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# Digital twin as enabler for an innovative digital shopfloor management system in the ESB Logistics Learning Factory at Reutlingen - University

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**Abstract**

Technologies for mapping the "digital twin" have been under development for approximately 20 years. Nowadays increasingly intelligent, individualized products encourages companies to respond innovatively to customer requirements and to handle the rising product variations quickly.
An integrated engineering network, spanning across the entire value chain, is operated to intelligently connect various company divisions, and to generate a business ecosystem for products, services and communities. The conditions for the digital twin are thereby determined in which the digital world can be fed into the real, and the real world back into the digital to deal such intelligent products with rising variations.
The term digital twin can be described as a digital copy of a real factory, machine, worker etc., that is created and can be independently expanded, automatically updated as well as being globally available in real time. Every real product and production site is permanently accompanied by a digital twin. First prototypes of such digital twins already exist in the ESB Logistics Learning Factory on a cloud- and app-based software that builds on a dynamic, multidimensional data and information model. A standardized language of the robot control systems via software agents and positioning systems has to be integrated. The aspect of the continuity of the real factory in the digital factory as an economical means of ensuring continuous actuality of digital models looks as the basis of changeability.
For the indoor localization sensor combinations that in addition to the hardware already contain the software required for the sensor data fusion should be used. Processing systems, scenario-live-simulations and digital shop floor management results in a mandatory procedural combination. Essential to the digital twin is the ability to consistently provide all subsystems with the latest state of all required information, methods and algorithms.

Peer review under responsibility of the scientific committee of the 7th Conference on Learning Factories

*Keywords:* Digital twin, business ecosystem, cloud- and app-based platform, digital factory, software agents, indoor localization, sensor combinations, digital shopfloor management


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## 1. Introduction

The ESB Logistics Learning Factory, Business School Reutlingen University pursues a holistic approach of the digital and real factory. The digital twin has to be developed. This is a bidirectional term which means that the transformable Learning Factory depicts any change in real time in both the digital and the real factory 1:1 and vice versa. Hybrid automated guided transport systems (robots), an intelligent conveyor system, software for self-control of work orders, a pick by light system, and driverless transport systems for the collaborative tugger train are some of the available real components.
Technologies for mapping the digital twin have been under development for approximately 20 years [1]. In an age of an increasing demand for individualized products, challenges companies to both, innovatively respond to customer demands and to quickly gain control of the increasing product variation [2] as well as a view in the future with less work and on average much older employees [3] requires completely different working models.
So the development of a concept with prototypical realization of a mobile digital shopfloor management system is the consequence with the digital twin as enabler. Machine-learning, stream analytics, cognitive services, as well as interaction and information building blocks based on a changeable production concept in the self-controlled ESB Logistics Learning Factory [Fig 1] are some of the digital modules.

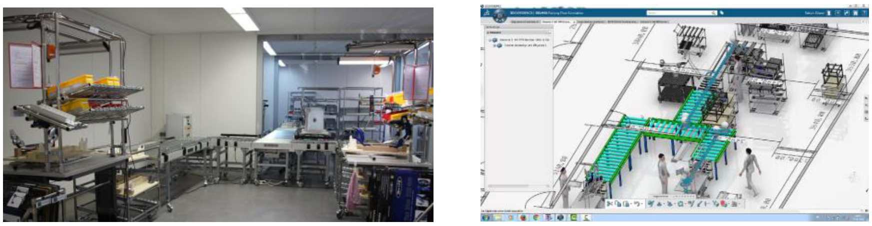

Fig. 1 Real ESB Logistics Learning Factory and cloud based 3D model

## 2. Combination of several methods for imaging the digital twin

An integrated engineering network, spanning across the entire value chain, is operated to intelligently connect various company divisions, and to generate a business ecosystem for products, services and communities [Fig 2].

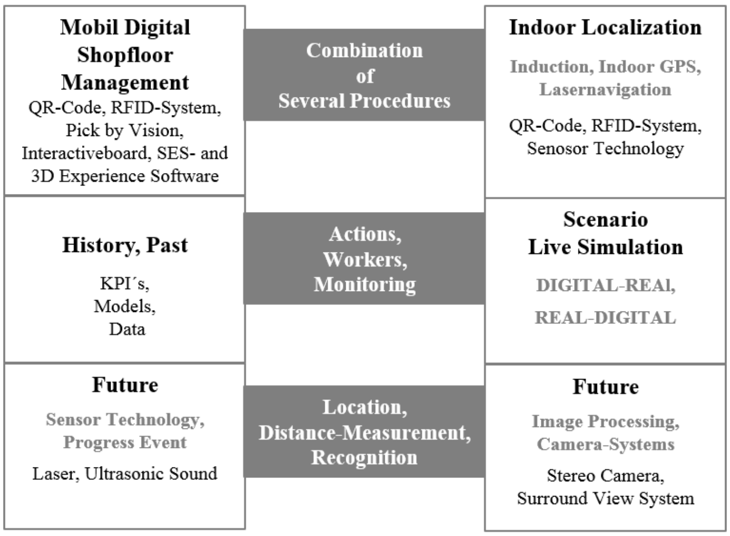


Fig. 2 Combination of several methods for imaging the digital twin**

### *2.1. Restructuring of organizational units*

Restructuring of organizational units [4] is necessary to generate new working models and to create the opportunity to work in communities, change of information across organizations, to generate focal points on knowledge and value creation, interdisciplinary communication and transfer of data for and to each member. The significance is the effect of organizational structure, leadership and communication on efficiency and productivity.

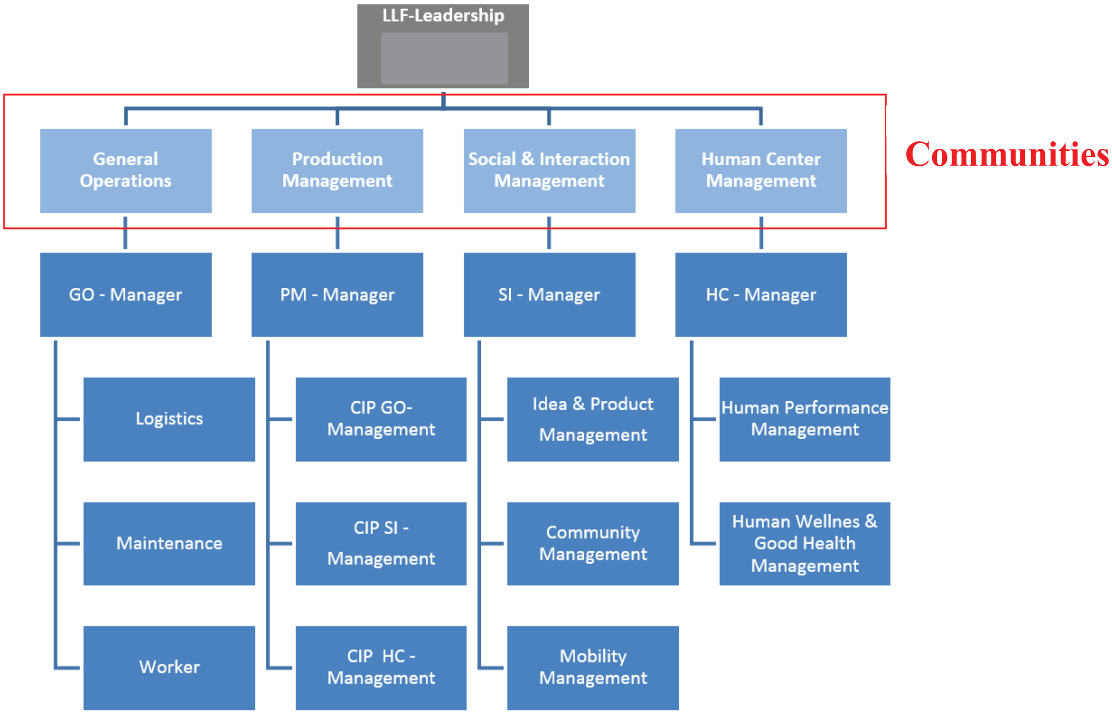


Fig. 3 New organizational units in the ESB Logistics Learning Factory**

### *2.2. Mobile digital shopfloor meeting*

Depending on the organizational units different shopfloor meetings are held. Within these meetings and structures, certain topics have to be dealt with such as provision of the data obtained for the simulation of production scenarios and integration into the knowledge database. Creation and situation-dependent variable visualization (GUI) of key figures based on past, forecast and real time data OEE, lead time, fault times and utilization, forecast of production-related KPIs based on employee- and machine- characteristics performance, stress and learning curves, improvement of the production processes by adaptation of the factory layouts are principal constituents.
Employees submit individual work requests for the following week. Monday to Sunday (variable weekdays), 0-24 hours (variable time), minimum working time (specified in the contract) must be inscribed in a new programmed App. The job length can be adjusted depending on the employee's demand on the respective day [Fig 4].
Mobile digital shopfloor meetings [5], [6] are mandatory regarding globalization. The decentralized use of the shopfloor meeting (SFM) - dashboards and interaction (read, send, change from all sites around the world) via mobile devices is state of the art. The used hardware as interactive board is the Microsoft Surface Hub 84” (MSH) [Fig 5] free-moving without power supply by cable using a UPS, USB hubs for webcams, interaction facilitates the use of mobile devices of different generations. Two-sided display, transmission and processing of data, images, etc. between MSH and mobile devices are applied.

Communication and video conferencing via MSH and mobile devices around the world is now possible with a conferencing system for researchers or Skype for Business. Already with the digital image and after the generation of the digital twin (bidirectional connection with the real time representation of digital images - sensors - real objects), a shopfloor meeting can be implemented in the shortest possible time and results in faster improvements due to the simultaneous optimization of the digital and real problem.

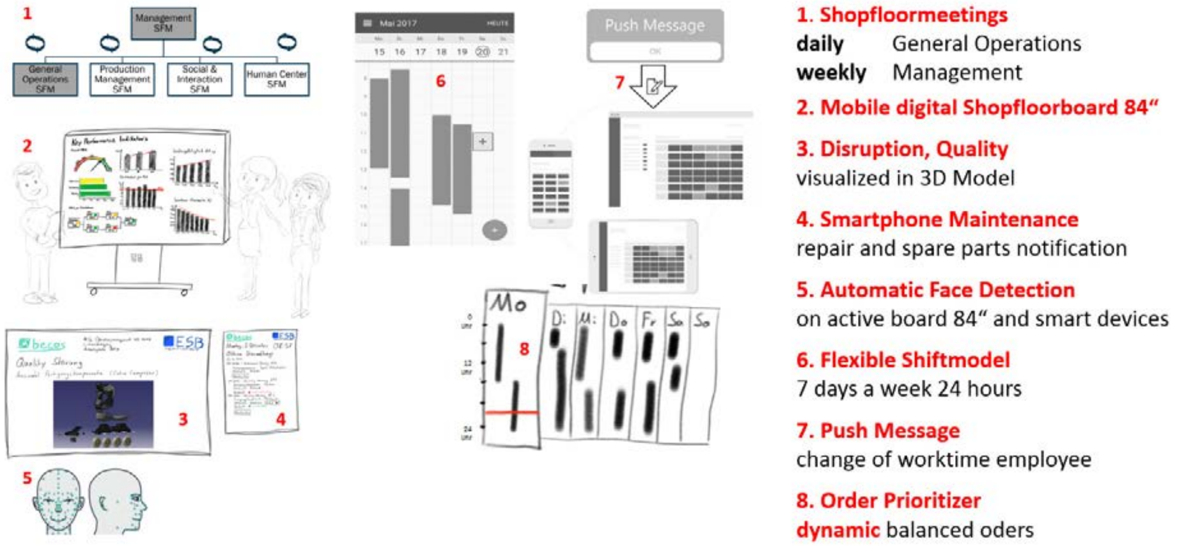


Fig. 4 Concept of the mobile digital shopfloor management system in the ESB Logistics Learning Factory, MSc Operations Management project 2016/17 (see also Fig 7).

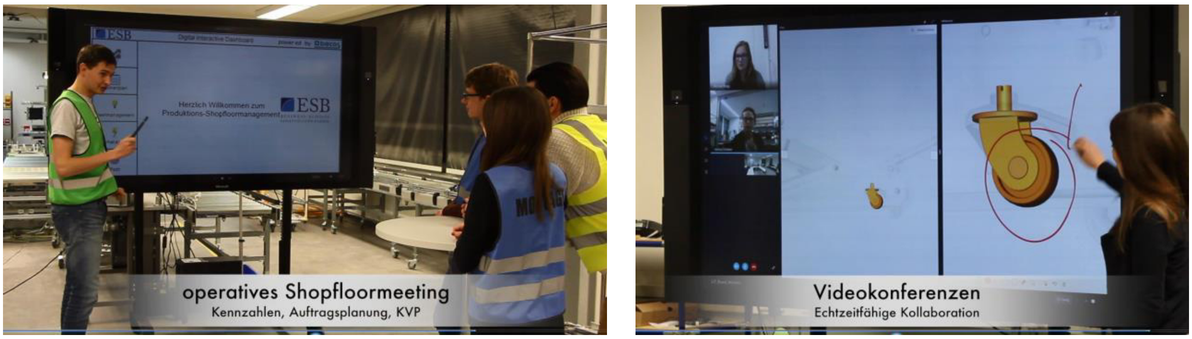


Fig. 5:
Microsoft Surface Hub 84”mobile interactive board [7]. Workers shopfloor meeting in the ESB Logistics Learning Factory. Videoconference, real time collaboration in the EOC engineering and operations cockpit room of the ESB Logistics Learning Factory.

### *2.3. Software Systems and Indoor Localization*

Essential to the digital twin, is the ability to consistently provide all subsystems with the latest state of all required information, methods and algorithms by a standardized informatics language which has to be defined [8]. The 3D Experience platform (SWYM) by Dassault Systèmes, the self-execution system SES enlarged with a couple of Apps by Becos and the indoor localization system with a new sensor generation by Telocate [Fig 8] and last but not least the Microsoft Surface Hub 84” 4K interactive board are a selection of the technology elements to realize and visualize the digital twin.

For coupling the digital and the real world the indoor localization system is needed first. The intralogistics concept of the fourth industrial revolution will be realized in the ESB Logistics Learning Factory with sensor mounted autonomous navigating transport vehicles and dynamic logistics and production processes. The worker and also the production - controlled product can be located from the first part up to the completion at anytime, anywhere.

Retrievable information from idea generation to service offers to the end customer by “RFID or QR” technology is part of the scenario.

Who has the right of way when the autonomous Baxter robot and the "FTS" of the tugger train are on the road at the same time? Can the 2D ground plan of the ESB Logistics Learning Factory be visually presented as a suitable map for navigation? [9] What about bin and container management? Will the logistics containers also receive the relevant information? Which standardized informatics language permits the programming of the interfaces from the digital images to the real components with diverse age and varying controls?

Only a combination of several technologies can answer these questions and the ESB Logistics Learning Factory team and partners have to combine them individually for each case study. In the future, artificial intelligence and corresponding algorithms such as self-calibrating localization [10] will play a major role. As in case of the autonomous vehicles of automotive OEMs a connection of hardware, software, sensor technology and image processing is required also in the ESB Logistics Learning Factory [11].

The social media platform SWYM is used for working in communities and as knowledge base on the shopfloor. The first interfaces will be programmed between the Becos-SES system and -Apps, the sensors to localize the worker and the product and the SWYM-App. [Fig 7]

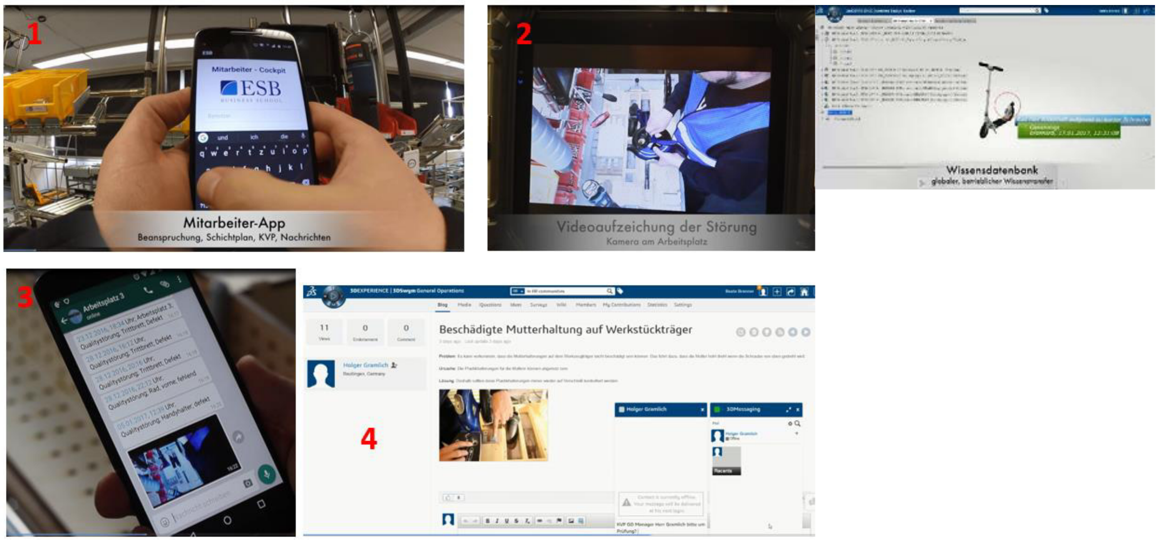


Fig. 6: **1** Interface Becos WorkerApp, worker login. [7A]. **2** Video sequence on workplace, dysfunction of wheel. Product scooter visualized in ENOVIA Design Review App (3DExperiencce platform) for additionally integration in SWYM knowledge database.

**3** Interface Becos MaintainenceApp - message to responsible person to change defect wheel.

**4** Documentation in SWYM knowledge database, Blog and Wiki.

In the social media platform SWYM the main task is defining communities and their contents and integrate them into the CIP process [Fig 7]. To teach the blues and the employees to use the knowledge base professionally and not only to have a look in the telephone directory or canteen plan that they understand the even more important benefit is to handle errors, problems, causes and the problem solutions. Construction of an error-causes documentation e.g. via posts with fast problem solving is a great advantage.
Save errors and search through iQuestions (ask questions to all community members or across communities and receive their replies) and Wikis, integrate knowledge databases into the work process and use them as simple as possible is a new but a contemporary challenge.

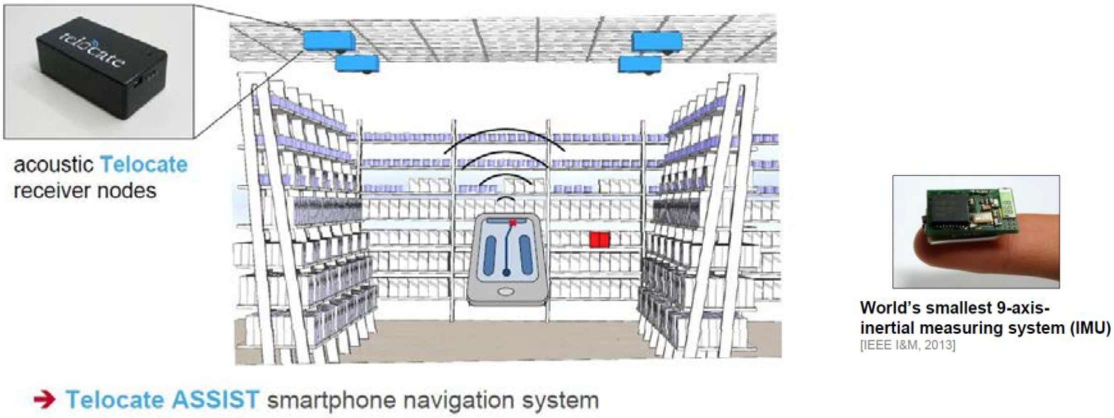


Fig. 7: Telocate used sensor and one possible localization system*

## 3. Research questions

1. What additionally chaining techniques and programming language or file formats are necessary to link the digital twin with the real factory in real time visualized with the mobile interactive board Microsoft Surface Hub 84" ? Are we able to define one standardized informatics language for the communication between any real or digital object? Can we continue with the digital twin without artificial intelligence involved in the study of mechanisms of intelligent human behavior and running through simulation using artefacts, usually with programs on computing machines? [12].
The approach is to list every object and check if it already has its own IP-address and by which informatics languages or protocols it can be activated. From this list a standard will be defined for all objects and the respective interfaces to the software tools. Also a decision is made which objects are not suitable. Further we have to gain knowledge in which way we can apply artificial intelligence e.g. regarding machine learning.
The validation scenario for the digital twin provides a change in the real world and this change is in the digital world also pursued in real time and a change in the digital world causes an immediately modification in the real world.

2. Is this seamless digital and real factory model with integrated mobile digital shopfloor managment transferable to other disciplines e.g. healthcare regarding digitalization in clinical associations, a larger number of connected hospitals?
The data-, process- and information model of the digital ESB Logistics Learning Factory has to be adapted to the clinical processes.
A hospital stay of about one week has to be shown digital. From the patient's accommodation, the medical treatments and the daily medical visits, the computer tomograph- and X-ray images displayed three-dimensionally should all operations and information's be managed with one software system platform which is able to access reference data online from each used medical software tool.

## 4. Conclusion

The majority of the necessary infrastructure components for the digital twin as enabler for an innovative digital shopfloor management system in the ESB Logistics Learning Factory is implemented. The Microsoft Surface Hub interactive board 84” is delivered. There was a need for a special introduction to administrate, to work with and to install some universal Windows10 Apps. The video conferencing system in addition to Skype for Business and all named software tools used in the ESB Logistics Learning Factory must be executable on the board.
In addition, the ceiling installation of the receivers of the sensors is finished and the hardware and software therefore is no less extensive and we are combining some applications e.g. selected Becos Apps and the 3DExperience platform with the localization results. Completing these installations the bidirectional programming between the real and the digital world will be continued to use the real time digital twin as enabler [13]. This supposes that shopfloor management even with paper is possible but neither innovative nor digital without the digital twin and the results are not cross-linked and always accessible visualized anywhere in the world.
The ESB Logistics Learning Factory can finally start with the flexible factory in every aspect and network the applications together.
Our first global shopfloor meeting for the general operations community (workers, logistics person, maintenance) was taking part with a manager on a business trip on a different continent with the new factory structure, a highly dynamic shift model and order prioritizer, human center healthcare etc. and the interactive board as well as mobile devices and the newest KPI´s out of the production and human management.
All informations of the product scooter regarding product idea, factory structure with communities, project management, data management, product design, parts- and manufacturing-lists, additive-parts-manufacturing, processes with time analysis and balanced on the production area, resources with libraries, layouts and simulations are already stored in the cloud based 3D Experience platform.

The job control is executed by the cloud based Becos self-execution software (SES). The new Becos Apps are partially programmed as you can see in the figures and will be finished in the next weeks: 1 disruption and quality on the workplace tablet, 2 smartphone maintenance, 3 automatic face detection, 4 flexible shift models, 5 order prioritizer for dynamic balanced orders.
The localization of the worker and the product plus the bin is conducted by the Telocate sensor software. A map of the ESB Logistics Learning Factory is currently being prepared and the system with the sensors is in the integration phase. The next steps are to define a plan which of the named software tools are combined regarding sequence and content and to identify all possible informatics languages of each object.

Our type of factory needs a technically experienced, economically active IT-architecture-team with a maximum overview. The communication of the software modules, the flawless production and the economic interaction between man, machine and product has to be ensured [14]. These objectives have been hand down into appropriate trainings and target agreements to the workers (students had the roles of workers for production, maintenance and logistics).

The ESB Logistics Learning Factory (LLF) is really a bit visionary regarding the different generations and cultures of people working in five to ten years maybe with the real digital twin, a flexible shift model 7days/24hours, human center management and mobile digital shopfloor meetings for the blues [15].

**Company names of used technologies (extract) in the ESB Logistics Learning Factory:**

**Becos GmbH,**
Zettachring 2, 70567 Stuttgart – Germany

**Dassault Systèmes,**
10 rue Marcel Dassault, 78140 Vélizy-Villacoublay – France

**Telocate GmbH**
Georges-Köhler-Allee 71, 79110 Freiburg im Breisgau – Germany
*https://de.telocate.de/assist

** Own representation

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[15] http://www.gartner.com/smarterwithgartner/gartners-top-10-technology-trends-2017. © 2017 Gartner, Inc. and/or its affiliates. All rights reserved. Gartner is a registered trademark of Gartner, Inc. or its affiliates. The analysts predict that hundreds of millions of things will have a digital twin within three to five years.