ISBN: 978-628-95207-8-1. ISSN: 2414-6390. Digital Object Identifier: 10.18687/LACCEI2024.1.1.1807

Assessment of the Level of Digital Maturity Through a Process Analysis

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***Abstract*— This study examines the challenges faced by companies in assessing their digital maturity. It focuses on Industry 4.0, which incorporates digital technologies to improve efficiency, productivity, and quality in the ship design and construction sector. Initially, the outfitting department of a ship company in Colombia was analyzed exhaustively, identifying areas of opportunity, and establishing a basis for continuous improvement using the methodology proposed by the ISO 90001 standard and various methodologies such as interviews and flow charts to understand the processes developed in this area of the company. Subsequently, a digital maturity model was proposed based on existing models and a literature review. The proposed model was then applied to the outfitting department as a valuable tool for evaluating progress in digital transformation. The results presented in this article highlight that improving digital maturity can reduce costs, increase efficiency, and improve quality. Additionally, this study presents an activity path and the 5W2H tool to eliminate criticalities in the design process, offering a practical and effective approach for implementing improvements.**

Keywords-- digital maturity, industry 4.0, outfitting, process improvement, ship sector.

I. INTRODUCTION

Digital transformation today is seen as a need for business competitiveness that occurs when organizations involve digital technologies in their operations. Allowing them to standardize efficient and effective processes in a changing market to provide better service to their customers using tools to capture sensitive and useful information for decision making.

Thus, within the strategic direction of a ship design and construction company that has been selected for this research, the general management has proposed a strategic initiative called ASTILLERO 4.0, considering that to date for this type of companies there are few projects that contemplate a route with different phases required for the digital transformation processes from a corporate perspective, being these phases: awareness, diagnosis of the level of digital maturity, digital transformation plan, implementation and strengthening of the enablers of digital transformation, monitoring and measuring the impact [1]

In this sense, from the Design and Engineering department it has been established to execute the diagnostic phase for the processes and sub-processes that are carried out within this department, to know the detailed process, they develop to then know in what level of digital maturity it is. Therefore, the main objective of this research is to perform a diagnosis of the digital transformation maturity level of the division, through the survey and characterization of the process for the definition of a preliminary digital transformation roadmap.

This article is organized as follows, initially a theoretical framework that addresses the issue of process survey and techniques developed to structure a process, followed by the methodology used to propose a maturity model for this type of companies in specific by comparing different models studied in the literature, then the proposed methodology is implemented, the results of the maturity of the department are shown, finally the conclusions and future recommendations are shown.

Digital Object Identifier: (only for full papers, inserted by LACCEI).
ISSN, ISBN: (to be inserted by LACCEI).
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II. THEORETICAL CONCEPTS

To initiate the research, it is necessary to establish the concept of a process. A process is defined as the execution of a sequence of organized tasks aimed at achieving a pre-determined objective[2]. The activities that take place in a process can be performed by people or artifacts using various resources. In a naval ship engineering design process, the agents who perform the tasks and the attributes of the resources involved must be considered. Now, the importance of processes in a manufacturing or service company is essential for its performance and operation. Making an analogy it can be said that the processes in a company are like the lungs of the human body, if the company stops working it cannot produce resources, that is why a good process management would disappear to achieve success in its operations. In fact, if there is no such order, it will not even be able to start its activities correctly.

In addition, some companies are dedicated to identifying activities and tasks within their processes, with the objective of more accurately reflecting the operational reality of the company. These activities and tasks are often referred to as process studies, a practice deeply rooted in organizational methodologies. Several authors describe the process study as "the systematic process of identifying, analyzing and documenting an organization's existing processes, with the overall objective of understanding their functionality and identifying opportunities for improvement" [3]Simultaneously, this practice is interpreted as an activity, defined by IBM [4]as "process mapping", which involves the meticulous collection of detailed information about the execution of tasks within an

organization. The purpose of process mapping is to examine, improve and optimize these processes. Furthermore, in line with the definition provided by [5]process mapping emerges as a fundamental enterprise for effective process management, allowing a deep understanding of process dynamics and the identification of improvement.

On the other hand, process mapping is a technique used to document and understand an organization's processes, with the objective of improving both efficiency and effectiveness. Currently, several methodologies, tools and techniques are used for process mapping, such as Business Process Reengineering [6], [7], ISO 9001:2015[8], [9], [10], Six Sigma Method [11], [12]s, Lean Manufacturing[13], [14]g, and BPM (Business Process Management) [15], [16]. To review these approaches provides a comparative view of their concepts, techniques, tools, application phases and contributions.

Business Process Reengineering

- **Concept**: Radical redesign of business processes to achieve improvements in critical performance measures such as cost, quality, service, and speed.
- **Techniques and Tools**: SWOT Analysis, Benchmarking, Cost-Benefit Analysis, Identification of Strategic Processes.
- **Application Phases**: Development of improved new processes, Process redesign, Testing of the new processes.
- **Contribution to Digital Transformation**: Automation of tasks, creation of new digital products and services, adoption of new business models.

ISO 9001

- **Concept**: An international standard that specifies requirements for a quality management system.
- **Techniques and Tools:** Deming Cycle, Root Cause Analysis, Flowcharts, Diagnosis of the current situation.
- **Application Phases**: Commitment, planning, documentation, and training, Implementation, Internal and external audit, Improvement of competitiveness.
- **Contribution to Digital Transformation**: Raising awareness of change, identifying risks and opportunities, Improving information management.

Six Sigma Methods

- **Concept**: Focuses on reducing process variability to achieve perfection in an organization's productive processes.
- **Techniques and Tools**: Statistical Control, Statistical Tools, Define, Measure, Analyze, Improve, Control.
- **Application Phases**: Helps identify critical processes, reduce variability, improve data quality.
- **Contribution to Digital Transformation**: Adaptability and digitalization of productive processes, integration with other methodologies and digital transformation technologies.

Lean Manufacturing Tools

- **Concept**: Focuses on minimizing waste and maximizing value creation for the end customer.
- **Techniques and Tools**: 5S, Kanban, Kaizen, Specifying Value, Value Chain Analysis, Flow Improvement, Pull Principle.
- **Application Phases**: Specifying value, Analyzing the value chain, improving flow, Implementing pull principles.
- **Contribution to Digital Transformation**: Adaptability and digitalization of productive processes, and practical application with other methodologies and digital transformation technologies.

BPM (Business Process Management)

- **Concept**: Systematize and facilitate complex individual or business processes, both inside and outside of companies.
- **Techniques and Tools**: BPMN Modeling, Automation Systems, Analysis and Redesign.
- **Application Phases**: Analysis and redesign of processes, Implementation, Monitoring, and control.
- **Contribution to Digital Transformation**: Understanding of processes, Monitoring, and automation of the same.

In general, it can be concluded that there is no single approach that is best for all organizations. The choice of the appropriate methodology will depend on the organization's objectives, approach, and resources.

Thus, process mapping is a useful technique that could improve the efficiency and effectiveness of a maritime company's processes. These companies have specific processes related to ship management, loading, and unloading of goods, port logistics, maritime safety, among other aspects.

As indicated in the literature, the survey of processes in maritime companies can be carried out using different methodologies and tools, such as interviews, direct observation, flow charts, process maps, among others. A widely used methodology in the maritime industry is the PDCA (Plan-Do-Check-Act) model, which allows identifying improvement opportunities in existing processes [17]It is a fundamental practice for understanding and optimizing operations in this highly specialized industry. This process involves the identification, documentation and detailed analysis of all activities and procedures involved in maritime operations.

About the gathering of information requirements, there are several classic methods used in various sectors, including the maritime sector. These methods include:

- Interviews: are the most common method for requirements gathering since they question the people directly involved in the process [4]
- Process sheets according to ISO 9001-2015: Process sheets are tools for collecting information on the operation and performance of processes[9], [10]
- Process modeling: It is a set of standards for the diagramming of the different processes existing in the organization. It models the processes of the organization and thanks to this it is more understandable for the final users to understand the necessary requirements for the creation of the system[15].

On the other hand, there have been several studies that have analyzed the effectiveness of different methodologies and tools. According to the study conducted [15], [18], [19], compared the effectiveness of BPMN and Six Sigma in process mapping and found that both methodologies are effective, although with differences in the complexity and ability to model different aspects of the processes. However, when the same procedure was performed using the ISO Standards for process mapping, it highlighted an increase in effectiveness and with a much lower complexity than the previous ones.

Therefore, the map of processes based on the knowledge of the process must start by establishing a common language between the person who knows the operation of the business and the developer or whoever performs the survey of the requirement. Based on the research conducted, it is recommended to make use of the ISO 9001- 2015 standard. In addition, for the compilation of the information of the study processes so that there can be a clear, complete, and efficient specification, so that the information is readable for anyone in the company and can easily understand the diagramming done [4].

There are several references that address the topic of process mapping in maritime companies and discuss the methodologies, tools and techniques used in this process. The literature highlights the importance of improving the efficiency and effectiveness of processes in maritime companies, and the application of methodologies such as Lean, Six Sigma and PDCA, as well as the use of tools such as ISO 9001-2015 standards in their process sheets and flow charts, can be useful in this regard.

Process mapping is a fundamental tool for improving the efficiency and effectiveness of processes in maritime companies. However, in today's digital age, digital transformation can offer new opportunities to further improve processes. Process mapping can identify opportunities for improvement in existing processes, and digital transformation can help leverage these opportunities through process automation, data analytics and other digital technologies[20].

Digital transformation is a continuous and strategic process that seeks to maintain relevance and competitiveness in an increasingly digitized world. It is not just about adopting technology for technology's sake, but using it effectively to improve efficiency, innovation, and customer satisfaction, among other aspects. Each organization approaches digital transformation in a unique way, according to its specific needs and objectives [21]

In Colombia the digital transformation is a priority for the national government, who have developed the document CONPES [22]which is the declaration of a national policy for digital transformation.

This policy focuses on the following pillars:

- Digital infrastructure: the government is investing in the development of telecommunications infrastructure, such as fiber optics and 5G.
- Digital training: The government is developing digital training programs for citizens and businesses.
- Digital government: The government is implementing a digital government model, which uses digital technologies to improve the delivery of public services.

Digital transformation in Colombian shipbuilding and design companies began in the 2000s, with the development of information systems for logistics and supply chain management. In the 2010s, digital transformation intensified, driven by the adoption of new technologies such as automation, data analytics and artificial intelligence. Several Colombian companies are investing in new technologies to improve their efficiency, competitiveness, and sustainability.

On the efficiency front, digital transformation allows shipbuilding and design companies to reduce costs, improve response times and enhance safety. In the area of innovation, digital transformation developed new products and services, improve their processes, and adapt to market changes. In the area of sustainability, digital transformation is helping shipbuilding and design companies reduce their environmental impact [9]

III. METHODOLOGY

As mentioned previously, this study focuses on carrying out a survey of the process of the outfitting department in a naval design and construction company to then establish the level of maturity of that department on based of Methodology for Digital Transformation. The Fig. 1 highlights in red colour the main stages on which this study focuses.

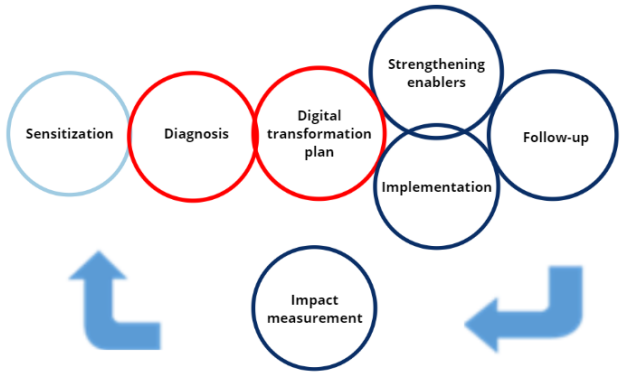

Fig. 1 Digital Transformation Model. Innpulsa Colombia- MINTIC, 2019.

To carry out the process survey of the outfitting division of the ship design and construction company based on the ISO 9001:2015 standard the organization's processes were identified, described, and documented [9]. Therefore, the following phases were developed, PHASE I: Planning, PHASE II: Process Identification, PHASE III: Process description, PHASE IV: Process representation, PHASE V: Review a conducting survey, PHASE VI: Assessment of the Level of Digital Maturity. The following describes each phase developed:

PHASE I. Planning

The process survey activity was planned. In this stage the objectives, scope, resources, and schedule of the activity were defined. That objectives is to indicate the general guidelines required to develop the phases corresponding to Product Engineering (Transition Engineering and Workshop Engineering) of ships and naval artifacts.

PHASE II. Identification of processes

The development of this phase, several interviews with one of the process leaders and a documentary analysis were implemented.

PHASE III: Process description

For the process of the product ING. Product department where the Outfitting division is located, all the design information for each of the SWBS systems that make up the vessel is coordinated, oriented, and assigned in an electronic model to the set of zones and PWBS blocks defined in the construction strategy.

In addition, there are four roles or actors involved, represented as titled boxes at the top of the diagram. These are, from left to right: "Outfitting Head," "Outfitting Lead," "Outfitting Administrator," and "Modelers.". The Fig. 2 highlights the most relevant activities for ship design.

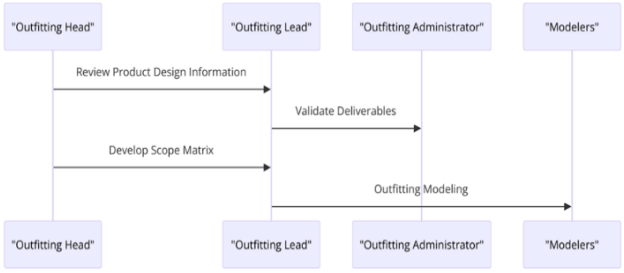

Fig. 2 Process in Outfitting department

The process begins with the "Outfitting Head" performing two actions. The first action, review product design information, is directed towards the "Outfitting Lead." The second action, develop scope matrix, is also directed towards the "Outfitting Lead." These actions are represented by solid lines with arrowheads pointing from the "Outfitting Head" to the "Outfitting Lead," indicating the direction of communication.

Subsequently, the "Outfitting Lead" performs the action validate deliverables, which is directed towards the "Outfitting Administrator." This is shown by a solid line with an arrowhead pointing from the "Outfitting Lead" to the "Outfitting Administrator."

The final action in the diagram is outfitting modeling, which is performed by the "Outfitting Administrator" and directed towards the modelers. This is depicted by a solid line with an arrowhead from the "Outfitting Administrator" to the "Modelers." The main activities that were documented in this department are:

- *Organization of work*: It starts with the reception of the available technical information resulting from the basic design, together with the file containing the geometry of the hull surface corresponding to the ship or naval artifact to be built by the business units. The above is required to perform the scheduling of resources according to the units (zones, blocks) in which the ship or artifact will be built during the following time stages: blocks, slipway, on board; and the creation of the project (in case it has not been created in previous stages) in the technological platform and/or its configuration).
- *Model Control And Review:* In parallel and progressively to the model development activities, the members of the technological group or the designated person in charge, review the electronic model and check the integration of the different systems, verifying that it complies with the functional design, in order to identify, report and later resolve any new developments by the model developer, by implementing the changes generated as a result of the joint review with the model designer. The revisions must be recorded in e-mails or minutes, with the specific observations. Their follow-up and control are the responsibility of the Project Coordinator.
- *Model Development:* The model of the different elements and systems that occupy the functional spaces in each unit (block, zone) is made by the assigned personnel of the Outfitting specialties, and using the applications found in the "Marine Design" module of the technological platform.
- *Delivery:* Once the electronic model is delivered to the Construction Management, a review process is carried out by the latter. Evidence of the review, follow-up and correction is left in a medium defined by mutual agreement between the two managements and through an e-mail or meeting minutes the implementation of the corrections that took place is reported.

PHASE IV. Process representation.

Representation of the activities involved in each of the processes described above. This representation was made in Visio software.

PHASE V: Review a conducting survey.

Review and conducting surveys, the review (surveys and interviews) of the process survey was carried out with leaders of the department studied to analyze the flow chart and obtain approval of the structure.

PHASE VI: Assessment of the Level of Digital Maturity.

To evaluate the digital maturity level of the Outfitting Department, a comparison was made of the most used digital maturity models worldwide. The models chosen are illustrated in Fig. 3:

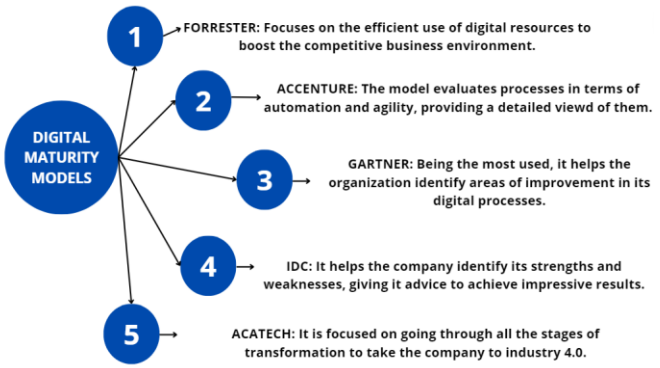

Fig. 3. Digital Maturity Models

To select the criteria or dimension that were evaluated within the context of digital transformation, the digital maturity assessment model with the highest references in terms of the number of citations of scientific articles worldwide in SCOPUS that has been conducted from 2016 to 2023 was selected, as shown in the Table I.

TABLE I
FREQUENCY OF CITATIONS OF MATURITY MODELS

Digital Maturity Model	Number of citations
Forrester [23], [24]	209
Accenture [25], [26], [27]	209
Gartner [28], [29]	889
ACATECH [30], [31]	48

The results of the assessment allowed us to identify that the Forrester, Accenture, and Gartner models were the most relevant, understandable, and valid for the Outfitting Department. Therefore, the Gharner model was used to determine the criteria or dimensions to evaluate (organization, technologies, strategies, management system, and product), and four levels of maturity classification were proposed, as shown in the Fig. 4 and Fig.5:

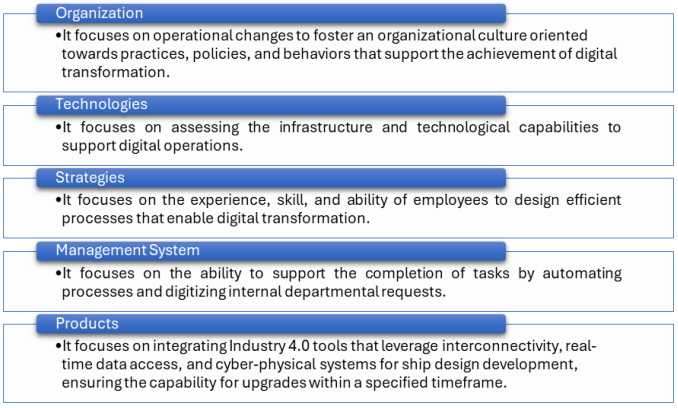

Fig. 4. Dimensions of maturity classification

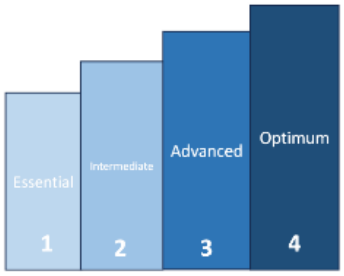

Fig. 5. Levels of maturity classification

1. ***Basic Level:*** The company exhibits a limited digital presence with partially digital processes, still anchored in obsolete and isolated methods. It lacks a clear digital strategy, has not invested in digital technologies, and has not provided digital skills training to its employees.
2. ***Intermediate Level:*** The company has an active and proactive digital presence, with mostly digital processes supported by integrated and updated systems. The organization has established a digital strategy, invested in basic digital technologies, and trained its employees in fundamental digital skills.
3. ***Advanced Level:*** The company has consolidated a transformative digital presence with completely digital processes based on intelligent and automated systems. The organization has a comprehensive digital strategy, has invested in advanced digital technologies, and has trained its employees in advanced digital skills.
4. ***Optimal Level:*** The company has an innovative digital presence with digital and flexible processes supported by concurrent and automated systems. It is at the forefront of digital trends, uses digital technologies to create new business models and has cultivated a digital culture that encourages innovation.

In this study, the following numerical categories are proposed to weight each level, establishing a minimum and maximum score for each of the levels, as shown in Table II:

TABLE II
LEVELS OF DIGITAL MATURITY MODEL

Level	Score
Basic Level	[1,2)
Intermediate Level	[2,3)
Advanced	[3,4)
Optimal	[4,5]

Furthermore, the design and implementation of a robust validation process for the diagnostic tool outlined in this study is paramount. This validation is crucial to ascertain the tool's applicability across diverse operational contexts and to verify

the integrity of the derived outcomes. It is proposed that an initial series of pilot evaluations be conducted within various organizational divisions, which will facilitate the collection of critical feedback. This feedback will serve as a basis for necessary refinements, thereby enhancing the tool's precision and relevance for broader corporate deployment.

IV. RESULTS AND DISCUTIONS

The digital maturity level of the division has been calculated by applying a survey to each employee of the outfitting department, to evaluate and validate the key points of each criterion or dimension of the model, and in turn measure at what level it is. The questions were answered on a scale of 1 to 5, with 1 being the lowest score and 5 the highest score. This, to make a weighting for each dimension and measure how their digital transformation process is going. Each dimension has a different number of questions because each one evaluates different key factors. After receiving the survey results, we calculate the average score for each dimension to determine its level.

To calculate the overall level of digital maturity (DM) or the level of digital transformation in the outfitting division, we use the average scores of each dimension to calculate an overall average. The digital maturity level of the outfitting division is determined by calculating the average of each dimension and dividing the sum by the total number of dimensions. Six questions related to promoting innovation, learning, and sustainable culture were asked for the organization and culture dimension. The collaborators of the analyzed department classified this dimension as advanced with a score of 3.95.

For the technology dimension, eight questions were asked relating to the skills, experience, tools, and technological culture managed in the department. This dimension yielded a score of 4, considered to be at an optimal level by the employees of the department analyzed. For the Process Management Systems dimension, seven questions were asked relating to the use of technologies in their operations. This dimension yielded a score of 3.66, classified at an advanced level by the employees of the department analyzed.

For the strategies dimension, five questions were asked on the use of digital strategies for the department. This dimension yielded a score of 3, classified at an advanced level by the employees of the analyzed department. For the product dimension, five questions were asked about the technological and standardized tools used to realize the department's designs. This dimension yielded a score of 3.41, classified at an advanced level by the employees of the analyzed department, so these levels are illustrated in Fig. 5.

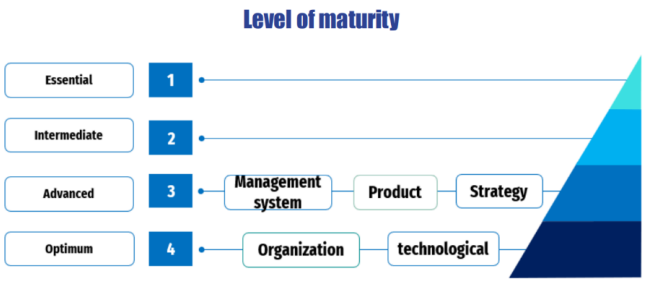

Fig. 6. Result of maturity classification

For the overall calculation of the overall level of digital maturity or the definition of the level of digital transformation in which the outfitting division is located, the results given by the averages of each dimension are used and an overall average is calculated. The sum of each of the averages of the dimensions is made and divided by the number of dimensions, and thus the result is the level of digital maturity of the outfitting division, the equation is:

$$\text{Levels of DM} = \frac{3{,}925+4+3{,}66+3+3{,}41}{5} = 3{,}59. \quad (1)$$

After analyzing the results, the level of digital maturity of the Outfitting Division is 3.59. This means that the division is at the advanced level, which is confirmed by the fact that most of its dimensions are at this level, and by the fact that it has a wide scope for improvement in all dimensions.

Also, the 5W2H is a flexible tool that can be adapted to any type of improvement project. They can be used to improve internal processes, to develop new products or services, or to implement organizational changes. For our case study, the 5W2H is useful to carry out a process improvement journey because.

- ✓ They help to identify the root causes of problems.
- ✓ They provide a framework for developing solutions.
- ✓ It facilitates communication and monitoring.

The Table III shows the suggested improvements for the critical points.

TABLE III
5W2H TOOL

What?	Where?	Who?	Why?	How?
Train and supervise modelers	Modeling	The modeler training and supervision team	Ensure that modelers have the necessary skills and knowledge to deliver effective and timely results.	Through a formal and informal training program.
Streamline requests to the change	Change management portal.	The change management team.	To reduce approval time for requests, which will	To reduce the number of steps required to

What?	Where?	Who?	Why?	How?
management portal.			enable teams to implement changes more quickly and efficiently.	approve a request. To implement a notification system to inform stakeholders about the status of requests.
Streamline the management of the request for missing deliverables of the basic design for the development of the electronic model.	Basic Engineering Department	Company	To ensure that all deliverables are available on time.	Establish a clear process for requesting missing deliverables. Automate the request process.

The execution of the plan is scheduled to commence from January 1, 2024 (When). Regarding the costs (How much), a thorough review of each of the elements will be conducted by the company's budget department.

In our analysis, while the assessment of digital maturity is recognized as a pivotal element for technological and operational advancement within the organization, a deeper exploration into how such assessments tangibly benefit operational efficiencies is warranted. For instance, an illustrative case from a manufacturing enterprise revealed that following the integration of technologies aligned with elevated digital maturity levels, there was a notable 25% increase in production line efficiency and a 15% reduction in operational costs over a six-month period. These findings highlight the critical need not only to conduct digital maturity assessments but also to strategically enact changes based on these evaluations. This approach not only elucidates the rationale behind digital maturity assessments but also offers a pragmatic framework for other organizations to emulate and measure specific benefits derived from such initiatives.

V. CONCLUSION

The project to diagnose the digital transformation maturity level of the outfitting division was a journey of discovery that revealed valuable information about the state of digital transformation in the division. Additionally, it provided a roadmap to help the division move towards the optimum level of digital maturity.

The project was successful thanks to the teamwork, collaboration, and dedication of the team members. The team gained valuable insights into digital transformation and shipyard processes and developed skills applicable to future projects. The project's results are expected to benefit the outfitting division and help achieve its strategic objectives. The project also revealed that the outfitting division has achieved an Advanced level of digital maturity. Most of the dimensions are at this level, but there is still ample room for improvement in all areas. The dimensions found at the Advanced level are:

- The division has a strong digital culture that promotes innovation and change. Employees are committed to digital transformation and are willing to learn new skills.
- The division uses advanced digital technologies to support its processes and operations. Additionally, the division has a well-defined process management system that helps optimize its processes.

The analysis identified areas for improvement in the dimensions of strategy and product. Specifically, the digital strategy could benefit from more specificity and detail, while the digital customer experience could be enhanced in the product dimension. Additionally, the project provided valuable insights into the state of digital transformation in the outfitting division. For instance, it was discovered that the employees of the division are highly interested in digital transformation. Additionally, the division has made significant investments in digital technology and has a commendable track record of adopting new technologies.

ACKNOWLEDGMENT

Special thanks are extended to the project engineering students, David Torres G, Andres Castro P, Roberto Reales A for their valuable contributions to the advancement of this study. Their dedication and collaboration have been instrumental in the successful development of this research. We would like to express our gratitude to the Outfitting Department at COTECMAR.

REFERENCES

[1] H. Shaughnessy, "Creating digital transformation: Strategies and steps," *Strategy and Leadership*, vol. 46, no. 2, 2018, doi: 10.1108/SL-12-2017-0126.

[2] L. Miyamaru, M. Lourenção, S. I. Dallavale de Pádua, and J. de Moura Engracia Giraldi, "Business process management applicability to destination country-brand management," *Benchmarking*, 2023, doi: 10.1108/BIJ-02-2022-0086.

[3] "Business Process Analysis: A Step-by-Step Approach | MEGA." Accessed: Feb. 25, 2024. [Online]. Available: https://www.mega.com/blog/what-is-business-process-analysis

[4] "What is Process Mapping? | IBM." Accessed: Feb. 25, 2024. [Online]. Available: https://www.ibm.com/topics/process-mapping

[5] R. Clancy, D. O'Sullivan, and K. Bruton, "Data-driven quality improvement approach to reducing waste in manufacturing," *TQM Journal*, vol. 35, no. 1, 2023, doi: 10.1108/TQM-02-2021-0061.

[6] Shivam and M. Gupta, "Quality process reengineering in industry 4.0: A BPR perspective," *Qual Eng*, vol. 35, no. 1, 2023, doi: 10.1080/08982112.2022.2098044.

[7] H. L. Bhaskar, "Business process reengineering: A process-based management tool," *Serbian Journal of Management*, vol. 13, no. 1, 2018, doi: 10.5937/sjm13-13188.

[8] M. A. Sanchez-Lizarraga *et al.*, "ISO 9001 standard: Developing and validating a survey instrument," *IEEE Access*, vol. 8, 2020, doi: 10.1109/ACCESS.2020.3029744.

[9] "ISO 9001:2015 - Quality management systems — Requirements." Accessed: Feb. 25, 2024. [Online]. Available: https://www.iso.org/standard/62085.html

[10] L. M. C. M. da Fonseca, J. P. Domingues, P. B. Machado, and D. Harder, "ISO 9001:2015 adoption: A multi-country empirical research," *Journal of Industrial Engineering and Management*, vol. 12, no. 1, 2019, doi: 10.3926/jiem.2745.

[11] Y. Ren, M. Zhang, Y. Bai, and H. Bai, "Six Sigma for improving tensile strength: a case study in the impregnating resin manufacturing company," *International Journal of Lean Six Sigma*, vol. 13, no. 6, 2022, doi: 10.1108/IJLSS-08-2021-0136.

[12] M. N. Mishra, "Identify critical success factors to implement integrated green and Lean Six Sigma," *International Journal of Lean Six Sigma*, vol. 13, no. 4, 2022, doi: 10.1108/IJLSS-07-2017-0076.

[13] N. Kumar, S. Shahzeb Hasan, K. Srivastava, R. Akhtar, R. Kumar Yadav, and V. K. Choubey, "Lean manufacturing techniques and its implementation: A review," *Mater Today Proc*, vol. 64, 2022, doi: 10.1016/j.matpr.2022.03.481.

[14] A. Sanders, C. Elangeswaran, and J. Wulfsberg, "Industry 4.0 implies lean manufacturing: Research activities in industry 4.0 function as enablers for lean manufacturing," *Journal of Industrial Engineering and Management*, vol. 9, no. 3, 2016, doi: 10.3926/jiem.1940.

[15] H. A. Reijers, "Business Process Management: The evolution of a discipline," *Comput Ind*, vol. 126, 2021, doi: 10.1016/j.compind.2021.103404.

[16] H. Kir and N. Erdogan, "A knowledge-intensive adaptive business process management framework," *Inf Syst*, vol. 95, 2021, doi: 10.1016/j.is.2020.101639.

[17] A. Neves, R. Godina, and S. O. Erikstad, "Enhancing Efficiency in the Maritime Industry Through Lean Practices: A Critical Literature Review of Benefits and Barriers," in *Lecture Notes in Mechanical Engineering*, 2024. doi: 10.1007/978-3-031-38165-2_35.

[18] W. Lafollette, "BPM, Lean and Six Sigma-All Together Now - ProQuest," *ASQ Six Sigma Forum Magazine*, vol. 15, no. 1, 2015.

[19] S. Hahn and H. Bill, "Applying Lean , Six Sigma , BPM , and SOA to Drive Business Results," *IBM corp.*, 2013.

[20] J. Vásquez, S. Aguirre, E. Puertas, G. Bruno, P. C. Priarone, and L. Settineri, "A sustainability maturity model for micro, small and medium-sized enterprises (MSMEs) based on a data analytics evaluation approach," *J Clean Prod*, vol. 311, 2021, doi: 10.1016/j.jclepro.2021.127692.

[21] N. Hernández-Díaz, Y. C. Pañaloza, Y. Y. Rios, J. C. Martinez-Santos, and E. Puertas, "Intelligent system to detect violations in pedestrian areas committed by vehicles in the City of Cartagena de Indias," in *Proceedings of the LACCEI international Multi-conference for Engineering, Education and Technology*, 2023. doi: 10.18687/laccei2023.1.1.1447.

[22] Departamento Nacional de Planeación, "Documento Conpes 3975: Politica Nacional Para La Transformacion Digital e Inteligencia Artificial," *Consejo Nacional de Politica Economica y Social - Republica de Colombia*. 2019.

[23] N. A. Govoni, "Forrester Research," in *Dictionary of Marketing Communications*, 2012. doi: 10.4135/9781452229669.n1350.

[24] G. Press, "Top 10 Technology Trends To Watch: Forrester Research," *Forbes*, 2017.

[25] Y. Paik and D. Y. Choi, "The shortcomings of a standardized global knowledge management system: The case study of Accenture," *Academy of Management Executive*, vol. 19, no. 2, 2005, doi: 10.5465/ame.2005.16963096.

[26] H. Kumar M, K. Prasad K, and S. Bhat, "Accenture – Understanding Sustainable Business Strategies," *International Journal of Case Studies in Business, IT, and Education*, 2018, doi: 10.47992/ijcsbe.2581.6942.0028.

[27] Accenture, "Improving Customer Experience is Top Business Priority for Companies Pursuing Digital Transformation, According to Accenture Study | Accenture Newsroom," *Newsroom.Accenture.Com*, 2015.

[28] "Gartner Hype Cycle Research Methodology | Gartner." Accessed: Feb. 25, 2024. [Online]. Available: https://www.gartner.com/en/research/methodologies/gartner-hype-cycle

[29] M. M. S. Sodhi, Z. Seyedghorban, H. Tahernejad, and D. Samson, "Why emerging supply chain technologies initially disappoint: Blockchain, IoT, and AI," *Prod Oper Manag*, vol. 31, no. 6, 2022, doi: 10.1111/poms.13694.

[30] G. Schuh, R. Anderl, J. Gausemeier, M. ten Hompel, and W. (Eds.) Wahlster, "Industrie 4.0 Maturity Index: Managing the Digital Transformation of Companies," *Acatech Study*, 2020.

[31] H. Schuh, G., Anderl, R., Gausemeier, J., ten Hompel. , H. , Wahlster, "Industrie 4.0 Maturity Index," *Gnther Schuh, Reiner Anderl, Jürgen Gausemeier, Michael ten Hompel, Wolfgang Wahlster*, vol. 11, no. 2, 2005.