MAPPING THE DIGITAL TRANSFORMATION CHALLENGES FOR PRODUCTION FACILITY PLANNING/MANAGEMENT

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ABSTRACT: The digital transformation is one of the driving forces of economic and societal change for the past 25 years, being accelerated in the past years by the restrictions imposed by the COVID-19 pandemic and the opportunities brought forth by the tools of generative artificial intelligence. Production management is one of the fields that has a more classical appeal to it and as such there are many benefits and opportunities related to digital transformation that are not being used to their full potential. The current paper aims to perform a mapping of the situation related to digital transformation of production companies in the sub-field of facility planning and management, which has the potential to set the direction for a considerable number of years in the administration of a factory or related production unit

KEYWORDS: facility planning, facility management, digital transformation.

1. INTRODUCTION

There have been significant external pressures to transform the manufacturing sector for a few decades now, either related to the environmental impact, or the need to employ new technologies or the complex development of supply-chains including off-shoring and re-shoring. The use of computers and other digital instruments in the production sector is evolving continuously and the impact they have is conceivable in terms of customers engagement and satisfaction, employee work environment, equipment productivity, product interactivity and many more. However, when approaching the area of production facility management, and especially the planning phase, digital tools are not so often encountered, because companies tend to be both conservative and fearful of change, on top of having to face multiple regulatory constraints.

The current paper recognizes the need for digital transformation in this area and sets out to map the challenges in various related domains, using a mind-map based approach. Additionally, a digital readiness assessment is performed on a generic case, in order to quantitatively evaluate the current situation and propose improvement measures, based on interviews with production managers and the results of various manufacturing process and product consultancy projects.

2. LITERATURE REVIEW

Facility planning and management form a continuous preoccupation or project within the production company, aimed at supporting the various needs of the production processes as they are being implemented and delivering the products required by the customers. Change happens with difficulty due to the interface with the even more conservative construction industry in one direction and the uncertainty of results in the relation with the markets at the other end of the spectrum.

On planning side of the topic approached in this paper, the authors [1] describe the capabilities and challenges in implementing complementary BIM and IoT solutions, which can support enhanced facility management results. Furthermore, [2] analyze the use of digital twins for facility management, proposing further integration with other smart systems, BIMs and GIS. The article [3] discusses the uses of BIM and mentions compatibility and regulations among future research directions.

Concerning the management of facilities, [4] showcase the benefits of using deep learning for improving the predictive maintenance of HVAC systems with impact on the provided work environment and health and safety of the users. The authors [5] emphasize the benefits of the large scale use of interconnected digital twins in managing all aspects and processes of a smart factory, while [6] reveal the limitations in interfacing manual tasks with automated virtually planned ones in factories that operationalize the concept of smart manufacturing.

However, the field of smart factories remains very fruitful for current and future research [7] and the role of Digital FM must also be considered for a well-rounded approach.

3. METHODOLOGY

The current paper undertakes to achieve a mapping of the main challenges encountered by companies seeking to use digital transformation strategies and instruments to improve their facility planning and management processes. The methodological approach to this demarche involves the definition of a Digital FM Conceptual Framework (Figure 1) based on the work experience of the authors. In this framework, six domains have been identified as being the most impactful in terms of delivering a modernized version of the classical FM process: personnel training, use of cyber-physical systems during construction and use, integration of digital solutions into a Building Information Model, changing the legal perspective in the interaction with stakeholders, improving the delivery of corporate support services, and adopting new and adequate Key Performance Indicators. The following chapter describes, in relation to the current state of the art, the most common functions to be performed in Digital FM.

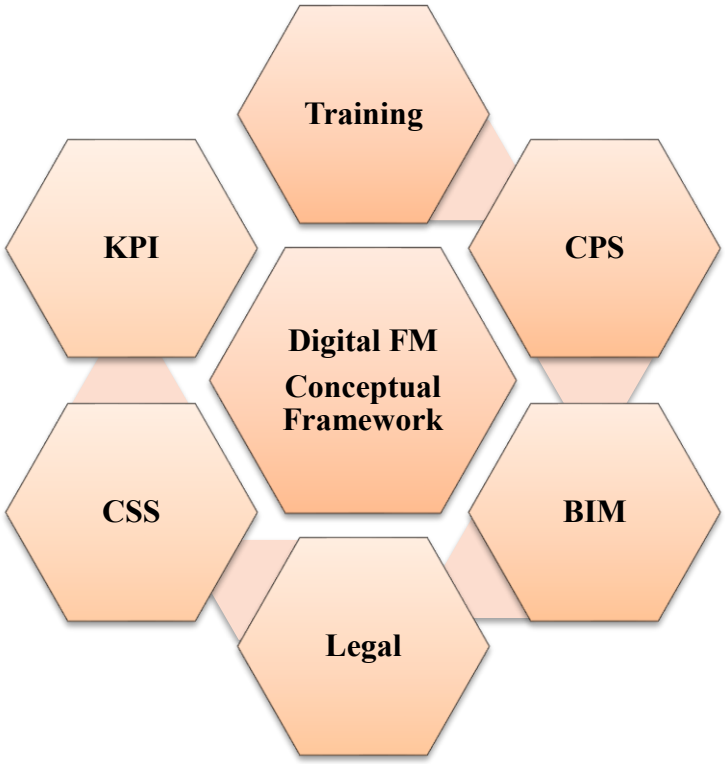

Figure 1. Digital FM Conceptual Framework

4. RESULTS

4.1 Training Impact

The digital transformation of personnel follows the pattern of virtual environment-based skills development of most engineering fields. The use of VR is especially useful in the planning and development phase of production facility, in conjunction with modeling and simulation solutions. The AR tools can also come in handy when implementing the facility project as a construction endeavor, to increase speed and efficiency and limit the possible oversights and errors.

A significant change in this area is that problem-based learning can be digitalized to real time or near-real time status, using data collected in the facility during the construction or operation phase, to deliver concrete solutions. Training solutions can be deployed in cloud-based solutions across different media, permitting the delivery of modular targeted learning in international settings, if the HR approach is adequate.

4.2 CPS impact

Cyber-physical systems can be used for gathering data and implementing direct solutions during construction (e.g., for project administration, worker safety, functional performance testing) or operation of the new facilities (e.g., environmental data processing, maintenance delivery and assessment, utilities management, access control and security).

The types of CPS that can provide useful information in this regard are:

- In-line parameter determination (temperature, flow, weight);
- Encoders and enumerators (presence, position, counting);
- Video and audio data (photos, clips, recordings);
- Complex data (security credentials, cryptography, blockchain);
- Special cases (drone data stream, sensor fusion).

As with all situations when CPS are involved, a proper connection to cloud storage and edge processing solutions can help the companies deliver the exact needed solution at lower costs and within an acceptable timeframe.

4.3 BIM impact

Building Information Modeling is starting to be used on a large scale in construction projects, usually in the residential and commercial sector, but it is ready to transition to facility management in the production sector too. It involves modeling and simulation software, real-time data collection and automated or assisted decision-making modules.

The BIM systems for facility building should interface with the CPS, as mentioned before, to determine the project execution status, assess workplace safety and communicate with contractors for deliveries. BIM for facility administration, during the active life of the facility, should be able to process Big Data and work with large information databases in cloud environments to direct and control utilities, critical subsystems (e.g., security and fire suppression, data uplinks), and smart building features related to energy management, carbon dioxide emission and waste management. They can represent the backbone to integrate all other digitalized facility management components and sub-systems and should become the focus of Digital FM with properly tailored functions, which may differ from the cases to be encountered in the civil engineering area.

4.4 Legal impact

The digital transformation of production facility planning/ management eases the burden of proof for compliance audits and external inspections that companies must pass. The data processed by the digital systems must adhere to security and ethical regulations, especially concerning intellectual property and personal data protection, in a more thorough way than in the classical version of this process.

Also, relations with stakeholders and various authorities can be facilitated in terms of shortening contract negotiations, verifying imposed conditions and addressing legitimate community and social concerns. Document management and signature validation is usually the start of this process, but complex functionalities can be integrated within the employed BIM systems (AI assistance, blockchain based chain of custody, telepresence in legal matters, advanced data analysis to support argumentation, etc.).

Although this area is somehow subtle and something one could think of when discussing Digital FM, the possible implications the changes mentioned here can have in terms of time and costs can have far reaching impacts upon the activity of the companies operating in this domain.

4.5 CSS impact

The Corporate Support Services are provided by the building company or its suppliers to the facility under construction and the completed facility. They exhibit a wide variety and can range from providing lunch to the construction workers up to ensuring the cybersecurity of sensitive transmission the tenant companies may use. Digitalization in this area impacts communication between the entities involved in their delivery, the measuring of their performances, and the determination of trends related to implementation, inspection, acceptance and complaints.

The main challenge in this respect is represented by the need to interface varying IT systems through secure network connections to provide seamless delivery and the required uptime for professional services. Another aspect to be observed is generated by the very large array of possibilities to integrate these services with the production facility, which will in most cases require involvement as partners or service providers of specialized companies. A limited solution, which can be implemented as of right now, is to handle CSS through the ERP and MRP systems, which are very common with production companies, if they permit the necessary customization. Also, one must pay additional attention to the moment the CSS are transferred from the facility developer to the company operating it in the long run, which might involve information loss, quality complaints and stakeholder uncertainty.

4.6 KPI impact

The digitalization process can considerably enhance the performance management functions based on tracking KPIs in relation to internal objectives and

external requirements. This has the potential to impact on all aspects related to facility planning and management in all phases of this process, also requiring an important change in the way decision makers are trained and operate.

Big Data analytics also allows for establishing more complex and subtle KPIs to track various important issues (e.g., voltage fluctuations in the electrical grid, impact of repetitive movements upon joint health, circadian rhythm impact on work, feedback loops in heating systems that can lead to energy waste and carbon emissions etc.). With the help of the BIM system and the site deployed CPS, a complex network of interconnected KPIs can be employed continuously to enhance the effectiveness and efficiency of the production facility.

5. CONCLUSION

As a conclusion, the conceptual framework proposed combines technical deployment solutions and managerial approaches into a coherent procedure that can guide the digital transformation process in facility planning, by showcasing its strengths and warning about its potentially related challenges.

For future research in this area, the framework will be open up for discussion with the specialists in the field through interviews, questionnaires and the application of the Delphi methodology regarding the concrete improvements that can be delivered.

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