in Industrial Design from Politecnico di Milano, he leads large-scale WAAM applications for the Nuclear and Aerospace sectors. Filippo specializes in process digitization, quality assurance, and design-for-additive strategies, having overseen landmark projects including the world's first 3D-printed steel bridge.

How is the ROI of WAAM Calculated?

Understanding the ROI of WAAM starts with a clear view of what is included in 'production cost'. Although WAAM clearly delivers a lot of additional value in strategic autonomy, increased availability & flexibility, local manufacturing, and high reliability and repeatability at its core, ROI is determined by the cost per part manufactured using WAAM relative to alternative manufacturing technologies. For this paper, we will focus on the cost of replacing a cast or forged base part with a WAAM-printed part.

A Simplified Cost Model for WAAM

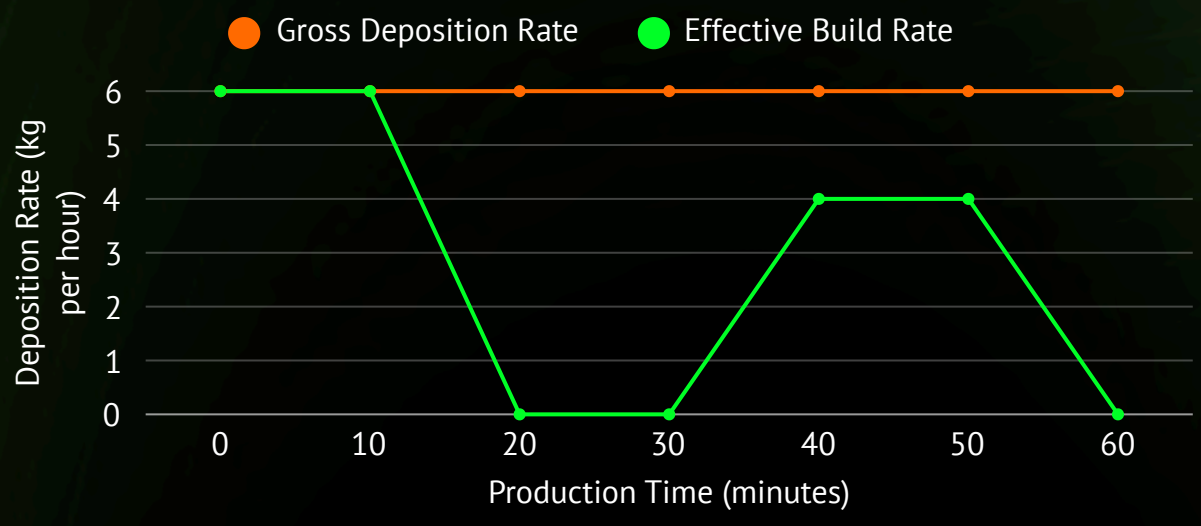
COST PER PART

File preparation & Qualification steps
+
(Machine hourly rate × Total production time)
+
Consumable & feedstock cost
+
Post-processing cost

While all variables matter, the dominant factor for large parts is typically the total production time, which is directly linked to the effective deposition rate. The smaller the part, the more other cost elements, such as qualification, file preparation, and buildplate factor.

Expressing production efficiency as cost per kilogram of deposited material gives the most practical ROI metric:

- Higher effective build rate → lower machine write-off per kilogram
- Reduced cost per kilogram → lower production cost per part
- Lower part cost → higher ROI



Deposition Rate as the Primary ROI Driver

A critical distinction in WAAM economics is the difference between gross deposition rate and effective build rate.

The gross deposition rate is the theoretical mass of wire melted per hour under continuous welding conditions. Many WAAM companies communicate this value. However, this is never fully achieved in real production. The effective build rate represents the actual throughput, accounting for transitions between layers, cooling time to preserve the mechanical properties, and torch repositioning. This effective rate is the true metric for accurate ROI calculations.

The effective build rate depends on several distinct factors:

- Wirefeed speed
- Wire diameter and alloy type
- Robot path planning
- Temperature control

WAAM Versus Other Metal AM Processes

When evaluating ROI, it is essential to compare WAAM's deposition capabilities against other additive manufacturing methods. WAAM typically operates in the range of:

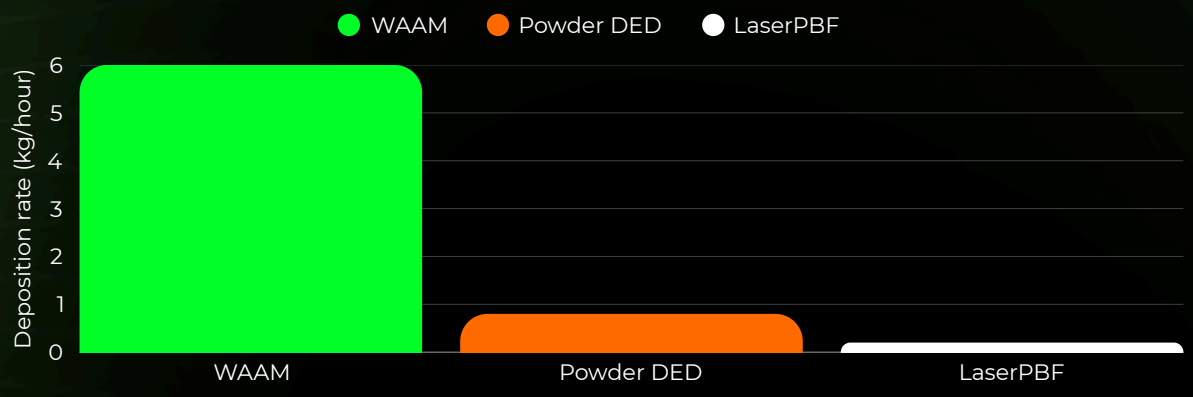
- 2–8 kg/hour for steel, stainless steel, and ⅓ of those values for aluminum.
- Higher rates are possible for selected geometries and materials. With the MX3D multi-robot solution, the deposit rate doubles, triples, or quadruples.

Compared to powder-based Directed Energy Deposition (DED) or Laser Powder Bed Fusion (LaserPBF), WAAM represents:

- 5–10× higher material throughput
- Significantly reduced feedstock price per deposited kilogram

Deposition Rate Comparison

Between metal additive manufacturing technologies



Lead Time Reduction and Supply Chain Impact

One of the most immediate ROI drivers of WAAM is reduced lead time. By having distributed local manufacturing available in workshops, on ships, and close to the battlefield.

In conventional manufacturing, long lead times are mainly driven by tooling, mold production, and procurement of semi-finished parts, multiple supplier handovers, and sequential processing steps such as casting or forging, followed by extensive machining. Furthermore, many casting and forging companies have been offshored and consolidated, giving customers few local options.

WAAM accelerates production by eliminating dedicated tooling and producing near-net-shape parts directly from digital designs in a single, digitally controlled manufacturing flow.

Key benefits of WAAM for lead time and logistics include

- **Improve readiness by digital inventory: having on-demand digital part files ready to go**
- **On-demand manufacturing close to the point of use**
- **Widely available supply chain of feedstock and consumables**
- **New or extra systems can be operational in as little as 2 months**
- **High deposit rate vs other 3D technologies**

For spare parts, repairs, and low-volume production, this speed advantage translates directly into operational value.

Furthermore, strategic autonomy and rapid local production minimizes expensive downtime by reducing:

- Equipment downtime
- Project delays, manual labor, & supply chain risks
- Emergency logistics and expedited shipping costs



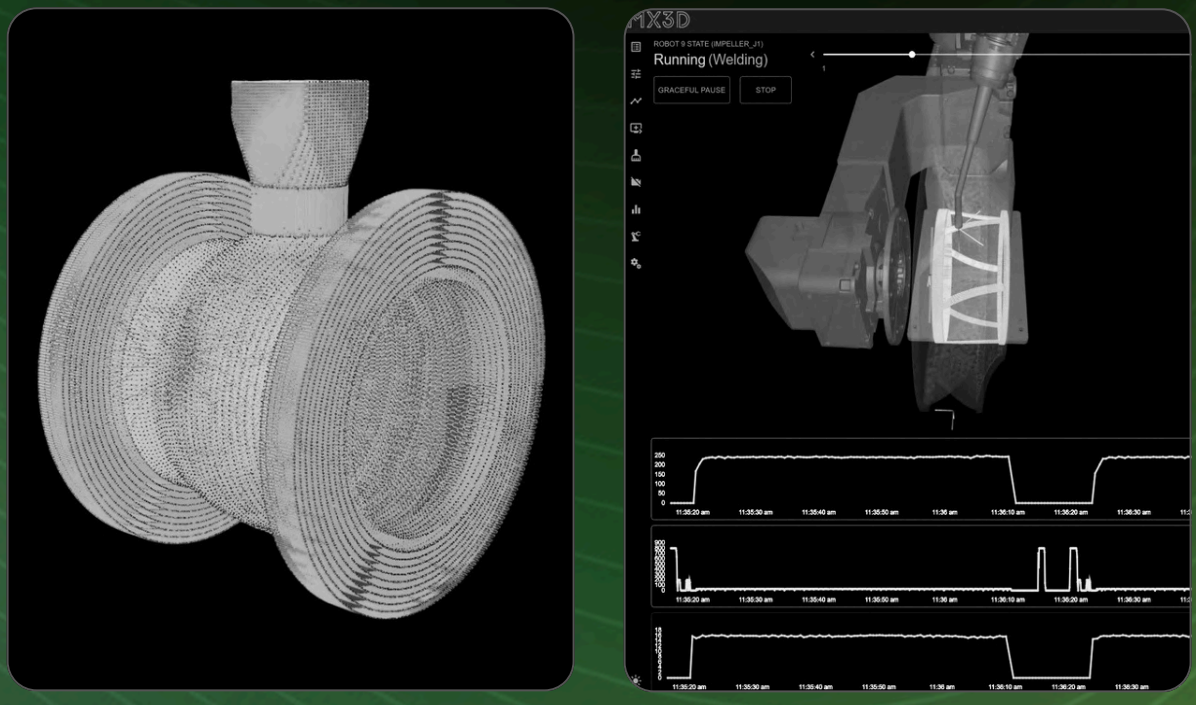
Process Automation as an ROI Facilitator

While high deposition rates are critical, WAAM must also minimize manual intervention to be economically viable. Process automation serves as a primary ROI facilitator by shifting the operator's role from continuous manual intervention to highly efficient digital supervision.

Advanced WAAM turnkey systems like MX3D's M1 and MX increase the ROI by enabling 24/7 production:

- Digital Anomaly Detection: Instead of requiring an operator to constantly watch the print, the software continuously monitors the process. If an anomaly occurs, it automatically pauses the print, preventing critical failures, delays, and wasted material.
- 24/7 Printing: By automating all steps and using industrial-grade machine components, WAAM machines can operate continuously for a decade or more.
- Multi-Robots: By adding more than one robot, WAAM can increase its output rapidly.

By reducing interpass idle time and allowing a single operator to manage multiple cells, automation drives down the total machine hours and labor overhead per part.



MetalXL software interface showing optimized digital process monitoring

Additional ROI Drivers: Design Freedom & Qualification

While deposition rate, lead time, and automation are the most immediate drivers of part cost, WAAM unlocks further, long-term ROI through geometric freedom and certification capabilities.

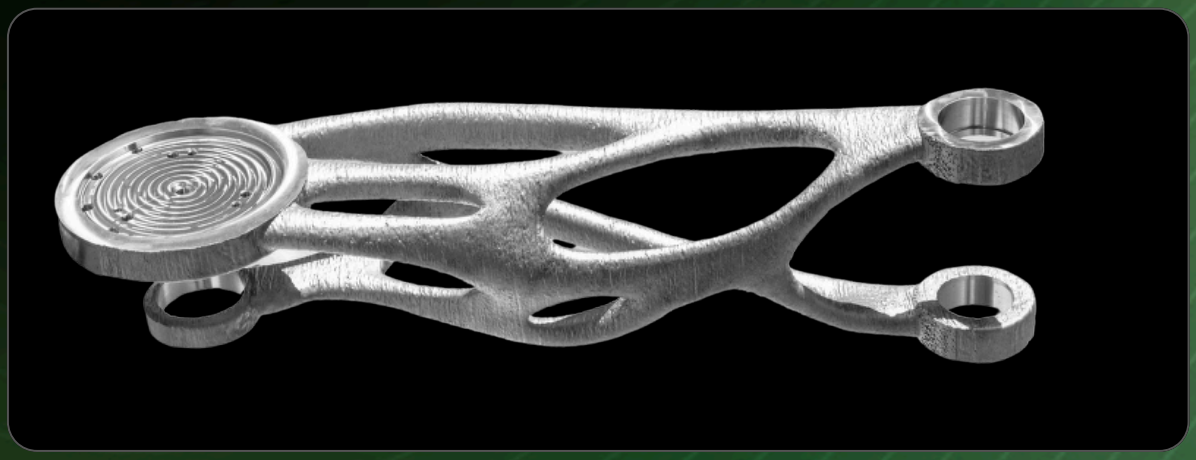
Performance-Driven Design Freedom: By building components layer by layer, engineers can design parts around performance rather than traditional manufacturing limitations. This unlocks:

Material Efficiency:
Placing material only where structurally needed via topology optimization yields significant weight reduction and an improved performance-to-weight ratio.

Part Consolidation:
Multiple welded or bolted sub-components can be redesigned into a single printed part, reducing assembly time and the risk of joint failure, and therefore increasing strength and durability.

Qualification and Risk Reduction

For industries like energy, maritime, and aerospace, WAAM parts must meet strict compliance requirements. WAAM reduces regulatory risk because it uses an arc-welding-based process that builds upon established welding standards (e.g., ASME Section IX, ISO 15614). When these are combined with AM-specific standards and the full digital process traceability provided by automated WAAM systems, companies achieve faster time to certified production, significantly reduced human error, and lower inspection costs.



Robot Arm, a consolidated part with a optimized topology for strenght

Conclusion

Wire Arc Additive Manufacturing has moved beyond technical feasibility into a scalable, economically competitive manufacturing solution for critical industrial applications.

The return on investment is primarily driven by a small number of controllable factors: **effective build rate**, **reduced lead times**, and a **high degree of process automation**. The strongest ROI impact is achieved when WAAM is treated as a **fully integrated**, digitally controlled production workflow rather than a stand-alone printing process.

By optimizing deposition strategies, minimizing idle time through automation, and replacing physical inventory with on-demand local production, WAAM provides immense strategic value for industries facing supply-chain risks and lead-time pressure.

To help realise the highest ROI possible, MX3D offers advanced turnkey WAAM systems for quality in-house manufacturing. Visit our systems page for more information.



The MX (left) and the M1 (right) WAAM systems of MX3D

If you would like to assess the ROI potential of WAAM for your own part or if you have a system inquiry, reach out to MX3D to evaluate feasibility, performance, and business impact based on your specific application.

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