



Fraunhofer
CML

FRAUNHOFER CENTER FOR MARITIME LOGISTICS AND SERVICES CML

TERMINAL OPERATING SYSTEMS 2021

AN INTERNATIONAL MARKET REVIEW OF CURRENT
SOFTWARE APPLICATIONS FOR TERMINAL OPERATORS



FRAUNHOFER VERLAG

FRAUNHOFER CENTER FOR MARITIME LOGISTICS AND SERVICES CML

Editor:

Prof. Dr.-Ing. Carlos Jahn

Authors:

Patrick Zimmerman, M.Sc.

Julius Kühle, M.Sc.

Collaborator:

Scarlett Rautmann

Sina Willrodt, B.Sc.

TERMINAL OPERATING SYSTEMS 2021

**AN INTERNATIONAL MARKET REVIEW OF CURRENT
SOFTWARE APPLICATIONS FOR TERMINAL OPERATORS**

FRAUNHOFER VERLAG

Contact address:

Fraunhofer Center for
Maritime Logistics and Services CML
A unit of the Fraunhofer Institute for
Material Flow and Logistics IML
Am-Schwarzenberg-Campus 4
21073 Hamburg, Germany
Telephone +49 40 42878-4451
Fax +49 40 42878-4452
E-mail info@cml.fraunhofer.de
Website www.cml.fraunhofer.de

Cover photo acknowledgment:

C. Steinweg (Süd-West Terminal) GmbH & Co. KG

Printing and finishing:

Esser printSolutions, Bretten

Printed on acid-free and chlorine-free bleached paper.

All rights reserved; no part of this publication may be translated, reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the written permission of the publisher.

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. The quotation of those designations in whatever way does not imply the conclusion that the use of those designations is legal without the consent of the owner of the trademark.

© by Fraunhofer Verlag

Fraunhofer Information-Centre for Regional Planning and Building Construction IRB
P.O. Box 80 04 69, D-70504 Stuttgart
Nobelstrasse 12, D-70569 Stuttgart
Phone +49 (0) 7 11/9 70-25 00
Fax +49 (0) 7 11/9 70-25 07
E-Mail : verlag@fraunhofer.de
URL www.verlag.fraunhofer.de

Disclaimer

The contents of this study were prepared with the utmost care. The product-specific information in this document provides an overview of a product or a provider at the time of writing. The Fraunhofer CML cannot guarantee, however, that the information provided is correct, complete and up to date as the products or provider strategies are subject to constant change and market situations can change radically.

Hamburg, December 2020

Fraunhofer-Gesellschaft

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded 1949, the research organisation undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 67 institutes and research units. The majority of the nearly 24,000 staff are qualified scientists and engineers, who work with an annual research budget of more than 2.1 billion Euros. Of this sum, more than 1.8 billion Euros is generated through contract research. More than 70% of the Fraunhofer-Gesellschaft contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30% is contributed by the German federal government and German states governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society until five or ten years from now.

International collaborations with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress an economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays prominent role in the German and European innovation process. Applied research has knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region throughout Germany and Europe. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at university, in industry, and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organisation that takes its name from Joseph- von Fraunhofer (1787-1826), the illustrious Munich researcher, inventor and entrepreneur.

www.fraunhofer.de

Fraunhofer Center for Maritime Logistics and Services CML, Hamburg

The Fraunhofer Center for Maritime Logistics and Services CML develops and optimises processes and systems along the maritime supply chain. We support private and public-sector clients with the initiation and realisation of innovations through practical research projects in the fields of shipping, ports, and logistics.

In accordance with the project and customer requirements, we put together interdisciplinary teams of engineers, economists, mathematicians, information scientists and marine engineers to create customer-specific solutions for ship and fleet management, marine transport and navigation, ports and transportation markets.

We take both the results of our varied research activities and the latest scientific insights into account. Fraunhofer CML is part of the Fraunhofer Institute for Material Flow and Logistics IM L in Dortmund.

Ports and Transport Markets

Ongoing globalization, the availability of innovative technologies and rapidly changing market requirements are altering maritime supply chains. Making infrastructures and transport chains more flexible is one answer to these developments. CML supports its customers with market development trend studies and assists with strategic, future-oriented investment decisions.

Sea Traffic and Nautical Solutions

The growth of maritime transportation and increasing ship sizes poses safety and efficiency challenges in maritime shipping that can be overcome through information technology innovations and nautical solutions. CML brings these two sides together in maritime transport and navigation. Ship technologies, traffic, and waterways are analysed, assessed, and optimised, thereby improving the efficiency and safety of shipping traffic.

Ship and Information Management

Modern maritime information management on board and on land harbours significant efficiency and cost effectiveness potential. One focus is on crewing and procurement processes that often constitute a large proportion of the operating costs. CML develops and pilots' individual solutions for its customers to optimise business processes for the operation and control of shipping fleets.

www.cml.fraunhofer.de

Dear reader,

Port Terminals today, are highly complex ecosystems where many areas of operation intersect. Activities ranging from cargo handling and yard management to veterinary services and customs need to be planned, coordinated and executed at a minute's notice.

Terminal Operating Systems (TOS) fill this role. They act as inherently complex systems that manage and monitor all aspects of a terminal's operative tasks. However, as no port is like another, TOS come in equally different designs, each with a specific terminal in mind, and are then highly customized towards the needs of the customer. This implementation is costly and time consuming, which makes it crucial to make an informed choice when selecting a new TOS for introduction.

There are a number of innovations that, over the span of the last ten years, have made TOS all over the world more productive, leaner and more self-sufficient. Especially the emergence of the means for omnipresent data collection laid the groundworks for one of the pinnacles of recent technology - Artificial Intelligence. This development is by all means ongoing, however, more and more providers and users of TOS start to tap into this enormous potential as Artificial Intelligence opens up opportunities for better coordinated and more efficient operations, lower energy consumption and seamless communication.

This is why this year's study on TOS focuses on the implications of Artificial Intelligence on the way terminals are managed now, and will be managed in the near future.

It will inform you about what is on the market and what the capabilities of these systems are, and hopefully help you in the quest of becoming the terminal of the future by using what is available today.

Enjoy your read!

Carlos Jahn



*Prof. Dr.-Ing. Carlos Jahn
Head of Fraunhofer Center for Maritime Logistics and Services CML*

TABLE OF CONTENTS

1	MANAGEMENT SUMMARY	12
2	TERMINAL OPERATING SYSTEMS	14
2.1	Terminology clarification	14
2.2	TOS functional areas	16
3	ARTIFICIAL INTELLIGENCE IN PORT TERMINALS	20
3.1	Artificial intelligence - a new reality at TOS	20
3.2	Integration and synchronisation	24
3.3	Opportunities and challenges through AI	26
3.4	Conclusion	27
4	TOS USERS' PERSPECTIVE	28
4.1	Selection process	28
4.2	Expectations on artificial intelligence	29
4.3	Key performance indicators	29
4.4	Accuracy of planning and forecast	30
4.5	Interfaces and IT systems	30
5	TOS PROVIDERS' PERSPECTIVE AND PRODUCT OVERVIEW	34
5.1	AI developments in TOS products	34
5.2	Overview of TOS products	35
5.2.1	Input / Output	38
5.2.2	Internal Transport	42
5.2.3	Storage	47
5.2.4	Administration	52
5.2.5	Management and IT	56
6	BIBLIOGRAPHY	60

LIST OF FIGURES

Figure 1: Core and support functional areas	16
Figure 2: Input / Output functions	17
Figure 3: Internal transport functions	17
Figure 4: Storage functions	18
Figure 5: Administration functions	18
Figure 6: Management and IT functions	19
Figure 7: Typical IT system architecture	32
Figure 8: Types of cargo covered by TOS	51

LIST OF TABLES

Table 1: Most promising features for AI	34
Table 2: TOS provider overview	35
Table 3: TOS product overview "Input / Output"	38
Table 4: TOS product overview "Internal Transport"	42
Table 5: TOS product overview "Storage"	47
Table 6: TOS product overview "Administration"	52
Table 7: TOS product overview "Management and IT"	56

LIST OF ABBREVIATIONS

AGV	AUTOMATED-GUIDED-VEHICLE
AI	ARTIFICIAL INTELLIGENCE
AIS	AUTOMATIC IDENTIFICATION SYSTEM, GERMAN: AUTOMATISCHES IDENTIFIZIERUNGSSYSTEM
ASEAN	ASSOCIATION OF SOUTHEAST ASIAN NATIONS
ASW	ASEAN SINGLE WINDOW
ATLAS	AUTOMATISIERTES TARIF- UND LOKALES ZOLL-ABWICKLUNGS-SYSTEM
BI	BUSINESS INTELLIGENCE
CCTV	CLOSED CIRCUIT TELEVISION
CSV	COMMA-SEPARATED VALUES
DB	DATABASE
EDI	ELECTRONIC DATA INTERCHANGE
ERP	ENTERPRISE RESOURCE PLANNING
GCP	GROSS CRANE PRODUCTIVITY
GUI	GRAPHICAL USER INTERFACE
HR	HUMAN RESOURCES

ICT	INFORMATION AND COMMUNICATION TECHNOLOGIES
IoT	INTERNET OF THINGS
ISO	INTERNATIONAL ORGANIZATION FOR STANDARDIZATION
IT	INFORMATION TECHNOLOGY
KPI	KEY PERFORMANCE INDICATOR
MS	MICROSOFT
MSW	MARITIME SINGLE WINDOWS
NSW	NATIONAL SINGLE WINDOWS
OCR	OPTICAL CHARACTER RECOGNITION
PCS	PORT COMMUNITY SYSTEMS
PDF	PORTABLE DOCUMENT FORMAT
RDT	REAL-TIME-DATA
RFID	RADIO FREQUENCY IDENTIFICATION
RIS	RIVER INFORMATION SERVICES
RoPax	ROLL-ON/ROLL-OFF & PASSENGERS
Ro/Ro	ROLL-ON/ROLL-OFF
STS	SHIP-TO-SHORE
TAS	TRUCK-APPOINTMENT-SYSTEM
TEU	TWENTY-FOOT EQUIVALENT UNIT
TOS	TERMINAL OPERATING SYSTEM
VHS	VERY HIGH FREQUENCY
VTS	VESSEL TRAFFIC SERVICE
WLAN	WIRELESS LOCAL AREA NETWORK
XML	EXTENSIBLE MARKUP LANGUAGE

1 MANAGEMENT SUMMARY

Technological progress and changing business environments of port terminals can force port terminals to consider updating or changing their present Terminal Operating System (TOS). Up-to-date TOS offer the potential for higher productivity and efficiency in the operation of port terminals. To realize these potentials, port terminals need to select a suitable TOS system from the right TOS provider. Just buying a product off the shelf often won't work, it rather requires substantial financial and personnel commitment towards a TOS provider. Procurement and implementation may last years. Thus, a prudent decision needs to be made on which provider and which TOS product to choose..

The TOS 2021 study provides support in the first steps of a TOS user's procurement process, giving an overview of 38 TOS providers at market, their products and modules. For TOS providers the study gives valuable insights in the demand of TOS users and their needs. Both parties profit of an extra spotlight of the 2021 study on the benefits and prevalence of Artificial Intelligence in TOS products.

A strong diversification and specialisation of TOS products can be observed over the last years. Port terminals handling containers face a more and more consolidated market, in which the number of TOS products declined by 21%. Also, the number of available TOS products for Ro/Ro port terminals falls by 24%. Contrarily, there has been an influx of new products marketed towards port terminals handling dry and liquid cargo as their numbers increased significantly. The market for TOS specialised on general cargo port terminals remains unchanged.

Methods of Artificial Intelligence within TOS offer several innovation pathways for both TOS users and providers.

- Artificial Intelligence will support decision making and thus help to make better decisions based on the available data and knowledge gathered by deep learning

and neuronal networks. This enables better forecasts based on Artificial Intelligence.

- Optimization problems are omnipresent in port terminals, for instance Stowage Planning, Yard Planning or any scheduling tasks. AI-based algorithms promise to generate solutions to these problems faster and often more effectively than traditional solutions.
- Maintenance and repair modules in TOS products will profit from Artificial Intelligence. Predictive maintenance will help to reduce equipment failures and thus increase the reliability of plans and schedules. Wear and Tear can be assessed more accurately and incorporated into the maintenance strategy. Especially, if port terminals strengthen their collaboration with port equipment providers and their data centres.

Benefits of AI become additional features within current TOS products. Port terminals pursuing the course of a first mover strategy should conduct R&D jointly with their TOS provider, tackling the systems requirements for Artificial Intelligence applications. This will open many promising pathways as well for the TOS provider, to shape future TOS product developments and maintain the company's success.

**FRAUNHOFER CENTER FOR
MARITIME LOGISTICS AND SERVICES CML**

Head:

Prof. Dr.-Ing. Carlos Jahn

Am-Schwarzenberg-Campus 4
21073 Hamburg
Germany

Telephone: +49 40 42878-4451

Fax: +49 40 42878-4452

www.cml.fraunhofer.de