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ROLE OF DIGITAL TRANSFORMATION IN METROLOGY FOR INDUSTRIAL GROWTH OF COUNTRY

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Abstract– The digital transformation has emerged to be a novel concept in recent times with numerous innovative advantages and some associated unpredictable risks like cyber security, data encryption, data storage and secured communication etc. It is a multifaceted and emerging phenomenon that has significant impact and is this essentially required in the industrial sector for taking the advantages of cutting-edge technologies and internet of things so that the machine can communicate with the outer word in real-time mode. The main objective of this paper is to understand and analyze the effects of digital transformation in metrological sector and its relevance and suitability for the industrial and economic growth. There have been various innovative frameworks developed and reported in recent times employing the various novel tools like digital and smart sensing, rapid prototyping, risk analysis and mitigation, real time data analysis, cyber security, cloud development and Internet of Things etc. Machine learning, artificial intelligence and cybersecurity are the main support systems of developing digital transforming capabilities. The key benefits of digital transformation are the sustainable development and economic growth of any manufacturing unit which indirectly related to the improvement in the overall performance of the retail sector. It is thus the need of hour to focus and implement these aspects in developing a national digital quality infrastructure for augmenting the economic and industrial growth of India.

Keywords**:** Digital Transformation, Metrology, Smart Sensors, Industry 4.0, Cyber Security, Artificial Intelligence, Machine Learning, Internet of Things (IoT) and Industrial Information and Communication Technology (IICT).

1. INTRODUCTION

Digital transformation in metrological sector helps organization to increase their efficiency and raise the performance globally which has the impact on the economic growth of any country. Digital transformation in metrology is directly affecting the manufacturing processes that involve big data, machine readable information and decision-making capability based on artificial intelligence. These inclusions are directly responsible for enhancing the economy [1]. A deep and thorough analysis of all the components of digital transformation is done previously [2] to develop a model which can accelerate the way of digital transformation in any industry. The developed model predicts the rate of acceleration of digital transformation based on artificial intelligence (AI) enabled process automation, customer feedback and financial impacts on the industry. A verification of the application-oriented software and its effect on digital transformation has been studied, that illustrates that how this platform directly coordinates with existing infrastructure [3]. Industry 4.0 and integration of manufacturing processes with smart sensors have introduced a drastic change in the digital transformation for accelerating the quality of product and manufacturing processes. A case study of operator oriented digital transformation is reported in [4], where a case of oil and gas industry has been considered. The critical challenges faced by the operators are highlighted in the study. A recent study reported by Ramesh (2022) highlights the dependency of digital transformation on the digital customer experience (DCX) index. DCX invariably quantifies the customer's service quality experience and expectation with a company's digital offering [5]. The digital transformation provides numerous benefits to the industry enhancing the efficiency, but some studies have reported a higher failure rate associated with it implementation [6]. Implementation of digital transformation for any organization is accomplished through the digitization of the organizational functions. However, the successful digitalization depends on the strategic adoption of digitalization [7]. Internet of Things (IoT) and Industrial Information and Communication Technology (IICT) had been playing a vital role in digitalization which is being designated by the series of interconnected digital sensors that enable diverse applications. The relevance and applicability of digital sensors in metrological services integrated with IoT framework is briefly discussed in [8]. Smart sensors are the backbone of digitalization in metrology with a prior condition of reliability, security, accuracy and precision. The conceptual framework of Digital Calibration Certificates (DCC), Digital SI (D-SI) and cryptographic digital identifiers have been identified to secure traceability and validation thus facilitating the decision making and security [9]. This study analyzes the pros and cons associated with the digital transformation in the metrological framework for its impact on the industrial and manufacturing sector for economic and industrial growth of a country.

2.RELEVANCE AND OBJECTIVES OF DIGITALIZATION IN METROLGY

A multi-fold increase in the adoption of digitalization is being reported all across the globe. Moreover, industrial organizations are increasing their investments towards developing and implementing a digital infrastructure that will result in quicker adoption of latest and cutting-edge

technologies. There is a need of improving the existing infrastructure for establishing digitalization in metrology. The very first objective that needs prior consideration is brainstorming on the effect of the digital metrology on the existing measurement system [1]. Thus, latest and advanced measurement system framework employing the latest technological innovations becomes imperative for the successful implementation of digitalization in metrology. Intelligent sensor network is the main pillar for the digital transformation of industrial processes and circumventing the challenges faced [11,12]. A real-time analysis and improvisation in the industrial process based on the analysis is essential for smooth functioning of the manufacturing process and accomplishing the targets. Thus, a dynamic framework needs to be developed that provides innovative inputs from the continuous analysis and exchange of information and feedback obtained from the customer experiences. The industrial sector relies on the advancement of their metrological activities and processes traceable to the national measurement standards realized by the National Metrology Institute (NMI) of that country. Establishment and implementation of a digital metrology infrastructure shall be indispensable for meeting the challenges and sustain the existing demands of industry and market.

3. COMPONENTS OF DIGITAL METROLOGY AND THEIR BENEFITS

The digital transformation of industrial processes is creating new challenges and opportunities for the metrologists, researchers, IT experts and legal experts. The vital constituents of a digital infrastructure which are essential for implementing the digitalization in metrology are summarized in Fig. 1. Some of these essential features and aspects of digital metrology are discussed in details.

3.1. Digital Twins

The feature of digital twins is the necessity of digital transformation. Digital twin is the one of the important aspects of industry 4.0. The details of any industrial process can be accessed with the help of digital twins. Now a days, advanced and latest equipments and technologies are used in the manufacturing process/industry which can give the results in a fast and dynamic way. Digital twins are used for the future prediction of that component or equipment. Digital twins helps in enhancing the decision making capability and to make the decision making process automated with the dynamic calibration of any measurement device. Moreover, the expected deficiencies in the process before setting up the physical prototype for that process and associated risks can be optimized by using digital twins. The benefits of digital twins in industrial process are that production can be enhanced keeping the risk assessment in consideration. Predictive maintenance can be scheduled based on the feedback received from the real-time data analysis. Basically digital twins are used to create a virtual world and create a simulative environment such that the physical assets related to that process and manufacturing system can be explored. Thus, the concept of digital twins shall serve as one of the vital tools of establishing a digital quality infrastructure.

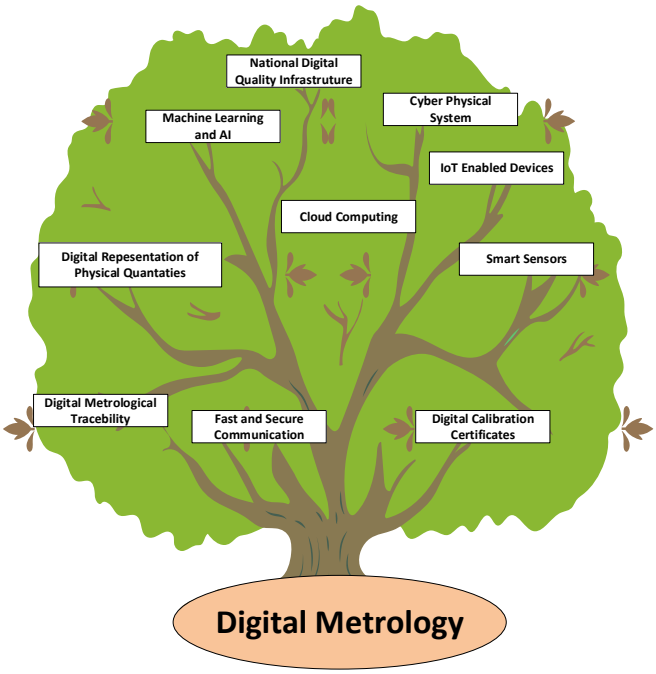

Fig. 1 Network of Digital Metrology Infrastructure.

3.2. Smart Sensors

Smart sensors are the very first stage of any manufacturing process which initially collect information regarding any measurement and utilize digital processors for monitoring the process and helps in the decision-making process through the analysis of collected data. The main paradigm of digital transformation in metrology is the industrial internet of things which employs a network of interconnected intelligent sensors for real time analysis of any measurement process. The sensing network is directly associated with the measurement processes. The automation of any industrial process directly depends on the performance of sensors deployed for collecting the data from the physical environment. The automation structure consists of five different stages [11]. First stage comprises of a network of intelligent sensors which acquires the measurement data from the physical world and transfer the data for analysis. In the second stage inputs are basically a I/O module from where control action is taken based on the process data. Next stage consists of IT infrastructure which is responsible of data exchange with added security protocols. Fourth stage is the Process Management System (PMS), which keeps the record of all the activities going on. The last stage consists of operational and planning details [11].

3.3. Digital Calibration Certificate

All the NMIs throughout the word are moving towards the implementation of digital calibration certificates (DCC). DCC can be transferred directly to the consumer. The information contained in the DCC is always secured and machine readable. However, a digital security is necessary in case of DCC so that that it can maintain the unbroken chain of traceability through the national/international standards.Since DCC contains all the information about the calibration, therefore, the DCC information can be used by the processes to acquire that information through the sensors and take the corrective actions as per the data received.

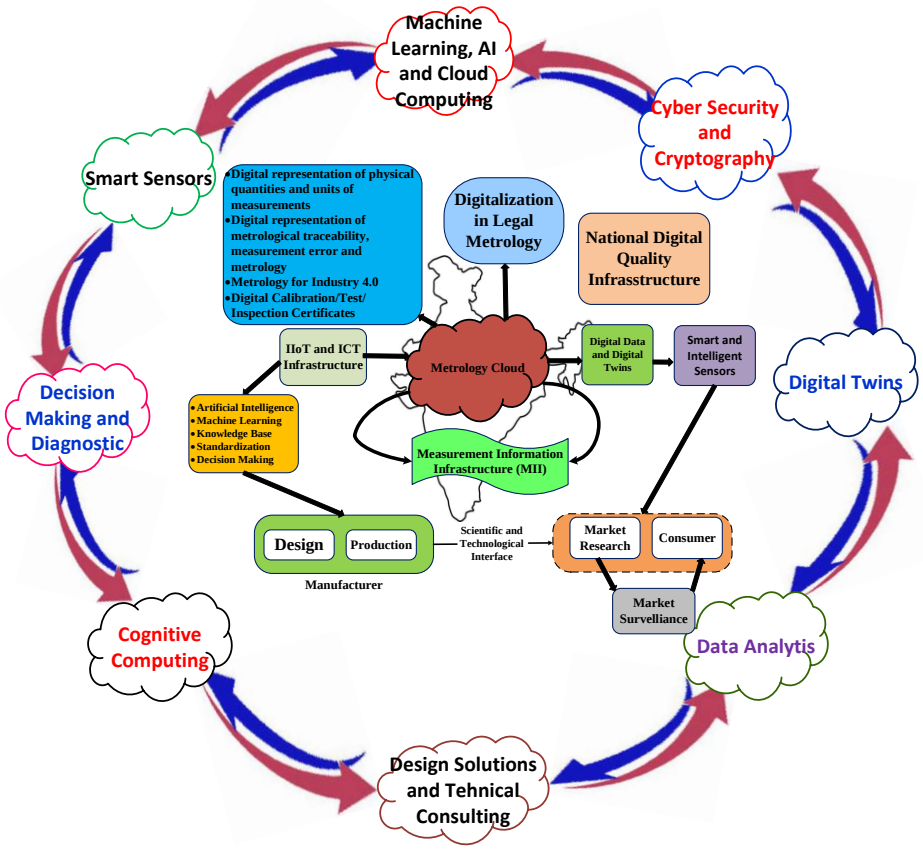

Fig. 2 Theoretical paradigms of the proposed Metrology Cloud with key components.

3.4. *Digital Customer Experience*

The success rate of digitalization in metrology depends on the interaction of the customers with organization. Digital customer experience is considered the weakest factor which most of the organization take into consideration. However, customer/user's probability of adopting digital transformation decided the rate of success of digitalization of metrological services. The level of digital customer experience can be measured on scale and that scale may be used to identify the likelihood of digital calibration services offered by the organization. The improvement in the index may be productive for any organization with minimization in the risks.

3.5. *National Digital Quality Infrastructure*

The main role of metrolgy cloud and quality infrastructure is to establish a core platform for the metrolgical activities enabling data-driven innovation for creating a single point of contact for all the member states. The theoretical paradigms of national digital quality infrastructure and its key components is proposed in Fig. 2 based on the recent studies and idea reported on European Metrology Cloud [13]. Such developments require the implementation of the IoT based infrastructure, inclusion of artificial intelligence and machine learning (ML) modules with added features of cyber security.

3.6. *IoT Infrastructure*

The Internet of Things (IoT) is characterized by numerous interconnected devices and the indications of the devices, measurement instruments are in digital format [8]. The efficient implementation of artificial intelligence techniques and machine-interpretable representation in conjunction with IoT technology has many technological challenges. The measurement devices need to be calibrated in certain period of time. Therefore, these devices either calibrated at any designated metrology lab or onsite calibration is done. Onsite calibration is having benefits of reduction in cost and risk of transportation and dismantling the devices is avoided. To facilitate onsite calibration, a highly secure, reliable and robust IoT infrastructure is required which is composed of integration of smart sensors, cloud computing facilities, artificial intelligence and machine learning modules. IoT plays an important role for establishing a bridge between physical word and digital word. However, for developing a secure system, there is a need of including IoT communication protocols [14]. The data over internet can never be considered safe and when data is concerned with the economic growth, the data modification, forging and alteration are the main risks which are associated with it. Therefore, inclusion of cryptography is a major challenge for establishment and implementation of IoT infrastructure [15-16].

4. ADVERSE EFFECTS OF DIGITAL TRANSFORMATION

Digitalization of metrological services enables the users to store an ample amount of data over the cloud. The data may contain sophisticated information about the organizations and measurement standards with associated measurement processes. Therefore, there is always a risk of maintaining the integrity and confidentiality of the data. There is always a risk of data privacy in digital transformation. Moreover, manipulation and altering of data is possible in case of digitally stored data. The main concern with the digital technology is the cyber security which may be critical in case of measurement. A small error in the measurement may result in the errors affecting the product quality and thus incur financial losses.

5. EFFORTS AT CSIR-NPL TOWARDS DIGITAL METROLOGY

CSIR-NPL, India is aggressively working towards the implementation of digitalization in metrology and also for the metrological services. A dedicated team is working on the development of automated system for technical services and rigorously working for the efficient, safe and secure data conversion systems. A project has been initiated for the execution and implementation of DCC for the calibration and testing services provided by the CSIR-NPL. Also, CSIR-NPL is working for the realization and dissemination of Indian Standard Time (IST) over the internet via indigenously developed devices and applications. Dissemination of IST is carried out through calibration services, satellite links and network time services. The IST is traceable to UTC through satellite links with an uncertainty of 3 ns [17]. Moreover, there are two metrological programs are going on to disseminate IST to Indian Space Research Organization's NavIC (Navigation with Indian Constellation) and five secondary timing centres.

6. CONCLUSIONS

The paper briefly highlights the pros and cons associated with the digital transformation in metrology and its impact on the industrial and economic growth. Various objectives of digital metrology and role of digital metrology in industrial growth is discussed. With the advancement in digitalization of metrological services, remote measurement and concept of digital traceability are gaining importance. Therefore, to meet the challenges faced by industry, DCC needs to be introduced in place of the conventional certificates with utmost considerations on the security and safety of the data. The paper proposes a theoretical concept of metrology cloud as reported in some of the recent contemporary studies that shall be indispensable for development of a national digital quality infrastructure and meeting the growing demands and challenges faced by the industry for economic and industrial growth of country.

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