HOW TIC4.0 STANDARD DATA LANGUAGE-DRIVEN DIGITAL TWIN CREATES VALUE FOR TERMINALS IN THE LONG RUN

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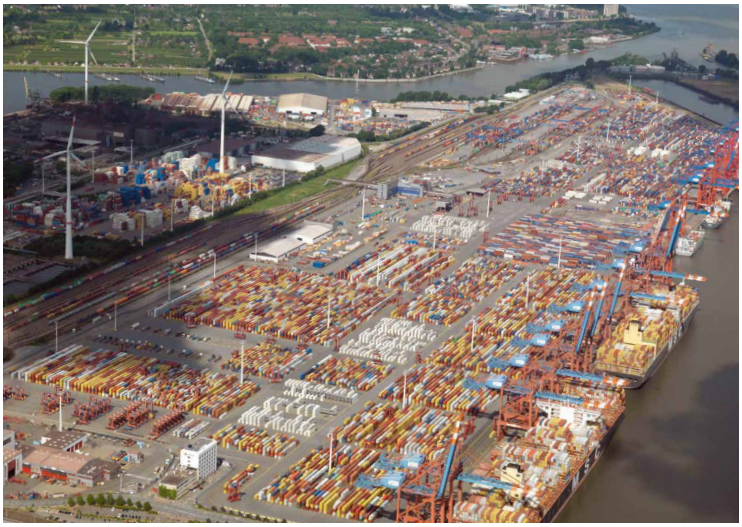
The digitalisation of the logistics flow in ports and terminals is a future must-have for a modern and efficient facility. The key to a digital flow is consistent, good data from different sources to represent the actual cargo and equipment flow. Creating value from data will require a good data setup and a good use of the data. One key use of data is a Digital Twin to enable applications and users to digest and work with the increased amount of data.

The TIC4.0 language sets a cornerstone in the logistics industry for data standards and increases the ability to generate value from the data. A Digital Twin is a good example of value generation from data using TIC4.0.

A container terminal Digital Twin is a complex system consisting of various data sources and consumers, with data being transferred and processed at multiple stages. It involves numerous equipment and software solutions working hand-in-hand. All these systems and data flows are orchestrated within one unified architecture, which forms the essential foundation of every Digital Twin. The second key aspect of a Digital Twin is its functionalities, which operate on the data gathered—whether it's decision support to a TOS system by real-time data, AI-based analysis of the data or forecast generated by simulations into the future. Furthermore, replaying past data may help the operational staff to better understand previous events, while "what-if" simulation scenarios may support planners in optimising future actions by using data to explore different approaches, such as "what if I had used X equipment".



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EUROGATE Container Terminal Hamburg. Courtesy of EUROGATE.

The implementation, operation and maintenance of such Digital Twins not only requires in-depth comprehension of the overall system architecture and software solutions being used but also urges for close cooperation between involved stakeholders, with one major part being the specification and implementation of interfaces between all involved systems. Long-lasting technical discussions on interface specifications may overshadow more important discussions on functional requirements and use cases.

A typical flow of data might begin with the collection of sensory data from container handling equipment (CHE) on an edge device. This data is then transferred to a data broker before being forwarded to a data lake, where it is processed, validated, and stored.

The same applies to the terminal operation system (TOS) or other systems such as weather data or ERP systems, which could ideally provide insightful complementary data to the Digital Twin by sending data into the data lake.

Finally, various software solutions connect to the data lake and act as data consumers, enhancing Digital Twin by providing dashboards, visualisations, alerts, predictive maintenance, and other valuable insights.

In the past, discussions and alignments on the overall data "language" and each interface to be used would have been a vital step when implementing a Digital Twin. Aligning interfaces and specifying data attributes is a time-consuming and tedious task and usually results in multiple loops of such specifications being made between its stakeholders, with lots of technical discussions.

Furthermore, discussions between stakeholders often revolved around basics definitions, such as "what is a move?", "where does a move start and where does it end?" or "how do you measure productivity of the equipment?". In the port and maritime industry, different understandings and usage of terminology is a prevailing issue and often leads to uncertainties or the need for clarification between involved stakeholders.

This is where TIC4.0 (Terminal Industry Committee 4.0) comes into play:

- Firstly, by using TIC4.0 as the standard data language, the effort for alignment, implementation of interfaces, and data storage is minimised. TIC4.0 provides a standard language with a vast amount of standard data attributes. Using TIC4.0 as the communication protocol, each vendor and system are using a mutual platform to connect their systems, with all data attributes defined beforehand. Hence, TIC4.0 facilitates a "plug and play" philosophy, as each software only needs to "talk TIC". If a software or system is once built up to work with TIC4.0, the need for interface discussion is fully eliminated. Technical discussions are thereby minimised, and room for functional talks is created instead, further driving innovation and saving resources.
- Secondly, using TIC4.0 as a basis streamlines the terminology and definitions used in the port environment. If a Digital Twin is built using TIC4.0 definitions, stakeholders have a common ground and understanding of the terms being used. For example, the standardised definition of a "move" or "equipment productivity" provides a common understanding for all stakeholders and eliminates uncertainties when looking at this data.

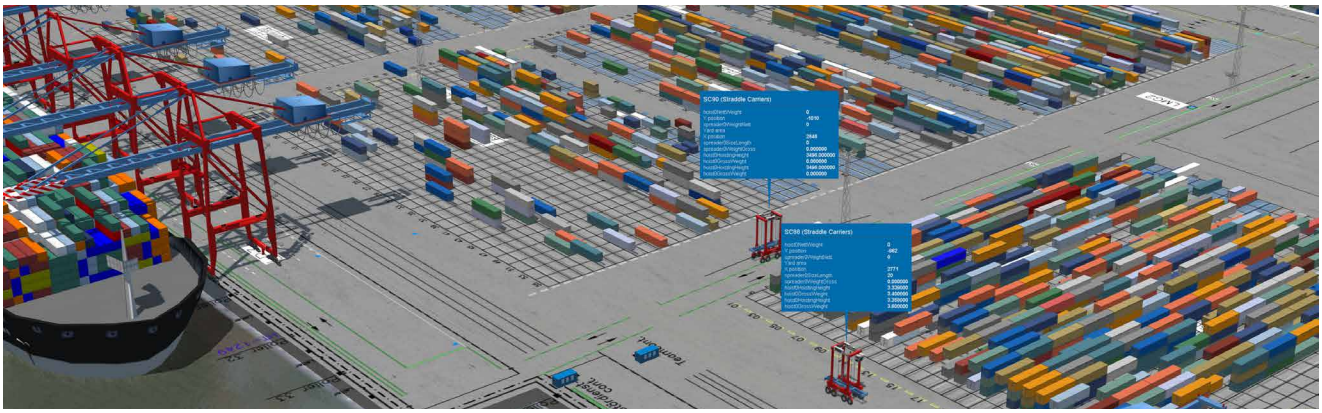
Utilising TIC4.0 uncouples data creation and data consumption (value creation), as these are no longer dependent on each other. Applications for data consumption may be prepared in advance before data is available, as definitions and attributes are already fixed and do not need alignment. Any third-party application connecting the Digital Twin at a later stage only needs to "talk TIC", and thereby can be connected as easy as "plug and play".

At the EUROGATE Container Terminal Hamburg (CTH), Germany, a Digital Twin was developed and implemented using TIC4.0. The project, named "IHATEC TwinSim", was funded by the German Ministry of Digital Affairs and Transport. Launched in 2021, it successfully concluded in 2024. Key project partners included the EUROGATE Group, EUROGATE Technical Services, the University of Hamburg and akquinet port consulting, with CTH serving as the pilot facility.

One of the project's main goals was to implement a fully-fledged Digital Twin by using TIC4.0 as the standard communication language, thereby gathering insightful experience and knowledge not only on the usage of TIC4.0 but also its application to real-world use cases.

Starting with data collection, EUROGATE's straddle carriers and quay cranes gather and collect data from multiple sensors, consolidating it with edge devices installed on the equipment. At this stage, all data is already in TIC4.0 format before being transferred to a data broker. For all telemetric data—such as tyre pressure, hoist height or equipment location—, TIC4.0 provides a matching and definitive data attribute within its model. With the TIC4.0 data model offering high flexibility and encompassing a wide range of attributes, any new telemetric data points sent by the equipment can be seamlessly added to the interface.

In parallel, EUROGATE CTH's TOS provides and pushes its planning data from the TOS in TIC4.0 format and feeds this into the data lake, where it is processed and merged with the equipment data. Other applications or data—such as weather data or ERP systems—also feed complementary data in TIC4.0 format into the data lake, making it available for further usage by data consumers. One of the key advantages of this setup is that both the equipment and the process (TOS) communicate in the same TIC4.0 language. This enables value creation across



different applications by using both data sources simultaneously.

Based on the standardised data processed and stored in the data lake, the Digital Twin is brought to life by connecting data dashboard or other tools, such as CHESSCON.

Being responsible for the 3D-visualisation of data, as well as real-time-based simulation, CHESSCON plays a major role in providing value-added Digital Twin capabilities alongside other solutions. As CHESSCON is developed to "talk TIC", integrating it with the data lake requires minimal effort. This unified data view from the process and the equipment unlocks a wide range of possibilities: the Digital Twin is not just a nice 3D representation of a terminal but also enables value-added features within the CHESSCON LiveView, such as replaying past operations with "what-if" scenarios or forecasting future operations based on the current data set and status of the operations.

Similarly, if CHESSCON or any other solution is returning data into the data lake—such as simulation results—the format and attributes remain standardised in TIC4.0.

As a result, application and interface development at each end of the Digital Twin is decoupled from other solutions and can be done independently, saving time, effort, and avoiding misunderstandings. New equipment or subsystems talking TIC4.0 can be easily integrated into the whole system, thanks to TIC 4.0's standards—#wetalktic.

Finally, rolling out the solution to other terminals and integrating other applications and data users will significantly reduce time for future implementations by building a common data standard.

ABOUT THE AUTHORS:

Norbert Klettner is Vice-President of TIC4.0 and Managing Director of the Akquinet Port Consulting and RBS EMEA Office. VP since 2019, he has been an active member of the TIC4.0 from day one. Starting at EUROGATE and moving on in the industry with akquinet and RBS for more than 20 years.

Michael Nagel-Kugler is Senior Consultant for Ports and Terminals at Akquinet Port Consulting, with more than 10 years of experience in the maritime sector, both on seagoing vessel as well as the port industry. He is an active member in the Terminal Industry Committee 4.0 (TIC4.0) task forces from day one.

ABOUT THE COMPANIES:

The Terminal Industry Committee 4.0 (TIC4.0) was founded in 2019 as an international non-profit association whose purpose is to promote operative standards in the sector through the development of digital standards aimed at facilitating interoperability, allowing the implementation of 4.0 technologies, and thus achieving new levels of productivity, efficiency, and sustainability as a sector. TIC4.0 has 66 members globally with 12 leading terminal operators and 54 innovative solution providers. The association published standard definitions and white papers to guide the industry to a more standard approach to data and connectivity.

Akquinet Port Consulting offers consulting services for ports, terminals and the maritime industry, including automation consulting, strategic planning, design consulting, bottleneck analysis, as well as simulation and emulation services with akquinet's own inhouse-developed CHESSCON solution.

EUROGATE Technical Services is the technical service company of the EUROGATE Group and guarantees the constant and reliable availability of essential port technology. At the locations in Bremerhaven, Hamburg and Wilhelmshaven, highly qualified personnel deal with all aspects of the life cycle of complex facilities and systems. This includes design, planning, procurement, commissioning and maintenance as well as technical development. The focus of our solutions: the future topics of decarbonisation and digitalisation.

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