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Review of Digitalization using IoT Maturity Models: The Case of American Automotive SMEs

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Abstract— **This study aims to review studies related to IoT maturity models in manufacturing systematically. Digitalization is vital for small and medium enterprises (SMEs) to retain a competitive advantage, reduce their operational expenses and compete with larger firms in their respective market. Globally IoT-induced transformation in manufacturing has been significant. Due to the lack of resources, American Automotive SMEs have not been farsighted with regards to digitalization but benefits like improved workflows, efficiencies, reduced overheads, and value creation make it beneficial and invaluable to customers. This paper reviews the state of IoT applications in American Automotive SMEs using the assessment provided by the IoT maturity model.**

Keywords— **Industry 5.0; Maturity Model; IoT maturity model; Maturity level; digitalization**

I. INTRODUCTION

In the IoT ecosystem, devices that have built-in sensors are connected to IoT platforms which store data from all the connected devices, and the necessary data is then used to perform tasks as needed [13]. IoT need not be connected to the internet and can be connected to a network and be directly accessible. As the number of IoT devices is rising rapidly, the interconnection between dissimilar IoT devices becomes a major concern for the success of IoT [7]. There are privacy and security issues with IoT as the devices collect data regarding individual users. By 2025, the world could anticipate around 64 billion IoT devices in use [4]. In this paper, Digitalization will refer to IoT-induced transformation.

IoT can be divided into three main categories by end user [1]. These three categories are Commercial IoT, Consumer IoT, and Industrial IoT. Commercial IoT alludes to devices and systems for business and enterprise use. An example is healthcare. Consumer IoT alludes to B2C systems or products. An example is mobile phones. Industrial IoT alludes to devices and systems used for manufacturing purposes. An example is fleet tracking [1]. IoT is a consumer-centric concept, whereas IIoT is more involved in the supply chain, manufacturing, and management [14]. IoT solutions like enabling predictive maintenance, optimizing quality control, warehouse management, mass customization, and safety improvements allow manufacturers to distantly observe, manage and command all details of their facilities.

The global automotive industry sector's revenue from the IoT in 2021 has been 115 billion U.S. dollars and is forecast to be 219 billion U.S. dollars in 2026 [9]. Almost two-thirds of net new private sector jobs are in 30 million American SMEs [12]. SMEs employ 61.2M Americans and it is 46.8% of the total workforce [19]. In 2021, 923,000 Americans worked in motor vehicles and parts manufacturing and 3% of America's GDP is from the auto industry.

American automotive SMEs form the backbone of the American automotive manufacturing hub. There are efforts from upskilling workers to retooling skills. American suppliers are working smarter using technology to retain a competitive edge. Lagging countries are accelerating the adoption of technology and digitalization efforts to close the gap. SMEs need to look closely at IoT advances and implement them despite the financial constraints and complexity of technology adoption.

American automotive SMEs have been the frontrunner for digitalization in the American manufacturing industry but there is a need to accelerate this effort and improve overall efficiency and more agile operations. Automotive

manufacturers are globally sourcing components due to competitive pricing and quality considerations. American vendors especially SMEs need to retain their competitive edge to outsmart their global competitors vying for a slice of the huge manufacturing market. There is a need to assess the IoT digital readiness to inform stakeholders about implementing change and adopting recent developments in all dimensions of the IoT Ecosystem. The IoT maturity model can help in gauging digital readiness and give a measure to stakeholders. This will allow them to plan digitalization efforts and improve the level of expertise and innovation culture in the organization.

There are existing maturity models which are in different domains and the aim is to answer the following questions.

RQ1 How can IoT maturity models be used to assess the level of digitalization readiness in the automotive manufacturing domain?

RQ2 What levels are seen in different maturity models in the literature review?

RQ3: How can organizations achieve the next maturity level in the automotive manufacturing domain?

A systematic literature review is carried out for the present IoT maturity models to get an overview of the dimensions for assessment. The IoT Maturity Assessment is a procedure designed to assist organizations evaluate their present IoT capabilities, perceiving gaps and areas for enhancement, and developing guidelines to build a more successful IoT program. This study will investigate the research gap and direct future research and studies which need to look along the above-mentioned dimensions.

II. MATURITY MODELS

IoT implementation in most organizations is still evolving. IoT strategy can be beneficial. IoT technology can help organizations to increase value, cost reduction, improve operational efficiency, streamline operations and move towards profitability in the long run. IoT helps in automation, improved productivity of employees, and efficient operations management. IoT -assisted streamlined operations cause reduced downtime and help in optimized workflows.

A maturity model can be a great tool for organizations to help assess the current state of effectiveness and help in the next steps to achieve objectives. Stakeholders need a measure to know the current digitalization efforts and to plan for the road ahead. IoT is still in the emergent stage and has adoption-related issues. A maturity model provides layered levels of accomplishment for impartially assessing the maturity in these

areas so that you can pick out areas for development and improvement.

A Literature review is done for the maturity model. There are many maturity models in different domains. In this paper, maturity models assessed are mostly in the manufacturing domain primarily where IoT implementation is also done. After evaluating the different maturity models, it is explicit that each of them has a distinct basis and is planned with dissimilar requirements. The assessment methodology, scoring approach, and how the model evolves are not corroborated by other maturity models. There is a distinct need for an IoT maturity model which is specifically designed for the automotive market.

TABLE 1

OVERALL COMPARISON OF THE IOT MATURITY MODEL

Author	Maturity Model Dimensions	Strategic Goals	Title
[3]	5 levels	Manufacturing Industry	Manufacturing capability maturity model
[8]	3 Levels	Manufacturing industry	Digital Servitization Maturity Model
[5]	8 Levels	IoT application for the manufacturing industry.	IoT technological maturity model.
[17]	3 levels, 2 Dimensions	Organization IoT maturity assessment	Gartner's IoT maturity assessment

Analysis shows the differences in dimension for different models.

These Industry 4.0 maturity models need to be updated as per new requirements.

III. AN IoT MATURITY MODEL FOR THE AUTOMOTIVE SME MARKET

A maturity model checks the readiness of the organizations and details the weaknesses. Organizations are to fix these weaknesses and improvement actions are required to move up the assessment level. The IoT maturity model needs to assess as per Industry 5.0 which is the future evolution and build a more human-centric, resilient, and sustainable industry. Industry 5.0 steers joint working between humans and

advanced technologies. Industry 4.0 is reasoned to be technology-driven, while Industry 5.0 is value-driven [18].

There is a need to make the organization human centered. The Maturity model need not be just a technological assessment. People should be the center of focus. Digital strategy needs to be progressive and has to combine people. The Future SME industry needs to be resilient enough to withstand upheavals and assist critical infrastructure during contingency. SMEs have acknowledged that sustainability measures can improve their recovery, accelerate growth, and have lasting commercial enterprises [6].

There is an emerging Electric Vehicle(EV) market. Do we need to repurpose our existing assessment criteria? Digital transformation is the basis for being prosperous and a digital backbone can reshape the manner EV manufacturers work [10]. Innovation-oriented support and research are required. IoT manufacturing solutions can improve processes. New EV entrants are a significant driving force who are bringing in disruptive change compared to established automobile manufacturers. The Maturity model assessment needs to include EVs as it will help to measure the transition to electric vehicles (EVs) and zero-emission.

Three major technologies empower IoT. 5G, Artificial Intelligence (AI), and Big Data. 5G gives a viable high-speed data networking option to wired fiber optic networks [2]. For enterprise settings, 5G's higher throughput and lower latency are advantageous for industrial IoT [15]. IoT applications are looking at low-latency communications. An example of a latency critical IoT use case is factory automation as it is characterized by real-time control of machines and systems and having latency and reliability demands [11].

Electrification and Automation have helped the automotive industry to innovate rapidly, occurring simultaneously with advances in the communication industry through 5G progress and 6G research advances [8]. 6G will open new business opportunities and help digital transformation with improved reliability and lower latency. Hyper automation using 6G will lead to better connectivity.

IV. CONCLUSIONS

This paper has offered an assessment of current MMs as well as a recommendation to expand the current MMs to cater to Industry 5.0 requirements, EVs, and 6G. SLR evaluation assessed the existing MMs as applicable to the automotive SMEs. There is an existing research gap that can be addressed by having a human-centered focus and including technological upgrades via EVs and 6G.

American automotive SMEs need to collaborate and work towards a higher level of digitalization. MMs will be able to assess the level and address the shortcomings. A Need exists to review present MMs and future MMs apply to automotive SMEs. Promising future technologies like 6G and EVs coupled with Industry 5.0 human-centered approach provide solutions for the SME industry as well as society to bring benefits to society, employees, and industry.

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