Developing a Maturity Model and an Implementation Plan for Industry 4.0 Integration

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Abstract

The world faces a fourth industrial revolution, known as Industry 4.0, following the first three revolutions: mechanizing production, energizing production, and automating production. Industry 4.0 focuses on digitizing and optimizing production in order to keep up with the increasing and ever-changing customer demands. This research establishes a maturity model (MM) for companies and organizations to assess their readiness towards integrating Industry 4.0, regardless of their business domain. The utilization of the maturity model allows these professional associations to develop a personalized implementation plan for Industry 4.0.

Keywords
Industry 4.0, Maturity Model, Manufacturing, Simulation

1. Background
What started as a push by the German government, Industry 4.0 has been adopted globally, with countries such as the U.S., China, and South Korea coining their own initiatives [1]. With such an increase in exposure and research, companies have begun to recognize the benefits brought forth by Industry 4.0 adoption. Following three industrial revolutions, Industry 4.0 initiatives aim to improve upon current industry practices via data-driven insights, integration, and connectivity. Such initiatives are set to bring forth benefits such as an increase in productivity, higher quality products, ability to customize, transparency of data in real-time, greater connectivity, and decrease in downtime [2]. However, while some companies have prospered, others have continued to face heavy barriers, making it difficult to reap the benefits brought on by widespread adoption. These barriers are more prevalent for Small and Medium-sized Enterprises (SMEs), who often lack the capital and market share needed to effectively implement Industry 4.0 [3]. In the U.S. specifically, SMEs make up approximately 99.9% of businesses; therefore, reducing the barriers to entrance for SMEs is essential for widespread Industry 4.0 adoption [4]. Such barriers may be a lack of knowledge regarding Industry 4.0, a lack of capital, or lack of appropriate human resources [5]. Larger enterprises may also fall victim to these barriers, especially a lack of knowledge, as many enterprises may not be aware of the initiative's applicability to their own operations.

For instance, Industry 4.0 represents a new era for the manufacturing sector; however, its initiatives apply to a variety of other industries like that of healthcare. In such cases, the Industry 4.0 movement has been adapted to meet the area's needs, with initiatives such as Health and Care 4.0 being coined, yet widespread adoption of these initiatives has also been scarce [6]. Concerning the mass movement toward data-driven optimization, Industry 4.0 continues to be the leading term. Therefore, regardless of industry, all initiatives that have been adapted from the Industry 4.0 initiative will be referred to as Industry 4.0 for this paper, which aims to produce a general maturity model and an implementation plan applicable for businesses of any size in any industry.

2. Relevant Literature
The exact year of the maturity model is debated due to its creation in 1986 but publication in 1993 [7]. Regardless, academic and business organizations still employ maturity models as step-by-step assessments to determine their maturity or readiness at a given point in time. These steps, or stages, help many industries to develop strategies or plans to achieve the highest level of maturity and obtain a certain level of success. For example, a Social Media Maturity Model with At Internet Online Intelligence Solutions was created to aid individuals and companies in

establishing a social presence in their communities [8]. More relevantly though, Andreas Schumacher et al. created a similar maturity model to help companies integrate Industry 4.0 into their business model [9].

Both, by definition, are considered maturity models; yet, the designs vastly differ. The Social Media Maturity Model follows a pyramidal structure, seen in Figure 1, with 4 sections: Beginner, Junior, Senior, and Expert; moreover, it offers information about each stage and what the individual or company should apply to their social media habits in each consecutive stage [8]. That being said, the maturity model for Industry 4.0 by Schumacher et al. implores the company to fill out a questionnaire and then generates a graph to interpret the company's maturity on 6 different fronts [9]. Thus, maturity models take on many different forms and many different delivery styles despite having the same function or purpose: assess the company's readiness and help create a plan for the future.

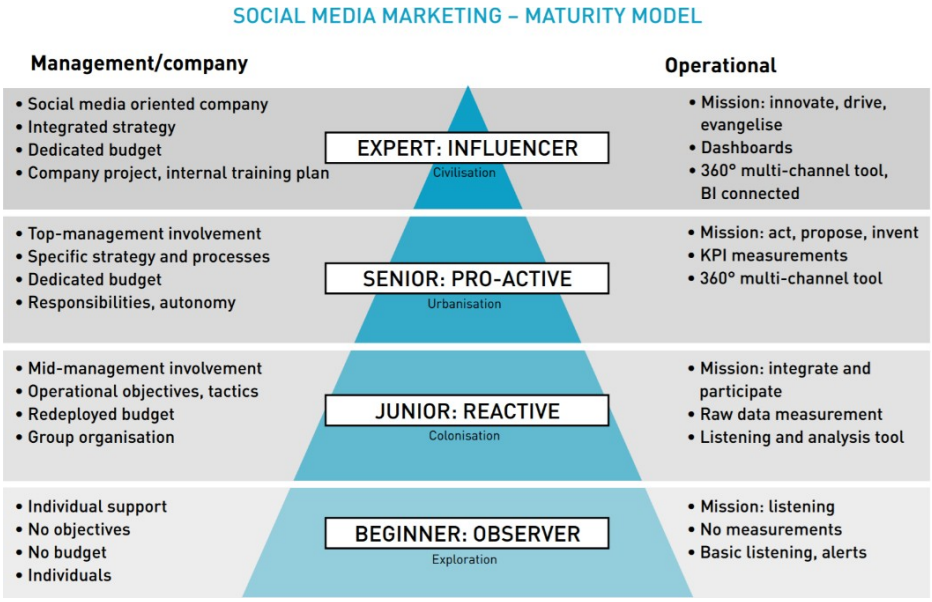

Figure 1. Pyramidal structure of the Social Media Marketing Maturity Model [8]

Due to their reflective nature, however, these models typically receive serious criticism for offering an oversimplified plan or sometimes even no plan at all. To make amends, maturity model developers often describe one specific path to reach full maturity, which unfortunately fails to acknowledge the existence of other successful paths. As if they were not critiqued enough, maturity models tend to imply an end-state and are criticized for possibly stunting the company's improvement after using the model [7].

Similarly, a maturity model was developed to assess the adoption level of a Scaled Agile Framework rather than Industry 4.0 or social media. Scaled Agile Framework (SAFe) describes the structure of an organization that encourages and facilitates the integration of lean and agile processes [10]. The SAFe maturity model clearly defines each skill a company should possess and how the skills evolve as the levels of maturity increase. It then utilizes a questionnaire that analyzes a company's achievement of those skills as defined within different principles or categories. To assess adoption, their model produces a sort of flow chart based on company input. The model compares original practices, adopted or altered practices, and completely new practices to give a holistic view of how the company's processes have changed [10]. It also offers little to no guidance towards a specific path, opening up the opportunity for the company to make a personalized plan aligned with its goals.

A review of Industry 4.0 models uncovered "key ingredients for evaluating Industry 4.0 readiness" as well as research prompts for future investigations [11]. The authors compared and categorized eight models to assess Industry 4.0 maturity while searching for commonalities to isolate six themes. These themes describe the essence of Industry 4.0 and provide a broad understanding of the professional consensus on Industry 4.0 which includes: Organization Strategy, Digitization of Organization, Digitization of Supply Chain, Smart Product and Services, Employee

Adaptability, plus Top Management Involvement and Commitment [11]. Figure 2 visualizes the thematic connections and results of Sony and Naik's review on Industry 4.0 readiness assessments.

Figure 2. A visual representation of thematic connections and results of Industry 4.0 readiness assessments [11]

Moreover, the Industry 4.0 Maturity Index is one of the leading frameworks with over 10,000 downloads to date [12]. The index provides a maturity framework split into four categories: resources, information systems, culture, and organizational structure. Each category is measured based upon two characteristics, which are further defined into several unique aspects. Using a graphical interpretation, the index weighs the characteristics' maturity level against each other to determine the overall maturity level for the category. The maturity levels range from level 1 to level 6, with level 1 and 2 grouped under "Digitalization" and levels three to six grouped under "Industry 4.0," pictured in Figure 3. Recommendations regarding implementable innovations are given throughout the index to provide users with a basis for growth. Sample maturity maps and strategic plans are also provided. While the index provides an in-depth analysis of Industry 4.0 and a comprehensive maturity framework, it orients itself for industrial manufacturing businesses. While the index proves useful for bridging the information gap of Industry 4.0, several of the recommended implementations remain difficult for SMEs, further limiting its true applicability.

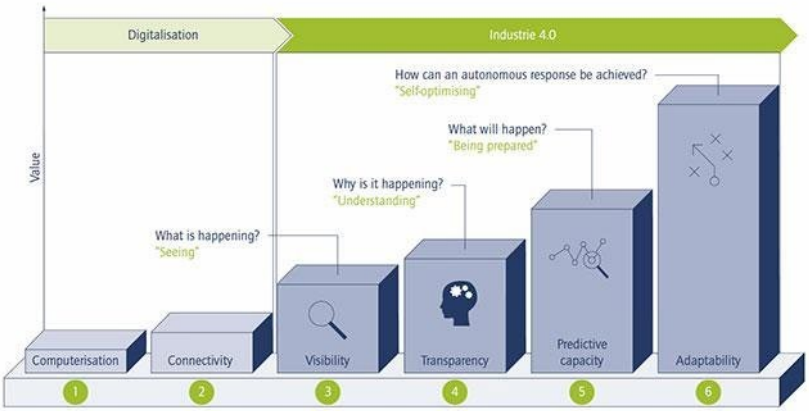

Figure 3. The Industry 4.0 Maturity Model [12]

In conjunction with the Industry 4.0 Maturity Index, a complementary paper titled Using the Industry 4.0 Maturity Index in Industry presents several use cases for the Index [13]. These use cases came three years after the initial publishing of the index, which makes them appropriate indicators of the index's applicability. The use cases provided in the paper consist of organizations beyond that of SMEs, which may further prove the Index's limitations. The maturity levels obtained by the companies averaged around level 2 to 3. As level 1 and 2 are pre-requisites to the Industry 4.0 stages, this gives cause to believe that Industry 4.0 implementation is difficult and time-consuming.

Further analysis of the companies (including a variety of company sizes) in a few years would give a better indication of its applicability.

To broaden the applicability of Industry 4.0 the benefits of integrating were described through a review of its applications in the healthcare and service industries. The review explains two branch initiatives known as Health 4.0 and Care 4.0; both of which stem from Industry 4.0 topics [6]. Health 4.0 employs these topics to focus on six main principles: Interoperability, Virtualization, Decentralization, Real-Time Capability, Service Orientation, and Modularity; it combines the aforementioned categories resulting in a company that communicates between machines and people to create a virtualized copy of its processes, allowing it to optimize customization based on real-time changes in customer and market demands [6]. Care 4.0 encompasses all assets to aid in the next revolution of the service industry. Care 4.0 enacts trust between the consumer and their source of service; for example, Chute and French illustrate the consumer's choice to either form trust with the organization or with the people working in it. They express that trust can be established by applying Industry 4.0 capabilities such as Cyber-Physical Systems, Internet of Things, Internet of Services, and the Virtual Twin [6]. Figure 4 is their visual aid for comparing Industry 4.0, Health 4.0, and Care 4.0; working inside out the diagram compares each initiative's Role/label (who is the focus), Default Location of Care, Core Process, Key Driver, Tailoring Method, Key Complication, and Key 4.0 Contribution.

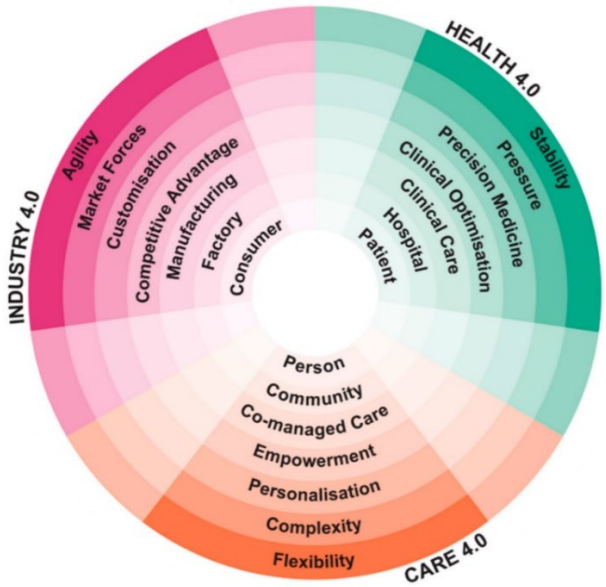

Figure 4. Visual aid used to compare Health 4.0, Care 4.0, and Industry 4.0 [6]

3. Research Goals and Methods

Given the breadth of concepts and technologies Industry 4.0 covers, the initiative lacks a single designated definition. Therefore, a cohesive and comprehensive understanding of the topic proves to be difficult, further complicating the process of its contextualization to unique businesses. For this reason, companies have found themselves adopting Industry 4.0 in a stock-like process in which they blindly adopt the plans of a company that has already successfully implemented Industry 4.0 [14]. This adoption, however, is often atomistic and poorly integrated, which may be due to the limited, often surface-level, understanding such companies are exposed to when observing Industry 4.0 frontrunners [15]. The implementation plans Industry 4.0 frontrunners execute are complex and contextualized in such a way that makes it difficult, if not impossible, to successfully replicate. Even in the event of successful replication, the company doing the replicating is unlikely to experience the same level of positive results, as important aspects like the company's goals and objectives may not align [15]. Therefore, while this paper aims to provide a framework for Industry 4.0 implementation, a definitive, step-by-step process is not provided. Rather, a questionnaire consisting of 50 statements evenly distributed across 5 categories (Strategy, Operations, Culture and Customer, Tech and Data, and Security and Governance) is provided to assist companies in determining their current level of Industry 4.0 implementation. The questionnaire is located in the Appendix of the paper. A weighting system is provided to aid in the contextualization of the statements to the company's needs.

The categories were determined through the reading and analysis of a variety of readiness models, implementation plans, and maturity models, as well as articles and interviews, regarding Industry 4.0 and its related, industry-specific counterparts. Most papers (beyond those with problem specific focuses like sustainability) provided overlapping or industry-specific categories. As the aim of the paper is to provide resources for businesses of all industries and sizes, these categories were placed into an already existing broad category instead, leaving 5 categories in the end. The natural patterns developed throughout these readings also provided a starting point for statement development. Given the nature of the questionnaire, the statements needed to represent aspects of a fully integrated Industry 4.0 category. Therefore, each statement was boiled down to a fundamental, yet encompassing, representation of Industry 4.0.

In its current stages, the questionnaire provides three options for weighting criteria: that which represents a production company, which represents a service company, and the option to enter custom weightings. While contextualization is a vital part of ensuring that such a framework is truly beneficial, as previously mentioned, many SMEs and companies residing beyond the manufacturing industry struggle with understanding how Industry 4.0 may benefit their business [5]. Therefore, the options to use pre-existing weightings for either a service or production company provide businesses with a starting point better suited for its operations. Such weightings may also be altered to further suit the company's needs.

The pre-set weightings were determined using the following methodology. First, service and production Industry 4.0 frontrunners were chosen based upon the innovations they have made in their field, specifically regarding Industry 4.0. A number of interviews and articles were then chosen, of which key quotes were taken and added to a document for later analysis. These quotes were chosen based on importance to the company (made apparent in the article) or the importance to Industry 4.0 (determined using knowledge from the prior literature review). Once these quotes were selected, they were referenced against the questionnaire statements. If the quote was deemed representative of a statement, a point was added to said statement. Given the interconnections of the categories, as well as the interdisciplinary nature of Industry 4.0, a single quote could be representative of multiple statements. Approximately 70 quotes were chosen for the production company, whereas the service company had approximately 30 quotes. The disproportion in the number of quotes was due to the relative scarcity of information regarding Industry 4.0 in service companies, as well as the general regulations imposed upon the chosen service company's industry. After each quote was assigned its corresponding statements, the total number of statements attributed to each were tallied, with a maximum score of 30 for production and 15 for service. As the weightings represent the importance of each statement to the company's goals and objectives, each statement's tally was divided by the maximum tally rather than the total number of quotes observed. This allowed for the statement with the maximum tally to be given the highest rating (5), which corresponds to its level of importance. It is important to note, while the weightings were determined methodologically, they are still subjective. Greater accuracy is hoped to be achieved in future works.
With the weighting criteria chosen, the company can rate their implementation level for each statement using a Likert scale, where 1 is "no implementation" and 5 is "full implementation." The rating is then multiplied by its corresponding weight, and the average maturity level for each category is found. The maturity level corresponds to the maturity model framework depicted in section 4 and is represented graphically in a radar chart. The maturity level for each category is found using the following equation:

$$\text{Maturity Level} = [[\Sigma(\text{Weight} * \text{Rating})] / \Sigma\,(\text{Weight})] * (3/5)$$

The decision to represent the company's maturity level in 5 separate categories rather than one overarching level was influenced by the "Industry 4.0 Maturity Index," however they vary greatly [12]. The separation allows the company to plan strategic improvements in an efficient way. For instance, a company that has already reached level 3 (the highest maturity level) in the Culture category would likely receive greater benefits improving a level 1 Technology and Data category instead. This further lessens the need to provide a definitive, step-by-step implementation plan, as companies will be able to visualize areas requiring improvement. Therefore, the implementation plan provided in section 5 solely consists of recommended considerations for the strategic planning process, as well as a general framework for the creation of a contextualized implementation plan. These considerations were determined via the literature review conducted throughout the research process.

4. Maturity Model

To create a successful maturity model, the research had to improve on past models and adopt bits and pieces from others. The research resulted in a 50-question questionnaire for companies to rate themselves on a scale from 1 to 5 for each one. These ratings are compiled to calculate maturity levels for each pillar or category of Industry 4.0: Strategy, Operations, Culture & Customer, Technology & Data, Security & Governance.

'Strategy' represents all of the strategic and conceptual actions the company has taken to prepare for Industry 4.0 implementation. Actions such as defining company objectives and forming strategic partnerships fall under this category. 'Operations' represents physically implemented innovations, such as utilizing data for decision-making insights and maintaining flexible assembly lines. 'Customer and Culture' represents the behaviors and characteristics present throughout the company. A goal-oriented work environment and flexible workforce fall under this category. 'Tech and Data' represents the current technology being employed, produced, and/or serviced throughout the company, as well as data handling capabilities. Key aspects of this category are abilities to aggregate data and the retrofitting of legacy machines. 'Security and Governance' represents the cybersecurity protocols and adherence to government regulations being employed throughout each area of the company. Sustainable initiatives and data ownership and safety protocols are important aspects of this category.

The maturity model provided in this paper was modeled after the Industry 4.0 Maturity Index; however, there are some key differences [12]. For instance, the levels of maturity model provided in this paper are based upon a company's percentage of implementation and integration as well as its understanding of Industry 4.0. In the Maturity Index, the levels were defined by key indicators and aspects, such as how data is used at a certain level. While both models provide levels for pre-industry 4.0 implementation, the paper's model only provides one, which is again based upon an implementation level and understanding of Industry 4.0. While basing a maturity level upon its key characteristics may provide a greater understanding of Industry 4.0 implementation, it limits its uses for companies of different industries and sizes. The paper's model, however, while less in-depth, is useable by companies of any size and industry, as it does not base itself upon key performance characteristics. It, therefore, is subsequently defined by its corresponding questionnaire, which contextualizes the company's goals and objectives to fundamental aspects of Industry 4.0. This allows for a greater variety of uses, as companies are able to change their statement weightings as they see fit. Figure 5 depicts a sample row of the Industry 4.0 questionnaire.

Category	Number	Statements	Weight	Rating	Maturity level
Strategy	1	Innovations are employed holistically across the company rather than in isolation.	3.33	5	2.44
	2	Company goals and objectives are explicitly defined, adjusted as needed, and made apparent to all members of the company on a consistent basis.	2.67	2	
	3	Innovations are implemented in a timely and iterative manner.	3.00	3	
	4	Stakeholders are fully involved in the decision-making and planning processes.	1.33	2	
	5	Strategic partnerships are formed to share expertise, build platforms, and exchange information.	5.00	4	
	6	Project viability is comprehensively assessed early on in the process and revisited often.	1.00	5	
	7	Implementation plans are fully defined and contextualized to the company's goals and objectives.	2.67	5	
	8	Complementary technological innovations are done in conjunction with one another as well as with corresponding organizational innovations.	1.67	3	
	9	Company implements technology to increase innovation and competitiveness rather than maintain current standing.	3.33	5	
	10	Current and future customer needs are weighed prior and throughout the design process to ensure only value-adding features are integrated.	4.33	5	

Figure 5. Sample items of Industry 4.0 questionnaire

Figure 6 depicts the levels of maturity which range from 0 to 3 and implies the stage of maturity, with 3 being the highest. Level 0 represents the starting stage where users do not yet have a solid foundation of Industry 4.0 and its categories. Users of this level must gain a better understanding of Industry 4.0 and its related concepts prior to beginning their Industry 4.0 implementation journey. For reference, a complementary paper titled "Industry 4.0 Concept Relationship Map and Simulation," was previously published to provide a basic visual understanding of Industry 4.0 and its nine pillars [2]. In this stage, companies have implemented 10% or less of Industry 4.0. Level 1, dubbed "Digitalization", refers to Industry 4.0 relying almost entirely on digital information and contains the basic or general requirements to begin implementing Industry 4.0. This level moves beyond that of legacy processes and systems, requiring businesses to digitalize their previous pen-and-paper workings. Companies of this level have a

basic understanding of Industry 4.0 but have only have an implementation percentage between 10% to 40%. These companies are likely to have poor integration and utilization of their innovations. Level 2, dubbed "Connection", encompasses the organization's ability to connect all of the topics and develop a stronger understanding of Industry 4.0 as well as the ability to connect machines and operations to streamline global improvement. Vertical, horizontal, and end-to-end integration is a vital part of this level. This level is characterized by an implementation percentage ranging between 40% and 70%. Companies of this level are likely to have a staggered integration of Industry 4.0. While implying a final stage, Level 3 - "Optimization" - was aptly named so to remind users the improvement does not stop here even if all objectives are met. During the optimization stage, businesses are encouraged to improve upon their previous innovations using data-driven insights and collaboration. These businesses are set to maintain an implementation percentage of 70%-100%. A 100% implementation is used to denote a company's full implementation of its previously planned innovations. Once these innovations have been fully integrated and new plans have been put into action, the company will be able to reevaluate itself for determining a new implementation and maturity level.

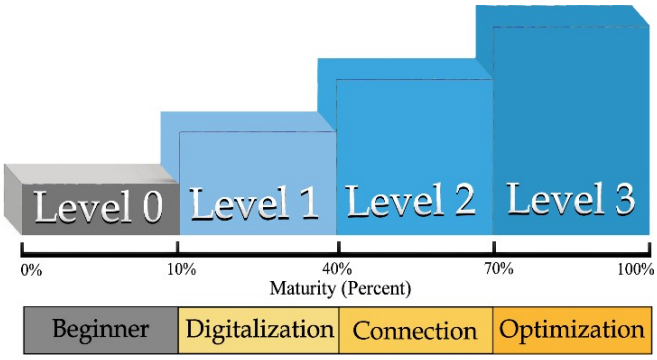

Figure 6. Industry 4.0 Maturity Model

Upon completion of the Maturity Model questionnaire, the user is provided with a graphical representation of their categorical maturity levels. An example graph is provided in Figure 7. This representation allows businesses to see where their key improvements must be and can be used to guide their implementation plan. Following the implementation plan allows companies to define objectives to improve their current stage depending on the category.

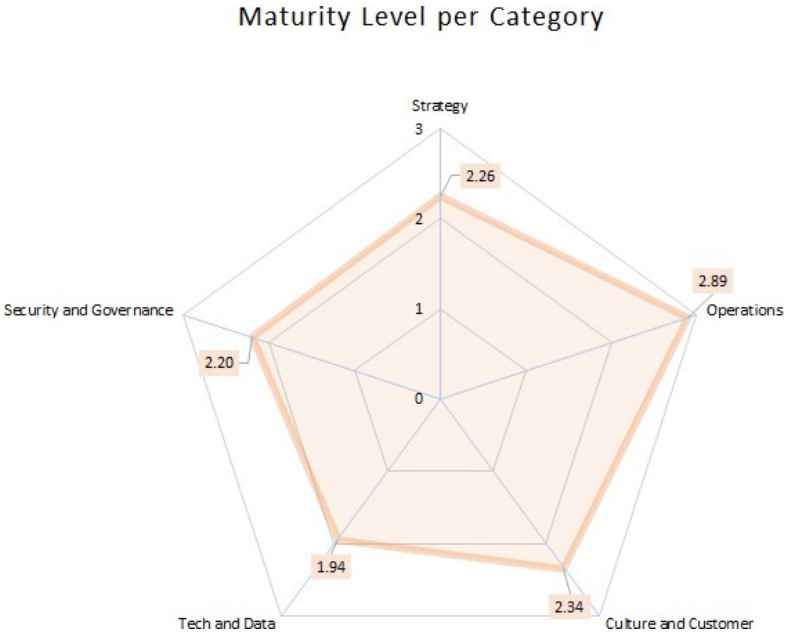

Figure 7. Radar graph depicting each category's maturity level

5. Implementation Plan

As each business has unique goals and objectives, a single standard and fully-defined implementation plan cannot be produced. However, a basic framework for an Industry 4.0 implementation plan consistent with the maturity model criteria provided in section 4 was created to give companies a general idea of where they should aim to be. Figure 8 provides an implementation plan which breaks each category into its own "innovation process." A fully defined plan would consist of several "innovation processes" per category tailored to the company's specific needs and objectives.

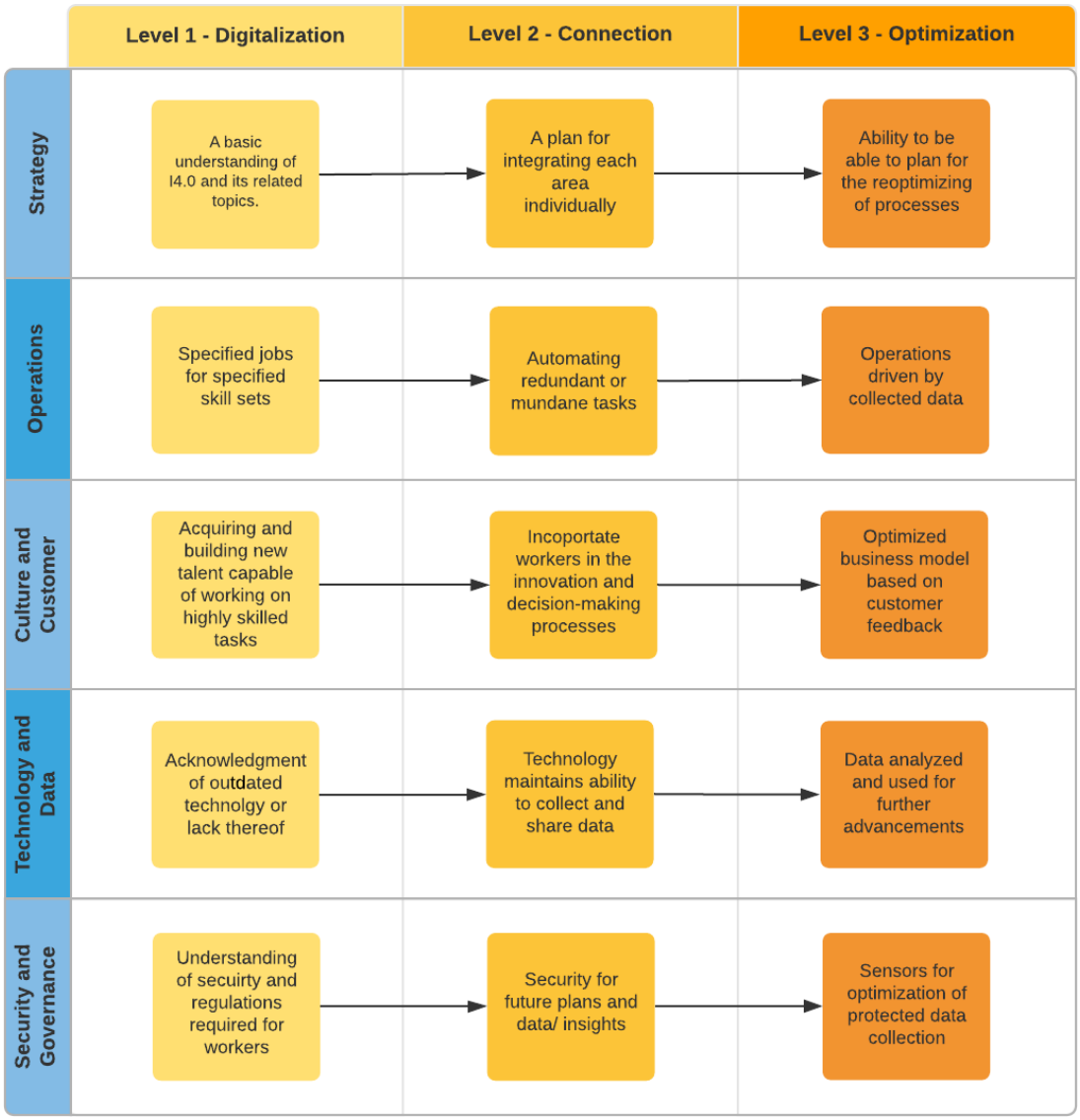

Figure 8. Implementation plan and framework for Industry 4.0

While a single standard implementation plan cannot be accurately provided, there are several implementation process recommendations that hold true for most businesses. First, it is recommended that companies move beyond level 0 before beginning their strategic planning for Industry 4.0 implementation. Without, at the very least, a basic understanding of Industry 4.0, efficient strategic planning cannot be properly completed. A proper understanding will allow the company to contextualize their needs when creating their implementation plan. To complement this, it may be best to establish an Industry 4.0 specific task force. This task force would be able to focus on learning more about new innovations and relaying them back to the company in a contextualized manner. If the company lacks such

capabilities, partnering or hiring a company with Industry 4.0 expertise to aid in the creation and implementation of a strategic plan may be another option.

It is important to note that companies must be willing to make certain organizational and cultural changes. This would include involving all members of the business in the decision-making and innovation planning processes as recommended by the Industry 4.0 Maturity Matrix and other literature [12]. This would allow those in different areas of the company to share their unique perspective, benefitting the company as a whole, and streamlining the process.

The reasoning for implementing Industry 4.0 is also something to take into consideration. Especially in the case of SMEs, implementation to maintain a current standing is unlikely to provide as great benefits as implementation to increase innovation [15]. Companies set to innovate are more likely to invest in R&D and other innovations, allowing them the opportunity to be both a provider and user of Industry 4.0 technology [14]. Those who innovate quickly may be able to receive first-to-market benefits, which can greatly improve their competitive standing [16]. SMEs in particular must also take into consideration, however, their ability to keep up with larger corporations. The use of third-party providers and partnerships to increase company capabilities may be more economical and efficient than building such capabilities in-house [2][13]. Scalable infrastructure provided on a pay-per-use model is both economical and efficient for companies with time-varying needs, such as a seasonal business or a company that is gradually increasing in size [2]. These third-parties also provide companies with the expert support they need to run their businesses efficiently [2].

Maturity models and implementation plans can help revolutionize a company to increase profits and redefine success. At the same time, the research team recommends considering factory or service simulations to prove or exemplify the benefits of implementing Industry 4.0. One such Software, RoboDK, opens up the opportunity to digitalize company operations and calculate legitimate data (see figure 9). Rather than having an employee or outside-hire draw plans for how the factory floor will look, one can easily import the robots or machines they plan to use and even program them with minimal programming experience required. In RoboDK, organizations can use Python programming to give the machine's instructions, however, using the tools provided in the software, a system of "targets" can be used to move the machines as needed, and automatically have the machine's code generated. Additionally, RoboDK provides an exact time to run for programs generated by the software. For example, if a program had a UR10e robot grab a manufactured part, taking about 10 seconds, then has the conveyor move the part for another 20, followed by another UR10e taking 10 seconds to grab the part from the conveyor, RoboDK will display that the entire process took 40 seconds to complete, as well as the individual time for each machine's section, if chosen. This allows for advanced optimization of floor layouts, as finding a configuration that shaves a few seconds now will save significant time in the long run. Finding this optimized layout is as simple as a few mouse clicks, with little to no mathematical calculation required by the user, meaning just about anyone can optimize a process. Simulation allows even the smallest businesses an easier entry point into optimization through Industry 4.0 standards and allows for planning of such features highlighted in sections above.

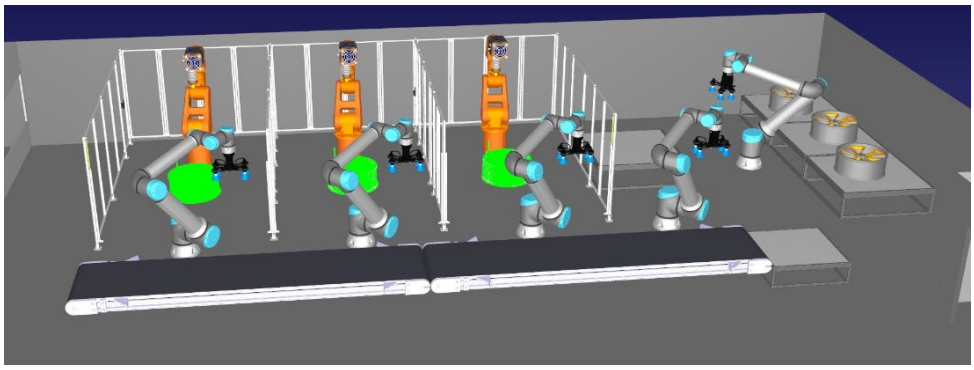

Figure 9. RoboDK Simulation of Factory Layout for Industry 4.0

6. Conclusion

Industry 4.0 takes advantage of digitalized information in order to optimize processes and increase a company's connectivity, efficiency, and profitability. The word "Industry" implies an industrial setting, but many business models have been created, such as Care 4.0 or Health 4.0, to prove that Industry 4.0 applies to many different sectors besides manufacturing. The research resulted in the creation of a descriptive, yet broadly applicable, maturity model for companies to begin their integration. To help with using this model, an implementation plan was created to explain how a company could progress through the stages of maturity. Model users must possess a deep understanding of Industry 4.0's main pillars and practical categories as explained in the questionnaire and implementation plan to begin integrating. Then, an intuitive process begins to set in for organizations to reach their fullest measurable Industry 4.0 potential. Graphing the maturity levels for each category offers a visual representation of the company's readiness to optimize outside of the model's scope.

Some software can produce hyper-realistic laboratory simulations to test and analyze Industry 4.0 concepts and personalize the implementation. That being said, the maturity model and implementation plan are general suggestions and can be customized and changed depending on the company or industry. Further, they could change based on the evolution of Industry 4.0 as it is currently considered a cutting edge and relatively new concept. Future work will focus on improving and optimizing the models to create a more efficient system of integrating into the fourth industrial revolution.

Correspondingly, the questionnaire will be expanded and refined to allow for a more fundamental view and rating of Industry 4.0 concepts. Additional weighting options will be provided to allow for more accurate results. While a singularly defined and standard implementation plan cannot be provided, future analysis of companies and use cases will allow for further comprehensive recommendations. Industry 4.0 simulations will also be improved upon to allow for a more applicable visual understanding of Industry 4.0's uses.

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Appendix

Strategy

1	Innovations are employed holistically across the company rather than in isolation.
2	Company goals and objectives are explicitly defined, adjusted as needed, and made apparent to all members of the company on a consistent basis.
3	Innovations are implemented in a timely and iterative manner.
4	Stakeholders are fully involved in the decision-making and planning processes.
5	Strategic partnerships are formed to share expertise, build platforms, and exchange information.
6	Project viability is comprehensively assessed early on in the process and revisited often.
7	Implementation plans are fully defined and contextualized to the company's goals and objectives.
8	Complementary technological innovations are done in conjunction with one another as well as with corresponding organizational innovations.
9	Company implements technology to increase innovation and competitiveness rather than maintain current standing.
10	Current and future customer needs are weighed prior and throughout the design process to ensure only value-adding features are integrated.

Operations

1	Changes are met quickly and without issue throughout all stages of the production/service process.
2	The correct talent is currently in place throughout the company and is being utilized to their full potential.
3	Machines and resources are monitored and controlled remotely.
4	Individualization (Lot-size 1 production) can be implemented without financial loss.
5	The supply chain is flexible and partners are chosen based upon data-driven insights regarding availability, patterns, services, and cost effectiveness.
6	Repetitive tasks are automated across the company.
7	Order inquiries and estimations can be processed automatically.
8	Technological operations are optimized via data-driven insights.
9	Predictive and remote maintenance is utilized (to reduce downtime, increase efficiency, and improve worker safety).
10	Any capabilities the company lacks are met by third-party providers.

Culture & Customer

1	Workers are informed of new changes within the business and are included in the planning and decision process.
2	Current workers are trained to work with new processes, programs, and technology often.
3	Workers are flexible and open to change.
4	Tasks are assigned to those with the ability to best complete the job rather than in a hierarchal fashion.
5	A goal-oriented work environment built upon collaboration and communication is in place.
6	Workers are given the authority to make decisions in accordance with data-driven insights.
7	Communication lines between workers and customers are short and efficient.
8	Workers are encouraged and given opportunities to learn new skills and improve upon their current ones.

9	Data gathered from the end-product customer is utilized to provide the immediate customer with value-adding services and insights.
10	Mistakes are treated as learning opportunities and used to optimize processes.

Technology & Data

1	Data is aggregated from all areas of the company, stored, and analyzed for insightful decision-making.
2	The company maintains a robust, accurate, and exhaustive digital twin.
3	Legacy machines and processes are replaced or retrofitted to allow for interoperability between new machines and processes.
4	Data is received via a single point of access which is accessible and shareable at any physical point.
5	Technological infrastructure is scalable, economical, and can be adjusted as necessary.
6	Platforms and interfaces are intuitive, easily accessible, and standardized across the company.
7	Company is capable of aggregating and analyzing large amounts of heterogenous data in real time or near real time.
8	The flow of data is continuous and insights are updated as such.
9	Technology, such as VR/AR or simulations, are utilized to reduce the prototyping/pilot project process.
10	The company's products/services utilize or offer digital/smart functionalities.

Security & Governance

1	Security levels access is upheld between members of the company as required by government and organizational regulations.
2	Standards and protocols are clearly communicated and revisited/adjusted consistently.
3	Worker safety standards and protocols are accounted for during the planning and innovation process.
4	Data shared by partners and members of the supply chain are as equally protected as company-produced data.
5	Data is stored redundantly to ensure accessibility in the case of loss or corruption.
6	Sustainable initiatives in accordance with government regulations and recommendations are actively pursued and implemented across the company.
7	Sensors are utilized to ensure and regulate working conditions.
8	Data ownership standards are set in place and upheld across company operations and the value chain.
9	A comprehensive documented mitigation strategy exists for any unauthorized access to data.
10	Security measures are continuously monitored and updated in a timely manner to prevent a data breach.