

An analysis on industrial internet of things in digital transformation of shipyard industry in Turkey

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Abstract

Shipyards often face unique challenges, as the construction of ships takes months or even years to complete. As in any sector, Industry 4.0 (I4.0) also affects the shipbuilding sector. With this digital transformation, it aims to meet the challenges of shipbuilding more personalized ships with shorter delivery times, greater flexibility, and higher quality. Therefore, this study aims to review IIoT technologies that will perform the digital transformation in the shipyard. In this study, an analysis of the digital transformation for the shipyard industry of Turkey in general was made and more specifically focused on how to implement IIoT for Sedef Shipbuilding Inc., which is one of the leading shipbuilding companies in Turkey. This study contributes to digital transformation technologies that can be applied in shipyards by providing analysis of existing reference frames for IIoT technologies in shipyard digital transformation.

Keywords: ; IIoT Ecosystem; IIoT Architecture; Industry 4.0; Industrial Internet of Things; Shipbuilding 4.0; Shipyard 4.0

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1. Introduction

Since digitalization is seen as a priority in manufacturing companies, the research on Industry 4.0 (I4.0) is gaining momentum. I4.0 is a new paradigm that integrates all resources, such as physical objects people, machines, production lines, and allows real-time information sharing [1]. The revolution, especially thanks to IIoT, connects everything in the value chain: machines, employees, materials, finished products, processes, suppliers, customers, and all infrastructures used in the production environment [2]. IIoT acquires its power from the ability to collect data and turn that collected data into useful information. In this direction, increasing operational efficiency, reducing downtime, and maximizing asset utilization are the underlying realities of IIoT adoption by organizations. [3]

The I4.0 is actually forcing all sectors to face a deep digital transformation, which is a challenge that researchers and professional practitioners are working on today [4]. This trend is pushing the shipbuilding industry to adapt to the digital age as well. An analysis to review IIoT technologies that will perform a digital transformation. Therefore, this study reviews IIoT technologies that will perform the digital transformation in the shipyard. At the same time, considering the importance of digital transformation in complex production processes such as shipbuilding, IIoT transformative technologies that need to be applied in the context of I4.0 will be evaluated. The analysis of the digital transformation for the shipyard sector in Turkey, in general, is considered, and more specifically for how to implement IIoT technologies for Sedef Shipyard, which is one of Turkey's leading shipbuilding companies.

1.1. Research Background

1.1.1. Shipyard Industry in Turkey

The shipyard industry in Turkey has a history of more than 700 years [5]. The Turkish shipbuilding sector is one of the major producers of the world, both in quantity and tonnage [6]. Over the past two decades, the Turkish shipbuilding industry has experienced significant growth in the global dimension. In this context, the shipbuilding industry in Turkey has shown a great development both in terms of production and in terms of shipyard production [7]. As of 2016, there are 80 active shipyards in our country .

The sector has sufficient facilities, technology, and workforce to make good use of global opportunities. However, digitalization is an important issue, especially in the Far East and in competition with some EU countries. The shipbuilding sector, which is one of the sectors that provide the most added value to Turkish exports, should pay more attention to R & D and innovation within the scope of I4.0 in order to carry this value higher. In this direction, it is very important to provide R & D support to the sector. The most important element that will make Turkish shipbuilding industry activities efficient is the labour that has up-to-date information. Since shipbuilding is also a prominent element in terms of competition, intelligent human-machine interactions should be provided by adding a human element to the work in digitization. Companies and countries that have a higher level of new technology, knowledge, and competence in their production structure and therefore have a more diversified product range are in a more competitive position. Complex products, which require

more knowledge and competence to produce, are produced by countries such as South Korea, China, Thailand, which invest in a small number of new technologies.

Currently, companies are trying to implement I4.0 on the one hand, before they understand what it is, industry 5.0 is on the agenda. With industry 5.0, there are computers that are very complex, capable of processing different information, as well as nanotechnology, robotic systems. With industry 5.0, the possibilities for robots and humans to work together are presented, wireless transmission of electrical energy, irradiation of matter are discussed. With industry 5.0, robot-human cooperation projects are on the agenda. All of these provide timesaving, labour-saving, efficiency in production, and cost advantage. Smart shipyards are also on the agenda in the shipbuilding sector in Turkey. In other words, as the world moves towards this place in shipbuilding and provides certain savings from this, Turkey continues to invest in this area and support practices.

1.1.2. Shipyard Industry in the World

When we look at the shipbuilding sector in the world, there is an excess of shipyard capacity due to declining demand. Today, competitive shipyards that operate profitably can survive. Shipyards have to offer high-quality ships as soon as possible and at the cheapest cost. Shipyards in countries with expensive labour have responded to these problems with the digitalization of production and automation. Shipyards with low competitiveness have also had to improve their processes to become profitable again [8]. For example, Germany has transformed its shipyards into modern high-performance shipyards. Asian shipyards have been prominent in recent years. China and Korea have increased capacity by building new shipyards and expanding existing shipyards [9]. China is now one of the three countries with the largest shipbuilding industry in the world, with South Korea and Japan [10]. It has now increased its capacity with attempts to enter the civilian market in shipyards in the American and Russia that produce only warships.

Western European shipyards are the only World region where political practices are carried out on capacity limits in exchange for subsidies. Labour costs are high and, therefore, costs in terms of European shipyards compete with shipyards in the Far East who are forced to, not being dependent on this sector by developing various support mechanisms on behalf of the strategically important shipbuilding industry is trying to keep it alive. On the other hand, developed countries have shipyard investments in countries such as the Philippines and Vietnam due to cheap labour costs.

1.1.3. Research on I4.0 and IIoT in the Digitizing of Shipyards

Numerous studies have been conducted on the extraordinary effects that IIoT will have on businesses. Outstanding exemplary practices have also been carried out in many large organizations [11,12,13]. In recent years, there have also been numerous studies in IoT-related literature. Some researchers have explored the definition and system features of IIoT in relation to I4.0 applications [14,15]. Some researchers have presented new trends in IoT applications. They demonstrated the characteristics of the IoT system. [16-18] prepared new business models for IoT and data management.

The interconnected device ecosystem, known as IoT, has made significant progress in this direction around the world recently. As more organizations and industrial products joined the connected network over time, the mystery surrounding IoT began to dissipate. In the 1990s, all IoT-related activities focused on theoretical concepts, discussions, and individual ideas. 2000's and 2010's, were becoming successful IoT projects and finds some practical applications was a period of rapid development, smart lamps, self-driving cars and smart cities, small and large project. These developments have been made possible by the emergence of wireless connections capable of transmitting information over a long distance and the increased bandwidth of the Internet communication. In the following time, IoT evolved into a completely different internet so that all available protocols could not meet their needs and provide seamless connectivity. For this reason, customized IoT communication protocols and standards have started to be developed, and they are still being developed.

Recently several studies on IIoT architectures have been published [19,20]. [21] provide a brief summary of the relevant frameworks. Various organizations have published IoT reference architectures that focus on different aspects that stem from views influenced by different industries and technologies. GE proposed the concept of the Industrial Internet revolution in 2013. Later, five leading industrial companies in the United States, including AT&T, Cisco, GE, IBM, and Intel, formed the Industrial Internet Consortium (IIC).

In 2017, the Industrial Internet reference architecture (IIRA) v1.8 was released by IIC. The architecture has attracted attendance all of the worldwide, becoming a common choice for most industrial firms. It consists of three tiers: edge, platform, and enterprise tier. The edge tier collects data from edge nodes through edge gateways and transfers it to the platform tier which in turn provides management functions for assets and offers data operations and analytics. Finally, the enterprise tier provides interfaces to end-users and implements applications and decision support systems [22]. Different networks connect layers: proximity network connects sensors, actuators, devices, control systems, and assets, collectively called edge nodes. It typically connects these end nodes as one or more clusters associated with a gateway that bridges other networks. The Access Network allows the connection of data and control currents between the edge and platform layers. It can be a corporate network or the public internet. The service network provides services at the platform layer within each layer and the connection between the enterprise layer and services. It can be a public internet or a private network.

Today, the IoT initiative is moving at an impressive jump. A recent survey conducted, shows a significant increase in the implementation of I4.0 technologies [23]. The growth of digital start-ups among manufacturers was surveyed in a recent survey of 200 production managers who found IoT adoption was three times higher than just two years ago. The survey was conducted before the start of the Covid-19 outbreak in the spring of 2020. Almost 84% of respondents are currently implementing or evaluating digital manufacturing strategies, whereas in 2018 only 27% were doing so. More than 66% see industrial IoT as a crucial part of the future of their company's success. The main technologies that are part of the industrial IoT include process and product simulation (76%), and big data and analytics (69%). Autonomous robots and sensors (56%) and product and plant digital twins (56%) are also seen as key to IIoT initiatives. The motivations for moving to Digital are varied. 54% of advanced manufacturers state that their main challenge is to reduce production costs, and 51% are to

improve on-time delivery and predict delays. The other 47% want to reduce quality risks. At least 39% are trying to improve their skills in predicting machine or tool failure. Although the survey has made progress towards digital production, there is still much to be done, according to the report. While the manufacturing sector produces large amounts of data, only a few companies use that data to improve operational efficiency, they say.

In addition, there is a high demand for IIoT in European countries. European countries are allocating significant budgets to IIoT to take advantage of the potential benefits of I4.0. IoT spending, a booming market is expected to increase by 14.4% between 2017 and 2021. Investment rose from \$ 674 billion in 2017 to \$ 1,100 billion in 2020, 55% of which is software and services. The reasons for adopting these technologies vary from country to country: for the UK it is mainly for designing and prototyping solutions; in France, it automates processes and improves quality; in Italy, the priority is more focused on cost reduction and optimizing logistics, while the Nordic countries are primarily focused on reducing costs [24].

2. Methods

Since the subject of IIoT ecosystems has not been extensively studied in the shipyard sector, an exploratory analysis has been conducted to understand this relatively complex shipyard space. The analysis is based on observations made at the shipyard area and available literature on the field.

2.1. Data collection instrument

The study is mainly based on existing literature review, and it will shed light on how to enable comprehensive digitalization technologies in the shipyard environment and will contribute to the firm's digital transformation projects. The analysis was conducted based on observations of the shipyard site activities, information obtained through interviews with experts and employees, and available literature related to the field.

2.2. Research procedure

This article is structured as follows: First, Shipyard Industry in Turkey and in the World are reviewed in a general dimension, and research on I4.0 and IIoT in the Digitizing of Shipyards is criticized. IoT, IIoT, IIoT-enabled production, IoT Ecosystem, and IIoT architectures are shortly described. Then, an assessment is made about the use of IIoT technology in the shipbuilding sector and recently developed applications in the sector is researched. Then, the necessity digital transformation of shipbuilding industry, I4.0 and Digital Transformation are discussed. Then, how I4.0 can be applied to the shipyard, and how the transition to digital transformation is managed were evaluated in detail. Finally, the results are presented.

3. Findings

IIoT applications are at an early stage in the shipyard sector, and very few successful IoT applications are discussed in the literature [25,26,27]. Recent developments in the I4.0 transformation in the shipyard sector can be listed in Table 1.

Table 1: Recent developments in the I4.0 transformation in the shipyard sector.

In January 2020, Wärtsilä produced a carbon fibre removal vehicle through additive manufacturing. This 3D printed vehicle will be used as a special piece of hardware that allows cargo ships to carry heavy engine parts.

In December 2019, European shipbuilder Navantia selected Siemens Digital Industries software as its technological partner to digitize the company's shipbuilding process.

In October 2019, Siemens Digital Industries Software announced the launch of New Simcenter system simulation solutions designed to help industries with accurate and competitive system modelling.

In November 2019, Wartsila and Singapore-based PSA Marine agreed to cooperate for the co-creation of intelligent technologies for the marine industry. Areas envisaged in the collaboration include the use of electric or hybrid technologies; the inclusion of next-generation smart ship technologies; the adoption of secure connectivity to facilitate ship-to-shore data exchange; marketing and branding activities.

SAP and Accenture in May 2019, shipbuilding companies effectively manage their business processes with new SAP Cloud solutions to help utilities and customer experiences innovation and development agreement.

In December 2018, MV Werften Shipbuilding Company renewed its contract with AVEVA Group Plc to continue to use a wide range of software solutions and technologies.

Navantia has recently completed the study and analysis of the I4.0 for adaptation to shipbuilding.

KT and Hyundai Heavy Industries (HHI) Group are working on fifth-generation-based smart shipyards. The innovation implies equipping workers with neckband cameras enriched with 5G function being able to broadcast real-time 360-degree videos in the integrated control tower. It enables a faster and more efficient reaction to emergency cases.

NYK, a Japanese shipping company, is planning to implement Green Bonds into the industry. These plans are part of NYK's program "Staying Ahead 2022 with Digitalization and Green" which is supposed to realize environmental, social, and governance principles in management strategies. The earnings are going to cover environmental-friendly projects' funds [28].

3.1.I4.0 and Digital Transformation

Digital transformation covers all industries gradually and not an exception to the shipbuilding industry. The I4.0 entails utilizing IoT to create systems where resources, information, objects, and people are connected through networks and the internet [29]. This would allow industries where the machines, warehousing systems, and production facilities to communicate and coordinate with each other to organize and optimize the production. This industrial revolution refers to the industrial paradigm transformation through digital transformation. The IIoT takes this digital revolution to unprecedented heights, breaking down old business models and creating new opportunities, digital transformation, and exciting new avenues for growth in businesses of all types. It provides opportunities to increase the productivity and efficiency of production processes. On the other hand, the digital transformation is not only a project, but also is a transformation strategy driven by a vision and supported by a committed program and a range of technologies, often involving multiple IIoT projects. Digital transformation needs to redesign of shipyard processes for the digital age. The digital transformation is the realization of digital technologies such as data acquisition, cloud computing, machine learning, automation, as the basis for meeting changing the shipyard needs. The ultimate goal of digital transformation, as well as profit growth, is mainly to improve the customer experience, ensure employee health and safety, and become more competitive. Today, IoT has become the foundation of digital transformation and automation, and in creating smart environments. I4.0 will have a major impact on the workforce, predicting a radical change in the entire product value chain, as well as many innovations that will bring on productivity and profitability and competitive superiority in the shipbuilding sector. Perhaps the most important of these is that employees as subcontractors can also increase their effectiveness.

3.2. IoT, IIoT and I4.0

Internet of Things (IoT) is the most basic component of I4.0, which is rapidly developing and has the opportunity to apply in different fields. Industrial IoT (IIoT), on the other hand, is a special area of IoT that focuses mainly on critical industrial applications in the production area. The IoT is a structure that connects smart devices through the internet, allowing data to be controlled and application processes to be executed in the desired way. It contains many other structures such as remote sensing, performance monitoring, and task execution [30].

As explained, IIoT refers to the expansion of IoT in industrial sectors and applications, and the two are not the same, i.e., IoT \neq IIoT. There are obvious differences between IoT and IIoT. In some cases, the elements are the same, but the purposes of their using purpose vary. Using a smartphone to observe the temperature of the home environment, for example, is an example of it, but if you use the same smartphone to monitor the temperature in the controlled environment of a room used in production, this is now an IIoT use case. Studies show that it significantly increases companies' productivity. IIoT goes beyond the internet operation of normal consumer devices and physical devices often associated with IoT. Thanks to IIoT, organizations gain more information and control over their physical resources, production processes, and work environments. IIoT mainly connects transport tools and all other industrial devices to the internet for machines in the factory and differs from other IoT applications in its daily impact on smarter, integrated, and more efficient production activities. IIoT runs applications to control devices, machines, buildings, or facilities. Some examples are smart factory, predictive and remote maintenance, smart metering, security systems, and equipment monitoring. Collecting and analysing data is key to the industrial sector to provide useful insights [31].

These insights help industrial companies make more informed business decisions faster than ever before.

The difference between IoT, IIoT, and I4.0.0 is summarized as follows: the IoT is a broad umbrella term for connected devices - specifically, it includes consumer-oriented aspects such as smart cars, smart speakers. IIoT is interconnected machines, devices, software, and platforms, especially used by businesses to increase efficiency and therefore profitability. I4.0.0 is the definition of the current global revolution in manufacturing and is referred to as the 'Fourth Industrial Revolution'. The relationship between IoT, industrial IoT and Industry 4.0 concepts can be summarized as follows. The relationship between IoT, industrial IoT and Industry 4.0 concepts can be shown graphically in Fig. 1. These three concepts: IoT, IIoT, and I4.0 are intertwined, but cannot be used interchangeably.

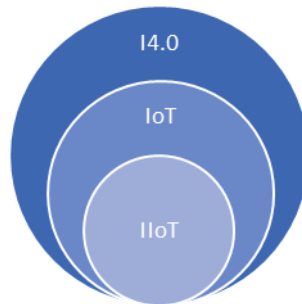


Fig. 1 The relationship between IoT, industrial IoT and Industry 4.0

3.3. IIoT-Enabled Production

IIoT-enabled manufacturing refers to an advanced principle in which production resources are transformed into intelligent production things that can detect, connect, and interact with each other to execute production logic in an automated and adaptive way [32]. In IoT-enabled manufacturing environments, human-to-human, human-to-machine, and machine-to-machine connections are performed for intelligent detection [33]. Therefore, the use of connected technologies in production and efficient sharing of resources can be enabled with IIoT implementation. As mentioned before the IIoT is considered a modern production concept within I4.0 and covers the latest developments, such as the latest information technology infrastructure for data collection and sharing, which greatly affects the performance of a production system. The IoT-enabled manufacturing has the ability to collect and share real-time data across a variety of production sources, such as machines, workers, materials, and processes. It is based on some basic technologies such as real-time data collection, data sharing, and wireless communication standards [34].

3.4. The Internet of Things Research

Here we will briefly discuss issues and challenges related to IoT and IIoT [15]. The main building blocks of IoT, including various protocols and standardization efforts, are reviewed [35]. Some researchers are concerned with protocols and standardization for the IoT. Another research direction is concerned with the non-functional requirements of the IoT [36]. One prominent research direction is concerned with developing gateways to interface IoT smart devices to the Internet or the cloud via various protocols. Some research studies are concerned with protocols for interfacing IoT smart devices to web servers . Some researchers are concerned with sensor data storage and analytics on the cloud [37]. Some researchers are concerned with programming and management support to benefit from the provided IoT devices' and sensors' data.

3.4.1. Ecosystem of Industrial Internet of Things

The IoT ecosystem consists of different components, due to numerous differences in various sectors such as health, public transport, transportation, industry, and energy. There are also unlimited applications for IoT, and therefore, a large number of IoT ecosystems can be found in literature. Five IoT technologies are commonly used in a successful IoT application: 1. devices; 2.wireless sensor networks; 3. software layer; 4.cloud computing; and 5. IoT application software [38].

In the academic literature, almost all of the existing ecosystems are mainly focused on the IoT. There is almost no ecosystem focused on IIoT in particular. In the same way as in the description of the IoT ecosystem, the IIoT ecosystem will be able explained as easy to understand in terms of easy understanding. To achieve the benefits associated with IIoT, firms need four components: intelligent sensors embedded in industrial assets, the internet networks, IIoT analysis software, and users (Fig.2).

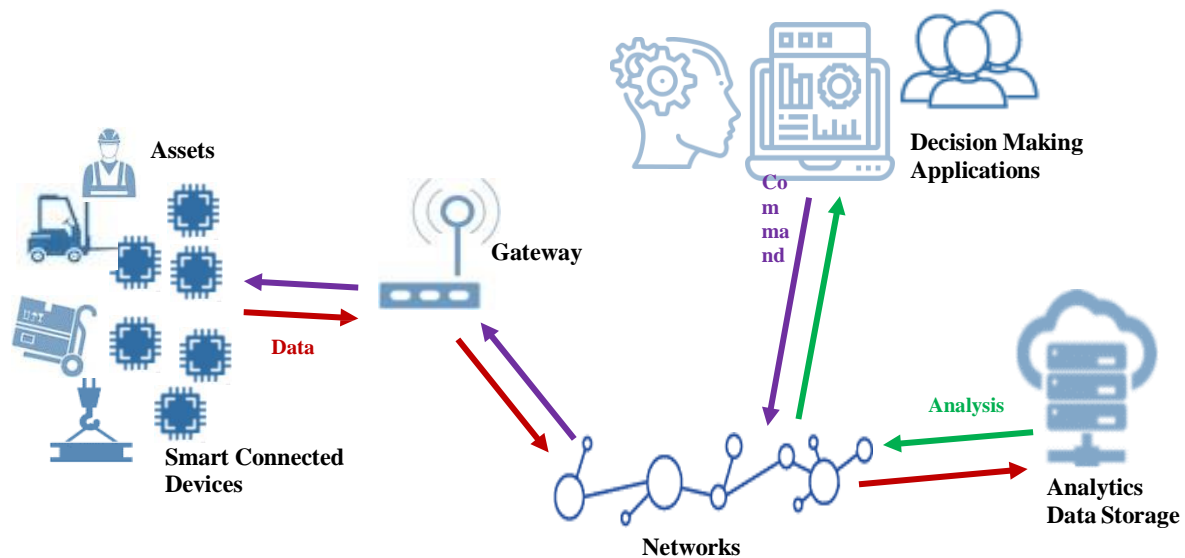


Fig.2 : Ecosystem of the IIOT

However, when we look at what is happening in an ecosystem, the entire system can be explained by a simple scheme, there are four basic components: devices, networks, platforms, and people. These components will now be discussed in detail:

Intelligent sensors and Devices: Devices usually have a wireless network connection from electronic sensors and actuators i.e., devices that move on objects such as switches or rotors with low energy consumption processors. The devices can range from monitoring machine performance to gas measurement sensors to control the environment on the production floor. The more diverse and numerous sensors, the more accurate the data. Thanks to sensors, these devices can detect temperature, humidity, pressure, sound, gravity, and motion, and measurement data can be transmitted over the Internet through the software on the device. When talking about the devices needed for the IoT ecosystem, gateways have an important place. Gateways are a piece of hardware that serves as the basic connection between devices or between devices and the network.

Intelligent sensors in IIOT embedded in industrial assets. These sensors collect and transmit real-time data through cloud technology, monitoring equipment status, usage statistics, operator information, inventory, and more. Intelligent sensors can detect, transmit, and store information about themselves, i.e., applications, controllers, sensors, and security components. Machines and intelligent sensing devices consist of physical assets such as controllers, actuators, material, and assets.

Networks: IoT requires both objects and the Internet. Presumably, the real strength of this concept lies in connection. Wi-Fi, IEEE 802.15.4, Bluetooth, Z-wave, 6LoWPAN, and LoRaWAN communication technologies are mainly used in the communication of devices used in IoT. The efficacy of an IoT system depends on to have different communication, processing, storage, and power-supply characteristics of the protocol. Table 1 lists protocols widely used for data transport, short-range, and local-area wireless network [39].

The network for IIOT connection deals with end-to-end data flow, which connects industrial systems and fulfils the transmission and seamless integration of industrial data. The networks connect intelligent machines, industrial control systems, people, and other assets.

Platform: IoT platforms are always binding for any IoT ecosystem, whether in the cloud or not. The center collects and aggregates data and allows extracting meaning from them. There are currently different global IoT platforms such as Microsoft Azure IoT Suite, SAP, Salesforce IoT, ThingWorx IoT Platform, and Oracle Internet of things, Cisco IoT Cloud Connect, Bosch IoT Suite, IBM Watson Internet of Things, Google Cloud IoT, Amazon Web Services and Software AG Cumulocity IoT platform.

IIOT analysis software can convert sensor data into actionable analyses and applications. This is a wider software environment that promotes information fusion, intelligent optimization, and decision-making. The essence of platform is to implement emerging technologies that rely on cloud platforms and efficient data collection system. This addresses the digitalization, networking, and intelligence by creating an intelligent service system by implementing digital tools such as big data storage and processing, CPS, resource allocation, and optimization.

Table 2: IoT Protocols

| Protocol | Standard | Frequency | Range | Data Rates |
|-----------|--------------------------|-----------------|---------------|--------------------|
| Bluetooth | Bluetooth 4.2 | 2.4 GHz | 50-150 m | 1 Mbps |
| ZigBee | IEEE802.15.4 | 2.4 GHz | 10-100 m | 250 kbps |
| Z-Wave | ZAD12837 | 900 MHz | 30 m | 9.6/40/100 kbps |
| Wi-Fi | IEEE 802.11 | 2.4 GHz 5 GHz | 50 m | 150 600 Mbps |
| NFC | ISO/IEC 18000-3 | 13.56 MHz | 10 cm | 100 420 kbps |
| Sigfox | Sigfox | 900 MHz | 30-50 km | 10 1000 bps |
| Neul | Neul | 900 MHz | 10 km | 10 100 kbps |
| LoRaWAN | LoRaWAN | Various | 15 km | 0.3-50 kbps |
| Cellular | GSM/GPRS/EDGE (2G), | 900 MHz Various | 35 km (GSM) | 35-170 kps(GPRS) |
| | UMTS/HSPA (3G), LTE (4G) | | 200 km (HSPA) | 120-384 kbps(EDGE) |

People: users involved in the ecosystem are all those whose actions affect the IoT ecosystem. They can be engineers who design IoT deployments and design platforms, but also platform operators. However, probably, most importantly, it is the stakeholders who ultimately get results. After all, IoT deployments are not just art for the sake of art. These complex ecosystems have a reason: to increase productivity and improve quality of life. People also decide how to use devices, networks, and platforms to achieve these results. This is where technology and business converge, as it is the business goals that largely shape the IoT ecosystem. People are an important part of that equation. Ecosystems are created and managed by humans, and ultimately realizing their full potential is again the responsibility of humans. They are the devices that collect data, but they are the ones that make sense of it and put it to use. Similarly, for networks and platforms that are a necessary component of the ecosystem, but would not be very valuable if it were not for the people who created them and perfected them to meet their needs.

Users generate information from raw data and convert it into productivity gains. Operators interact with equipment through the man-machine interface. Users analyse the data and create models. Typical applications include quality management, energy management, production application, equipment operation optimization, etc. They also develop a variety of innovative applications such as device failure monitoring, device usage monitoring and product processing status monitoring. The IIoT

is the network that includes these basic elements. The competitive advantages that IloT can provide require a customized, modern approach designed for each environment. However, as the IloT evolves connected devices, and their associated systems are becoming extremely complex.

3.4.2. Industrial IoT Architecture and Data Flow

The IloT architecture is an integrated set of components required for successful implementation of IloT. In digital transformation, IloT implementation should be started by creating a strong framework. As stated in section 2.3, several researchers suggests that traditional network architectures are not suitable for the large scale of IoT. Based on industry experience and literature research, a four-stage architecture would be an appropriate way to proceed (Fig.2). The first stage of an IoT architecture consists of connected objects, sensors, and actuators. Phase 2 includes sensor data, data acquisition systems, and data conversion from analog to digital. Phase 3 performs pre-processing of data before moving to the data center or cloud. Finally, at the Phase 4, data is analysed, managed, and visualized [35].

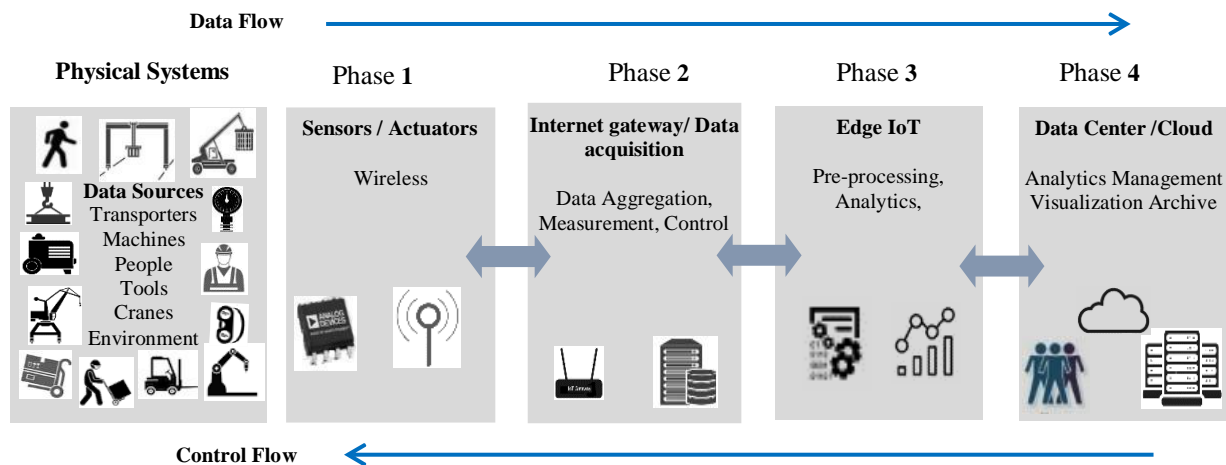


Fig.2 Four-Stages Approach to Develop IloT Infrastructure

Phase 1-sensors / actuators: Data is collected from smart connected devices and converted into useful information. Actuators, on the other hand, interfere with devices in the environment to alter the conditions that generate the data.

Phase 2-Internet Gateway: since data is collected in analogy format, this data must be converted to digital streams for subsequent operations. Data collection systems perform data collection and transformation functions. The gateway receives collected and digitized data and redirects it to Stage 3 systems for further processing. Intelligent gateways also provide malware protection, analytics, and data management services. They also have little computational power to provide real-time alert information from the data. Gateways are the latest devices-they are outside the data center-so the docking location is important. If there are a large number of machines and it is desirable to process data within the company, it can combine the information and transfer the data to a center to create a

factory-wide idea. A wide range of environments, gateway devices and data collection systems, mobile field stations can be found at the factory, so these systems are often temperature, humidity, dust, vibration to withstand changes such as portable, is designed to be easy to setup and powerful.

Phase 3- Edge IoT: After IoT data is digitized and combined, it is arranged to further process that may be required before entering the data center. There are also security concerns, storage issues, and delays in processing data. Through a phased approach, data is pre-processed, can produce meaningful results, and only transmitted them. For example, instead of transmitting raw vibration data for machines, data can be collected and converted, analysed, and only projections can be sent about when each device will fail or need service. Another example: machine learning can be used to examine for abnormalities that identify upcoming maintenance issues. Then this information is visualized using graphics and charts.

Phase 4 – Data center and Cloud: Usually data requires more in-depth data processing. If data does not need immediate feedback is delivered by more powerful IT systems to a data center or cloud-based systems where data can be analysed, managed, and securely stored. It takes longer to transport data to the cloud, but it can perform a depth analysis and combine sensor data with data from other sources for deeper insights.

The four steps approach to developing IoT infrastructure requires IoT professionals and IT professionals to work together. Therefore, they can develop better skills by working together.

3.5. Necessity of the Digital Transformation in Shipbuilding Industry

Shipyards are very large production areas in which many different kinds of ships are built. The shipbuilding sector is characterized by complex production processes based on low volume mass production and with high added value, using a wide range of production resources in the shipyard environment [26]. Ships produced in the shipyard are known for long construction times, complex production processes, intensive labour use, a high degree of customization, long service life and high cost and complex products produced according to order orders. In turn, they build products that provide high added value and require large amounts of fixed capital investments. Technological innovation in the sector is at a slower pace compared to other sectors. Because companies focus on their short-term profits, they often ignore technological advances, which complicates the early entry of disruptive new technologies into the sector and leads to a lack of competitiveness. Shipbuilding, on the other hand, has a very complex and wide product value chain with design, procurement, construction, equipment, paint, assembly, inspection, and testing processes. These processes and related activities are often carried out and completed in cramped intervals to suit certain time constraints. By its nature, it is considered a sector within the scope of heavy and dangerous jobs. In addition, the shipbuilding, the heavy and large blocks, different equipment large and small, in different tonnage cranes, welding machines, various CNC machines, robots, qualified professionals, labour-intensive to use, long delivery times and heterogeneous resource requirements, which is characterized by a complex production process.

The shipbuilding process is divided into sub-processes such as ship design, cutting and bending operations, block assembly, painting, pre-assembly, assembly in the shipyard. In this context, productivity in the shipbuilding sector is lower than in other manufacturing industries. But getting rid of an inefficiency in project-based industries such as shipbuilding and using new disruptive technologies to improve their performance is a fundamental area of research that both academics and practitioners focus on [40]. As part of the I4.0 transformation, it is inevitable that new technologies will also be applied in shipyards to increase productivity and develop value-added processes. Faced with intense competition and unpredictable conditions in the shipbuilding industry, which adapt better to the global market as the most dynamic shipyards get better results long-term goals are forced to restructure [41]. To achieve this, they have to pay attention to research, development, and innovation within the scope of digital transformation. They are launching bold business initiatives to address these uncertainties and risks by using technology-driven applications that create infrastructure and empowerment, and all these efforts prepare the shipyard sector for future challenges.

I4.0 is seen as a necessary and vital development for the survival of a shipyard. Specifically aiming global markets, organizations pursue a strategic difference that supports the necessary excellence in their products [42]. This difference can be realized with I4.0 and this is true within the shipbuilding sector. Management of shipbuilding projects, improvement of processes, the layout of workplaces, and improvement of staff skills will be realized through digital transformation. I4.0 will make processes more efficient by modernizing them. These processes cover all shipyard activities from the operational level to strategic management. In this context, redesign of strategies will not only enable better resource allocation but also enable infrastructure investment and quality systems [43].

Shipyards aiming at high quality, free from waste, are committed to continuous development in order to differentiate themselves from their competitors. In this sense, they will be able to achieve higher levels of efficiency and productivity by incorporating new digital technologies into their processes. The use of new destructive technologies helps shipyards create higher value, share information within the organization, and increase technological innovation [44].

From a wider viewpoint, I4.0 is able to support the shipbuilding industry with technologies such as process automation, pattern recognition, simulation, occupational health and safety, and decision-making. Thanks to these technologies, programs can be prepared more realistically; analytical and mathematical analysis models can be developed; instant monitoring and evaluation of the performance of production processes will be provided; and production and operational efficiency will be optimized [38].

3.6. How Industry 4.0 is Realized in Shipyard

Digital transformation starts with the collecting data. Regardless of the technologies used, data is fundamental to digital transformation. So, creating a data collection platform is the beginning of the digital journey. In that context, the IIoT is the most basic technology that will collect data and realize the transformation of a smart shipyard. The shipyard is a complex system that integrates a wide range of raw materials, semi-finished products, pipes, profiles, blocks, cranes, conveying systems, welding

machines, cutting, and punching bending machines, other resources, a wide range of business and engineering processes.

The shipbuilding process, although it may seem like a project type, can be considered as an assembly industry with its general lines. From this point of view, it can be easily predicted that digitalization and conversion to automation will increase its share in the sector, resulting in a significant increase in productivity and production volume. Shipbuilding by using new technologies can be carried out in a flexible, efficient, and environmentally friendly manner in the planned time. Shipyards will realize hundred-percent quality control and cost advantages compared to traditional production systems. Within such a system employees, machinery and equipment, and shipbuilding processes will have the ability to improve processes through self-optimization and autonomous decision-making of the resources used. One of the key elements to do these potentials is undoubtedly IIoT, which is a collection of connected devices that communicate with each other and can work in harmony to collect, share, and process information. For example, an air sensor attached to the employee's thematic card can detect the rapid drop in pressure. This information can then be transmitted to the cloud and processed there, which transmits a message to the employee that the environment's mood is about to change. For safety, the sensors can be placed on wearable accessories such as watches and helmets, especially IIoT-enabled thematic cards. Thus, it can measure the pulse of the employee, his or her height from the ground, or the number of steps he or she takes. For example, if employees work in a confined space, their heart rate and temperature can also be monitored.

An IIoT-enabled card can determine whether the worker is installing the relevant equipment in a mandatory personal protective equipment environment. In a similar safety theme, IIoT-enabled card readers can be connected to equipment such as a winch to verify that the user has the correct certificates to use the machine. Shipbuilding 4.0 can be considered as the transformation of all stages in the shipbuilding product value chain within the scope of digitalization and intelligent production, faster and closer relationship, optimization of workflow, automation of repeated activities. Achieving this evolutionary transformation will mean that the shipbuilding industry will transfer Shipyard 4.0, which will mean the realization of I4.0 in this sector. Shipyard 4.0 refers to profound changes in the shipyard system, primarily including facilities, management changes, and the implementation of digital technologies. For this reason, the Shipyard 4.0 initiative will be the exact equivalent of the transition of the shipbuilding sector to digital transformation. Some businesses in the industry refer to their digital transformations as "Shipyard 4.0", "Smart Shipyard", and "Smart Shipbuilding" with different names. So far, some companies have begun to take important steps in this process, some are planning to act, and some are considering staying away from this idea for now [27].

There are some challenges to digital transformation that need to be considered and overcome. When businesses are considering whether to invest in Industry 4.0, there needs to be thought about some potential challenges associated with incorporating new technologies into your organization. Here are some of the most common questions most business owners consider when it comes to smart manufacturing. With the successful implementation of IIoT, competitors are prevented. For this, data must be seen and used as the most important asset. Collecting and measuring data provides useful information about production sources. This information can be used to optimize resource usage. All industrial devices need to be identified. Every industrial device, sensor, machine, crane, carrier, and the entire system can produce information on the cloud or be controlled through the cloud. Identify

all these tools, and the information collected during production processes and during the use of a product should be considered. It is necessary to place the cloud and connectivity in the basic work. Incorporate cloud and connectivity into your core activities, and investment should be made in IIoT devices, connectivity and an IIoT platform. Take a step forward and master IIoT in your industry. These will help fast-forward IoT projects.

3.7. How to Manage Digital Transformation

Driven by digital technologies such as IIoT, shipyards are on the verge of transformative change. How the change to digital transformation is managed is as important as the transition itself. The following considerations will be able to guide how the transition is general managed. Before any IIoT solution can be implemented, there must be a strongly need. A clear understanding of business requirements is essential that must be documented to ensure that the IIoT solution will meet the need. Next, in digital transformation, the goals should be clearly defined. As is known, any major change in an organization requires a plan. The most important contribution to making this plan is actually setting goals. Any plan starts by defining the goals that you will achieve when you start implementing new applications.

It is also necessary to answer a simple question: “What commercial results are desired for customers?” or “What really matters to customers and users?” The answers to these questions will be the guiding Polar Star in digital transformation. Therefore, digital transformation should be addressed from a customer perspective. From this point of view, it is very important for the shipbuilding industry to accurately predict and plan the shipbuilding production times. Every digital transformation process that will contribute to this will be on the right track.

Another an important point is to accurately predict what may happen in the future in a transformation. What will digital transformation look like in the next decade? How can businesses prepare for this? These are questions that technologists are now scrambling to answer. It should also be asked which technology providers in the market could help to be more competitive [45]. According to the answer to this question, it is very important to identify and have the right technology. Is the transition to digital critical for business or industry? What if there is no investment? What is the projected risk here? Why should this transformation be done? Revenue growth or cost-cutting? What is the basic measure by which digital transformation can be driven or activated? Are there any new trends pointing in a particular direction? Ultimately, digital transformation is not just about technology and its implementation. More issues need to be considered about looking at business through a technological lens and figuring out how it changes the ability to generate revenue and operate.

The other important issue in digital transformation is the creation of a project team. It is necessary to start with a team that will adapt and implement these new technologies. It is necessary to make sure that application teams will easily use these new technologies. Adoption is the most important subject of a digital transformation process and one of its often-overlooked components. Employees' good understanding of how new features in the business will benefit them will further increase their likelihood of internalizing and adopting the solutions that will be applied. How well digital transformation tools are adopted is central to the success of the digital transformation. For example, you may need to develop training modules and an internal communication plan. The tendency to

resist change can be expected. Resistance to this change must be managed transparently because everyone sees what is happening.

4. Discussion

This study provided an overview of the how an IIoT solution can be realized in the shipyard sector. We basically overviewed the IIoT technologies, ecosystem, architectures, and how they can be applied in the shipyard sector. Furthermore, an analysis is made on IIoT, which is the most basic technology in digitizing a shipyard environment. IIoT is gradually bringing a wave of technological change to all sectors and in this context Shipyards, which together with various technologies and applications promise to make industrial activities more efficient and more efficient. IIoT offers shipyards a range of benefits to monitoring overall business processes, ensure proactive occupational health and safety, improve customer experience, save time, increase productivity, make better business decisions, and generate more revenue.

According to basic observations in the literature, there are no standards related to IIoT in the worldwide, and a universal standardization is required at the architectural level. In the last two decades, many solutions, projects, and technologies related to IIoT have been developed. However, IIoT is still the dream of a smarter and better future. In this context, it is predicted that there would be made some radical changes in the shipyard industry in the future.

5. Conclusion

Most of today's shipbuilding processes are manual. More automated processes and more digitalization will be seen in shipyards in the near future as well. It is seen great opportunities to use IIoT technologies to help streamline these processes, both in terms of efficiency and security. For this reason, there are many advances in technologies that can be used to improve the shipyards work, and the IIoT can assist in digitalization in all shipyard sector, and it offers specifically opportunities for SEDEF Shipyard and the other shipyards in Turkey. With IIoT, the tracking of individually identified assets is carried out effectively. Thanks to IIoT, all assets can be counted quickly and efficiently and can be easily accessed.

Determining whether the relevant asset is located in the correct location. In a defined area with the IIoT system, many values such as temperature, air quality, vibration, smoke, humidity and so on that are desired to be measured and monitored are controlled and effective location management is provided. Values are measured with different sensors according to demand and collected in a single center. The IIoT allows employees to track routes that they must repeat at certain intervals and how effectively they perform operations. Real-time location tracking improves health and safety of workers. It allows effective and easy route tracking in all areas of the shipyard, regardless of area size. The collected data can be evaluated, turned it into information, and sent it to the cloud, or other proprietary software for support decision making.

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