

Brains of the operation

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Terminal operating systems (TOS) are as diverse as the ports around the world. The market reflects that situation, as numerous solutions exist to tackle all kinds of operational requirements and challenges modern terminals have to handle. Choosing and implementing a TOS is no trivial task; it is costly and time-consuming. To ease this process, the Fraunhofer CML published the *Terminal Operating Systems 2021* study (now in its fourth iteration), providing an extensive overview of the providers and their products on the market, together with indications of the terminals' needs. This year's study puts a spotlight on Artificial Intelligence (AI) in TOS applications, giving insights into the state of the art, challenges, opportunities, and expectations associated with this technology.

Terminal operating systems are at the pulsing heart of managing modern terminal operations. The TOS documents what happens and can support planners and decision-makers by providing summaries and overviews, or even take decisions on their own. It is where all strings connect, where processes start and end.

Partnership technology in an increasingly specialised market

Given such a crucial role, it is therefore of utmost importance that the TOS of choice perfectly fits the operations at the terminal in question to enable and facilitate efficiency and effectivity. But choosing a TOS is not straightforward. While there is a huge market, filled with highly specialized products, there rarely exist solutions that can be bought and installed

straight off the shelf. Rather, after a terminal decides on a concrete TOS product, and the specific modules needed, a time-consuming implementation phase begins, which can last up to several years.

Since port terminals are equally as diverse as the TOS products meant to make their operations easier, it is an important first step to indulge in extensive market research. When deciding to implement a new TOS, its future users need to find a suitable partner, one that matches the terminal's requirements. The Fraunhofer Center for Maritime Logistics and Services CML aims to support this first procurement step with its *Terminal Operating Systems* study-series, created with the use of extensive questionnaires, sent to both TOS users and providers, to offer unique insights into this ever-developing market. The 2021 issue features 38 providers, their products and

modules, as well as puts a spotlight on AI applications in TOS from a user's and a provider's perspective.

According to our findings, the TOS market has developed towards diversification and specialization over the past couple of years. Providers started offering more modules aimed at tackling very specific tasks, often narrowed to certain terminals, rather than proclaiming one-fits-all solutions. At the same time, there has been significant market consolidation, as providers have increased in size and market power through mergers and acquisitions. This has been especially prevalent in the ro-ro and container terminal sub-markets, where the number of TOS products available declined by 24% and 21%, respectively, since the last edition of our study. Conversely, the TOS offered for facilities trading in general cargo has widely remained unchanged.

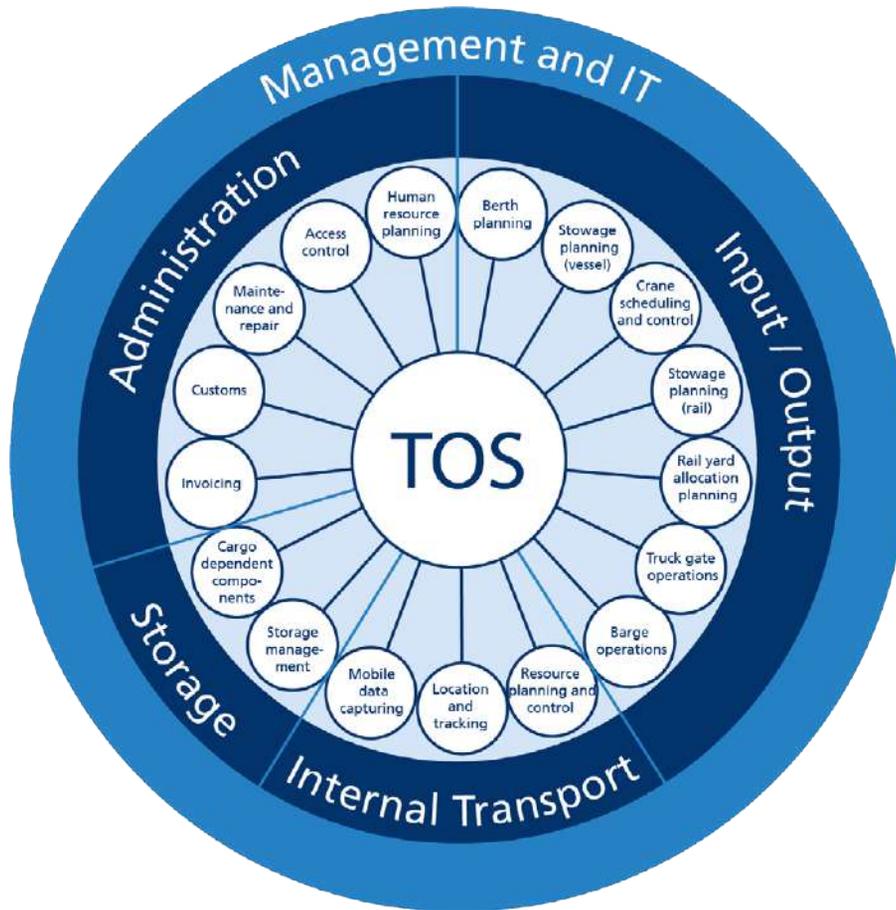


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Meanwhile, the number of solutions for the dry and liquid bulk segments has noted a significant increase.

The intelligent TOS

With AI being at the centre of attention of researchers and practitioners all over the world, the question arises: how well AI-methods can be applied to the TOS field. The 2021 study has identified several innovation pathways for AI-based systems for users and providers alike.

First and foremost, AI will be used in decision support systems based on the analysis of interconnected large data sets. AI offers the capability of using deep learning algorithms and neuronal networks to find patterns in data that would otherwise be too large or too complex to analyse. This is especially relevant for forecasting, where AI modules promise more accurate results while requiring fewer user inputs and maintenance compared to traditional forecasting techniques.

Secondly, AI offers the potential to solve optimization problems faster, in addition to often producing more robust solutions than traditional solvers. Such optimization 'puzzles' like stowage planning, yard

planning, or scheduling are prevalent in terminal operations. While, e.g., scheduling is still often done by hand, AI systems are capable of producing rosters in line with the predefined operational requirements with minimal input and at a moment's notice. A similar potential exists for most optimization problems.

The third identified innovation pathway is related to maintenance and repair modules. These are expected to profit heavily from incorporating AI. Using sensory data, technical specifications, statistics of equipment-usage, and historical data on equipment failures as input, an AI-TOS will be able to reach new levels of accuracy in predictive maintenance by assessing wear and tear more reliably. This will ultimately reduce disruptions due to repairs or breakdowns, thus increase the overall operational resilience.

However, AI functions fundamentally differ from traditional systems, as inputs to these systems are usually driven by data rather than user inputs. This means that in order to reap the aforementioned benefits AI has to offer, a comprehensive data infrastructure has to be set up in advance. Additionally, the robustness of the AI solution can often be greatly increased when primary data is put into context with secondary data sources. A predictive maintenance module, for instance, might greatly benefit from having access to data centres of equipment providers.

Such infrastructure and the collaborative relationships with owners of secondary data sources need to be planned and created carefully and with purpose in mind. For this reason, it is advised that terminals willing to incorporate AI in their TOS as part of their first-mover strategy may collaborate closely and invest in joint research & development with their TOS provider to tackle the system requirements for any planned AI application in their TOS.

For TOS providers, the incorporation of AI-based modules will mean that their solutions might be considerably more effective than other existing modules, giving that much sought-after competitive edge. Nevertheless, the development of AI is still very much ongoing. Even though some of the associated technologies, like machine learning or deep learning, can already be applied in terminal operating systems with great potential for success, there still remains some uncertainty in the market on whether the necessary investments to implement these systems will pay off like expected.

Avoiding buyer's remorse

That said, as the implementation of a TOS is a decision that will usually affect terminal operations for the foreseeable future, it might as well be worth shopping around for the best technologies available already now to give yourself the tools to become the terminal of the future today. And as in real life when we want to avoid buyer's remorse, shopping should be done in a conscious, well-informed manner by, among many other things, going through expert literature. ■



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