USE OF DIGITAL TWINS TO SMOOTH THE IMPLEMENTATION OF STS CRANE AUTOMATION: BRIDGING THE GAP BETWEEN TECHNOLOGY, PROCESS, AND PEOPLE

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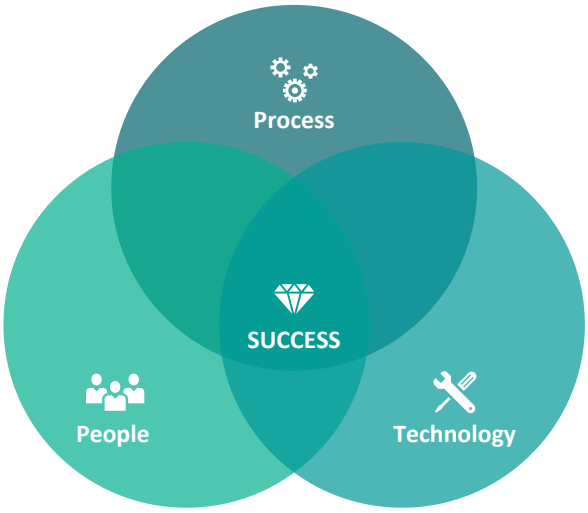
Ship-To-Shore (STS) cranes are the key equipment of a container terminal, and their productivity is the key for the whole terminal success. Larger ships are driving bigger STS cranes and larger call sizes. Lifting heights and trolley travel distances are increasing and the operator job's is becoming more demanding. In order to increase productivity and meet all the associated challenges, ports are investing in STS cranes automation and moving to remote operations.

In this article we explain how the use Digital Twins (physics-based, virtual twin of a product, able to simulate in real-time its behaviour and use) can smooth the implementation of STS crane automation by providing better alignment between technology, process, and people.

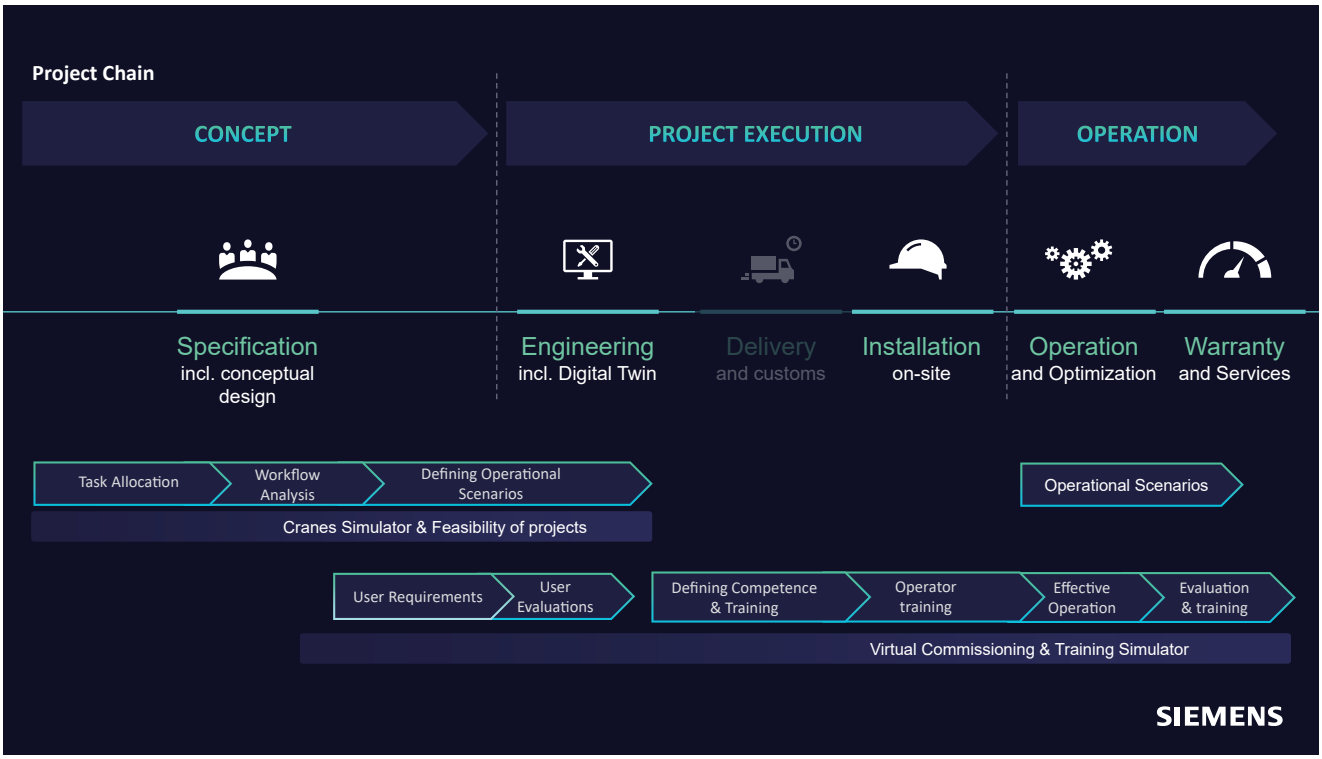
CONCEPT PLANNING PHASE

From a terminal operator's perspective, important elements during the concept planning are task allocation between automation and people, workflow analysis to identify new roles and collaboration within and between teams, and defining future operational scenarios. That is why early operational involvement is key in addition to technical designs. Together with the introduction of automation and crane remote control, new workflows will be created to the terminal. As an example, the crane driver is not alone, but is working together with colleagues in a control room (i.e. office space). Together they will handle all outstanding jobs that automation is not handling, and will be able to assist and learn from each other and even manage different types of cranes. Early alignment between technology, process and people is key. Operational scenarios will lead to functional design specification in addition to technical requirements. Together operational scenarios and functional design specifications will provide a valuable blueprint for objective user evaluations.

RIGHT
Balanced alignment between people, process and technology are key to success when implementing crane automation.



"STANDARDISATION OF THE AUTOMATION SOFTWARE, INTENSIVE IN-HOUSE TESTING AND THE INVOLVEMENT OF THE END-USER IN TESTING WITH SIMULATION AND THE DIGITAL TWIN HAS RESULTED IN A SIGNIFICANT REDUCTION OF THE ENGINEERING AND COMMISSIONING TIME."



Prior to final tender, Digital Twin-based simulation can be used to check a new crane concept feasibility either from operation or functionality perspective. Terminal operators should do this in co-operation with the crane/ automation provider proposing the new concept. Concept feasibility simulation would decrease the physical testing and risk of terminal operators being pioneers of an expensive experiment.

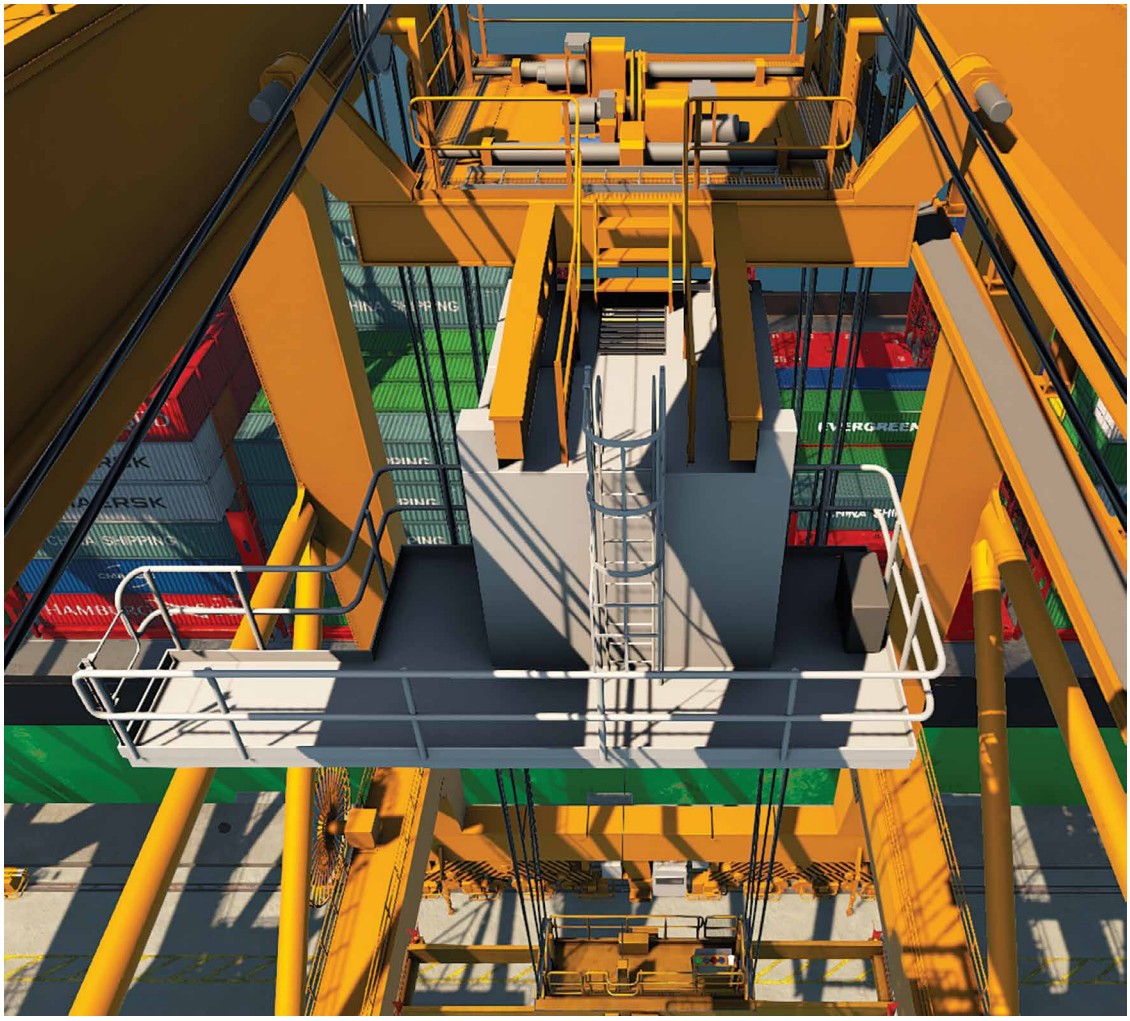
PROJECT EXECUTION PHASE

STS crane automation is a prerequisite for remote operations. In an ideal situation, all steps would be automated and remote operations would become remote supervision. Unfortunately, in practice this is not yet the case. Some steps have not been automated due to safety reasons (e.g. human in the work area) or technical challenges (e.g. below-deck automation). Based on Remote Control, parts of the workflow are being handled by operators. For some cranes the automation level allows remote operators to handle multiple cranes, but STS cranes are still being operated one-to-one. A seamless integration of automation, new workflows and new roles like remote control operation are essential. The agnostic remote control philosophy of Siemens is that different crane types from different crane manufactures can be controlled from the same desk. The agnostic vision of Ops Factor is to develop one multi-functional desk, enabling remote operations of different equipment (cranes, vehicles) with a modular operations dashboard.

ABOVE
Project chain for a smooth crane automation implementation (diagram by the authors)

A Digital Twin with identical remote control system as the one in the crane will be used to introduce a new way of working to operators, collect important feedback, (changes are still relative easy in this period) decrease resistance to change, and build trust to automation. This system can also be used to evaluate and train the operators based on the operational scenarios as identified and defined in the design specifications.

RIGHT
Crane Digital Twin on Remote Operation Station
Image: Mevea



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Very-detailed Digital Twin enables accurate simulations during all phases of the automation development
Image: Mevea

Throughout the years the use of Digital Twins has proven itself within the Siemens automation projects but is still evolving. For example, during the "Specification Phase", the Digital Twin is used to define the optimal sensor positions for cameras and laser scanners enabling efficient automation and remote operations. Within the 3D environment engineers can check if the feedback is correct, the maintenance department can check the accessibility and the operators can check the camera views. Alignment within the 3D environment makes it much easier than by means of "old way" 2D drawings. This has proven to save a lot of time and effort by doing it right from the start. Based on previous project experience without Digital Twin, sensors needed to be relocated during the actual commissioning due to mechanical and electrical changes on the crane, the lack of mounting positions on the crane, blocked viewing angles etc.

During the "Engineering Phase" simulation plays an essential role. The first simulation is related to the simulation of the actuators and I/O. The next step is software development in combination with Digital Twin with the goal to simulate the behaviour of the crane as in real life. This requires accurate, physics-based Digital Twin with short simulation cycle time. The philosophy is to use the same PLC automation software in simulation. This guarantees that the right software is tested, no merging of software is needed and the training concept can be used to test and train software engineers from the terminal.

Standardisation of the automation software, intensive in-house testing and the involvement of the end-user in testing with simulation and the Digital Twin has resulted in a significant reduction of the engineering and commissioning time. The end-users got a better understanding of what will be delivered, and the software is much more reliable; however, there are further opportunities to reduce lead-times by integrating other intelligent subsystems too, such as truck positioning or load collision prevention within the simulation environment.

To train the operators and

maintenance and engineering department, Mevea, Siemens and Ops Factor have jointly implemented a training solution which combines the real crane control system, operator desk and realistic operator feedback and scenario-based training exercises. This also means that the maintenance and engineering department of the terminal can use the training desk to test modifications in advance and to learn how the automation software works. As the same PLC software is used with the training desk, the desk itself can also be used for real crane operations.

The return on investment of a Digital Twin-based simulation solution, which can be used for both development and operator training, is calculated in months. This approach will also decrease the CO2 footprint, as during testing and training there will be no energy and fuel consumption of crane and horizontal transport equipment.

ABOUT THE AUTHORS:

Ilse Houting is Director of Ops Factor, a company delivering solutions for remote control rooms. As Human Factors Consultant, Ilse is integrating the operations factor in automation projects to bring synergy between operations and technique.

Raimo Nikkila is the co-owner and Director at Mevea Ltd, a Finnish high tech company providing simulators and Digital Twins for product development and operator training. At Mevea one of his key roles is to drive solutions which combine advanced technology and customer process understanding.

Douwe Wagenaar is the Manager of Remote Control & Simulation for Cranes at Siemens Nederland. In this role he oversees the crane control software development, testing and simulation for remotely operated harbour and industrial cranes.

ABOVE
Crane Digital Twins in a virtual port environment
Image: Mevea

ABOUT THE ORGANISATIONS:

Mevea Ltd.
Mevea is a Finnish high-tech company providing highly advanced and innovative solutions for Product Development, Operator Training and Engineering Education build on physics-based Digital Twins.

Mevea solutions produces accurate real-time simulations of machines, environments and work processes that yield tangible business benefits such as assistive and autonomous system development or port equipment operator training.

Siemens
For more than 165 years, Siemens has stood for innovative strength, a passion for technology, sustainability, responsibility and an uncompromising commitment to quality and excellence.

Siemens Cranes develops state-of-the-art technologies for fast, flexible and productive container terminals. Through co-creation, we combine the port's strengths with our front-running technology, process adaptation and integration knowledge offering electrification, automation and digitalisation in container terminals across the globe.

Ops Factor
Ops Factor is world's leading remote control room specialist. Ops factor delivers innovative and integrated design solutions for remote-control operation. Ops Factor is specialised in the Human Centred Design, connecting technology, process and people automation projects.