

PARTNERS IN CONNECTION

# THE DIGITAL WORKFORCE SUCCESSION IN MANUFACTURING

EXECUTIVE SUMMARY

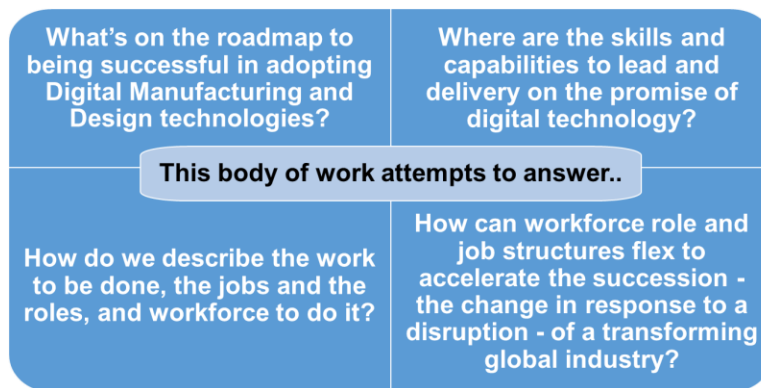


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Welcome to **Partners in Connection**, the report out of the public-private effort to define digital manufacturing workforce frameworks. The project was completed under the Department of Defense Cooperative Agreement No. W31P4Q-14-2-0001 Control No. 15-09-01. The approved technical domains, roles taxonomy, and role profiles have been peer reviewed by various industry, academic, and non-profit contributors. The views expressed for the broader narrative are those of the authors and their respective organizations.

The full copy of the report and the profiles is available for download from: UI LABS at [www.uilabs.org/taxonomy](http://www.uilabs.org/taxonomy)

Digitization has been changing – and will increasingly change – everything. Manufacturers need the right workforce in place to survive and thrive in this new paradigm. This body of work strives to capture a sense of the changing technology and business interactions, and job roles that are having an impact on our manufacturing sector. This modernization and advancement of technology effects the entire ecosystem of manufacturers (from the small to the huge), educators, government, and the workforce itself.



We contend that some of the most foundational answers begin with this Roles Taxonomy and the related outputs and assets. Based on the outcome of our efforts, we've identified the **Digital Manufacturing and Design Roles Taxonomy**, consisting of a technical domain structure, the identification of the broader set of 165 potential roles and role descriptors in digital manufacturing and design, and 20 success profiles for representative roles. These roles are a portion of the ones we believe will provide the bridge between our current and future workforce. With the fuller picture of the broader community of the roles and the technical domain structures, we see a more aligned and accelerated path for digital manufacturing workforce development and the economic benefits for individuals and companies alike.

### Manufacturing With or Without DM&D: A Workforce and Industry in Succession

For any number of reasons, different views are held on the digital transformation underway in life and in industry. Conscious conversations are essential and the issues are real. Our project had both a solid focus on workforce and a holistic view of the change territory that this workforce has to operate in and what is needed by organizations enabling and employing digital talent. Consider these basic factors:

- Advanced manufacturing – often synonymous with digital manufacturing – is 13% of the US economy
- Each job in advanced manufacturing industry supports 3 - 5 additional jobs in the supply network
- Annual compensation in manufacturing averages \$73K and in advanced manufacturing averages nearly \$95K
- 65% of the jobs that Generation Z (born in 1996 and after) will work at have not yet been invented

This process of regrowth that an ecosystem undergoes after a major change event is known as “succession”. In Digital Manufacturing and Design, the workforce has been undergoing early stages of this succession for decades, and will continue to do so. However the speed of those stages of change

and conversion are taking shorter and shorter windows of time. And so our efforts to define and develop the workforce must also accelerate.

Our framework captures the “*now* and *next*” views of the critical work and technical areas and roles; it also profiles what value those roles bring to the manufacturing enterprise and ecosystem. The taxonomy work isn’t a complete reboot of all manufacturing jobs, since many of those are essential and represent the legacy of production, and form the life cycle basis that digital is built on. Our framework does, however, have fundamental definition across the digital manufacturing enterprise so it is wide in scope, and has unique roles and conventional areas with innovative digital application focus; the full life cycle of products; the new operating environments; and the many roles with direct digital effect that enable the business.

The majority of the focus of the impacts of automation and digital and other influences on the workforce has legitimately been on the skilled worker area of manufacturing. This body of work purposefully worked with manufacturing experts in all disciplines and collectively took an enterprise scope including and going beyond the manufacturing production portion to the full product life cycle and the broader data-centric organization. That said, not every possible function was deeply examined. Project participants and experts evolved a scope of roles and work that reflected the following work and worker factors:

**While digital is changing work, social practices, and consumer behavior for almost everyone, this effort looked at those work areas and workers where participants sensed the highest “digital change delta” is occurring.**

- Those that were “more native” digital – those that are newer and do not have a conventional or early automation twin, those that wouldn’t exist without digital technologies
- Those most needed to deeply understand the cross-functional dynamics of the digital enterprise in order to best guide the digital enterprise transformation
- Those having their outputs changed more dramatically than others based on using digital technologies and data as a primary “input or tool” or those creating or producing digital products, interim or final
- Those changing or augmented by digital technologies well beyond the primary automation seen in prior decades and where the pace of change and new contributing tools and technologies is fastest
- Those areas that reflect the digital design, digital thread and digital product areas – domains that have more of the next generation roles than some others

While digital is changing work, social practices, and consumer behavior for almost everyone, this effort looked at those work areas and workers that participants sensed have the highest “digital change delta” – a composite view of the change made due to the above factors. The taxonomy also had an imperative to bridge the higher “delta” digital work and workers to more established roles and work areas where there is a **connection** for use of digital elements and even **progression** of work and workers. These connected areas include the production and processing arenas of manufacturing where there is a change delta also but with a lower sense of the above factors. The taxonomy presents “**connected roles**” and “**transition roles**”, both bridges that connect more of the manufacturing roles with different digital change deltas into a broader workforce system.

This emergence and increase of new capabilities can occur much more quickly when the environment is understood and stakeholders see roles that can take advantage of the new conditions for quicker, healthier, and more sustainable growth and business outcomes.

## Taxonomy Content – An Overview

Our taxonomy outputs came from a process that consistently emphasized our core principles:

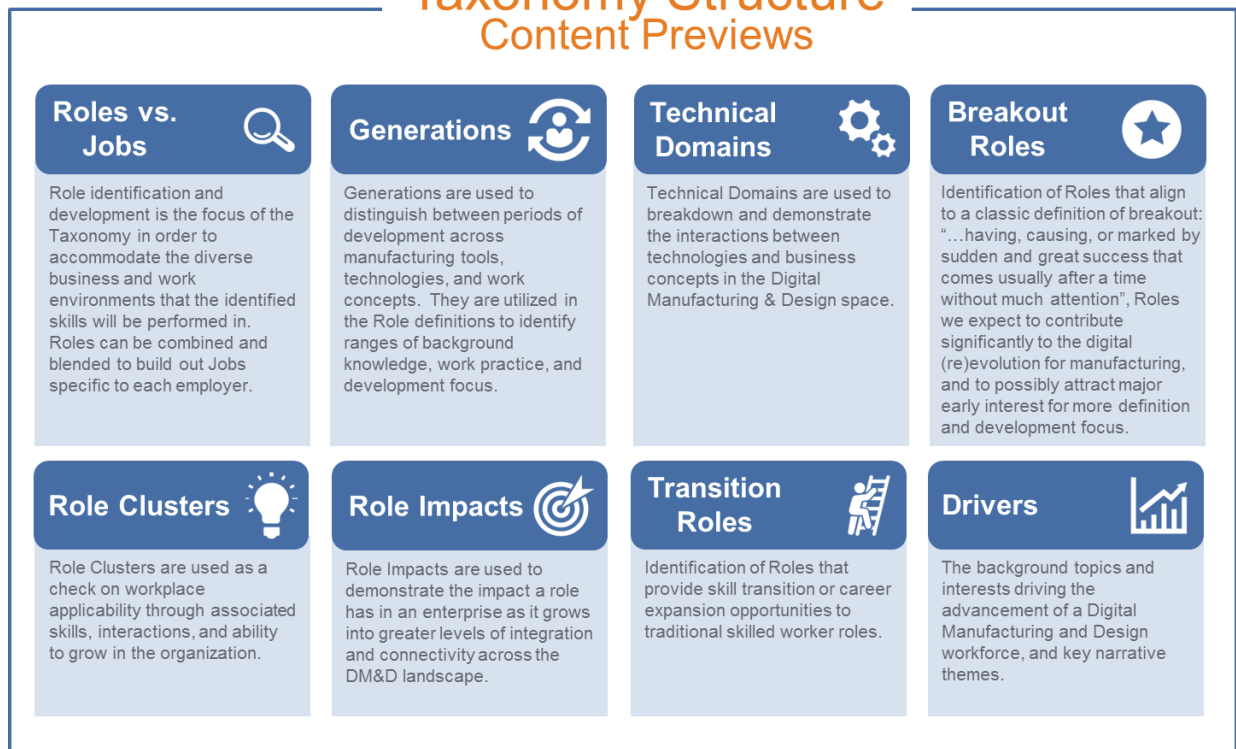
1. The frameworks would be based on industry demand and expertise of the future, enhanced and carried by workforce and organizational change innovation and best practice
2. We would build towards the opportunities of digital and not from the destructive perceptions of disruption
3. The reality of identifying and timing talent and workforce plans and investments should be staged and diversified to meet market opportunities and the diversity of the manufacturing base
4. And lastly, we would take a systems approach – as it is a systems challenge – and look for inspiration and proof from successful adaptations and changes

When it came to demand and expertise, we engaged experts and manufacturers. Over 50 representatives participated from over 30 different members. Dozens of others were engaged in major conversations; hundreds of others regularly heard presentations, received updates, and provided general acceptance and encouragement.

When it came to attitude and approach, we built towards a positive future and are knowingly leaving some of the essential debates about automation and workforce impacts to other important conversations and strategies. They were part of the conversations that focused on need and demand, and part of the challenges and the framing of scalable ways to look at the people and the work.

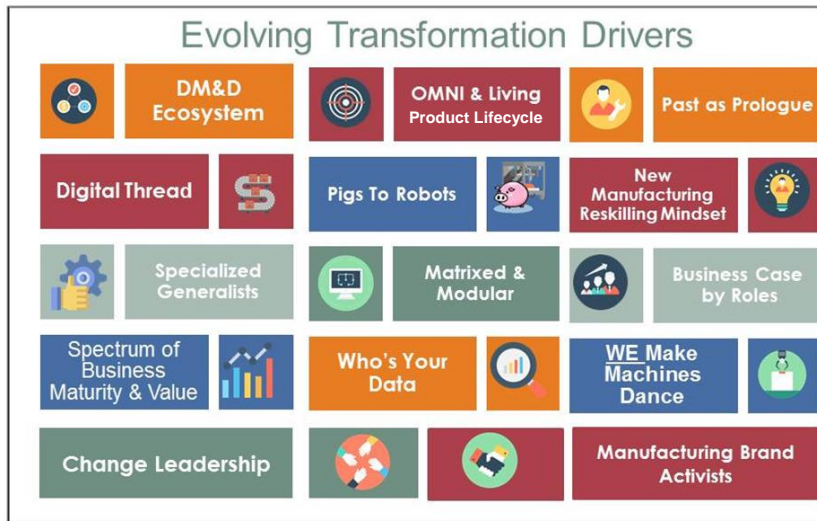
Building a taxonomy means engaging in a process of describing how a group of items are similar and how they are different. The purpose is to have a consistent way to identify, define, organize, and track important matters that you want to be able to distinguish and optimize. Taxonomies work best when they allow for groupings at several levels; in the case of a workforce taxonomy, it is important to be able to use it to describe the micro level – of an individual person (titles and success profiles); and also to work at the macro to describe groups of workers or a large pool of talent (the talent ecosystem and major body of technical information).

## Taxonomy Structure Content Previews



## Introduction to the Drivers

Many interactions supported the development of this body of work; a year of executive interviews, research reviews, academic assemblies, model brainstorms, database pulls and analysis, field interviews, supplier sessions, plant visits, domain conferences, conversations in the foundry, visits with technology vendors, and core project team work. From the many discussions, a set of factors emerged that we believe embody what is shaping and accelerating the evolution of the Digital Manufacturing and Design workforce and the related organizational changes.



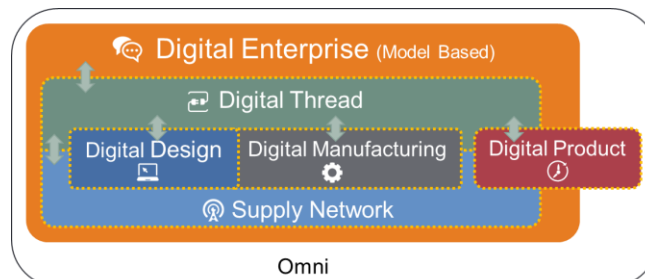
A full introduction to each emerging driver as a key influence on the taxonomy is included in the full narrative documentation.

## Overview of Technical Domains

Domains are commonly known as a body of knowledge or, more practically, an area of expertise. In the case of the DM&D Technical Domains, we have identified a major business and/or technical area of DM&D work activity, skill, knowledge, and/or tools. These Technical Domains define the space and place where digital manufacturing and design “happens”. This definition is necessary to outlining requirements, valued performance, and knowledge areas which in turn were used by us to design the DM&D roles.

Six primary DM&D domains have been identified. There is also a seventh domain discussed within the Roles – Omni – which is a domain area meant to establish the intentional cross-domain areas of work and expertise that are a hallmark of DM&D capability.

A nested graphical view allows for a spatial representation of the six primary domains. Following are the six primary domains starting at the first level of definition. Far greater detail is provided within the full narrative documentation.



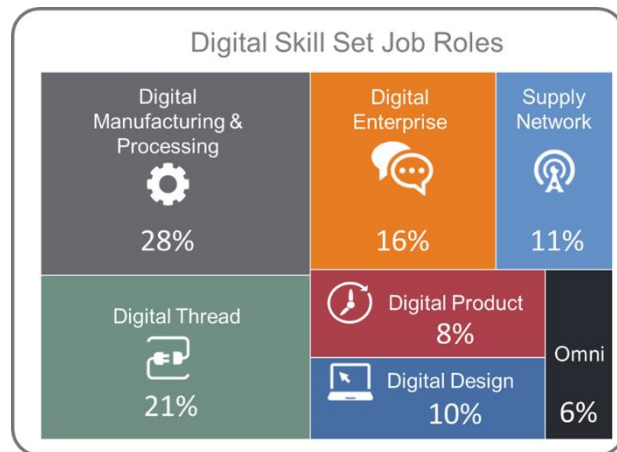
## Introduction to the Roles

The DM&D transformation begins with understanding the emerging roles in digital manufacturing and design and identifying at which stage their business is in terms of optimizing those roles and capabilities.

The main purpose of the taxonomy is to provide a way to define and classify the work that is being done in DM&D to enable workforce planning, development, and hiring. In a parallel to the domain definition, work role analysis and design efforts address DM&D opportunities and needs. Drawing on conventional manufacturing roles and jobs information as well as recommending novel roles only for the DM&D domains, a community of 165 roles across the domains evolved.

### 165 DM&D Roles Were Identified & Mapped to the Technical Domains

Our priority focus is on **Roles**, a cluster of related duties, skills, or knowledge that contributes to key outcomes of a work effort. **Jobs** are one or more roles tied together to meet a need or focus of an organization and managed as a position for one or more people to do. Organizations can assemble roles into jobs as needed. A Role can be an entire job and often is an entire job, especially in larger organizations; other organizations will combine roles especially in early stages or where the volume of work does not require dedicated positions.



To the left is the distribution of the roles across the domains. Digital Manufacturing draws the largest number of roles, with Digital Thread second, and Digital Enterprise roles the third most frequent home domain.

### Who Will Lead the DM&D Roles? Becoming a Digital Leader

Defining the future of digital manufacturing work includes a focus on leadership and enterprise management. The digital era brings shared challenges and opportunities for all leaders and workers in all industries.

Across the community of DM&D Roles there were 24 leadership roles identified with titles of Manager, Senior Leader, or Executive, and while many roles have elements of “leadership” in them, several specific or generic DM&D leadership roles were called out.

Before describing the many DM&D roles that will make the digital manufacturing enterprise succeed, we ask: What kind of leader will be needed to lead the digital manufacturing organizations overall and across domains?



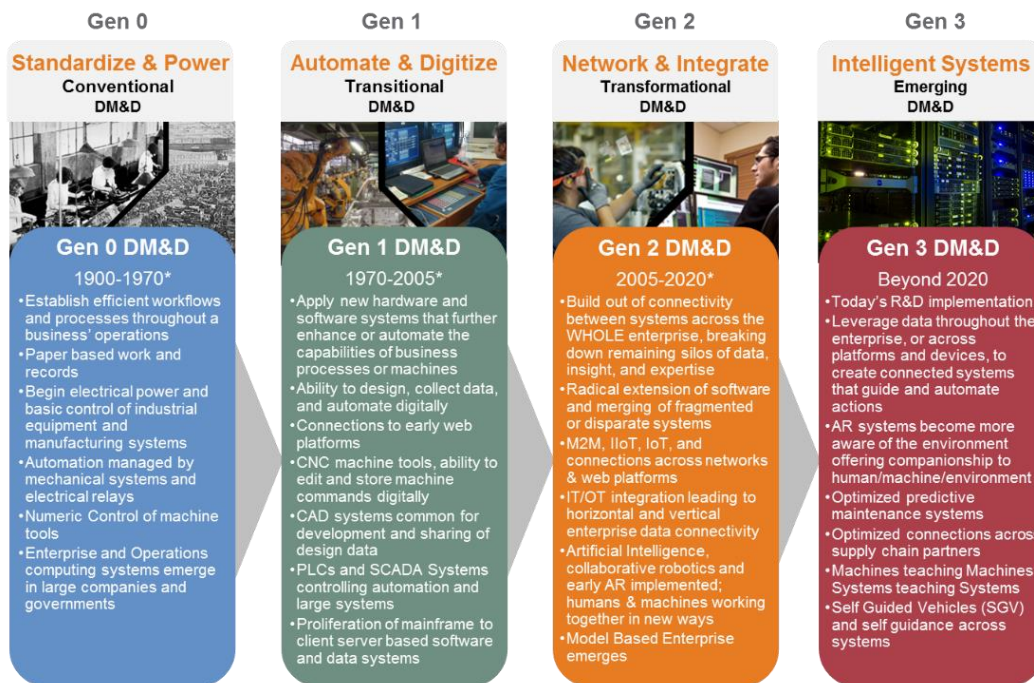
Digital leaders – in manufacturing and other sectors – will need to use five major “lenses” to be successful, seen in the image to the right. They are discussed further in the full narrative document.

## Technical Generations

### Background

With the broader community established, we can look at other aspects of the Taxonomy that provide richness to how the workforce is changing and evolving.

We have considered how the roles in the DM&D Community Map are reflective of evolving technologies. The concept of technology “generations” provides general markers of identifiable eras. Four possible “generations” of current or emerging roles – aligned to generations of manufacturing tools, technologies and work – were identified.



\* Specific eras for specific technology progressions may have slight variations

DM&D Technologies of previous years are still in place and have definite value for various manufacturers. There will be many transitional efforts and hybrids of the generational technologies, and hence the same would apply for roles. Most definitely the future is with later Generation technologies that forge new horizons.

These “generations” of technologies are important to understand as we migrate, leverage, enhance, and replace skills and knowledge of the existing workforce. As we transform our manufacturing organizations and support systems educators, workforce development entities, and others will need to understand the mix and migration to these DM&D technologies.

### Distribution of Roles across Generations

Based on the generation definitions above, each role was mapped in three ways and given a generation “profile”:

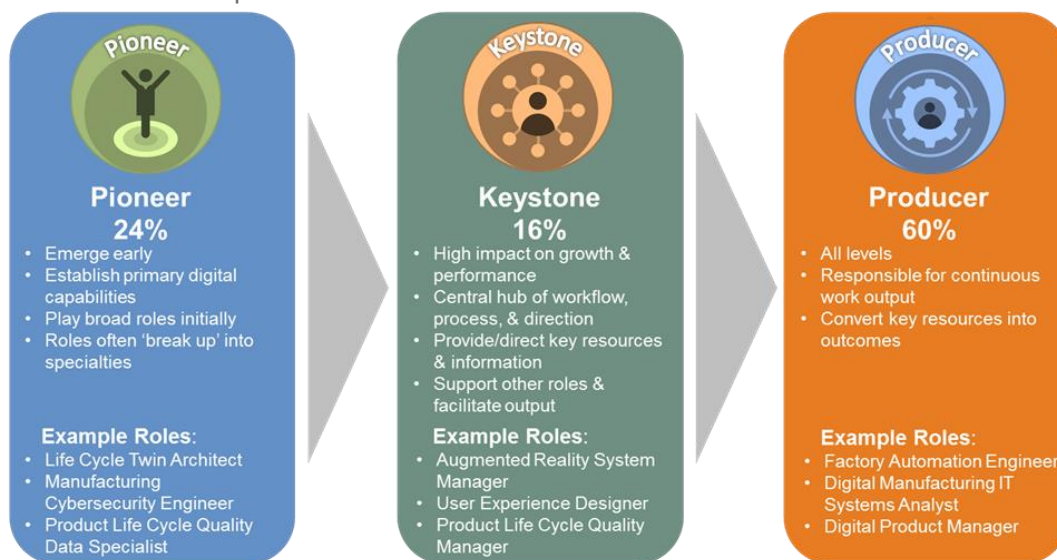
- **Generation Knowledge Range:** The useful background knowledge range for a role
- **Generation Work Focus Range:** The useful technology generation focus range for a role (where the majority of work takes place)
- **Generation 5-Year Industry Use Target:** The technology generation of the role we need to focus investment into over the next 5 years

## Role Impacts

### Consideration of Role Impact

Another aspect of the taxonomy considers the relationships of the roles to each other and to the organization in terms of general impact.

We identified three initial types of impact that a role can have in the succession of the conventional manufacturing industry as it grows through Digital Manufacturing and Design technology adoption. As shown in the graphic below, three types of roles emerged – each with important contributions from a workforce planning perspective. Looking at the broad taxonomy with this lens should help as companies examine the blend of capabilities they need based on where the company is its evolution and where it wants to move to in its adoption of DM&D.

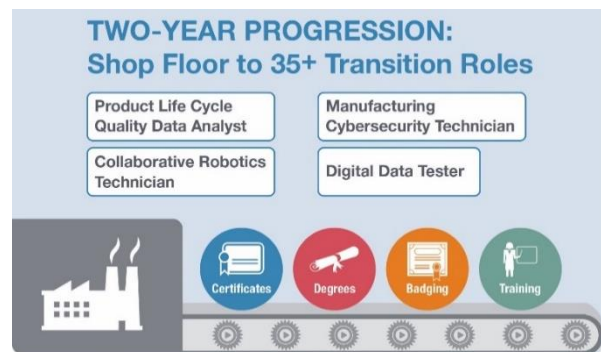


## Transition Roles

### Connecting DM&D Roles to Skilled Worker Roles

As manufacturing technologies and processes change, it is essential to mobilize and progress the well-matched team members from conventional production worker roles into new manufacturing positions. This leverages the capabilities and manufacturing and company knowledge and the investment made in those employees to date.

“Transition roles” in DM&D have been identified that may be target roles where the experience of employees who are interested and bring core capabilities can be the Launchpad to DM&D careers in the areas the Taxonomy establishes. With additional training and development, opportunities are seen for some to move to the newer, connected, smart-machine, augmented tech areas of the increasingly digital manufacturing space. We have identified over sixty roles – primarily Technicians, Specialists and Analysts – from the DM&D taxonomy Roles that are seen as opportunistic for skilled workers.





## Success Profile Overview

### Initial Roles Selected for Success Profiles

With 165 roles to choose from, which would be highlighted with an initial success profiling effort? Several of our most senior representatives from business, education, and government worked with recommendations and selected the targeted list of DM&D profiles.

### New Futures, New Roles

<div style="border: 1px solid #ccc; padding: 5px; background-color: #fff9c4;"> <p><b>DIGITAL ENTERPRISE</b></p> <ul style="list-style-type: none"> <li>Chief Digital Officer</li> <li>Digital Manufacturing Organizational Change Management Strategist</li> <li>Enterprise Supply Network Manager</li> <li>Enterprise Digital Ethicist</li> </ul> </div>	<div style="border: 1px solid #ccc; padding: 5px; background-color: #fff9c4;"> <p><b>DIGITAL THREAD</b></p> <ul style="list-style-type: none"> <li>Digital Thread Engineer</li> <li>Manufacturing Cybersecurity Strategist</li> <li>Digital Twin Architect</li> <li>IT/OT Systems Engineer</li> </ul> </div>		
<div style="border: 1px solid #ccc; padding: 5px; background-color: #fff9c4;"> <p><b>DIGITAL DESIGN</b></p> <ul style="list-style-type: none"> <li>Model Based Systems Engineering (MBSE) — Engineer</li> <li>Virtual Reality/Augmented Reality System Specialist</li> <li>Worker Experience Designer</li> <li>User Experience Architect</li> </ul> </div>	<div style="border: 1px solid #ccc; padding: 5px; background-color: #fff9c4;"> <p><b>DIGITAL PRODUCT</b></p> <ul style="list-style-type: none"> <li>Embedded Product Prognostics Engineer</li> </ul> </div>		
<div style="border: 1px solid #ccc; padding: 5px; background-color: #fff9c4;"> <p><b>DIGITAL MANUFACTURING</b></p> <table style="width: 100%;"> <tr> <td style="vertical-align: top;"> <ul style="list-style-type: none"> <li>Digital Manufacturing Engineer</li> <li>Predictive Maintenance System Specialist</li> </ul> </td> <td style="vertical-align: top;"> <ul style="list-style-type: none"> <li>Machine Learning Specialist</li> <li>Factory Automation Engineer</li> <li>Collaborative Robotics Specialist</li> </ul> </td> </tr> </table> </div>		<ul style="list-style-type: none"> <li>Digital Manufacturing Engineer</li> <li>Predictive Maintenance System Specialist</li> </ul>	<ul style="list-style-type: none"> <li>Machine Learning Specialist</li> <li>Factory Automation Engineer</li> <li>Collaborative Robotics Specialist</li> </ul>
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These profiles are representative of the kinds of changes the workforce is experiences in DM&D. The 20 roles are not to be seen as the most critical or highest value or where to start. Those decisions need to be made by individual companies or within supply networks and depend on DM&D maturity, business needs, and current talent supply and demand factors.

Yet these 20 profiles pave the way for deep understanding of the opportunities for manufacturers and the workforce alike, and represent targets for educators and workforce development programs.

The Success Profiles are an enhanced “job” or “role” description:

<p><b>Job Role Identification</b> </p> <ul style="list-style-type: none"> <li>Role Title</li> <li>Impact</li> <li>Summary</li> <li>Outcomes</li> <li>Technical Domain Profile</li> <li>Technical Generation Profile</li> <li>Business Case Contribution</li> <li>Sidebar &amp; Progression Roles</li> </ul>	<p><b>Key Responsibilities</b> </p> <ul style="list-style-type: none"> <li>Activities</li> <li>Accountabilities &amp; Decisions</li> <li>Interactions</li> <li>Situational Factors</li> </ul>	<p><b>Role Positioning</b> </p> <ul style="list-style-type: none"> <li>Line of Sight</li> <li>Peer Context</li> <li>Lifecycle / Business Process</li> </ul>
<p><b>Experience &amp; Education</b> </p> <ul style="list-style-type: none"> <li>Education Profile</li> <li>Experience Profile</li> </ul>	<p><b>Competencies</b> </p> <ul style="list-style-type: none"> <li>Essential Technical Competencies</li> <li>Essential Business &amp; Professional Competencies</li> </ul>	

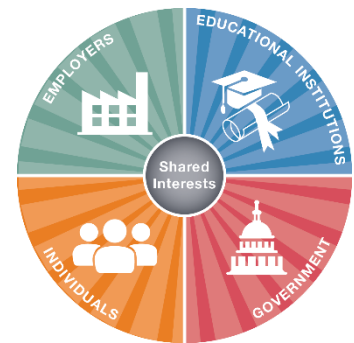
Improving the system of digital manufacturing talent will hinge on a better balance between supply and demand, including a fuller pipeline of workforce candidates. The old job boundaries, outdated workforce processes or conventional leadership practices towards the manufacturing organization will grow less and less relevant.



The guiding principles of the Taxonomy provide that foundation and ensure that the work can have impact and influence in the most critical spaces of the manufacturing sector and the fuller system by generating awareness. Next the foundation and awareness needs to move to adoption. Stakeholders each can advance their efforts by working with and implementing the Taxonomy, augmenting it and extending it for their particular uses. Then, as the benefits of having a clearer picture enable all parties to see how the workforce is succeeding and adapting to change, we should see acceleration of the promise of Digital. Acceleration of the manufacturing sector's workforce and for the economy at large should occur as we move into making progress on changes and adaptations that will take us into the future.

### Conclusion

Understanding the changing nature of our industry and the evolving nature of how the workforce is going through succession to a newer and more adapted state, demands the time to both honor our productive past and create a talent base for the future. Doing so will require alignment on the workforce as a community of capability, and leveraging its management as a talent ecosystem, where taking action collectively and having mutual accountability is the only guarantee of sustained existence. To achieve results as digital leaders and be digital optimizers overall, manufacturers will first and always need to optimize their talent.



**We welcome a conversation! All comments and questions on this report can be directed to:**

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