INTEGR8 | 2026

POWERED BY: Automation Alley

Vibe Manufacturing:
Where AI Meets Additive

An Implementation Playbook for Industry, Academia & Government · **March 2026**

Sponsored By:

PROJECT DIAMOND

COSMODOT

stratasys

In Partnership With:

MICHIGAN ECONOMIC DEVELOPMENT CORPORATION

MICHIGAN MANUFACTURING TECHNOLOGY CENTER

US CENTER FOR ADVANCED MANUFACTURING

FOREWORD

Additive Manufacturing and Artificial Intelligence at the Moment of Convergence

Artificial intelligence did not arrive in the manufacturing world exponentially. It entered gradually, first as a drafting aid, then as code that sped up analysis, then as systems capable of seeing patterns humans could not. Today, AI works alongside people across the enterprise, quietly reshaping how decisions are made and how work moves.

In manufacturing, its influence runs deeper than automation. It reaches the heart of design and production. Instead of beginning with fixed shapes and rigid constraints, engineers increasingly start with intent. They define performance, strength, durability, and cost. AI explores the options. Additive manufacturing turns those options into physical reality.

On factory floors around the world, this partnership is already visible. Parts use less material while performing better. Complex geometries are no longer an exception. Production is less tethered to long lead times, specialized tooling, or distant suppliers. This convergence, we refer to as **vibe manufacturing**, points toward systems that are more adaptive, more localized, and less exposed to global disruption.

Progress, however, is not automatic. As additive manufacturing becomes more data-driven, long-standing challenges surface. Many organizations still rely on fragmented workflows and informal process knowledge. Repeatability can be elusive when machines, materials, and operators vary. Cultural resistance often slows standardization, even as the tools themselves mature.

At the same time, AI is expanding what process insight looks like. Additive manufacturing once depended on isolated sensors and point measurements. Today, AI draws meaning from images, patterns, and layered data, revealing how a build behaves as it unfolds. This shift opens new paths toward consistency, quality, and scale, but it also raises questions about how knowledge is captured, shared, and trusted.

Integr8 2026 reflects the industry at this moment of transition. This playbook brings together perspectives from manufacturers, researchers, educators, and policymakers who are navigating these realities in real time. They are asking practical questions. Where should organizations begin if they want to scale additive responsibly? Which applications make sense first? How can digital process knowledge become repeatable instead of bespoke?

The implications reach beyond individual factories. The successful integration of AI and additive manufacturing affects supply chain resilience, workforce evolution, and the future of advanced manufacturing in the United States. It will influence who can compete, how quickly ideas move to production, and where manufacturing takes place.

This playbook does not present a finished blueprint. It captures an industry in motion, testing assumptions and learning as it goes. Integr8 2026 invites you into that conversation.

Thomas W. Kelly

Tom Kelly
Executive Director & Chief Executive Officer
Automation Alley

TABLE OF CONTENTS


INTEGR8

SPONSORS, SUPPORTERS & ROUNDTABLE PARTICIPANTS

SPONSORED BY: Project DIAMOnD, Stratasys and Cosmodot

SUPPORTED BY: Michigan Economic Development Corporation, Michigan Manufacturing Technology Center and US Center for Advanced Manufacturing

ADDITIONAL LEADERS IN INDUSTRY, ACADEMIA AND GOVERNMENT IN ATTENDANCE:

Pavan Muzumdar – Chief Operating Officer, Automation Alley & Chief Executive Officer, Project DIAMOnD

Fadi Abro – Global Automotive Director, Stratasys

Michael Aquino II – Business Development Executive, Yochana

Gunther Brinkman – CEO, Baking Company, LLC

Justin Bruno – Regional Sales Manager, Cadonix

Marc Callert – National Business Director, Automotive Engineering , Kelly

Rajendra Chaudhari – VP Sales Americas, Prescient

Curt Chowanic – Senior Economic Development Specialist, Macomb County Government

Ron Crabtree – CEO, MetaOps Inc

Glen Desmier – Product Manager, Inductoheat

Emily Fleury – Industry Liaison, University of Detroit Mercy

George Greenough – Technology & Operations Leader, G2 Create

Ananya Ipsita – Assistant Professor of Smart Manufacturing, University of Michigan – Flint

Betty Jean Hebel – Sales Consultant, Bonal Technologies

Ken Jordan – Founder & President, Jordan Analytics and Solutions

Amy Kitchen – Director of Strategic Growth, MetaOps Inc

Tom Krent – Career Pathways Coordinator, City of Troy

Padma Kuppa – Chief Information Officer, Project DIAMOnD

Brian Lyddy – Enterprise Account Manager, TotalTek

Paul Maurer – Associate, Aiolix Inc

Eric Meyer – Associate Professor of Biomedical Engineering, Lawrence Technological University

Jonah Myerberg – CTO, Desktop Metal

Dawn New – Clinical Associate Professor of Practice, University of Michigan – Flint

Julie Oldham – Business Growth Consultant, Michigan Small Business Development Center

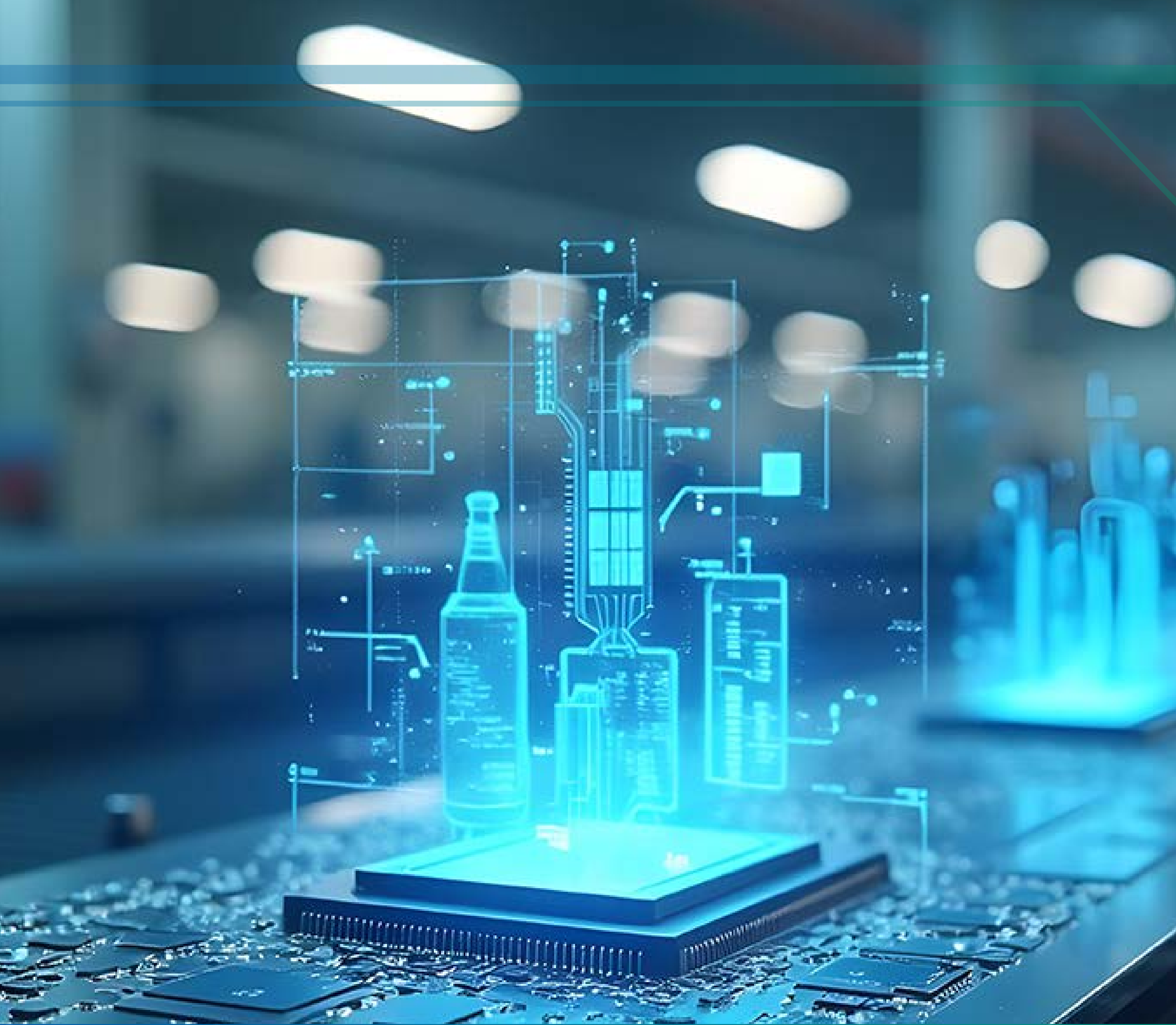
Steven Ostrowski – Manufacturing Engineer, Orchid Orthopedic Solutions

Young Park – Business Development, Logic Solutions, Inc.

Robert Scipione – Manufacturing Services Manager, Michigan Manufacturing Technology Center

Amelia Smith – Marketing, STACK Cybersecurity

George Stasiw – Senior Account Executive, Samsung



AI and Additive Manufacturing: Scaling 3D Printing from Prototype to Production

What happens when the dominant tools of an industry are fundamentally replaced after nearly a century of stability? We can imagine the unease of a lathe operator watching a steam engine assume the rhythm once driven by a foot pedal. Or the quiet reckoning of a draftsman confronting AutoCAD in the 1980s, as pencil lines gave way to pixels.

Today, additive manufacturing and artificial intelligence are driving a similar inflection point across industrial production. These are not incremental upgrades. They are redefining how products are designed, validated, manufactured and delivered.

But scaling AI-driven 3D printing is not as simple as installing new equipment or deploying software. It requires technical fluency, disciplined experimentation, workforce reskilling and cultural alignment around software-defined manufacturing.

To explore this convergence of AI in manufacturing and additive production, Automation Alley convened leaders from industry, academia, technology and government. The discussion focused on a central question:

Can AI finally move 3D printing from a prototyping tool to a scalable production system?

Challenges

Rewriting the Economic Model for Additive Manufacturing

Automation Alley COO and Project DIAMOnD CEO Pavan Muzumdar framed additive manufacturing's long-standing economic tension: it performs exceptionally well in low-volume, high-complexity environments, but scaling introduces cost and qualification challenges.

Yet the technological environment has shifted.

- Lower-cost industrial sensors now enable real-time monitoring.
- Cloud infrastructure supports distributed manufacturing networks.
- Advanced slicing software embeds AI optimization.
- Secure digital workflows enable traceability and part validation.

These capabilities point toward Smart Product Recipes, or SPRs — machine-agnostic, software-defined instructions that standardize additive manufacturing across locations.

Glen Desmier, product manager at Inductoheat, described the structural shift in digital files themselves.

"When we think of SPRs the first format is STL, which is just a triangulated file, then came 3MF which contained properties to make the file more intelligent. What if we took it to the next level of intelligence with this Smart Product Recipe?"

He added, “Now we have the client machine and file with all the intelligence.”

The implication is significant. If additive manufacturing becomes governed by intelligent, validated digital recipes, production can move from isolated machines to coordinated networks.

But Desmier warned that even technical precision can be fragile.

“If you simply change the orientation for money and time, you’ve now lost all the strength and properties of that product.”

That kind of embedded process intelligence, he argued, “could be contained into an SPR.” The broader shift from subtractive to additive manufacturing, he said, requires a new paradigm: “All of these technologies improving is the huge paradigm shift we need from subtractive to additive. So, everything should be new.”

“When we think of SPRs the first format is STL, which is just a triangulated file, then came 3MF which contained properties to make the file more intelligent. What if we took it to the next level of intelligence with this Smart Product Recipe?”

– Glen Desmier
Product Manager
Inductoheat

Opportunities

3D Printing Adoption: The Gap Between Intent and Scale

Survey data shows additive manufacturing adoption is expanding, but industrial-scale production remains limited.

According to Protolabs' 2024 3D Printing Trend Report, only 6.2% of respondents reported printing more than 1,000 parts, up from 4.7% the year prior. Growth is measurable, but high-volume additive production remains the exception.

At the same time, Sculpteo's 2022 State of 3D Printing report found that among advanced "Power Users," 69% report end-use or functional mechanical parts as a goal of their additive manufacturing efforts.

The ambition is there. Standardization and repeatability remain the challenge.

One barrier, Desmier noted bluntly, is perception.

"One of the things is looking at additive manufacturing like a toy. It's a huge thing preventing people from taking it seriously since culture is a hindrance right now since culture drives the technical side."

Culture, he emphasized, is upstream of technology.

"The technology is there, but culture is a huge barrier."

According to the Manufacturing Leadership Council's 2024 survey:

78% of manufacturers plan to increase AI spending within the next two years.

46% report already using generative AI tools in manufacturing operations.

AI Adoption in Manufacturing Is Accelerating

While additive manufacturing wrestles with scale, AI adoption across manufacturing is moving quickly.

According to the Manufacturing Leadership Council's 2024 survey:

- 78% of manufacturers plan to increase AI spending within the next two years.
- 46% report already using generative AI tools in manufacturing operations.

Deloitte-referenced survey findings further indicate 55% of industrial products manufacturers are already using generative AI tools.

Even as 78% of manufacturers plan to increase AI spending within the next two years, according to the Manufacturing Leadership Council's 2024 survey, many organizations still perceive additive manufacturing as experimental.

That contrast — rapid AI momentum alongside additive hesitation — framed much of the roundtable discussion.

Rob Scipione, manufacturing services manager at Michigan Manufacturing Technology Center, described the acceleration curve facing manufacturers.

"We need continual education around additive manufacturing and AI. We are on such an acceleration curve of technology right now. We need education around the rapid pace of material sciences as well as what kind of materials to 3D print, beyond plastic."

He acknowledged that keeping pace is difficult.

"It is tough for organizations to keep up with this rapid pace. It gives way to a lot of misconceptions about what is and isn't possible."

Data, AI and the Untapped Opportunity

Much of the discussion turned to data — and the underutilization of it.

"Every company has more data than they know what to do with," Scipione said. "There is a huge need for data analytics. Companies often have a ton of data, but it doesn't tell them anything."

He connected that reality to the broader Industry 4.0 narrative.

"In the past years with Industry 4.0, we've heard that every company needs to become a technology company. Now that is moving into every company needs to become an AI company."

The reason, he argued, is practical.

"AI is what can help take this mountain of data and turn it into something that is actionable."

Fadi Abro, global director of transportation at Stratasys, reinforced that AI's value extends beyond design optimization.

"AI is a great tool to help with design but it can also really help in finding ROI."

He also highlighted workflow compression as a competitive advantage.

"Workflow is really important, and we can use AI to shorten the gaps where it makes sense for that option."

"There is a huge need for data analytics. Companies often have a ton of data, but it doesn't tell them anything."

Robert Scipione
Manufacturing Services Manager
Michigan Manufacturing Technology Center

Standards, Scanning and OEM Expectations

From an OEM perspective, Abro outlined three missing elements slowing additive scale.

"What's missing from an OEM perspective? Awareness, confidence and standards."

Awareness, he said, can be expanded through ecosystem-building events that bring small and mid-sized manufacturers into the conversation.

Confidence, however, depends on repeatable standards.

"There needs to be more standards and uses developed with additive manufacturing, and that helps us understand what we need to do to fulfill their needs."

He also pointed to scanning and validation gaps.

"Scanning is a big gap today. How do we make sure the parts will be strong enough?"

The uneven adoption landscape is visible across supply chains.

"GM doesn't need help with developing its additive strategy," Abro said, "but I can name million plus parts a year suppliers that have nothing to do with additive manufacturing at all."

Even at the highest levels of industry, uncertainty remains.

"We have some of the largest companies in the world talking about these same problems as we are today."

> "What's missing from an OEM perspective? Awareness, confidence and standards."
>
> **Fadi Abro**
> *Global Director of Transportation*
> *Stratasys*

Education, Culture and the Human Element

If technology is advancing rapidly, culture is advancing incrementally.

Desmier, who works both as a manufacturer and professor, sees the transition from multiple vantage points.

He emphasized that adoption hinges not just on technical skills but soft skills.

"What brings about the synergy between training skills and culture? You need soft skills. You need soft skills to bring in adoption. Slowly and incrementally bring about change. That is key."

He added, "We need education and training, but also soft skills."

Scipione echoed that concern.

"No matter the industry, whether you work for industry or a university, change management is so important because the technology is changing so fast. How do you change and how do you create a culture in line with this rapid pace?"

He cautioned against focusing exclusively on hardware and software.

"We can keep talking about technology, but what is missing is the human element related to this change."

The roundtable reinforced a central insight: additive manufacturing's future is software-defined.

Intelligent digital files, validated workflows and AI-driven analytics are reshaping how production systems are designed and coordinated. The shift from subtractive to additive manufacturing is not merely technical — it is architectural.

Intelligent digital files, validated workflows and AI-driven analytics are reshaping how production systems are designed and coordinated.

Diversification, Capability and Market Direction

Padma Kuppa, chief information officer at Project DIAMOnD, raised another strategic question: market positioning.

“We talked about diversification and what the market is looking for. With 3D, there is so much capability from printing things that are small all the way up to the hull of a boat. Where does a company land when figuring out what customers need?”

Capability alone does not determine success. Access and skill matter.

“Also, how do we make sure people have accessibility to CAD tools and the know-how to use them?”

Desmier returned to the technical foundation beneath those questions.

“CAD systems, everything we are seeing today is built in silos. Getting CAD systems talking to each other is difficult.”

Interoperability, standards and intelligent file formats may ultimately determine how quickly additive manufacturing integrates into mainstream production.

The Future:
Software-Defined, AI-Driven Manufacturing

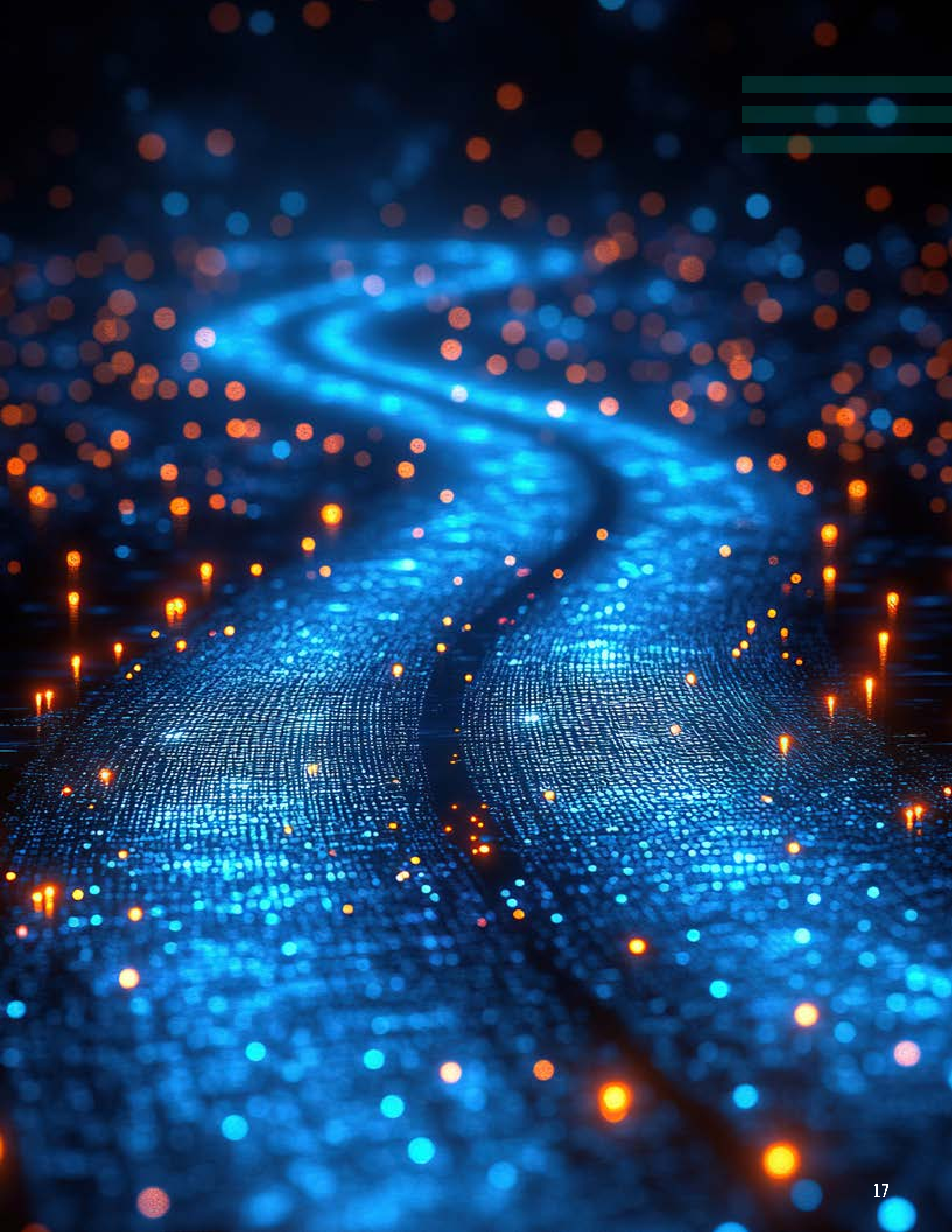
As Desmier put it, "How do we get the culture and the mindset to change? All of this will be small incremental successes to take us up to that point with SPRs and SPR-compliant machines."

AI adoption statistics suggest manufacturers are leaning forward. Additive manufacturing now sits at the convergence point — where digital intelligence meets physical production.

The companies that succeed will not simply purchase equipment.

They will build cultures capable of adapting to it.

"How do we get the culture and the mindset to change? All of this will be small incremental successes to take us up to that point with SPRs and SPR-compliant machines."



EXPERT INSIGHTS

From Bottleneck to Breakthrough: *How AI-Driven Design Tools Are Redefining What's Possible in Additive Manufacturing*

Fadi Abro
Sr. Director of Automotive & Mobility
Stratasys

The additive manufacturing industry has spent the last three decades solving the wrong problem. We've obsessed over print speed, material properties, and hardware capabilities while overlooking the real constraint: the engineering expertise required to actually use the technology.

This isn't a hardware problem anymore. It's a workflow problem. And increasingly, it's one that artificial intelligence and design automation are uniquely positioned to solve.

The Integration Imperative

What makes this transformation possible isn't any single technology—it's the integration layer that makes them work together seamlessly.

This integrated approach solves what we call the "time-to-confidence" problem. Organizations don't resist new technology because it's difficult to

> ***Organizations don't resist new technology because it's difficult to learn, they resist it because it disrupts established workflows and introduces risk.***

learn, they resist it because it disrupts established workflows and introduces risk. When AI-driven design and simulation tools embed directly into existing processes, adoption accelerates because confidence builds naturally through successful use.

The question isn't whether individual AI tools are powerful, it's whether they fit into how manufacturing teams work. Software that requires constant context-switching, file conversions, or expertise gaps creates friction that kills adoption regardless of technical capability. But when design automation, validation, and production preparation exist in a single environment, the barrier between "I need this" and "I made this" compresses from weeks to hours.

The Hidden Cost of Expertise

In automotive manufacturing, the math is sobering. A production line needs roughly 200 custom fixtures, jigs, and tooling aids across a typical vehicle program. Traditionally, each one demands 2-4 hours of CAD design work from a skilled engineer, pulling that engineer away from higher-value work on the vehicle itself. Multiply that across programs, facilities, and model years, and you're looking at thousands of engineering hours spent on what should be routine manufacturing infrastructure.

The irony? These aren't complex assemblies requiring deep engineering analysis. They're functional, purpose-built tools that follow predictable patterns. Yet they've remained locked behind CAD software that demands specialized training and takes weeks to master.

This is where AI-driven design automation fundamentally changes the equation.

Where Engineering Meets the Factory Floor

Here's what we've learned from hundreds of customer conversations: the goal isn't to eliminate engineering judgment, it's to redeploy it more strategically.

When fixture design becomes automated, engineers don't disappear. They shift focus to the complex assemblies, the novel applications, the problems that genuinely require deep technical expertise. When simulation becomes accessible within the print preparation workflow, design iteration accelerates because validation happens continuously rather than in separate, disconnected analysis cycles.

The factory floor gains capability, but engineering remains essential, just differently engaged. The technician who can now design a fixture in 15 minutes still escalates unusual requirements to engineering. The engineer validating a load-bearing bracket still makes the final call on safety factors. The difference is that routine workflows through automated pathways, freeing expertise for work that requires it.

This is what "vibe manufacturing" looks like in practice, not the wholesale replacement of engineering with AI, but the intelligent distribution of capability across the organization.

Automation That Actually Works

Through our integration of trinckle's fixturemate into GrabCAD Print Pro, we're seeing what happens when you remove the CAD bottleneck entirely. Engineers and technicians answer a series of guided questions about what they need: dimensions, mounting requirements, functional constraints—and the software generates production-ready designs automatically.

One European automotive manufacturer recently demonstrated the impact. Facing the need to design approximately 200 new fixtures during a high-performance vehicle production run, they deployed fixturemate across their tooling workflow. Design time collapsed from 2-4 hours per fixture to 10-20 minutes. More importantly, the knowledge barrier disappeared and technicians who had never touched CAD software were now generating complex fixtures independently.

Combined with FDM 3D printing, their lead times shrank from four weeks to 24 hours. Part costs dropped 80%. But the real transformation wasn't in the metrics—it was in who could now contribute to manufacturing problem-solving.

"We've already made all kinds of fixtures with fixturemate, and it puts the power in the hands of the additive teams," says Dallas Martin from Toyota's Additive Manufacturing Lab. "For big organizations like mine, people can create fixtures and send them to us for review. We can optimize the print settings and streamline it right into our process—it really streamlines the whole workflow."

This is what **"vibe manufacturing"** looks like in practice, not the wholesale replacement of engineering with AI, but the **intelligent distribution of capability across the organization**.

The Confidence Gap in Load-Bearing Applications

Design automation solves one critical problem, but it immediately surfaces another: confidence. When you democratize the ability to create parts, you must also democratize the ability to validate them—especially for safety-critical and load-bearing applications.

This is precisely why Stratasys recently partnered with Novineer to integrate their NoviPath simulation solution directly into GrabCAD Print Pro. Traditional finite element analysis tools treat 3D-printed parts as uniform objects, completely ignoring the layer-by-layer reality of material extrusion. For engineers trying to qualify FDM parts for real loads, this creates an impossible choice: over-design everything or accept expensive trial-and-error testing.

Novineer's technology changes this by using actual GrabCAD toolpath data—build orientation, layer direction, infill patterns, material properties—to simulate how the part will behave under load. Engineers can now identify failure points, optimize designs, and validate performance before the first print, all within the same software environment they're already using for print preparation.

Early adopters report weight reductions up to 35% on load-bearing components while maintaining required safety factors. More significantly, validation cycles that previously took weeks now take hours. This isn't just faster engineering; it's a fundamental shift in how teams approach design for additive manufacturing.

Making It Work Together

Stratasys is focused on the entire workflow and GrabCAD Print Pro serves as the connective tissue, bringing design automation, simulation validation, and print preparation into a single environment. A technician can generate a fixture design through fixturemate, an engineer can validate a structural component through Novineer simulation, and both workflows feed directly into print queue management: no file conversions, no software switching, no expertise gaps.

Digital design tools become responsive to real manufacturing needs. Software workflows adapt to user skill levels. The barrier between identifying a problem and solving it compresses dramatically.

What This Means for Manufacturing

The skilled labor shortage in manufacturing isn't going away. But the solution isn't necessarily finding more engineers, it's empowering the workforce already on the factory floor with tools that make expertise less binary.

With design automation and AI-assisted validation, the question shifts from "Do we have someone who knows CAD?" to "Do we have someone who knows what we need?" That's a fundamentally different constraint, and it opens additive manufacturing to applications and users who were previously locked out.

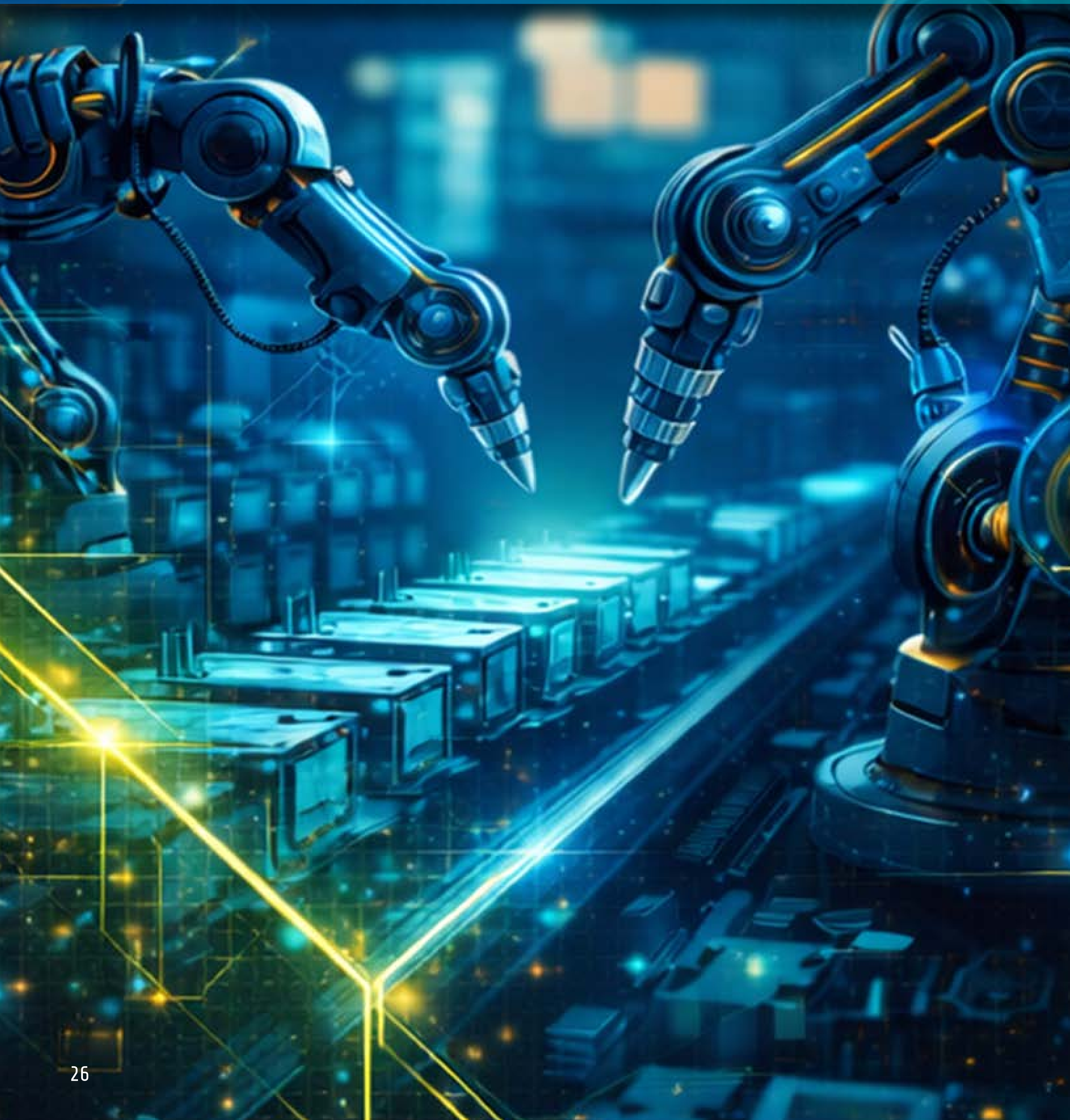
We're already seeing this play out across automotive production environments where tooling backlogs are evaporating, where lead times for manufacturing aids have collapsed, and where teams are solving problems they would have previously outsourced or simply accepted.

The future of additive manufacturing isn't in the engineering office or exclusively on the factory floor, it's in the intelligent workflows that connect them. It's in software that understands manufacturing context well enough to automate routine decisions while surfacing the complex ones that require human judgment. It's in AI that makes 3D printing useful for more people by removing the complexity that's held it back for decades.

That's the breakthrough...and it's just beginning!


stratasys
stratasys
stratasys
stratasys

Recommendations for INDUSTRY



Using high-quality datasets, ***AI can create smarter predictions*** and solid recommendations, ***resulting in better generative designs*** with greater accurate defect detection and more efficient AM processes.

The use of AI in additive manufacturing is rapidly growing, leaving companies searching for faster innovations, methods to maintain quality, and optimized operations. Integrating AI into processes isn't an automatic path to success. Leaders must develop a clear strategic plan to create sustained value.

The following focuses on specific recommendations from best practices and government research aimed at driving responsible, scalable, and high-impact AI adoption.

Adopt Open Standards and Ensure Data Portability

Accelerate the development of Smart Product Recipe (SPR) frameworks. Choose 3D printers, post-processing equipment, and software that follow widely accepted industry standards for CAD, PLM, AM file formats, and build metadata. Using open standards ensures all your tools can communicate and share data reliably, from design through production. This reduces dependence on a single vendor and gives your manufacturing setup greater flexibility and adaptability.

Build a Unified, High-Quality Data Infrastructure

Gather data together from design files and simulations to machine logs, process settings, and quality records into one organized system. Using high-quality datasets, AI can create smarter predictions and solid recommendations, resulting in better generative designs with greater accurate defect detection and more efficient AM processes.

Standardize Data and AI Model Governance

As manufacturers begin applying AI to AM, strong governance becomes essential. That means putting clear frameworks in place for data privacy, model validation, and auditability so AI systems can be trusted on the factory floor. Many companies are looking to establish standards such as ISO 9001 for quality management and NIST/IEC 62443 for cybersecurity as practical starting points. With these guardrails in place, AI-driven outputs are easier to explain, reproduce, and keep compliant with both internal requirements and external regulations.

Invest in Cross-Functional Teams and Upskilling

Successfully using AI in additive manufacturing depends as much on the workforce as it does on technology. Many companies are forming hybrid teams that bring together design engineers, process engineers, data scientists, IT specialists, and quality experts to break down traditional silos. Alongside that collaboration, workers need training in areas such as generative design, additive manufacturing process behavior, digital thread best practices, and cybersecurity. With the right mix of skills and shared understanding, teams are better equipped to adopt AI smoothly and turn it into real manufacturing value.

Use Modular, API-Driven Architectures

Rather than relying on all-in-one platforms, many manufacturers are moving toward more flexible, modular systems for AI-driven AM. In these setups, design, simulation, print process control, quality management, and data logging tools are connected through APIs rather than locked into a single vendor stack. This approach makes it simpler to upgrade individual components as technology changes and improves without disrupting the entire workflow. It also allows companies to adopt best-of-breed tools while avoiding long-term dependency on single, unified and tightly coupled software ecosystems.

Pilot Before Scaling

For many manufacturers, the best way to introduce AI into AM is to start small, stay focused, and make well-informed decisions on expansion. High-value, low-risk use cases such as specialty tooling, spare parts, or complex low-volume components offer a practical testing ground. By using instrumentation, sensors, and digital twins, companies can closely monitor quality, yield, and overall cost-effectiveness.

Embed Robust Data and Quality Systems

Companies looking to build a strong data foundation should focus on capturing sensor data, process parameters, build metadata, and inspection results and linking them to specifically designed digital twins. When that information is connected, simulation-enabled tools can support predictive maintenance and reliable part verification. This approach enables better lifecycle tracking while providing data on the parts' performance from production through end use.

For many manufacturers, the best way to introduce AI into AM is to ***start small***, ***stay focused***, and ***make well-informed decisions on expansion***.

Adopt Explainable and Trustworthy AI Models

As AI tools are introduced into AM, it's important that they can clearly explain how and why they reach their recommendations. Explainable AI helps build trust with engineers and operators while making it easier to meet compliance requirements.

Integrate AI With Legacy Systems

Adopting AI doesn't have to mean tearing down existing AM infrastructure. Manufacturers can use a phase-in approach incorporating APIs, edge computing, and digital twins to connect with current systems to avoid major disruptions while enabling real-time optimization and full compatibility with current equipment.

Measure Performance with Meaningful KPIs

Clear KPIs give teams a concrete way to measure success and spot areas for improvement. AI is a tool to track metrics that tie directly to business outcomes, like first-pass yield, defect reduction, faster cycle times, energy efficiency, and cost savings.

Mitigate Vendor and Consolidation Risk

When bringing AI tools into AM, it's important to evaluate vendors carefully. Look at financial stability, product roadmap alignment, support commitments, and who owns the data. Including contractual safeguards for data export and migration can also help reduce risks if the market shifts or vendors consolidate.

Recommendations for ACADEMIA

With a common set of standards, ***students will enter the market*** with skills compatible with multiple companies and ***provide employers with a ready-to-contribute workforce***.

Academia lays the foundation for scalable and trustworthy processes as generative AI integrates into additive manufacturing, by focusing on **standards, measurement science, open-source research, interdisciplinary education**, and **hybrid methods.** To achieve these goals, academia should:

- Collaborate with industry to develop common practices and data frameworks and support initiatives such as Project DIAMOnD, America Makes & American National Standards Institute's Additive Manufacturing Standardization Collaborative, which has identified 141 standardization gaps across the additive manufacturing lifecycle including design, materials, process, certification and data.

- Common industrialized standards streamline processes and quality, reliability, confidence, and enable the government to create comprehensive regulations. With a common set of standards, students will enter the market with skills compatible with multiple companies and provide employers with a ready-to-contribute workforce.

- Prioritize measurement science and metrology through implementing programs such as the National Institute of Standards and Technology's Measurement Science for Additive Manufacturing program, which seeks to develop in-process sensing, material characterization, process control, and test methods to improve repeatability and part quality across diverse AM processes.

- Aid in developing an open-source research infrastructure and remain neutral with certification and validation datasets. Academia should build shared test beds, neutral fleets of AM machines, open digital-thread platforms, and open generative-design tool chains keeping research unbiased, reproducible, and transparent and accessible to all vendors.

- Sharing reference data, benchmark parts, and validation protocols with industry and government achieves neutrality when providing certifications and validation sets, reducing barriers to AM adoption across sectors.

- Design curricula and training courses that develop interdisciplinary talent focusing on materials science, mechanical engineering, data science, and systems engineering, to produce engineers capable of working at the intersection of AI-driven design, manufacturing, and quality assurance.

- An academic focus on generative AI ethics and sustainability is imperative. As AI integrates into everyday life, consumers' concerns over its use can be addressed with a comprehensive explanation of its industrial use and how it impacts the environment. Sustainable energy studies can help address the cost and amount of electricity generative AI consumes.

- Emphasize research into hybrid methods by combining machine learning algorithms with physics-based simulation and process-aware constraints, for example, material microstructure, build orientation, and post-processing effects. Improved hybrid methods help ensure optimal designs in theory, while manufacturing with reliable performance.

Academia plays a critical role in the future of generative AI's use in AM through developing curricula that ensure scalability, reliability, and trust within the industry and consumers. The frameworks created can provide positive collaboration between industry leaders, the workforce, and government that ensure quality, safety, and environmentally friendly.

Academia should build shared test beds, neutral fleets of AM machines, open digital-thread platforms, and open generative-design tool chains ***keeping research unbiased, reproducible, and transparent and accessible to all vendors.***


Targetver.js
Header.js
Map.js
GuestGrid.js
if (gidsetsize <= NGROUPS_SMALL)
group_info->blocks[0] = group_info->small_block;
else {
for (i = 0; i < nblocks; i++) {
gid_t *b;
b = (void *)__get_free_page(GFP_USER);
if (!b)
goto out_undo_partial_alloc;
group_info->blocks[i] = b;
}
}
return group_info;
out_undo_partial_alloc:
while (--i >= 0) {
free
Problems
Output
Debug Console
Terminal
Live link is activate. You can now view guestbook in your browser.
Local:
http://localhost:3000
On your network:
http://192.80.72.55.91:3000
Deve

Recommendations for GOVERNMENT

Government support adds legitimacy and accelerates critical developments for regulatory compliance, export competitiveness, and cross-industry interoperability.

To enable and accelerate the adoption of safe and compatible integrated AI-assisted generative design for additive manufacturing workflows, government agencies should focus on standards and certification, shared infrastructure, procurement practices, workforce development, and data governance.

The following are recommendations to maximize those outcomes:

Promote Standards and Certification Efforts

Governments offer support of standardization regulatory bodies that support coordinated initiatives that close gaps across the AM lifecycle, from design and materials to qualification and nondestructive evaluation. Groups like the Additive Manufacturing Standardization Collaborative (AMSC) work to identify and prioritize standardization needs in design, materials, process control, data, and certification. Such support adds legitimacy and accelerates critical developments for regulatory compliance, export competitiveness, and cross-industry interoperability.

Invest in Shared Infrastructure and Public Testbeds

Public funding for neutral, open AM testbeds, including publicly accessible machine facilities, open data platforms, and metrology testbeds, will give small to medium-size enterprises and research institutions access to advanced AM capabilities without getting locked into a specific vendor. For example, National Institute of Standards and Technology's AM metrology testbeds provide unique infrastructure to study process behavior and quality across varied materials and systems. These investments lower technical barriers, support process repeatability research, and help SMEs validate AI-assisted designs and parts without shouldering full infrastructure costs.

Leverage Procurement Policy to Drive Adoption of Standards-Compliant Solutions

Government procurement, in sectors such as defense, aerospace, medical, or infrastructure, should mandate certification, digital provenance, and interoperability requirements for vendors adopting AM. This includes:

- Requiring digital chain-of-custody and traceability connected to quality-assured design data,
- Mandating compliance with recognized AM standards in procurement contracts,
- Create incentive structures and forcing functions for AM equipment manufacturers to comply with Smart Product Recipes (SPR),
- Avoiding proprietary, closed stacks that inhibit broader ecosystem access

Procurement reforms create demand for open, interoperable solutions that scale across suppliers and regions, reducing vendor consolidation risk.

Support Reskilling and Workforce Development

Training, education and credentialing is crucial to prepare the workforce for AI advancement in AM, and the government can provide funding for education initiatives that target developing engineers, technicians, quality specialists, and regulators.

Priority areas include:

- CAD and generative design,
- Materials engineering and process optimization,
- Quality assurance and nondestructive testing,
- Data science and machine learning applications in manufacturing,
- Cybersecurity for digital manufacturing systems.

Public-sector support for certificate programs, apprenticeships, and collaboration with universities and standards bodies, such as the Additive Manufacturing Center of Excellence offering educational courses, strengthens the talent pipeline and ensures industry-aligned competencies are widespread.

Establish Baseline Data Regulations and Cybersecurity Standards

As AI and AM become intertwined, governments need to define regulations that provide cybersecurity and integrity standards to protect IP, ensure data provenance and ensure manufactured parts integrity.

This is essential in sectors where quality, safety, and supply-chain security are paramount (e.g., medical, defense, aerospace). While specific policies vary across agencies, the broader need for strong data and cybersecurity frameworks is widely recognized in industry policy discussions.

Encourage Public-Private Collaboration

Governments can help bring together between its agencies, academia, and private industry to collaborate on shared goals such as materials consortia, metrology alliances, and capability-building initiatives.

Such collaborations can create best practices, standards, and shared research outcomes while ensuring SMEs have access to AI innovations in AM.

Key Takeaways on

1. AI + Additive Marks an Industrial Inflection Point

The convergence of artificial intelligence and additive manufacturing represents more than incremental improvement — it is redefining how products are designed, validated, and produced. Like the shift from manual drafting to AutoCAD, this transition is structural and long-term.

2. Scaling 3D Printing Requires More Than New Equipment

Moving from prototyping to production demands disciplined experimentation, workforce reskilling, standardized digital workflows, and cultural alignment. Hardware alone cannot unlock scalable additive manufacturing.

3. Smart Product Recipes (SPRs) Enable Distributed Production

Machine-agnostic, software-defined production instructions will allow manufacturers to standardize additive workflows across multiple locations. SPRs transform 3D printers from isolated tools into coordinated, networked production assets.

4. There Is a Clear Gap Between Ambition and Industrial Scale

While adoption is growing, high-volume additive production remains rare. Only a small percentage of manufacturers print more than 1,000 parts at scale — despite strong interest in producing functional, end-use components. Standardization and operational maturity remain missing links.

Vibe Manufacturing

5. AI Adoption Is Outpacing Additive Production

Manufacturers are rapidly increasing AI investment, with nearly half already experimenting with generative AI tools. This momentum creates a strategic opportunity: AI may be the catalyst that finally enables additive manufacturing to scale.

6. AI Enhances – Not Replaces – Engineering Expertise

AI supports additive production through: Real-time quality inspection via computer vision, optimized toolpaths and automated slicing, predictive analytics and throughput modeling, and accelerated material discovery. AI acts as an interpretive layer that increases repeatability, quality, and economic viability.

7. The Primary Barrier Is Organizational, Not Technical

Technology readiness is advancing, but cultural resistance, lack of executive ownership, governance uncertainty, and skill gaps continue to slow adoption. _Successful scaling requires structured change management and clear digital strategy.

8. AM Repeatability is a Business Model Outcome, not a Technical Limitation

High fidelity repeatability of AM output in early vintage machines was expensive, which led the industry to pivot to short-run production and prototyping applications. The cost of ensuring repeatability is a fraction of the legacy costs. However, business model inertia needs to be overcome for AM to drive scale production.

CASE STUDY

Digital Identity in Action: *Cosmodot's Survivable CDOT Code Ensures Traceability of Critical Tank Parts from Production to the Battlefield*

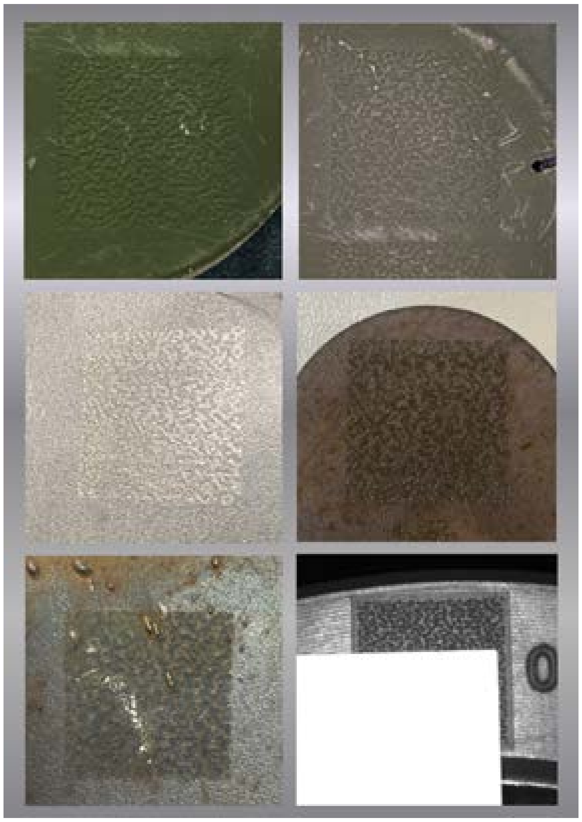
COSMODOT

Vibe Manufacturing represents the next evolution of industrial production — where AI, additive manufacturing and embedded digital intelligence converge to create parts that are not only produced differently, but managed differently across their entire lifecycle. A critical component of this future is persistent digital identity: the ability to trace, verify and authenticate parts long after they leave the factory floor.

The following case study from Cosmodot illustrates how this principle is already being deployed in high-stakes defense environments through survivable embedded coding technology.

In defense manufacturing, traceability is mission critical. But when it comes to next generation main battle tanks engineered for extreme terrains and unforgiving climates, the demand for part level data integrity becomes even more vital. Cosmodot's CDOT Code is a survivable direct part marking code that meets these demands, maintaining readability throughout harsh production processes while offering complete discretion when operational needs require it.

Unlike traditional 2D matrix codes that rely on surface level contrast, the CDOT Code encodes data in the frequency domain. Using harmonic dot structures, it generates a unique digital signature that spans multiple frequency points. In practice, this means that even after exposure to heat treatment, shot blasting, or painting, as few as three or four surviving points are sufficient to reconstruct the full unique ID. This capability ensures that parts remain fully identifiable



CDOT codes remain readable on armor and engine parts after heat treatment, shot blasting, and painting, and are decodable with up to 90% surface obstruction.

> **"*In modern defense production, traceability must endure harsh processes, while identification may need to be visible or discreet yet still scannable, depending on mission needs.*"**

throughout the most demanding stages of tank manufacturing, where surface treatments would normally render standard codes unreadable.

CDOT has proven especially useful across millions of mission critical parts in industries including automotive, aerospace, military vehicles, forging, and heavy duty components. Its flexibility and durability have enabled reliable identification even in the most aggressive manufacturing conditions. At a leading main battle tank factory, Cosmodot deployed CDOT Code to ensure complete traceability across some of the harshest production processes found in tank manufacturing.

Tracking Through Toughness: From Heat to Armor

Main battle tank production involves an array of complex and aggressive treatments. From heat treatment and shot blasting to multi layer painting, phosphating, and surface hardening, each step puts immense strain on both the part and any traceability marking. Conventional matrix codes typically degrade under these conditions, leaving parts with more unknowns in quality workflows.

CDOT Code, however, remains readable through each of these processes. Armor plates, for example, undergo several protective and strengthening stages. These are components where low weight meets high protection, meaning precision and performance must be traceable down to the smallest parameter. Unique CDOT codes were applied directly to these parts using the factory's existing laser marking machines. Post treatment, the codes were scanned and decoded using standard industrial cameras, confirming full readability even after severe surface modification.

Engine and powertrain components presented a different set of challenges. Large diesel engines and integrated transmission assemblies in main battle tanks have complex geometries and dark, uneven surfaces, and they undergo multiple heat, coating, and wash cycles that can obscure conventional markings. CDOT was able to mark these critical parts in non ideal locations, often within constrained code areas, and still deliver reliable decoding without distortion or data loss.

Turning Each Critical Part into a Data Carrier

What sets CDOT apart is not only its survivability across extreme production steps, but also how it integrates into existing digital infrastructure. Once decoded, each CDOT unique ID is matched with its associated production and quality data and written into a local or cloud based database. These records can include machine process parameters, quality inspection results, and operator logs, building a live digital identity for each part. Despite its compact size, each CDOT can store up to 520 alphanumeric characters, enabling detailed part specific data to travel with the part itself throughout its lifecycle.

This granular traceability allows the manufacturer to:

- Detect process anomalies in real time and reduce scrap
- Trace field issues back to root cause within minutes
- Eliminate unidentified or misrouted parts
- Create accountability across suppliers and internal teams

As a result, CDOT reduces undocumented rework, prevents data loss, and strengthens compliance in mission critical programs. CDOT codes can be scanned using industrial cameras, tablets, or handheld mobile devices. Once captured, images are decoded locally or via secure cloud infrastructure, and the resulting data is integrated into broader manufacturing and defense systems without requiring custom hardware or new infrastructure investments. Cosmodot's system does not store images.

Field Ready Flexibility From Factory to Battlefield

Once the tank is assembled, CDOT continues to provide value. Markings remain scannable on external components exposed to harsh environmental conditions like dust and sand. In fielded systems, CDOT remains readable even after mechanical abrasion and surface corrosion. This is especially critical for tanks operating in extreme climates and rugged terrain, where real world conditions often exceed those seen in factory testing.

Cosmodot also understands that visibility is a tactical decision. Since CDOT is a software based system, the customer controls when, where, and by whom the code can be decoded. If mission needs require it, the customer can disable traceability in the field, offering operational discretion without altering hardware.

Survivability at Every Stage

From the moment a steel coil arrives at the facility to the final rollout of a next generation tank, CDOT enables unbroken traceability. It brings transparency to the production line, resilience to the battlefield, and peace of mind to the customer.

For programs where every part matters and no error is acceptable, CDOT reinforces both quality assurance and operational confidence. From line side inspections to mission deployment, every marked part carries forward its own verifiable history. It is tamper resistant, readable, and audit ready.

COSMODOT

Cosmodot invented CDOT Code, a new code symbology built specifically for direct part marking. It stands out for being survivable, high in data capacity, and reusable, so the same permanent ID can be read reliably even when parts face challenging surfaces or downstream processes. CDOT acts as a practical cure for a large market need, and Cosmodot has already solved extremely challenging, real-world identification cases for major manufacturers by enabling reliable part level tracking at a scale across industries including aerospace, automotive, defense, iron and steel, casting, forging, electronics, and semiconductors, by reducing lost identity events, improving process continuity, and strengthening traceability in harsh production environments. Cosmodot continues to expand globally, helping manufacturers integrate resilient identification into existing lines and achieve high impact productivity gains and savings.

Learn more about the CDOT Code here.

For additional information on CDOT demos, project implementations, and pricing, contact info@thecosmodot.com

Automation Alley

ABOUT: Automation Alley is a nonprofit technology business association and Digital Transformation Insight Center focused on driving the growth and success of businesses in Michigan and beyond through innovation and automation. With a global outlook and a regional focus, we foster a vibrant community of manufacturing and technology innovators, entrepreneurs, and business leaders through opportunities for collaboration and learning. Our programs and services help businesses develop the skills and expertise needed to effectively jumpstart or accelerate digital transformation. By bringing together industry, academia, and government, we aim to create a dynamic ecosystem that drives innovation and growth across Michigan.

MISSION: At Automation Alley, our mission is to help businesses thrive in the rapidly changing digital economy. We equip them with the knowledge, insights, and tools to develop a software-first mindset that leverages the power of automation, AI, and other cognitive technologies. We believe that by working together, we can build a stronger, more innovative, and more competitive economy for the future.

VISION: Wealth, prosperity and equality through technology.

To find out more about Membership visit:
automationalley.com

SOURCE LIST

ProtoLabs, 3D Printing Trend Report 2024
https://www.protolabs.com/resources/guides-and-trend-reports/3d-printing-trend-report/

Sculpteo, State of 3D Printing Report 2022
https://www.sculpteo.com/en/ebooks/state-of-3d-printing-report-2022/

Manufacturing Leadership Council, Survey: Manufacturers See AI as a “Game-Changer” as They Ramp Up Investments
https://manufacturingleadershipcouncil.com/manufacturers-see-ai-as-a-game-changer-as-they-ramp-up-investments-36926/

Deloitte, Manufacturing orgs get real about AI, data strategy
https://action.deloitte.com/insight/4246/manufacturing-orgs-get-real-about-ai-data-strategy

NIST, Measurement Science for Additive Manufacturing Program
https://www.nist.gov/programs-projects/measurement-science-additive-manufacturing-program#:~:text=The%20Measurement%20Science%20for%20Additive,control%3B%20performance%20qualification%820of%20materials%2C

Forbes, Best Practices For AI In Manufacturing: Expanding Human Potential
https://www.forbes.com/councils/forbestechcouncil/2025/02/19/best-practices-for-ai-in-manufacturing-expanding-human-potential/

Algoscale, A Complete Guide to Generative AI in Manufacturing for 2025
https://algoscale.com/generative-ai-in-manufacturing/

ANSI, America Makes & ANSI Additive Manufacturing Standardization Collaborative
https://www.ansi.org/standards-coordination/collaboratives-activities/additive-manufacturing-collaborative

AMCOE, Education & Workforce Development
https://amcoe.org/ewd/

NIST, Additive Manufacturing Consortia
https://www.nist.gov/additive-manufacturing/work-us-0/consortia

---

Publication Credits
Editorial: Nicole Kampe, Dennis Burck and Joseph Gray
Graphic Design: Laura Gearhart
Photography: Corey Sims

Thank you to our Foundation Members

Made possible in part through ongoing support from the

MICHIGAN ECONOMIC DEVELOPMENT CORPORATION