Tritone

# METAL ADDITIVE MANUFACTURING IN RESEARCH CENTERS & UNIVERSITIES:

# UNLOCKING INNOVATION AND INDUSTRY ALIGNMENT

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# Contents

# Executive Summary

Additive Manufacturing (AM) has revolutionized how products are designed and manufactured, finding applications across industries from aerospace to healthcare.  research centers, as hubs of innovation and education, have enthusiastically embraced polymer-based AM systems. These printers, often used for prototyping, are ideal for teaching foundational skills.

As the AM industry shifts focus from prototypes to production, the focus in research centers is also shifting towards research of new materials and modalities to better achieve 'Industry alignment'.

Specifically, metal AM has emerged as a critical driver of innovation of competitiveness and the metal AM industry is growing rapidly. Metal AM enables the fabrication of production-ready parts with applications that transcend prototyping. By integrating metal AM systems, research centers, as epicenters of advanced research and innovation, can better align their capabilities with industry demands, enhance research opportunities and develop the materials needed to drive the future of manufacturing.

The urgency to embrace metal AM stems from two key factors:

**INDUSTRY TRENDS:**
The push for reshoring manufacturing in the U.S. has accelerated the adoption of AM technologies as a means of enhancing supply chain resilience and cost efficiency. Industry players are heavily investing in metal AM for its ability to produce production-grade parts locally, on-demand, and sustainably.

**ACADEMIC RELEVANCE:**
Research-focused universities need to align their capabilities with industry needs, both to drive innovation and to prepare students for the high-demand, high-skill jobs of tomorrow.

This paper provides a strategic guide for research centers to maximize their impact with metal AM. It outlines key considerations for adopting these systems, identifies common pitfalls, and explores future trends shaping the research and industrial landscape.

Whether advancing material science or building industry partnerships, research centers and universities that embrace metal AM will solidify their position as leaders in innovation.

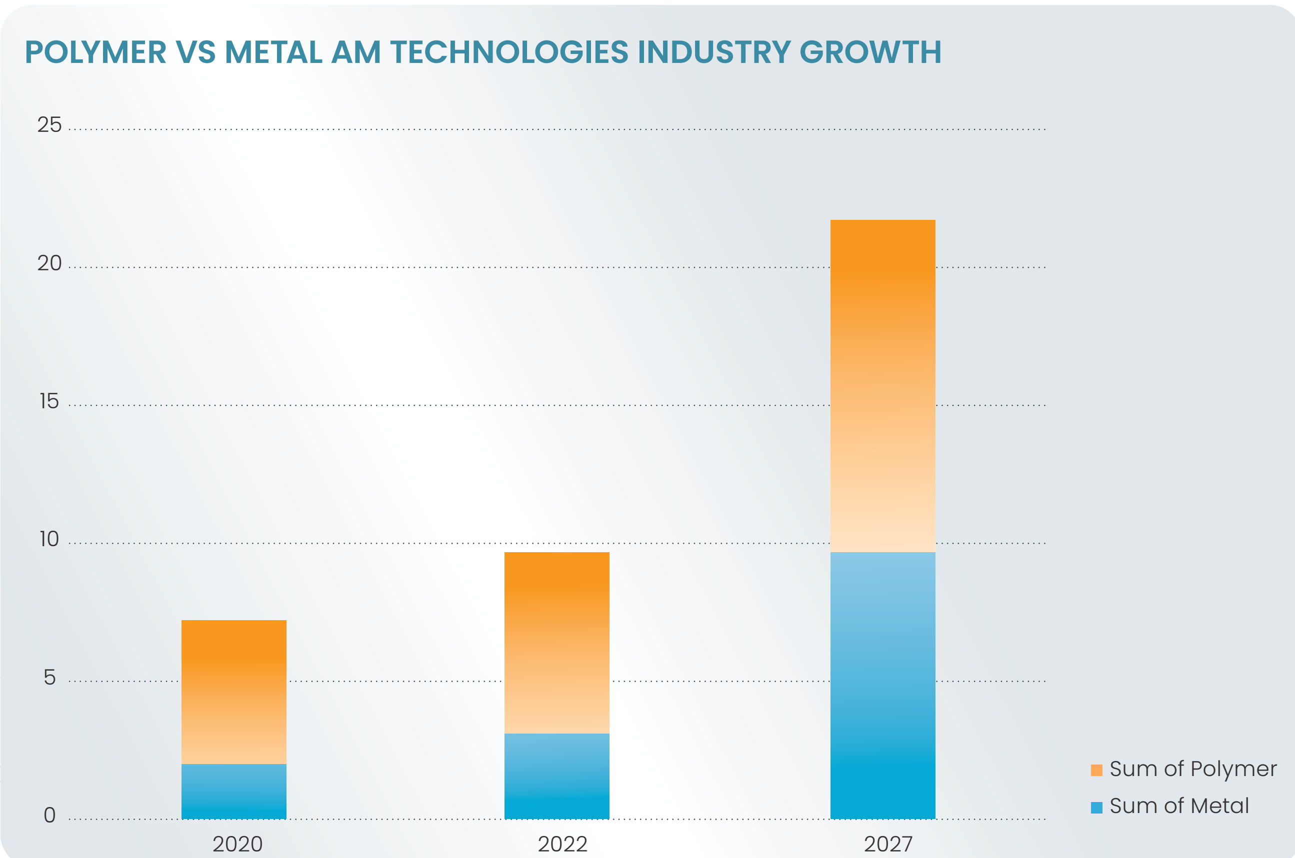
# Introduction:
# The Strategic Imperative of Metal AM

## WHY METAL AM?

Polymer printers have transformed engineering and design education. Affordable, accessible, and relatively foolproof, they've opened the doors to hands-on learning. Students and designers alike can iterate quickly, creating everything from architectural models to simple mechanical components. These systems have democratized prototyping—but they've also created a comfort zone.

Metal AM represents a paradigm shift from prototyping to **production-ready parts**, a capability that resonates across industries. Unlike polymer AM, which is largely limited to design validation, metal AM enables the creation of end-use components that meet demanding performance requirements. Applications include lightweight aerospace structures, patient-specific medical implants, and high-performance automotive components.

For research centers and universities, metal AM opens doors to cutting-edge research in materials science, manufacturing processes, and product design. It provides the tools to prototype and produce solutions for real-world challenges, driving innovation and establishing academic institutions as industry collaborators.



## WHY NOW?

The timing for metal AM adoption is critical for several reasons:

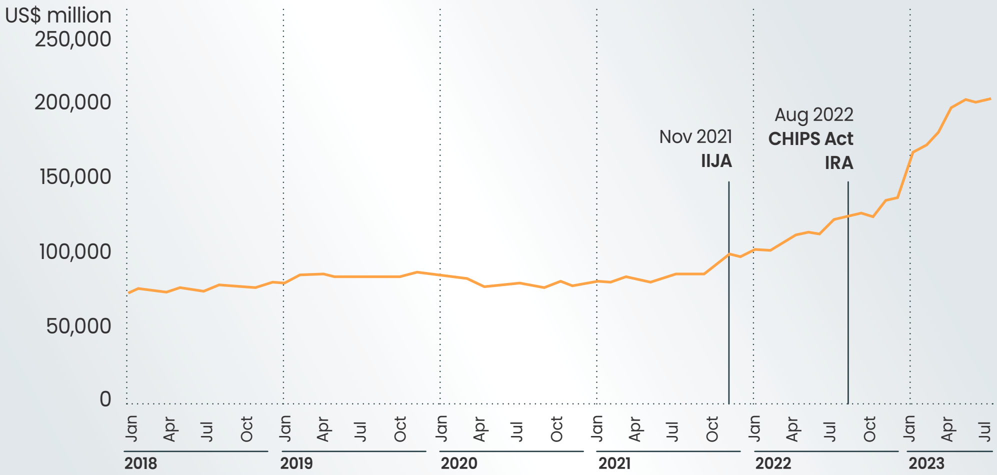
**Reshoring Manufacturing and Projected Increase in Short/Medium Runs:** With global supply chains under scrutiny, there's a renewed emphasis on producing locally to ensure resilience. Metal AM is a key enabler, reducing lead times and dependency on overseas suppliers. The trend toward reshoring manufacturing in the U.S. (and in other countries around the globe as well) is fundamentally altering supply chain dynamics. By moving production closer to consumption points, manufacturers are increasingly relying on shorter production runs to meet localized demand. Metal AM plays a critical role in enabling this shift, offering the flexibility to produce small and medium batches efficiently and economically.

**Sustainability Goals:** Industries are under pressure to adopt greener manufacturing methods. Metal AM reduces material waste through its additive process, aligning with sustainability imperatives. Further, as noted above in the context of short and medium production runs, these shorter runs not only improve supply chain resilience but also align with sustainability goals by reducing transportation distances and material waste.

**Industry-Driven Demand:** Companies across sectors are investing in metal AM to gain competitive advantages. Research centers and universities must parallel these advancements to stay relevant and maintain robust partnerships.

For research centers and universities, adopting metal AM isn't just an upgrade, it's a step toward aligning with industry needs, enhancing research potential, and equipping users (students or researchers) with sought-after skills. In short, it's about preparing for the future.

### ANNUAL CONSTRUCTION SPENDING IN THE US MANUFACTURING INDUSTRY HAS EXPERIENCED SIGNIFICANT GROWTH IN RECENT YEARS




Notes: IIJA stands for Infrastructure Investment and Jobs Act; CHIPS stands for Creating Helpful Incentives to Produce Semiconductors and Science Act; IRA stands for Inflation Reduction Act.

Source: Deloitte analysis of US Census Bureau data.
**Deloitte |** deloitte.com/us/en/insights/research-centers/center-energy-industrials.html

# Key Considerations for Research Centers and Universities Adopting Metal AM

As several research centers and universities have gotten to experience, transitioning to metal AM isn't as simple as upgrading to a newer version of a polymer printer. Research centers and universities must grapple with unique challenges, from safety concerns to post-processing requirements. Here's what to consider:

## OPEN-MATERIAL PLATFORMS FOR RESEARCH FLEXIBILITY

**Challenge:** Proprietary systems not only limit material exploration but also lock users into expensive supply chains, increasing the total cost of ownership (TCO). This restriction undermines innovation.
**Solution:** Opt for open-material systems that support research flexibility, allowing research centers and universities to:

- Develop novel metal alloys and ceramics for high-impact applications.
- Reduce material costs by sourcing from multiple suppliers.
- Collaborate with industry partners on experimental materials, enhancing grant funding potential.

## POST-PROCESSING INTEGRATION

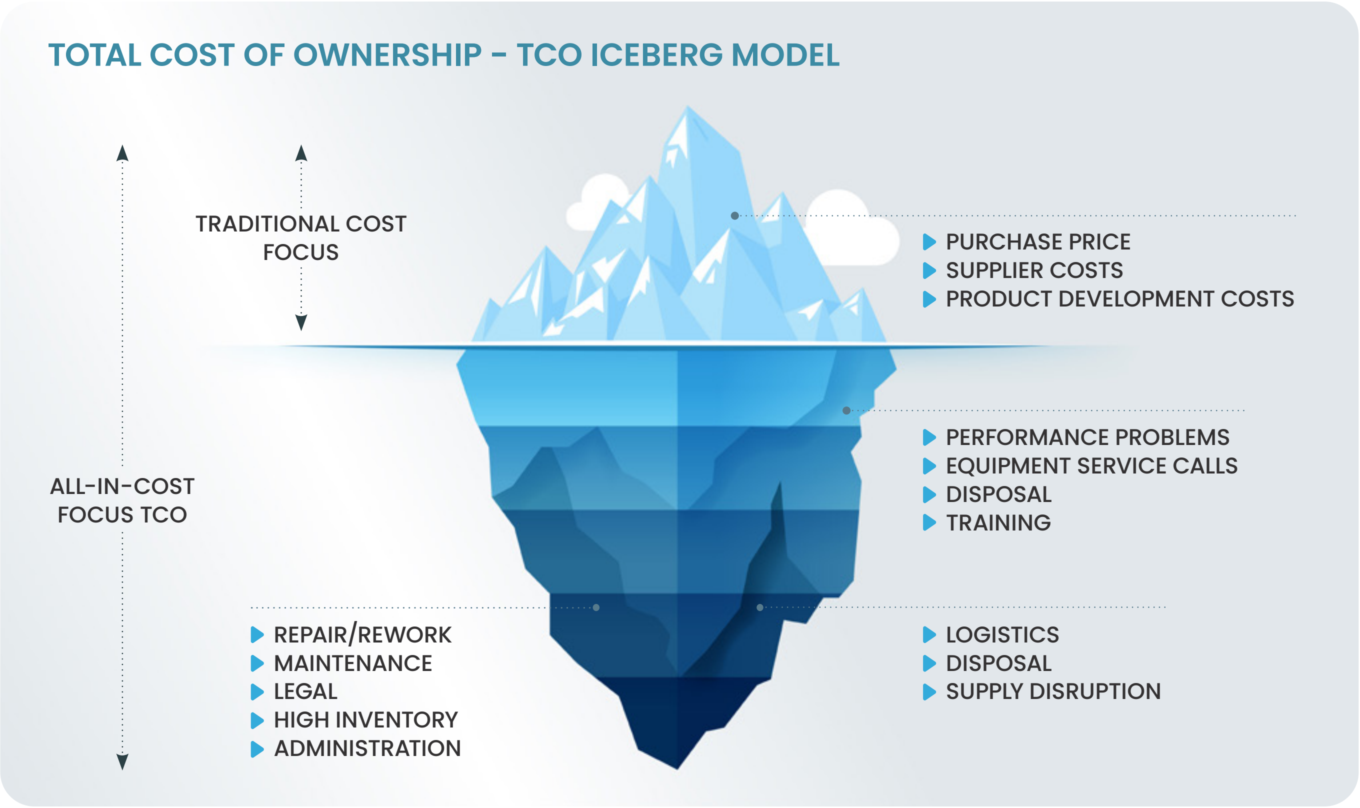
**Challenge:** Metal AM parts require post-processing to achieve desired properties, such as strength and finish. Post-processing equipment might be expensive and require significant expertise. Without considering post-processing in advance, a research center or university's metal AM lab risks becoming an expensive display case for half-finished parts.
**Solution:** Research centers and universities should assess their in-house post-processing capabilities (e.g., machining, sintering, heat treatment) to determine which steps require internal expertise and which can be outsourced.
For example, binder-jet (BJ) parts are weak when green and may break during shipping if sintered externally. Institutions without in-house sintering may prefer sinter-based technologies, like Tritone's MoldJet, which produce stronger green parts.

## TOTAL COST OF OWNERSHIP

**Challenge:** The sticker price of a metal AM system often hides significant downstream costs. Equipment for material handling, post-processing, safety compliance, and training can double or even triple the initial investment.
**Solution:** A TCO-focused framework offers research centers and universities clarity and control over their investments. Steps include:

- Identifying ancillary costs (e.g., EH&S, training, post-processing).
- Allocating phased budgets to expand capabilities over time.
- Prioritizing systems with minimal hidden costs. For example, sinter-based technologies like Tritone's MoldJet can reduce reliance on expensive post-processing equipment.

A detailed TCO model not only ensures transparency but also strengthens funding proposals, helping research centers and universities align their resources with their research objectives.



# Common Pitfalls for Research Centers and Universities

As several research centers and universities have gotten to experience, transitioning to metal AM isn't as simple as upgrading to a newer version of a polymer printer. Research centers and universities must grapple with unique challenges, from safety concerns to post-processing requirements. Here's what to consider:

1

### MISALIGNED EQUIPMENT CHOICES

**Oversight:** Research centers and universities sometimes choose systems without considering their specific research needs, leading to underutilized assets. For example, choosing a closed-material platform, inadvertently limiting its ability to develop novel alloys. (the same pitfall exists for teaching-focused centers as well, who might be dazzled by a complex research-grade machine—only to find that its students / employees can't safely use it and that the EH&S protocols prevent broader access to the machine).
**Mitigation:** Define clear objectives and prioritize systems that support these objectives. E.g. for a research-focused institution, opt for technologies that enable flexibility, scalability, and material innovation.

2

### IGNORING POST-PROCESSING CHALLENGES

**Oversight:** Many research centers and universities underestimate the importance of post-processing. Without this step, even the best-printed parts remain unusable, creating bottlenecks and frustration for students and researchers alike.
**Mitigation:** Either invest in post-processing capabilities upfront or establish partnerships with providers who can fill this gap reliably.

3

### UNDERESTIMATING TOTAL COST OF OWNERSHIP (TCO)

**Oversight:** When research centers and universities budget for a metal AM system, they often focus exclusively on the printer itself. Unfortunately, this is like buying a car without budgeting for tires, fuel, or a driver's license. EH&S equipment, training programs, and post-processing tools can significantly inflate the overall cost.
**Mitigation:** Develop a comprehensive budget that includes all ancillary costs to prevent project delays and funding gaps. If budgets are tight, consider phased investments, starting with the core system and expanding capabilities over time (for example: If considering a sinter-based technology and the current funds are insufficient for the purchase of a furnace, consider in lieu the interim costs of outsourcing sintering till such a budget becomes available).

# Research-Focused VS Teaching-Focused Universities

| | Research-Focused Centers & Universities | Teaching- Focused Centers & Universities |
|---|---|---|
| Key Need | Systems that allow for new material development and high-performance applications. | User-friendly systems that prioritize safety and ease of operation. Teaching-focused centers and universities benefit from intuitive, safety-first systems that maximize user engagement while minimizing operational risks. These systems are ideal for introducing users to AM fundamentals, laying the groundwork for careers in advanced manufacturing. |
| How | **Open Materials:** For research-focused centers and universities, the ability to innovate with open-material platforms is not merely a functional advantage—it's a strategic imperative. Open systems empower researchers to address niche industrial challenges, develop groundbreaking alloys, and secure long-term funding partnerships. | **Safety First:** Systems with minimal EH&S concerns enable broader user access, fostering hands-on learning. |
| | **Advanced Features:** Complex geometries, high-temperature alloys, and multi-material capabilities can unlock cutting-edge applications. | **Ease of Use:** Choose systems with intuitive interfaces and automated processes to reduce the learning curve. |
| | **Industry Partnerships**: Collaborate with aerospace, automotive, or medical industries to fund and co-develop advanced research initiatives. | **Dual Capability:** Hybrid systems that support both polymer and metal printing offer versatility and maximizing ROI. |
| Example Use Case | Exploring materials for aerospace or medical applications. | Introducing undergraduates to metal AM fundamentals. |

# Roadmap for Successful Adoption

1

**ALIGN WITH INSTITUTIONAL GOALS**

Define the role of metal AM in the research center or the university's research agenda.

2

**EVALUATE TECHNOLOGIES**

Choose systems based on flexibility, scalability, and compatibility with institutional capabilities.

3

**PLAN FOR SAFETY & COMPLIANCE**

Develop protocols for material handling, air filtration, and operator training.

4

**BUDGET FOR FULL LIFECYCLE COSTS**

ncorporate all operational expenses into funding proposals.

5

**ENGAGE WITH INDUSTRY**

Build partnerships to enhance research output and funding

# Future Trends in Metal AM

1 **SUSTAINABILITY IN AM PROCESSES**

Metal AM's ability to reduce waste and optimize material usage aligns with the global push for sustainable manufacturing. Research centers and universities are well-positioned to drive research into recyclable materials and energy-efficient processes.

2 **NEW FRONTIERS IN MATERIALS SCIENCE**

As metal AM matures, the focus is shifting to advanced materials such as high-temperature alloys and ceramics. Research centers and universities will play a pivotal role in developing these materials and expanding the applications of AM.

3 **AUTOMATION AND AI INTEGRATION**

Emerging trends include the use of artificial intelligence to optimize print parameters, predict material behaviors, and reduce defects. These technologies will make metal AM processes more efficient and scalable.

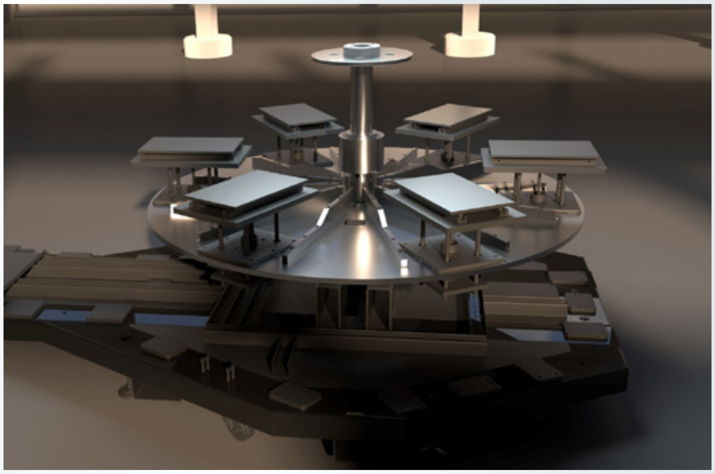
# How Fraunhofer Leveraged Tritone's MoldJet To Develop Inconel 713C

Fraunhofer IFAM Dresden, one of the leading institutes in powder metallurgy, conducts fundamental and applied research for solution-oriented material and technology development for sintered, composite and functional materials as well as cellular metallic materials for energy technology, mobility, and medical technology.

Fraunhofer IFAM in Dresden, became a beta tester of Tritone's MoldJet technology using the DOMINANT machine, leading to:

- Development of new paste systems (use of all sinterable metal powders such as stainless steel, tool steel, high temperature alloys, nickel-based alloys, titanium, copper-based materials possible). This led to develop a new material – Inconel 713C.
- Component / geometry development and testing
- Customer-specific profitability analysis
- Establishment of the entire process chain from material development to printing processing and sintering to dense metal components (> 99%)
- Process optimization / design according to customer requirements

Check out Fraunhofer Printer Talks >

Fraunhofer
IFAM

# Conclusion: Innovation Through Collaboration

Research centers and universities stand at the forefront of technological advancement, uniquely equipped to drive the evolution of metal AM. However, realizing the full potential of this transformative technology requires careful planning and alignment with strategic goals.

By embracing open platforms, universities can:

1. Unlock new research opportunities in materials science and advanced manufacturing.
2. Enhance industry collaboration, creating pathways for funding and innovation.
3. Prepare users to lead in high-demand fields shaped by metal AM.

Moreover, as the manufacturing landscape shifts toward reshoring and sustainability, research centers and universities that invest in scalable, open-material systems will not only keep pace with industry trends but also shape them. Investing in technologies that prioritize flexibility, efficiency, and collaboration will position these research centers and universities at the forefront of manufacturing innovation.

**Now is the time for research centers and universities to double down on metal AM—not just as a tool for research but as a driver of economic and societal progress. Through strategic investments and forward-thinking partnerships, these centers can lead the charge in shaping the future of advanced manufacturing.**

# About Tritone Technologies

Tritone Technologies transforms metal Additive Manufacturing to address the demanding standards and needs of industrial production. The company's innovative technology enables industrial throughput of accurate parts with a range of metal and ceramic materials, suitable for the Automotive, Consumer Electronics, Defense, Fashion, Medical, Industrial, and Tooling industries. Partnering with leaders from the education and research industry, Trintone aim to encourage exploring new materials to address niche industrial challenges and develop high performance applications.

Read more about Tritone's Moldjet Technology: www.tritoneAM.com | Info@tritoneAM.com