Enhancing Digital Transformation Through Maturity Modeling

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ABSTRACT

Organizations around the globe, whether industry or military, are embarking on a journey towards digital transformation (DX), which has been defined as leveraging the latest in emerging technologies to digitally enable business operations while enhancing customer interactions and increasing workforce engagement. Yet, transforming business by digitally enabling processes and procedures is just the first step in a DX journey. Utilizing data as a strategic asset to provide insight is what drives transformative value, in turn fueling unparalleled growth. But to capitalize on data within an organization and drive high-value return on investment, there needs to exist an integrated approach that links digital transformation objectives to overall business strategy to quantify gains and drive competitive advantage. New strategies and models must be considered, with value elements being defined that characterize digital maturity in a manner via which critical success factors, limiting conditions, and prospective transformation trajectories can be identified that drive digital value proposition. This paper describes the formation of a digital maturity modeling framework for an industry use case.

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INTRODUCTION

Digital transformation (DX) is focused on the integration of emerging technologies (e.g., advanced data analytics, immersive eXtended reality [XR], Internet of Things [IoT] connectivity, quantum computing) into an organization's products, processes, and strategies to transform business operations while enhancing customer interactions and increasing workforce engagement. DX promises increased efficiency and effectiveness, greater business agility, and the potential to unlock new value for customers, employees, and shareholders. By digitizing manual tasks and associated workflows, organizations can reduce costs, improve productivity, and enhance overall organizational performance (Schneider & Kokshagina, 2021). Digital tools and platforms can also facilitate collaboration, communication, and knowledge sharing, empowering employees to work more efficiently and effectively. This not only boosts productivity but also enables businesses to adapt and respond quickly to market dynamics, gaining a competitive edge. By embracing emerging technologies and digital business models, organizations can create disruptive offerings and enter new markets (Kıyıklık et al., 2022).

DX begins with digitally enabling processes and procedures through digitization (e.g., moving from analog to digital, such as by creating augmented reality [AR] overlays that provide point-of-need job aids). Such digitization is anticipated to lead to *evolutionary* gains in efficiency and effectiveness within business operations. Beyond the gains it realizes, digitization has a key benefit in that it makes organizational data more easily accessible, storable, maintainable, and sharable. To achieve *revolutionary* gains via DX, digitization must be coupled with digitalization, which involves putting organizational data collected via digitization to strategic use (Chakravarthy, 2019). Digitalization goes beyond the implementation of emerging technologies to enable work, to the unlocking of new value derived from aggregated data and associated analytics supported by cloud computing, Internet of Things (IoT), process automation, artificial intelligence (AI), and machine learning (ML), which taken together increase business intelligence. Such digitalization involves leading DX efforts with a data-driven enterprise strategy that sets objective business goals, builds transformative capabilities through the implementation of disruptive tools that apply AI/ML and advanced analytics to clearly demonstrate integrated DX value, and cultivates a results-driven, mindset. The latter is important, as less than a third of DX efforts succeed at substantially improving a company's performance, capturing fundamentally new value, and sustaining these gains (McKinsey & Company, 2018). For traditional industries, such as oil and gas, DX success rates are typically even lower, at < 10%. Further, nimble, small organizations (< 100 employees) are nearly 3x more likely to report success with DX than complex, large organizations (50K> employees). While there are many reasons for coming up short in DX efforts, a critical component of these failures is the fact that organizations have no readily available means of systematically determining where they are on the digital maturity curve, what their capabilities are to undergo such a transformation, and what is the most fruitful journey to increase digital value capabilities. Thus, it is critically important to determine how best to characterize and measure digital maturity to increase the probability of DX success.

MATURITY MODELING

An organization, whether industry or military, can start their DX journey with an evaluation of the maturity of processes, technologies, people, and data analytic capabilities that can support sharing of data and information across an organization to fuel strategic decision making and increase business intelligence. Maturity models (i.e., frameworks for assessing continuous improvement) serve as valuable foundations for organizations undergoing DX to assess their current capabilities and progress in the digital realm. These models provide a structured approach to understanding an organization's digital readiness and identifying areas for improvement. By defining various maturity levels or stages, organizations can evaluate their strengths and weaknesses in terms of technology adoption, process optimization, and enhanced organizational culture. According to Gökalp & Martinez (2021), maturity models enable organizations to navigate the complexities of DX by offering a clear roadmap for improvement. They provide a benchmark against

which organizations can measure their digital maturity, allowing them to identify gaps and set targets for progress. By aligning their DX initiatives with a maturity model, organizations can prioritize their efforts and allocate resources more effectively. Various industries have utilized maturity models in their digital transformation endeavors. For example, the Capability Maturity Model Integration (CMMI) is a well-known maturity model used in software development and IT service management. By following the defined stages of the model, organizations can enhance their software development processes and optimize their IT operations. Similarly, the Digital Maturity Model developed by Westerman et al., (2014) provides a framework to assess an organization's digital capabilities and identify areas for improvement in digital strategy, operations, and organization. By leveraging maturity models specific to their industry, organizations can systematically evaluate their digital readiness, set realistic goals, and track their progress throughout the DX journey.

The purpose of maturity models is to define a systematic path to maturation along **defined dimensions**, including defining the stages along the journey, relationships between stages, effective means of progressing through the stages, and means of assessing progress made (Monteiro & Maciel, 2020; Ormazabal et al., 2021; Röglinger et al., 2012). Thus, maturity modeling can facilitate organizations in progressing through the stages of DX in a methodical and metrics-driven manner, which given the noted high failure rate of many past efforts (McKinsey & Company, 2018), is of critical importance. Digital maturity modeling can support 1) benchmarking DX processes, procedures, technologies, and other dimensions to systematically measure an organization's current capabilities, 2) establishing clear targets for key performance indicators, and 3) communicating a target transformation's timeline via which progress can be made, thereby providing tangible targets for improvement and growth. Additionally, organizations that take a systematic, metrics-driven approach to DX are as much as 2x as likely to meet with success (McKinsey & Company, 2018).

When developing a digital maturity model framework, **value dimensions** and associated **sub-dimensions** (i.e., evaluation categories) can be used to specify maturity levels and assessment metrics along those dimensions. Once maturity levels and metrics are defined for each dimension/sub-dimension, an organization can begin systematically evaluating their progress towards digital maturity using both qualitative and quantitative data. Such an evaluative approach will allow organizations to either support or challenge their assumptions regarding the value being derived by their DX initiatives and the nature of the underlying value proposition (e.g., is it derived from technology, process, user experience, digitally derived service offerings, or other such gains). This paper describes a research process for creating such a maturity modeling framework as demonstrated through an ExxonMobil use case. This integrated approach can be used by organizations within industry or government to create their own DX maturity assessment tool.

INDUSTRY USE CASE: EXXONMOBIL'S DIGITAL REALITY ECOSYSTEM

It is key when developing a maturity modeling framework to start with a definition of the scope, target audience and the purpose of the model. The digital maturity model framework described below was developed in collaboration with ExxonMobil's Digital Reality Ecosystem (DRE) team as part of an ongoing DX maturity modeling effort. The DRE team is leading organizational change by focusing on DX and moving toward a visual and data-driven way of working. The key focus of this integrated team of designers, engineers, and solutions architects is to build a complex interconnected network of data (with 3D data at its core) that will allow asset data to be platform and system agnostic and open to integration. The DRE is, for ExxonMobil, a step towards the future where operators have access to the data they need right at their fingerprints, and in real time so that data can be used strategically. This DX effort will enable new and innovative work processes, such as the ability to perform maintenance or engineering design in a collaborative environment or the use of high-consequence scenarios for training in eXtended Reality (XR) to reduce ramp-up time. By building an open ecosystem that allows the integration of data across all assets, the DRE is poised to enable DX at scale.

The DRE is becoming the new way of working at ExxonMobil. Data, not only traditional 1 or 2D data, but 3D data as well, are being captured in real time and in a variety of ways, then accessed and manipulated whenever and however needed. However, currently the digital re-use of these data is not feasible because these data may be of different types (e.g., laser scanning, geospatial scanning, design), and they may be captured and stored in different formats, ways and locations. Further, the delivery mode may also be different depending on final consumption mode (e.g., training, model reviews, visual asset management). This diversity challenges the ability to integrate data across DRE's operations and optimize digital processes. To reach digital maturity, DRE needs to integrate their data and processes

in a systematic manner. These and other challenges make the DRE a prime candidate for maturity modeling. This will enable the team to assess the current state of digital maturity for ExxonMobil's chosen workflows that are undergoing DX and identify a path to optimize return on investment (ROI) and digital value throughout ExxonMobil's DX journey.

Development of a Digital Maturity Modeling Framework

The development of the digital maturity modeling framework commenced with a thorough literature review and analysis of twenty-eight (28) digital maturity models. These models were categorized by type, including conceptual, qualitative, quantitative, and derivative (Monteiro & Maciel, 2020).

- *Conceptual*: Maturity models that use a conceptualized theoretical framework via which to derive pertinent dimensions, define associated subcategories, and specify levels (i.e., stage) for each.
- *Qualitative*: Maturity models that incorporate a qualitative empirical approach to identifying dimensions, subcategories, and levels, verifying each via focus groups, interviews, and/or survey methods.
- *Quantitative*: Maturity models that incorporate a quantitative approach to deriving dimensions, subcategories, and levels, such as via psychometric modeling and analysis of categorical data (e.g., a Rasch algorithm-based approach).
- *Derivative*: Maturity models that adopt a prior published maturity model and fit a specified use case into the structure without strong theoretical or empirical foundations. Derivative approaches often apply the selected model to an idealized use case without considering its applicability (Ormazabal et al., 2021).

Table 1 presents all the models that were reviewed along with their type, application domain, specific topic within the domain, and validation type. Thirteen (13) of the twenty-eight (28) models reviewed were conceptual, one (1) was derivative, eight (8) were qualitative, five (5) of unknown type (i.e., no description of modeling approach provided), and only one (1) was quasi-quantitative. This indicates a distinct lack of data-driven approaches; thus, it will be critical to address this gap with a more data-driven, metrics-based approach to defining the maturity continuum in the future. Once this initial review was completed, the team began the process of categorizing and selecting key dimensions and sub-dimensions for the digital maturity modeling framework being developed.

Table 1. Digital Maturity Models Reviewed

Source	Title	Type	Application Domain	Topic	Validation Type
Amaral & Peças, 2021	Framework for Assessing Manufacturing SMEs Industry 4.0 Maturity	Conceptual	Manufacturing	Small and Medium Enterprise	Case Study
Aras & Büyüközkan, 2023	New Holistic Digital Maturity Model	Conceptual	Generic	Private & Public Sector	Literature Review
Blatz et al., 2018	Digital maturity level	Conceptual	Small and Medium Enterprises	Best Practice Model	Survey
Borstnar & Pucihar, 2021	Multi-Attribute Assessment of Digital Maturity of SMEs	Conceptual	Generic	Small and Medium Enterprise	Expert case studies
Chonsawat & Sopadang, 2019	Industry 4.0 Maturity Model	Conceptual	Industry 4.0	Small and Medium Enterprise	SME surveys
Gökalp & Martinez, 2021	DX-CMM: the digital transformation capability maturity model	Conceptual	Industrial Manufacturing	On-premises Technology	Expert Validation
Gollhardt et al., 2020	Exploratory Digital Transformation Maturity Model	Conceptual	IT Systems	Energy Sector	Likert Surveys
Haryanti et al., 2023	DX-Self Assessment Maturity Model	Conceptual	Generic	Organizational Sustainability	Case Studies
Ifenthaler & Egloffstein, 2020	Maturity Model for Educational Organizations (MMOE)	Conceptual	Education	Vocational Education	Case Study

Mittal et al., 2018	SM3E	Conceptual	Small and Medium Enterprises	Smart Manufacturing	None
Nerima & Ralyte, 2021	Digital Maturity Balance Model and Tool for public organizations	Conceptual	Public Organization	Generic	Survey
Valdez-de-Leon, 2016	Digital Maturity Model for Telecommunications	Conceptual	Telecommunications	Service Providers	None
Wagire et al., 2021	Maturity Model for Assessing the Implementation of Industry 4.0	Conceptual	Industry	Manufacturing/ Supply Chain	Likert Surveys
Almasbekkyzy et al., 2021	Digital Maturity and Readiness Model	Derivative	Industry	Large Enterprise	Survey
Almamalik, 2020	Maturity Model for Smart Manufacturing Companies 4.0	Qualitative	Industry	Smart Manufacturing	Survey
Begicevic Redjep et al., 2021	Framework for Digitally Mature Schools (FDMS)	Qualitative	Education	Primary and Secondary School	Self-Assessment Survey
Bibby & Dehe, 2018	Industry 4.0 Maturity Levels	Qualitative	Industry	Defense	Survey
Gimpel et al., 2018	Framework of Action Fields	Qualitative	Generic	Benchmarking	Case Study
Goumeh & Barforoush, 2021	Digital Maturity Model for digital banking	Qualitative	Finance	Digital Banking	Case Study
Ivančić et al., 2019	Organizational resources and activities in the digital transformation process	Qualitative	Generic	Telecommunication, Manufacturing	Case Studies
Lin et al., 2020	Smart manufacturing transformation Industry 4.0	Qualitative	Manufacturing	Smart Manufacturing	Survey
Rossmann, 2018	Conceptualization and Measurement Model	Qualitative	Generic	Information Systems	Surveys, Statistical Analyses
Berghaus, 2016	Digital Maturity Model (DMM)	Quantitative	Generic	Organizational Change	Survey
Deloitte, 2018	Digital Maturity Model	Unknown	Industry	Generic	Unknown
PWC, 2017	PWC Maturity Model	Unknown	Generic	Value Centric	Unknown
Quantum Metric, 2021	Digital Analytics Maturity Playbook	Unknown	Generic	Strategic Analytics	None
S. E. D. Board, 2020	Smart Industry Readiness Index	Unknown	Industry	Manufacturing	Survey
TM Forum, n.d.	Digital Maturity Model	Unknown	Telecommunications	Service Providers	Expert Surveys

Defining Key Dimensions and Sub-dimensions

Defining key value dimensions in digital maturity modeling involves identifying and articulating the critical factors that contribute to digital maturity. These dimensions should be constructed such that they align with the industrial or military organization's strategic objectives and encompass various aspects of DX. From the reviewed models for this effort (see Table 1), the key dimensions used in each model were identified and listed, duplicates were removed, and the remaining dimensions were compared to each other using a card sorting approach (Goodman et al., 2012). Card sorting is a popular method used in information architecture and user experience design to organize and categorize information. In this activity, the team used card sorting to categorize digital maturity dimensions based on the relevance to ExxonMobil's DX efforts. Specifically, a digital whiteboard containing virtual "sticky notes" of the 101 unique dimensions compiled from the models in Table 1 was reviewed by 12 organizational subject matter experts (SMEs) within ExxonMobil. These SMEs are leading ExxonMobil's efforts in virtual assembly, digital warehousing, turnaround planning, remote engineering, incident response, equipment strategies, routine maintenance, training,

project execution, construction progress, and systems completion, and thus are highly invested in the development and use of this digital maturity model framework. Each stakeholder independently sorted the 101 dimensions into several pre-defined categories and were asked to create any new categories as they saw fit. The whiteboards were then reviewed as a whole and distilled into the six key dimensions shown in Figure 1.

Figure 1. Digital Maturity Model Key Dimensions

Once the key dimensions were identified and distilled, the sub-dimensions within each dimension for all the models (see Table 1) were identified and listed. Next, for each of the six key dimensions, the sub-dimensions were mapped out for each model (see example in Figure 2).

	Strategy						
Almamalik, 2020	Collaboration	Innovation Management	Investment Strategy	Strategy Implementation	Teamwork		
Almasbekkyzy et al., 2021	Finance	Stakeholder Management	Strategic Management				
Amaral & Peças, 2021	Adaptation of Business Model	Digitalization Strategy	Enterprise Commitment	Innovation Management			
Aras & Büyüközkan, 2023	Business Model	Leadership	Operating Model	Strategies	Vision		
Begicevic Redjep et al., 2021	Development Plan	Integration Management	Learning Analytics	Regulated Access	Vision		
Berghaus, 2016	Digital Commitment	Strategic Innovation					
Bibby & Dehe, 2018	Agility Vision	Manufacturing Strategy	Technological Investment				
Blatz et al., 2018	Corporate Strategy	Market Position					
Borstnar & Pucihar, 2021	Cyber Security	Digital	Investment in IT	Planned Investments			
Chonsawat & Sopadang, 2019	Road-Map	Strategy	Business Model				
Deloitte, 2018	Brand Management	Ecosystem Management	Finance & Investment	Market & Customer	Portfolio, Ideation, & Innovation	Stakeholder Management	Strategic Management

Figure 2. Sample Mapping of Sub-Dimensions

Following this mapping, duplicates were removed, and then like terms were grouped together (e.g., interactions and interaction were combined into a single sub-dimension), and sub-dimensions were selected that were of relevance to ExxonMobil's DRE use case. Table 2 shows each key dimension, along with the number of unique sub-dimensions contained within the models reviewed, the number of sub-dimensions after the mapping process, and the number of selected sub-dimensions for the developing digital maturity model framework.

Table 2. Sub-dimension Analysis

Key Dimension	Unique Sub-dimensions	Sub-dimensions after Re-categorization Mapping	Selected Number of Sub-dimensions
Strategy	93	56	10
Technology	126	96	8
Process	81	57	8
People/Culture	96	57	10
Data & Analytics	41	33	4
Organization	116	84	9

The final digital maturity model framework consists of six dimensions and 49 sub-dimensions which were systematically defined and evaluated to support the DX goals of ExxonMobil. Figure 3 shows each of the key dimensions and their associated sub-dimensions as they will be used in the ongoing development of the maturity model.

As the DRE team leads their team in moving toward a visual and data-driven way of working, this digital maturity framework will help to assess and progress the team along the maturation process. The framework will become part of the greater process of enabling new and innovative work by building an open ecosystem that allows the integration of data across all assets. As shown in Figure 3, three of the six dimensions include a data- or analytics-driven component. This is an indicator that the data-driven approach is critically important, not just to ExxonMobil, but to the business community at large, and that data will be foundational throughout the framework.

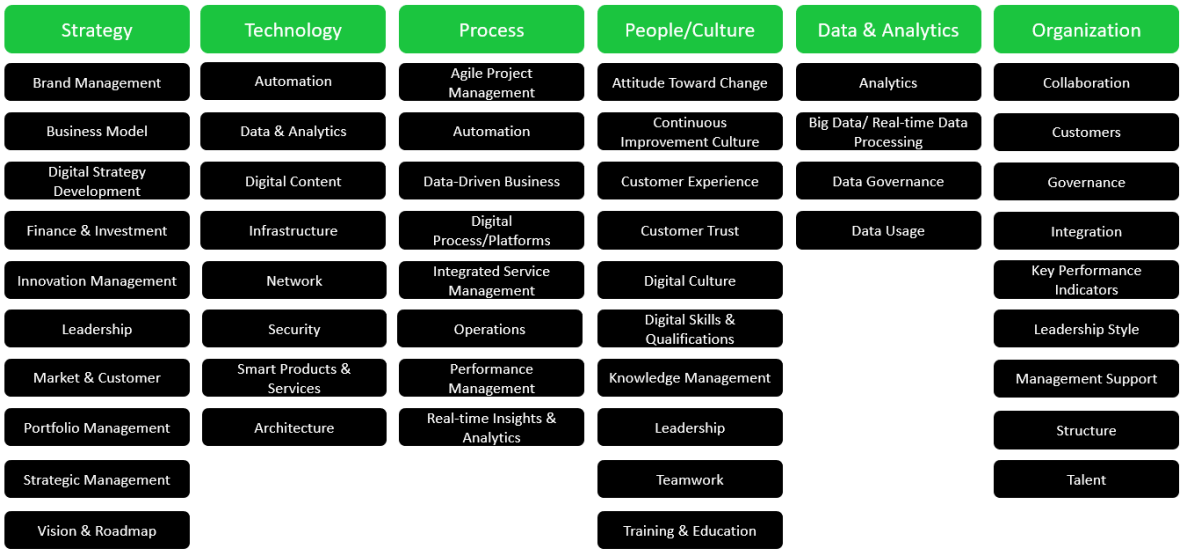

Figure 3. Digital Maturity Model Key Dimensions and Sub-dimensions

FUTURE WORK: MATURITY LEVELS AND ASSESSMENT CRITERIA

This effort focused on the first two steps of creating a maturity model, namely 1) defining scope of the model including the domain, target audience, and the purpose of the model, and 2) defining key value dimensions and sub-dimension, which are the criteria or characteristics that will be used to assess an organization's capabilities along a continuum of maturity levels. Now that the digital maturity dimensions have been defined, the next step will be to identify the maturity levels for each dimension. The path to maturity will be conceptualized and substantiated via process theories, including lifecycle, evolution, dialectic, and teleology (Plattfaut et al., 2011; van de Ven & Poole, 1995) which are defined as follows:

- *Lifecycle:* Maturity constitutes organic, irreversible, and linear growth derived via progression through a unitary, cumulative, and conjunctive sequence from initiation to end state.
- *Evolution:* Maturity constitutes a recurrent, cumulative and probabilistic sequence of variation, selection, and retention derived via competition with similar entities for resources.
- *Dialectic:* Maturity constitutes a change that derives from working out functional contradictions or conflicts, with each stage struggling to supplant and overcome the preceding one; negation becomes a means of advancing (i.e., solutions that resolve contradictions advance).
- *Teleology:* Maturity constitutes a deterministic, adaptive, and structured approach derived via an intentional change process that involves establishing goals towards an imagined end state; progression occurs as objectives are continually reformulated based on constant organizational feedback.

Following characterizing of the maturity levels, assessment tools (i.e., metrics) that can be used to evaluate the organization's capabilities at each level will be developed. Once the assessment tools have been developed, assessments of digital maturity will be conducted according to the defined framework and the results will be analyzed to identify patterns and trends of where DX efforts are performing well and areas where they need to improve. Based on the results of the analysis, the maturity model may need to be refined or updated.

CONCLUSION

The purpose of this applied research was to describe the research process conducted to define the key dimensions and sub-dimensions of digital maturity as a first step towards the creation of a holistic digital maturity modeling framework that can be applied to any organization, whether academic, industry, or military that is considering or embarking on a DX journey. The promise of DX is increased efficiency and effectiveness, greater business agility, and the potential to unlock new value for customers, employees, and shareholders, and in order to achieve these revolutionary gains, organizations must have a clear assessment strategy that incorporates the use of clearly defined metrics. If this is achieved, organizations can fundamentally change the way business is done by creating an infrastructure that can drive highly strategic decision making and optimization of every aspect of a business, thereby driving high value ROI and fueling unparalleled growth. In this paper, six key dimensions were defined: 1) Strategy, 2) Technology, 3) Process, 4) People/Culture, 5) Data & Analytics, and 6) Organization. In addition, a total of 49 sub-dimensions were defined. These key value dimensions and their associated sub-dimensions can next be used to specify organizational maturity levels and assessment metrics, which will allow organizations to begin systematically evaluating their progress towards digital maturity and either support or challenge their assumptions regarding the value being derived from their DX initiatives and the nature of the underlying value proposition.

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