



The Future Factory

Mapping the Skills That Will
Power Manufacturing



MANUFACTURING HAS ALWAYS BEEN AT THE VANGUARD OF TECHNOLOGICAL TRANSFORMATION

Against the backdrop of an existing skills shortage and with skills needs evolving so rapidly, employers can no longer go to market to buy new skills when they want them. They need to become builders of talent to develop a workforce with the skills they need to remain competitive. Talent is the most renewable resource on our planet: ready to learn, adapt and thrive in new environments.

*Rebekah Kowalski
Vice President of Manpower North America*

The potential for manufacturing to transform industries and drive economic growth has never been greater, thanks to the rapid advancement of new technologies. We can only reach this potential with new and evolving skills for the current and future workforce, a mission we are proud to support alongside our partners.

*Chandra Brown
Chief Executive Officer at MxD*





MANUFACTURING: THE TRANSFORMATION TRAILBLAZER

Digitization, automation and transformation are impacting every industry, disrupting skills and creating new jobs. Manufacturing is the vanguard, with new roles appearing as fast as others become obsolete.

Manufacturers are reporting growing talent shortages as they struggle to find the right blend of technical and soft skills to fill new positions. The catalyst for the early stages of this skills shift was automation – machine strength. Now sector-wide transformation has been turbocharged by the Internet of Things, the digitally connected enterprise, the relentless expansion of data and Artificial Intelligence (AI) to handle the scope of the challenge – machine thinking.

To find practical solutions to this skills shortage and ensure up to 2 million new manufacturing jobs do not go unfilled,¹ ManpowerGroup and MxD convened more than 30 academic, government and industry partners including Siemens, Microsoft, Caterpillar and General Electric to create an industry-recognized taxonomy that defines digital manufacturing roles of the future. The groundbreaking workforce analysis, developed in partnership with MxD (formerly the Digital Manufacturing and Design Innovation Institute) provides the first taxonomy of its kind, outlining skills and roles of the future and serving as a practical toolkit for manufacturing organizations.

The industry's transition to full digitization is already well underway and accelerating daily. This paper maps the trends reshaping manufacturing, identifies the skills and roles needed, and outlines how a culture of innovation and effective leadership will be critical to success as companies transform.

DIGITAL For organizations, digital is an integrated approach that combines software, data, interfaces and controls in order to design, model, simulate, analyze, control, share and manage the creation, delivery and performance of products and services. Digital will touch every aspect of the organization and ultimately become the way it functions.



Key Takeaways

- **Digital transformation requires new skills, new roles and new approaches to leadership.**
- **Companies need new approaches to upskill people at speed and at scale to develop the talent they need to remain competitive.**
- **The right blend of technology, people and skills is key.**

MANUFACTURING: THE JOURNEY TO TRANSFORMATION

Manufacturing has undergone many transformations, from dirty, dark and dangerous to advanced, digital and connected. We have mapped four technical generations of manufacturing — Generations Zero to Three. Today we are on the cusp of the third generation, characterized by the transformational power of radical improvements in connected systems and machine learning. **In 2020, we expect Generation Three to become mainstream as technology becomes more widely available, and machines become more intelligent, teaching and learning from each other and catalyzing a new generation of roles for people to manage these highly connected systems across the enterprise.**

Helping people and organizations navigate this rapid change will be far easier if employers, educators, and policymakers collaborate on strategies to prepare both the current and future workforce for the continuous change. No one can predict the future, but with the right skills, a culture of learning that nurtures people's desire and ability to continually learn and a focus on helping people develop their careers for in-demand jobs, we can be better prepared.

65% of all jobs that Generation Z (born in 1996 and after) will do don't exist yet²

GENERATIONS OF MANUFACTURING

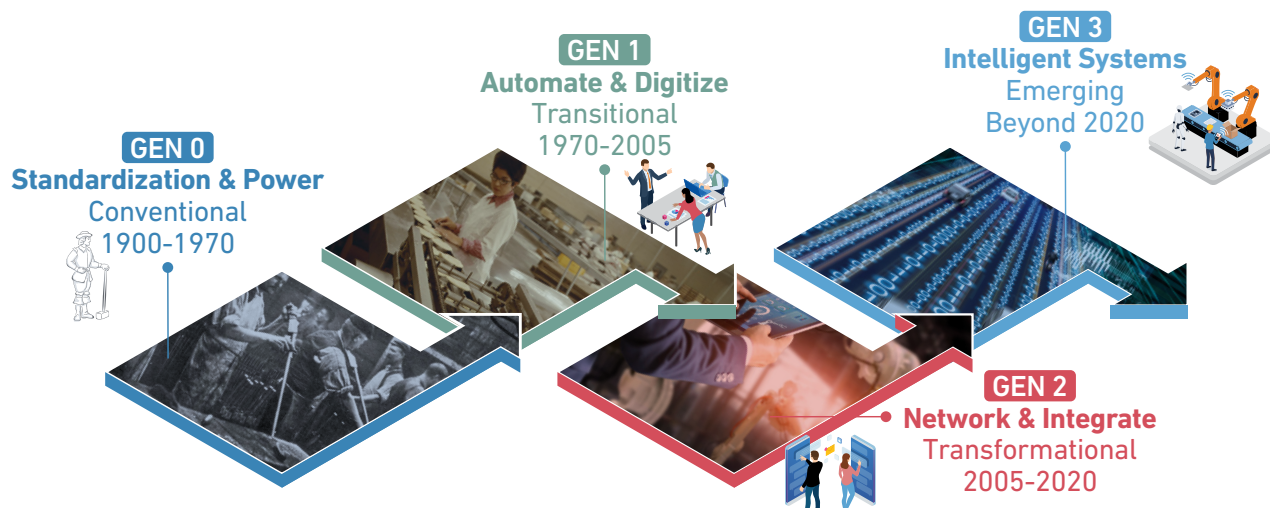
Each generation is aligned to different eras of manufacturing tools, technologies and work.

Generation Zero refers to conventional manufacturing, spanning the first seven decades of the 20th century.

Generation One – the 35 years from 1970 to 2005 – was ushered in by new hardware and software systems that rapidly improved processes through automation.

Today we are at the tail end of **Generation Two** – characterized by the transformational power of radical improvements in software. This has streamlined processes, using data far more effectively.

The next shift is to **Generation Three**. The rate of change is accelerating rapidly. It took nearly three-quarters of a century to move on from Gen Zero, yet the next shift was achieved in half that time. Gen Two began in 2005 and by 2020, we expect to be fully immersed in Gen Three.



DIGITAL TRANSFORMATION

Breakthroughs in mobile connectivity, the Industrial Internet of Things, AI, robotics, 3D printing, and advanced materials will radically transform manufacturing and production systems in the next five to ten years. This digital transformation is a key driver of sweeping change, creating a more connected world, a need for new skills, and opening new opportunities for businesses to grow and create value.

THE IMPACT OF TRANSFORMATION ON THE MANUFACTURING ORGANIZATION

Almost half of all roles in manufacturing (49%) will need to change within the next three-to-five years as the industry transitions to become fully digital. Our workforce analysis identified 165 new and evolving roles across seven areas of technical expertise — what we refer to as "domains."³

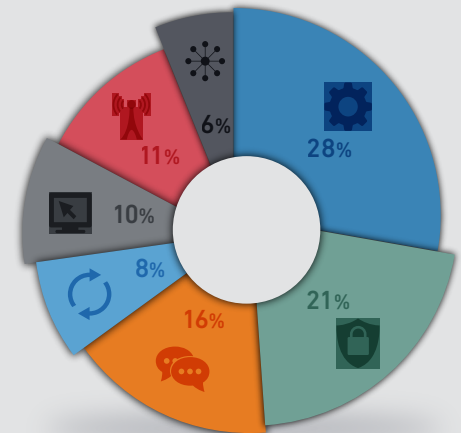
We also examined the skills, tools and areas of knowledge that boost individual careers, company performance and add value.

The evolution of roles is both diverse and significant – future roles are wide-ranging and varied: Service Technician, Predictive Maintenance Specialist, Robotics Engineer, Data Architect, Product Designer, Digital Manufacturing Manager, Supply Chain Strategist, Agile Project Manager, Digital Twin Architect, Digital Thread Program Manager, Application Developer, Data Scientist, Community of Practice Manager, Technical Trainer, C-Level Officer, Knowledge Curator and Ethicist.








Each job in the advanced manufacturing industry supports between three and five additional jobs in the supply network. **The impact of transformation differs for each domain with the greatest shift occurring between the shop floor and the Digital Manufacturing domain — 28% of the 165 new or evolved roles are in this domain.**⁴

THE 7 DOMAINS

Our research identified 165 roles within manufacturing, distributed across the seven domains.



% OF ROLES PER DOMAIN

-  **Digital Manufacturing | 28%**
Traditionally known as the "shop floor"
-  **Digital Thread | 21%**
Management of an asset's data across its product lifecycle
-  **Digital Enterprise | 16%**
Organizational-level leadership, strategy and governance
-  **Digital Product | 8%**
Aftermarket support services and feedback
-  **Digital Design | 10%**
Tools, techniques and innovative mindset to design, simulate and plan products
-  **Supply Network | 11%**
Technologies and capabilities that support the supply and delivery of resources and products
-  **Omni | 6%**
Wider, external cross-domain areas of work

THE IMPACT ON WORKERS: HOW PEOPLE CAN CATCH THE SHIFT

While the domains apply to the impact on an organization, workers themselves will be impacted differently by the manufacturing shift. Within the seven domains, specific roles can be mapped by the impact they make on the organization and the way they connect to each other. The fast-changing industry will require almost a quarter of workers to be Pioneers, first introducing the ideas and processes that will jumpstart transformation. Almost one in five will be keystones, putting processes in place to execute the strategy, while the majority, 60%, will be Producers, responsible for the output, making the change happen and executing on a daily basis.⁵ Producer roles exist in every domain, from executives to IT and on the production floor.



Pioneer (24%)

Trailblazes the ideas and processes



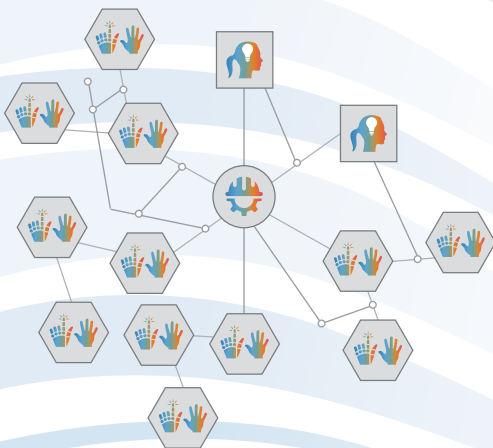
Keystone (16%)

Enables colleagues to adopt and execute those strategies

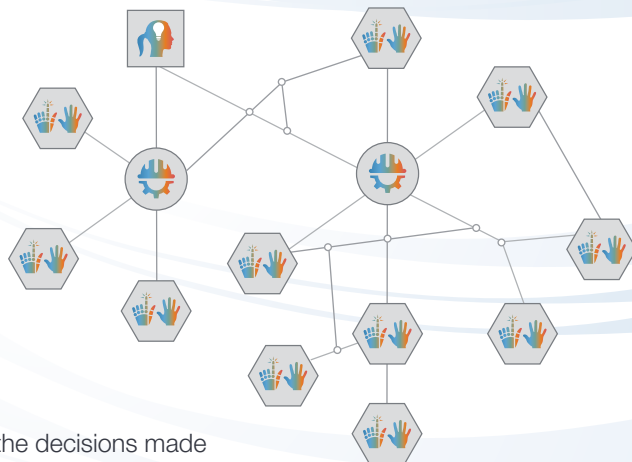


Producer (60%)

Converts key resources into outcomes



WITHIN THE SEVEN DOMAINS, SPECIFIC ROLES CAN BE MAPPED TO THE IMPACT THEY MAKE ON ORGANIZATIONS AND THE WAY THEY CONNECT



Organizations are more connected than ever before, so the decisions made have a ripple effect throughout the organization and extend into the supply network.

When a global consumer electronics company updates the power requirements for a display, suppliers will be required to address that change from updating the design for connectors and display housing to potentially remanufacturing the control panel. The effect on supply networks is substantial – so long as every aspect of the chain is agile and able to adapt rapidly to evolving demands, from vision systems and sensors for quality control to data analytics to detect maintenance issues in real-time.

ManpowerGroup and MxD have mapped out the required core capabilities and critical technical areas for the 165 manufacturing roles. This includes feeder or progression roles that may be required for a worker to step up to a new position. Summary personas describe the capabilities required by candidates. The Omni Manufacturing Engineer persona connects to over a dozen of the MxD/ManpowerGroup roles.

Monique — The OMNI Manufacturing Engineer

Optimizing integrated systems: people, process, production and technology



"In digital era manufacturing, Omni Manufacturing Engineers act as the 'wise guide' and the 'adventurous traveler.' Today we have more opportunities and choices for how and where we work, tackling more challenges than ever. By keeping an open mind, and continuing to learn, we become radical innovators and value creators across the life cycle."

TARGET ROLES Manufacturing Process Engineer, Factory Automation Engineer, IT/OT Systems Engineer, OT Integration Engineer, Systems Engineer, Product Engineer, System Integrator

PROGRESSION ROLES Product Performance Optimization Engineer, Digital Manufacturing Program Manager, Manufacturing Business Leader, Manufacturing Systems Scientist

SIDEBAR ROLES Supply Network Quality Data Engineer, Systems Consultant, Manufacturing Biomimicry and Sustainability Specialist, Instrumentation Engineer

NEED Need for this role increases at above-average rates for cross- or multi-domain engineers that are innovation and transformation minded

IMPACT



Pioneer



Keystone



Producer

OVERVIEW

The modern version of industrial and manufacturing engineers combine core engineering, industrial and production life cycle knowledge, and modern technologies in order to crystallize needs, perform robust data analytics, and upcycle designs with material and process innovations. They do this to optimize machine performance and connect factory and industrial systems to business side-data systems — all with possibility, precision and profitability.

Today's Manufacturing Omni Engineers are omni-skilled, systems-focused, and have diverse knowledge of industrial, tech and people areas to solve for many modern challenges. They are omni-located and found improving almost all manufacturing areas. They leverage digital and automation technology across the manufacturing enterprise to yield business and customer results.

ACCOMPLISHMENTS

- Understand needs, apply structured engineering and systems knowledge to recommend innovative processes and systems
- Optimize performance while improving user personalization and experience
- Collaborate across engineering and process domains to build and deploy smart, safe and secure modern factory environments
- Complete increasingly complex systems analysis, design, development, testing and implementation

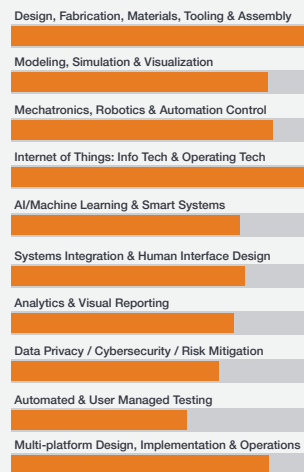
BUSINESS CONTRIBUTIONS

- Commercially viable solutions to complex problems
- Optimized new engineering, fabrication, production and supply network models; improved products and processes with improved commercial value
- Optimizes human, material, energy and environmental resource use
- Upcycling of legacy investments/facilities/machinery and high-value recommendations for new investments

CORE CAPABILITIES



TECHNOLOGY



A NEW APPROACH TO UPSKILLING

To upskill tomorrow's manufacturing talent at speed and scale, we need a new approach to training.

In our experience, the most effective skills development is achieved through shorter certification programs of six months or less. Higher retention of skills occurs when combined with on-the-job training.



ACCELERATED UPSKILLING IN ACTION

To help military veterans apply their military skills to roles employers cannot fill, ManpowerGroup and Rockwell Automation launched a first-of-its-kind program in 2017, the Academy of Advanced Manufacturing (AAM), to upskill 1,000 U.S. military veterans annually for in-demand, highly specialized roles in digital manufacturing. The AAM course curriculum is based on the groundbreaking MxD and ManpowerGroup Manufacturing workforce analysis outlined in this paper.

The accelerated learning is delivered through an innovative combination of classroom learning, hands-on training and soft skills coaching. **At the end of just 12 weeks, the program leads to certification and well-paid, sustainable employment as automation and instrumentation controls technicians.** Of the three cohorts since the AAM began, more than 95% of veterans have graduated and over 80% immediately secured permanent job offers from leading employers. This model is a blueprint for developing people's skills so they can stay employable for the long term.

More than 95% of veterans have graduated and over 80% immediately secured permanent job offers



CAREER PATHWAYS FOR IN-DEMAND ROLES

ManpowerGroup launched a specialist skills academy in Northern Italy, Experis Tech Academy, to reskill displaced people from the textile sector arming them with new skills to fulfill roles at manufacturers of high powered, prestigious motor cars.

The Experis Tech Academy was developed in partnership with Dallara, a leading European manufacturer for the motorsport industry. **The program initially started with upskilling skilled textile workers in carbon fiber lamination, but quickly expanded to reskilling programs for other in-demand roles:** CAD Designers, Aerodynamics Engineers, Vehicle Performance Analysts, Engine Builders, Programmers, Project Managers and IT Specialists.

The Academy brought together a coalition of technical schools, universities, employers and government to create training center that follows a unique, accelerated-learning model aimed at developing advanced skills that are in increasing demand.

Training is delivered through a combination of on-the-job, virtual and classroom-based learning. Learning paths are tailored to the individual's needs, with participants able to take courses during the weekend, weekdays or evenings over a 3- to 6-month period to upskill in fast-moving technical roles.



FINDING MYPATH® TO THE FUTURE

Digitization and automation are impacting roles across all sectors and industries. To help people adapt, ManpowerGroup has made a significant commitment to our hundreds of thousands of associates to be their partner in upskilling through our MyPath program.

By analyzing current and future demand for specific roles, MyPath creates tailored career tracks for our motivated associates to upskill and progress in their careers in growth industries including IT, manufacturing and business operations.

In the U.S., certified Talent Agents can guide individuals on a track to advance from payroll specialist at \$19/hour to financial analyst at \$41/hour and beyond. Individuals that demonstrate high motivation and soft skills – engagement, collaboration, curiosity, problem-solving, results-orientation and communication – receive medals of recognition from employers, positioning them to earn more and move up.

This combination of experiential learning, recognition and coaching certifies technical skills and rewards work skills. MyPath began in the U.S. and has already scaled to other countries, including France and India, helping thousands of people upskill and earn more.

DIGIPATHWAY A key component of Digital Transformation is making cultural changes, so you have a more engaged workforce. ManpowerGroup has developed the Digital Evolution Pathway assessment, for you to evaluate how digitally mature your organization is today and offers insight on how to accelerate your progress. **Available at digipathway.com**



LEADING THE WAY FROM THE DIGITAL SUITE

Among the new roles identified in our manufacturing research, 24 were leadership roles, including Managers, Senior Leaders or Executives. Developing leaders' skills will be more important than ever in a Skills Revolution where new roles emerge as fast as others become obsolete and people need to continually learn to stay relevant and employable.

The good news is leading through digital transformation in all industries, including manufacturing, does not mean a complete replacement of the makeup of strong leadership. Instead, the 80/20 rule applies.

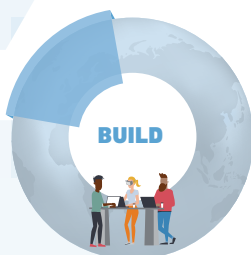
Foundational leadership skills like endurance and adaptability continue to be critical. Yet in the digital age, effective leaders must also nurture the additional 20 percent — unleashing talent, daring to lead, and at times failing, fast — all to accelerate performance. Most of all, digital leaders must encourage a culture of calculated innovation, while managing risk. Leaders must learn fast and be prepared to change course quickly, while optimizing opportunities.⁶

BUILDING TOMORROW'S MANUFACTURING TALENT TODAY

Technological disruption is contributing to a manufacturing skills revolution. Shop floor roles are being automated while new roles that optimize the potential of machine learning are being created. The pace of change is accelerating and companies, governments and universities need to collaborate to upskill people at speed and at scale.

Now Is The Time To:

- 1 Develop a connected workforce strategy: appropriately skilled workers aren't available in sufficient numbers to simply buy the necessary skilled talent, organizations must build, bridge and borrow the skills they need.



Invest in learning and development



Go to market to attract the talent that cannot be built in-house



Cultivate communities of talent beyond the organization



Help people move on or move up to new roles inside or outside the organization

- 2 Identify those skills that will be critical in the short, medium and long term. Map the 165 new roles within the seven domains and use this information to identify future talent needs.

- 3 Understand the game-changing ripple effect that resonates from each advanced manufacturing role throughout the entire supply network.



To find out more about the Skills Taxonomy and what it means to your business visit:

<https://workforce-resources.manpowergroup.com/home/The-Future-Factory>

ABOUT THE RESEARCH

MxD – previously known as DMDII – collaborated with ManpowerGroup to look holistically at manufacturing, identifying those areas requiring the greatest and most rapid skills transformation, and developing tools to guide businesses into their digital futures. We are pleased to be able to share this across the manufacturing industry.

In recent times, the significant challenge for manufacturing has been digitization strategy: determining how quickly and deeply to make capital outlays, which technologies to deploy and how to manage the operational transition. Indeed, navigating the shift to fully automated and AI-enabled operations will continue to dominate boardroom decision making.

To create value from the new technologies being deployed at scale, organizations must embrace talent transformation and work collaboratively to develop innovative, rapid training technologies to reskill their World's workforces.

ABOUT MANPOWERGROUP

ManpowerGroup® (NYSE: MAN), the leading global workforce solutions company, helps organizations transform in a fast-changing world of work by sourcing, assessing, developing and managing the talent that enables them to win. We develop innovative solutions for hundreds of thousands of organizations every year, providing them with skilled talent while finding meaningful, sustainable employment for millions of people across a wide range of industries and skills. Our expert family of brands – Manpower®, Experis®, Right Management® and ManpowerGroup® Solutions – creates substantially more value for candidates and clients across 80 countries and territories and has done so for over 70 years. In 2019, ManpowerGroup was named one of Fortune's Most Admired Companies for the seventeenth year and one of the World's Most Ethical Companies for the tenth year, confirming our position as the most trusted brand in the industry. See how ManpowerGroup is powering the future of work: www.manpowergroup.com.

ABOUT MXD

MxD (Manufacturing x Digital) is where innovative manufacturers go to forge their futures. In partnership with the Department of Defense, MxD equips U.S. factories with the digital tools and expertise they need to begin building every part better than the last. As a result, our more than 300 partners increase their productivity, win more business and better equip the nation's warfighters. MxD has invested approximately \$90 million in more than 60 projects in areas including design; product development; systems engineering; future factories; agile, resilient supply chains; and cybersecurity. The Institute operates from a nearly 100,000-square-foot innovation center near downtown Chicago. Its factory floor features some of the most advanced manufacturing equipment in the world, which partners can use for experimentation and training on everything from augmented reality to advanced simulation techniques. Learn more at www.mxdusa.org.

ENDNOTES

¹ Skills Gap and Future of Work Study, Deloitte Insights and The Manufacturing Institute, 2018

² Future of Jobs Report, World Economic Forum, 2018

^{3, 4, 5} The Digital Workforce Succession in Manufacturing, ManpowerGroup and UI Labs, 2017

⁶ From C-Suite to Digital Suite: How to Lead Through Digital Transformation, ManpowerGroup, 2018



Additive Manufacturing Engineer
 Digital Design Engineer
 Virtual Reality/Augmented Reality Hardware Engineer
 Virtual Reality/Augmented Reality Software Engineer
 Virtual Reality/Augmented Reality System Specialist
 Cognitive Systems Scientist
 Product Embedded Cognitive Systems Scientist
 Virtual Reality/Augmented Reality System Scientist
 Additive Manufacturing Analyst
 Additive Manufacturing Specialist
 Predictive Maintenance System Specialist
 Collaborative Robotics Specialist
 Digital Manufacturing Engineer
 Machine Learning Scientist
 Digital Manufacturing Analyst
 Embedded Prognostics Engineer Factory
 Augmented Reality Manufacturing Systems Specialist
 Digital Product Market Customization Engineer
 Digital Product Marketing Specialist
 Embedded Product Prognostics Analyst
 Embedded Product Prognostics Engineer
 Product Embedded Cognitive Systems Engineer
 Product Embedded Cognitive Systems Specialist
 Manufacturing Cybersecurity Application Developer
 Manufacturing Cybersecurity Engineer
 Manufacturing Cybersecurity Programmer
 Manufacturing Cybersecurity Strategist
 Manufacturing Cybersecurity Technician
 Life Cycle Digital Twin Analyst
 Life Cycle Digital Twin Architect
 Cognitive Systems Specialist
 OT/IT Systems Architect
 Product Life Cycle Quality Data Specialist
 Supply Network Quality Data Specialist
 Digital Manufacturing Sustainability Specialist
 Predictive Supply Network Analytics Engineer
 Self Guided Vehicle (SGV) Systems Engineer
 Fleet/Asset Optimization Specialist
 Digital Design Community of Practice Manager
 Virtual Reality/Augmented Reality System Manager
 User Experience Designer
 Chief Digital Officer -Manufacturing
 Digital Manufacturing Senior Manager-Business

Enterprise Supply Network Manager
 Digital Enterprise Community of Practice Manager
 Digital Manufacturing Organizational Change Management Strategist
 Digital Manufacturing Organizational Effectiveness Strategist
 Digital Enterprise and Integrated Product Intellectual Property Senior Manager
 Digital Manufacturing Chief Technology Officer
 Digital Manufacturing Executive Leader-Business
 Digital Manufacturing Executive Leader-OMNI
 Process Quality Data Manager
 Digital Factory Automation Manager
 Digital Manufacturing Community of Practice Manager
 Digital Product Community of Practice Manager
 Digital Knowledge Community Curator
 Digital Thread Engineer
 OT/IT Systems Engineer
 Product Life Cycle Quality Data Manager
 Continuous Improvement Manager
 Supply Network Quality Data Manager
 Supply Network Community Manager
 Fleet/Asset Optimization Manager
 Supply Network Integration Community of Practice Manager
 Digital Manufacturing IT Systems Analyst
 IT Systems Optimization Engineer
 Digital Manufacturing Systems Architect
 Digital Manufacturing Systems Specialist
 Digital Thread Technical Educator (Teachers 9-12)
 Digital Thread Technical Trainer
 Statistician
 Product Life Cycle Quality Data Analyst
 Continuous Improvement Engineer
 Continuous Improvement Specialist
 Omni Technical Educator (Teachers 9-12)
 OMNI Technical Trainer
 OMNI Vocational Instructor
 Sales Engineer
 Supply Network Quality Data Analyst
 Supply Network Business Analysts
 Automated Guided Vehicle (AGV) Systems Specialist

Inventory Systems Automation Specialist
 Fleet/Asset Optimization Analyst
 Supply Network Technical Trainer
 Supply Network Vocational Instructor
 Digital Design Analyst
 Digital Design Specialist
 Intelligent Workspace Designer/Ergonomics Specialists
 Model Based Systems Engineering (MBSE) Engineer
 Digital Design Technical Trainer
 Digital Design Vocational Instructor
 Virtual Reality/Augmented Reality System Modeler
 User Experience Architect
 User Experience Analyst
 Progressive Strategist Enterprise Direction
 Enterprise Digital Ethicist
 Enterprise Risk Manager
 Regulatory Analyst
 Digital Enterprise Technical Trainer
 Data Management Specialist
 Information Scientist
 Integrated Computational Material Engineering Scientist
 Manufacturing Analytics Scientist (Data Scientist)
 Manufacturing Researcher (Scientist)
 Manufacturing Systems Researcher (Scientist)
 Manufacturing Systems Simulation Researcher (Scientist)
 Process Simulation Scientist
 Software Scientist (Researcher)
 Additive Manufacturing Technician
 Manufacturing Analytics Analyst
 Manufacturing Analytics Manager
 Manufacturing Analytics Specialist
 Digital Manufacturing Program Manager
 Digital Manufacturing Project Manager
 Manufacturing Process Engineer
 Manufacturing Process Specialist
 Process Engineer
 Process Quality Data Analyst
 Process Quality Data Specialist
 Process Simulation Engineer
 Process Simulation Manager
 Process Simulation Specialist

Operation Technologies Integration Engineer
 Digital Manufacturing IT Specialist
 Collaborative
 Robotics Technician
 Digital Factory Automation Analyst
 Digital Factory Automation Architect
 Digital Manufacturing Safety Systems Specialist
 Factory Automation Engineer
 Instrumentation Engineer
 Machine Learning Specialist
 Digital Manufacturing Technician
 Manufacturing Systems Designer
 Manufacturing Systems Engineer
 Manufacturing Systems Modeler
 Manufacturing Systems Simulation Engineer
 Manufacturing Systems Simulation Manager
 Manufacturing Systems Simulation Specialist
 Digital Manufacturing Knowledge Manager
 Digital Manufacturing Technical Educator
 Digital Manufacturing Technical Trainer
 Digital Manufacturing Vocational Instructor
 Digital Product Safety Systems Engineer
 Digital Product Safety Systems Specialist
 Digital Product Manager
 Digital Product Support Manager
 Product Performance Optimization Engineer
 Digital Product Technical Trainer
 Digital Product Vocational Instructor
 Manufacturing Cybersecurity Analyst
 Manufacturing Cybersecurity Architect
 Manufacturing Cybersecurity Tester
 Data Management Analyst
 Data Management Manager
 Digital Data Tester
 Product Life Cycle Data Engineer
 Cognitive Systems Designer
 OT/IT Application Developer
 OT/IT Systems Analyst
 OT/IT Systems Specialist
 OT/IT Systems Strategist
 OT/IT Systems Technician
 OT/IT Systems Tester

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