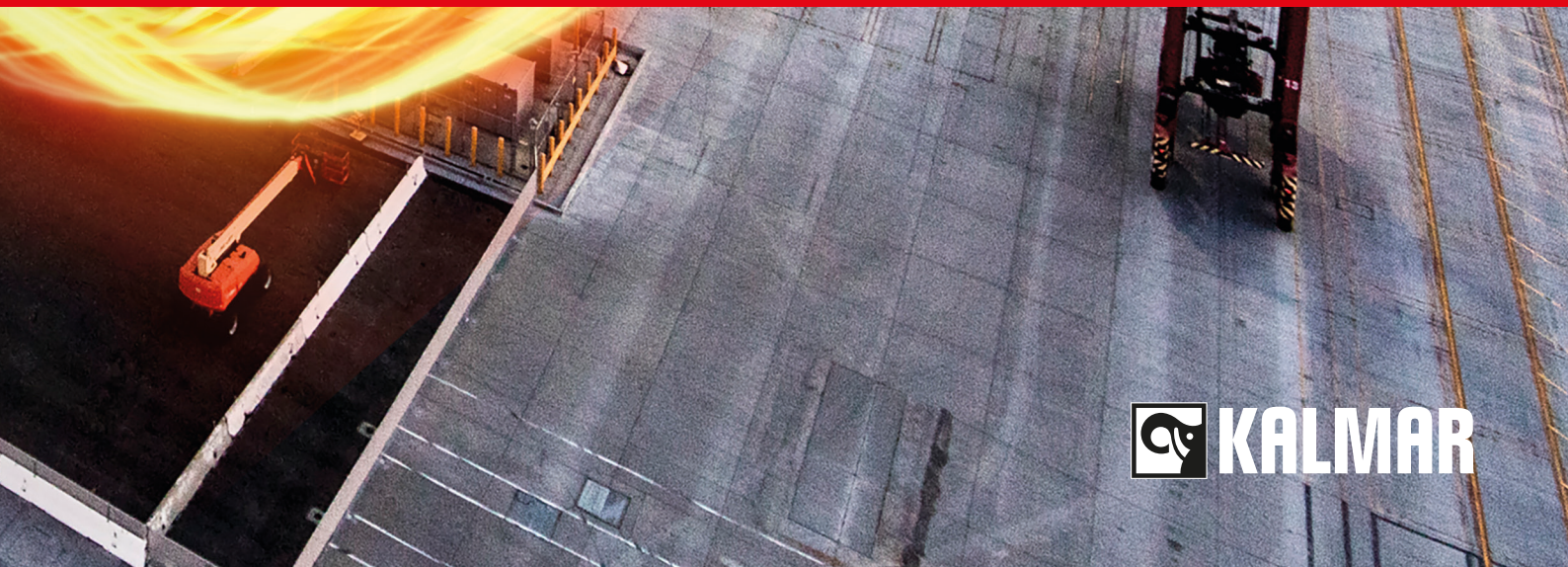




Automating terminal operations with a
**STANDARDISED
AND OPEN**
automation system

AUTHORS

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EXECUTIVE SUMMARY.

Across the globe, container terminal automation is advancing rapidly. Automation, including the insights learned from the data it produces, is recognised as the future of improved container handling productivity, safety and business performance. However, when compared with other fields such as automotive manufacturing or the process industries, the standardisation of automation in the container handling business is still in its early stages. Until recently, most terminal automation systems have been based on extensive integration of various subsystems and solutions, rather than conceived as complete end-to-end automation systems such as those in other industries.

This white paper argues for a systemic approach in designing terminal automation. A key element is the availability of new, open application interfaces that enable terminal operators to customise their automation deployments, allowing third-party developers to provide their own offerings that are interoperable with the automation system. These additional software interfaces supplement the application-independent core software components of the terminal automation system and significantly extend its capabilities.

Throughout this paper, the Kalmar One automation system is used to explain the wider approach of container terminal automation built around an open, standardised platform. Over the last few years, Kalmar One has expanded from the Kalmar TLS (Terminal Logistics System) equipment control system into a full-fledged automation system that supports a wide range of yard cranes and horizontal transportation equipment at various levels of automation. Unlike the previous TLS, Kalmar One also covers onboard control and measurement devices, as well as automation yard infrastructure and access controls.

When combined with support services and third-party developers, an open automation platform enables robust and diverse business ecosystems that provide new opportunities for terminal operators, independent developers and automation system providers. Ultimately, terminal operators will have a broader range of capabilities to develop their systems with agility, based on their individual business processes and needs.

As an equipment-agnostic concept, a standard terminal automation platform can significantly improve the cost-effectiveness of the automation system. Open interfaces enable a holistic view of data from multiple sources, enabling terminal operators to optimise their operations continuously and with greater ease. At the time of writing (1H2021), the COVID-19 pandemic and other world events have further highlighted the need for both accelerated digitalisation and robust, transparent and optimised logistics chains. A standardised automation platform can serve as the first step on the journey towards these goals.

Development of standardisation.

HISTORICAL PERSPECTIVE.

In order for terminal automation to develop to the next level in the speed of deployment and operational efficiency – and for operators as well as other industry players to be able to reap the benefits of this development – a significantly higher level of standardisation is required.

Currently, a major challenge for most terminal automation projects is that many design and implementation questions need to be solved anew each time. These questions range from basic connectivity and equipment functionality to user interfaces for applications and safety guidelines. With terminal operators unsure of the exact specifications needed for a terminal automation deployment, until now system providers have often needed to "reinvent the wheel" for each customer case.

A markedly different situation can be seen in general process automation. Initially, each manufacturer developed closed systems with unique interfaces for their equipment, but over the decades, the industry converged on a set of interfaces that enable seamless connectivity with standardised technology. This development shifted the competitive focus of automation technology providers away from low-level interfaces and towards higher-value automation systems. Once the connectivity is standardised, diverse industry players can come together to create robust ecosystems that further develop the capabilities of their equipment and software applications.

INDUSTRY OUTLOOK FOR STANDARDISATION IN TERMINAL AUTOMATION.

In many ways, the development and gradual adoption of container terminal automation mirror the steps taken by process automation in recent decades; however, some significant differences also exist.

Firstly, when compared to highly automated major industries, the container terminal business is significantly smaller. Resultantly, automation will be adopted at a slower rate, and the development of the entire field does not have the same "critical mass" as, for example, automotive manufacturing.

At the time of writing (1H2021), the container shipping industry has been making some strides towards a common, shared approach for determining the key standards needed for terminal automation. The two key industry organisations working in the field are the Port Equipment Manufacturers' Association (PEMA), and the newer Terminal Industry Committee 4.0 (TIC4.0), an open industry initiative established in 2020 whose members include both terminal operators and system providers. Kalmar is an active member and contributor to both organisations, and many of the company's initiatives for openness of the industry (e.g. the Kalmar Key interfaces) have served as inspiration for the standards being developed by TIC4.0.

TIC4.0 has a significant mission in developing the required standard sets for the container handling industry. The objectives of the association are

- To identify and define the technical vocabulary specific to the terminal cargo handling industry, starting with container handling

With terminal operators unsure of the exact specifications needed for terminal automation deployment, system providers often need to "reinvent the wheel" for each customer case.



- To produce a comprehensive body of information on definitions, terminologies, and their application to the operational dimension of the industry
- To develop messages and protocols that may be adopted by industry stakeholders for seamless data communication
- To facilitate the interoperability of different information sub-systems
- To enable the deployment of TIC4.0 concepts by all interested stakeholders

The TIC4.0 initiative released an introductory white paper and its first sets of definitions in May 2021. These definitions of measurable data points serve as the low-level building blocks for further industry standards, laying out the basic terminological, grammatical and semantic framework for the standardised interoperability of automated container handling, as well as new digital services in manual and automated terminals.

The task undertaken by TIC4.0 is significant in scope, requiring a specific and unambiguous way of defining the required concepts irrespective of the level of technology used in a terminal. Basic examples include providing definitions such as what precisely constitutes a "container move". These terms have previously been used and understood routinely in everyday language, but they have lacked the rigorous definitions required for unambiguous communication, valid performance measurement and seamless system interoperability.

Despite the challenges remaining, TIC4.0 is a significant step towards achieving the acutely needed level of standardisation in the next few years, not least because the association has managed to bring together a wide range of industry players that include major equipment and system providers as well as leading port and terminal operators.

With the Kalmar One and Kalmar Key concepts that Kalmar has launched during the last four years, the company aims to be a forerunner in taking into use the TIC4.0 standards in its own automation offering. The required actions for this are already implemented in the Kalmar One roadmap for the upcoming years.

For more information on TIC4.0, visit www.tic40.org.

Successful large-scale container terminal automation requires integrated automation platforms based on open application interfaces.

Terminal automation platform: What and why?

Until recently, container terminal automation has primarily been conceived as an "add-on" to equipment investment, instead of a comprehensive end-to-end solution. Automation solutions have been assembled as one-off projects that have required extensive integration of diverse systems and solutions, often from several vendors.

At the same time, as terminal automation advances, the focus in industry deployments is shifting from a limited number of new greenfield sites to automating hundreds of existing container terminals. These brownfield projects require that the automation system can interface with diverse existing fleets and processes at widely differing levels of automation. To reap the full benefit of terminal automation and to fully utilise their existing equipment and software, terminal operators need the ability to flexibly customise their solutions, possibly with the help of third-party developers.

As seen in other, further advanced automated industries, successful large-scale container terminal automation will require a balanced combination of two things: firstly, an approach that treats terminal automation as a holistic system, and, secondly, integrated automation platforms based on open application interfaces. These standardised platforms will enable faster deployments without having to build systems from scratch each time while facilitating the creation of wider ecosystems to further develop the capabilities of the automation platform.

Definition of an open terminal automation platform.

In the context of this white paper, an open terminal automation platform refers to additional software interfaces that extend the application-independent core software components of a terminal automation system. For terminal operators, open interfaces can streamline decision-making by integrating all data sources as well as control and monitoring functions into a single, vendor-independent solution.

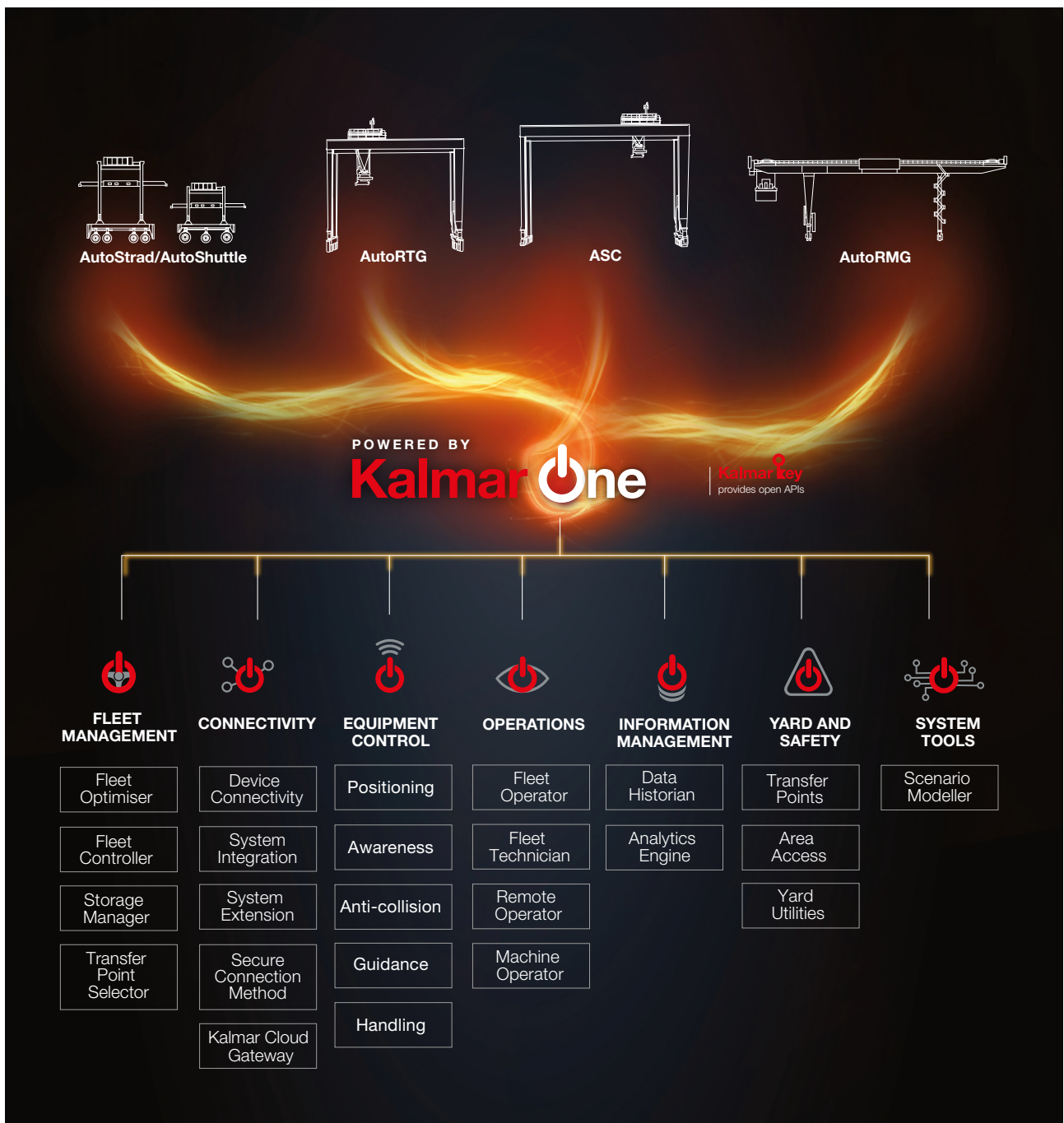
With interfaces that enable direct access to the application-independent automation platform core (and thus basic system functionality), the Kalmar One automation system can be extended with additional capabilities for partners and developers to customise and augment automated solutions at a customer's terminal. This aids and speeds the development of new applications, opening up a wider range of potential suppliers and partners that can work with terminal automation.

The Kalmar One system and Kalmar Key interfaces are also suited to the automation of mobile equipment in ports and terminals, as well as in other customer segments including distribution and industrial applications.

The added capabilities that open interfaces bring to Kalmar One can streamline decision making.

OVERVIEW OF THE KALMAR ONE AUTOMATION SYSTEM.

Kalmar One is a modular open automation system for boxed cargo handling, built on proven functionalities and well-established processes. Kalmar One enables customers to streamline their cargo handling operations faster, easier and more cost-efficiently and it is applicable for all equipment types and operation modes. The majority of applications are formed from codebases already used in other applications, leading to a robust core for the operations.



KALMAR ONE PRODUCT FAMILIES.

Kalmar One encompasses seven product families that cover the entire range of functionalities needed for automated container handling. These are:



Kalmar One Fleet Management

A full range of management and reporting capabilities that enable access to real-time equipment data.

- Fleet Controller - Manage workflow utilisation.
- Fleet Optimiser - Optimise fleet utilisation.
- Storage Manager - Stacking Area and Transfer Point management.
- Transfer Point Selector - Transfer point management and optimisation.



Kalmar One Operations

A portfolio of services that can be used to monitor and control the equipment fleet.

- Fleet Operator - Operations monitoring and control.
- Fleet Technician - Equipment monitoring.
- Remote Operations - Remote operator, displays and controls.
- Machine Operator - Local container handler operator, displays and controls.



Kalmar One Information Management

A set of services that store, analyse and provide access to fleet and systems data.

- Data Storage - Historical data storage and access.
- Analytics Engine - Provides KPI calculations and reporting



Kalmar One Yard and Safety

Infield technology for transfer and access areas.

- Transfer Points - In field technology for yard container transfer points.
- Area Access - In field technology for safe access to automated areas in the yard.
- Yard Utilities - Field devices supporting operation activities in the terminal area.



Kalmar One Equipment Control

A complete set of solutions to manage equipment position and movements.

- Positioning - Determines equipment position.
- Anti-collision - Unexpected object detection.
- Awareness - Shows equipment in relation to its setting.
- Guidance - Automated movement control.
- Handling - Automated container handling and override.



Kalmar One Connectivity

A complete set of solutions that assists with the seamless flow of data from one system to another.

- Device Connectivity - Equipment data collection and communication.
- System Integration - Communicating with external systems.
- System Extension - Open APIs for custom-built data connections.
- Secure Connection Method - Secure access for global Kalmar support experts 24/7.
- Kalmar Cloud Connectivity - Secure and safe Kalmar Cloud connectivity.



Kalmar One System Tools

A set of tools to assist users in solution design and implementation

- Scenario Modeler - Emulates and models specific operational scenarios.



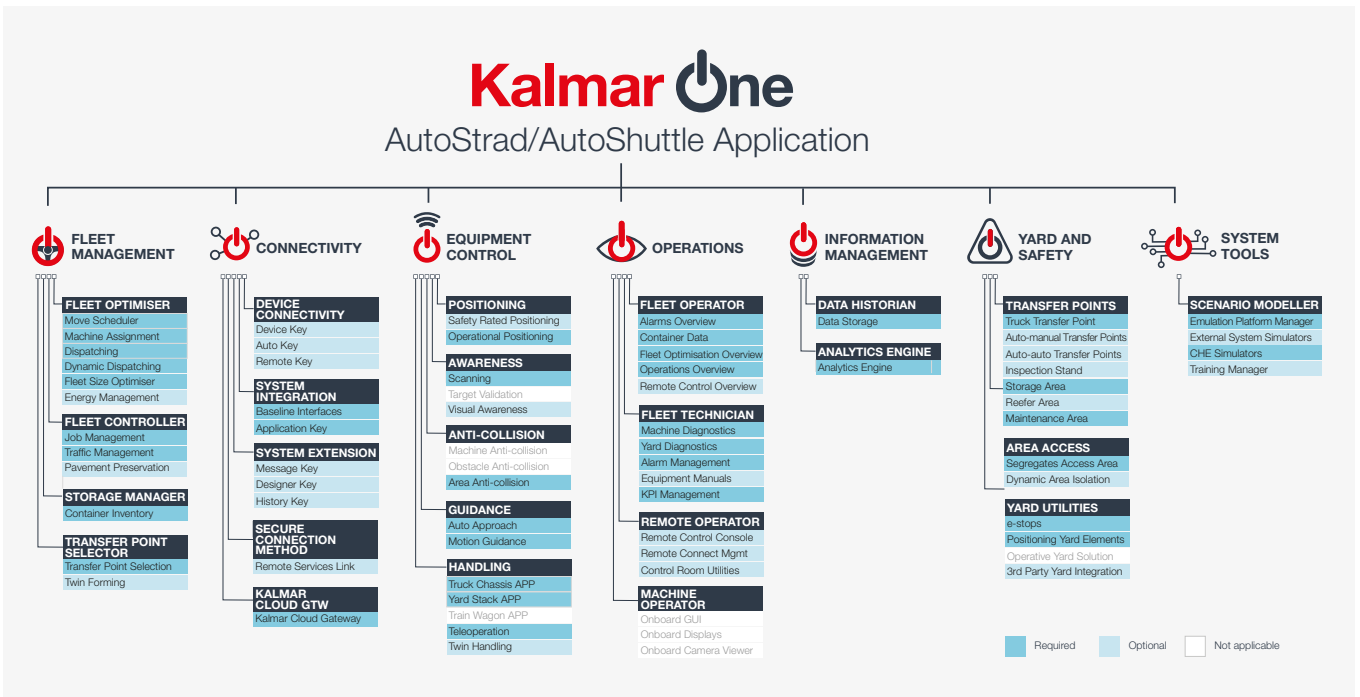
Applications powered by Kalmar One.

The Kalmar One automation system serves as the link between the various products that enable different types of functionality and the specific applications that are automated at the terminal. The four applications that are currently available are AutoStrad/AutoShuttle, AutoRTG, ASC and AutoRMG operation, and the system is also suitable for automating other applications in addition to the existing ones. Each specific usage application has its own Kalmar One blueprint, which is a standardised set of Kalmar One products and modules for the specific application. The software products and applications are linked by the open Kalmar Key APIs that are included in Kalmar One.

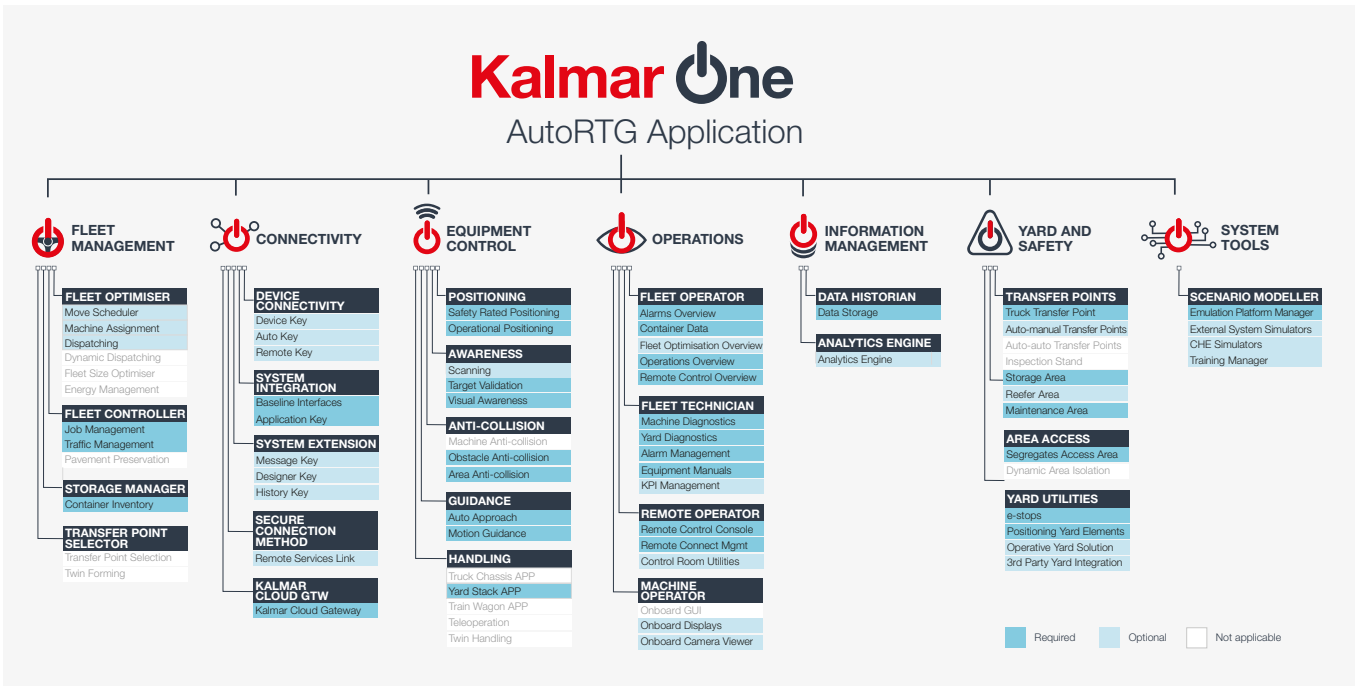
The various product families under the application include all the required software products to enable the required capabilities for the automations system. The individual products further contain Kalmar modules for the specific functionality that is needed. Required modules that are part of the standard application package can be complemented by optional modules for added functionality.

The choice of modules will also depend on the specific application, as not all modules will be applicable for every type of container handling equipment. Certain optional modules will also need to be implemented together as a package.

Each specific usage application has its own Kalmar One blueprint, which is a standardised set of Kalmar One products and modules for that application.



An example of the AutoStrad/AutoShuttle application blueprint, which is a standard set of automation products and modules used with Kalmar AutoStrads and AutoShuttles. Dark blue modules are included in the Kalmar AutoStrad/AutoShuttle application by default. Light blue modules are optional, while modules in white are not applicable for this specific application.



AutoRTG application blueprint.



Key functionalities and interfaces.

The concept of an integrated terminal automation platform with open interfaces benefits all parties throughout the industry. Existing and new users (terminal operators) will be able to customise and augment their solutions with the required functionality. At the same time, open interfaces enable smooth and consistent integration of third-party equipment into the original automation system. Technology development partners may integrate their products with the automation platform in order to extend the capabilities of the system as well as creating new markets for their own software and hardware products.

The terminal automation platform also provides a holistic view of data from multiple sources, allowing terminal operators to optimise their operations with greater ease.

A terminal automation platform encompasses several types of system elements. These include “core components” that provide access to automation platform data as well as tools for presenting data; “digital services” that enable creating new value from available data; and “controllers” that handle the integration with equipment and automation hardware. Open interfaces enable direct access to these elements, facilitating the creation of new and customised solutions in multiple application areas.

In the context of this document, a “key” refers to an open interface or framework with its attendant documentation and developer toolkit. The keys are accompanied by a partner ecosystem as well as licensing and support models for both developers and customers.

In the start-up phase, external experts can serve as “co-pilots”.



EXTENSIONS TO VISUALISATION.

Designer Key

The Designer Key provides a framework and toolset for software developers to access Kalmar One Operations widgets and re-use its set of standardised components in their own applications.



CONNECTING NEW NATIVE APPLICATIONS.

Message Key

The Kalmar Message Key specification provides a description of the MQTT protocol and API. It describes a peer-based communication method. When an application is connected to the network, it is able to communicate with any other application on the network and can both provide and use data.



INTEGRATION CAPABILITIES.

Device Key

This module enables connecting devices (such as PLCs, sensors etc.) to the Kalmar One automation system through common interfaces based on standard protocols (Multi-CAN, Iso-on-TCP, Hostlink, Linux SHM etc.).



COMMUNICATION WITH EXTERNAL SYSTEMS.

Baseline Interfaces

This module provides standardised, proven baseline interfaces for communication with STS crane control systems, the TOS, OCR systems, trucks (GOS) and rail control systems.

Application Key

The application key describes the moves and interactions between external systems and Kalmar One using the baseline interfaces.



HISTORICAL DATA MANAGEMENT.

History Key

The Kalmar History Key is an interface to connect Data Historian modules on equipment or in the central data storage.



AUTOMATED 3RD PARTY CONTAINER HANDLING EQUIPMENT.

AutoKey

The AutoKey module describes the communication between Equipment (Kalmar and 3rd party) and Fleet Management.

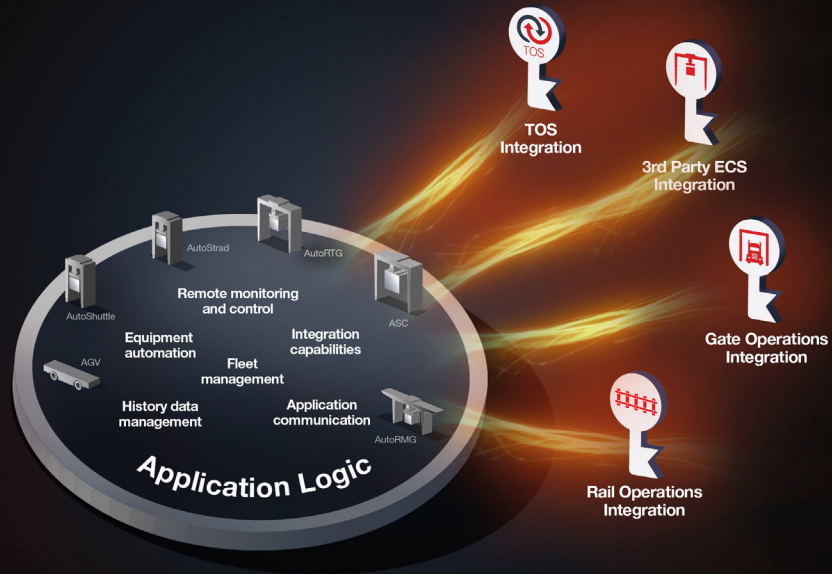


REMOTE MONITORING AND CONTROL.

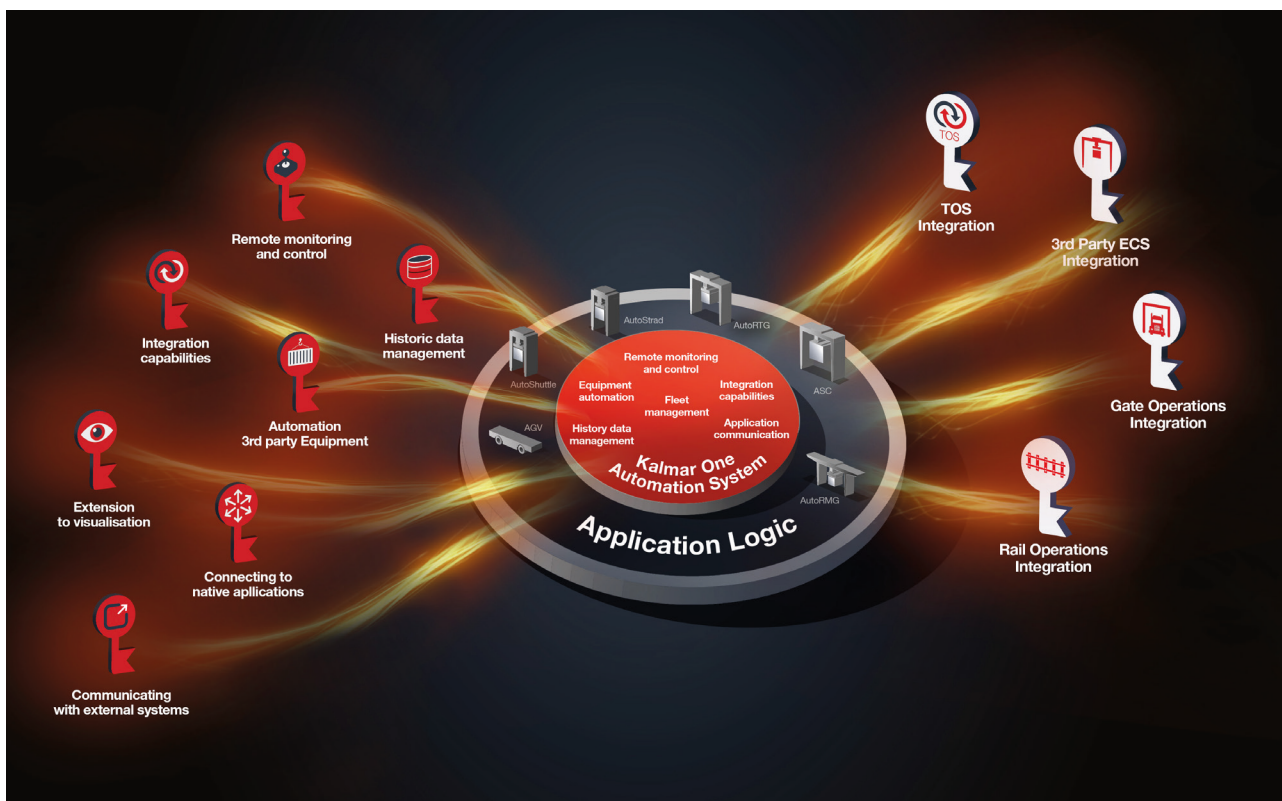
Remote Key

This module describes the communication between the equipment and the remote console.

Kalmar Key Open Automation Principles



Kalmar Key provides a series of open APIs which allow you to integrate the Kalmar One Automation System which manages your equipment with your other key systems, like your TOS.



Kalmar Key also provides a set of open APIs that allows you to integrate the Kalmar One Automation System with other systems and services you may use, like third party equipment or for the provision of Kalmar remote monitoring and control support.

Use case examples for open interfaces.

A key benefit of open interfaces is that they facilitate a joint ecosystem that benefits all parties in the value chain.

Open interfaces enable a wide range of new possibilities for terminal operators to customise their automation deployments, gain enhanced access to their operational data and develop the system according to their business processes. A key benefit of open interfaces is that they facilitate a joint ecosystem that benefits all parties in the value chain. Technology developers can create and market their own products that are interoperable with the terminal automation system; terminal operators can add new equipment or features to their systems with minimal business risk; and the automation system provider can offer new, advanced capabilities that utilise third-party solutions.

Some examples of potential user cases include the following:

Requirement: Terminal operator wants to customise the look and feel of their applications.

Brownfield terminals have existing, tightly defined business and administrative processes that any new automation deployment must accommodate. If the requirements of the process change, open interfaces allow terminal operators to carry out the necessary adjustments to their control room operational products either as in-house work or with the aid of partners.

Solution: Extension to visualisation keys (Designer keys)

The customer can build new dashboards and reports utilising the data provided by the Kalmar automation system.

Requirement: Terminal wants to automate step-by-step a fleet of Kalmar and 3rd party cranes.

As the first, most basic step towards terminal automation, remote control and monitoring provide immediate productivity gains by enabling a single operator to control multiple machines without having to physically move from one machine to another. Occupational safety and ergonomics are improved significantly by bringing machine operators from the container yard into the comfort of a remote control centre.

Solutions: Automated 3rd party container handling equipment keys, Extension to visualisation keys, Remote monitoring and control keys.

The customer can start with a solution based on the Kalmar automation system and Kalmar equipment, but can later complement the solution with third-party equipment, while retaining full flexibility for equipment vendor choice. Remote

control functionality can also be implemented for third-party equipment as part of the Kalmar automation system. Additionally, the terminal can enhance the Kalmar automation system with new user interfaces and customised visualisation tools that cover the third-party equipment.

For example, a terminal can start with a Kalmar AutoRTG and expand the automation deployment later to include a third-party remote-controlled STS crane. Or a straddle carrier terminal can start with a fleet of Kalmar AutoStrads and expand later to automating existing straddle carriers from other manufacturers.

Requirement: **Terminal needs completely new technical application as part of their automation solution.**

Open interfaces also enable the creation of completely new applications for terminal automation. Essentially any manual or automated process or data source can be visualised and connected into the terminal automation system. Even if the goal is not to fully automate the terminal equipment, standardised controller interfaces enable any machine to be remotely controlled through a single control desk and connected to Kalmar One software.

A natural way to utilise the open interfaces of the Kalmar terminal automation system is for technology partners to deliver enhanced sensor capabilities for the system. For example, machine vision enables a host of possibilities for improving the safety and performance of automated and semi-automated container handling equipment, but requires highly specialised technology.

Solutions: **New application development keys, Remote monitoring and control keys, Integration capabilities keys.**

With the new open interfaces, technology and software providers can develop and sell their Kalmar integrated products to container terminal operators. These could include, for example, solutions for laser scanners, anti-truck lifting, truck alignment, access control systems, target or load position measurement, busbar electric power distribution solutions or new connectivity solutions. Open interfaces enable technology from other manufacturers to be easily integrated into the Kalmar architecture.



Key enablers.

The basic structure of the licensing model for the Kalmar automation platform SDK is that it is free to try for partners.

In order to be usable, the open interfaces of a terminal automation system require a full Software Development Kit (SDK) as well as some degree of support from the provider of the system. In addition to the actual open API definitions, the SDK will need to include, at a minimum, developer documentation, tools and support. The application interfaces, together with their support and documentation, constitute the keys that enable access to the Kalmar automation platform. To summarise, the keys are licensable modules consisting of an open interface with its attendant SDK, documentation and support.

The basic structure of the licensing model for the Kalmar automation platform SDK is that it is free to try for partners, with various licensing options for development and production use. The license structure can be based on either usage volumes or fleet sizes.

Additionally, a support structure will be in place, ranging from forum access to an issue/ticket service. Optional services can include training modules, technical consultancy, help desk access or a Kalmar verification service that enables independent developers to have their applications certified by Kalmar for function and interoperability.

Risks and opportunities.

Any opening up of previously proprietary interfaces always involves some degree of risk for the party sharing the technology. Competition could increase; new players may enter the market to challenge industry leaders, or clients may choose to accomplish in-house what previously would have been delegated to a system provider.

However, it is Kalmar's firm belief that in terminal automation, shared and standardised interfaces are an absolute necessity for the development of the entire industry, and that the benefits of progressively opening these interfaces greatly outweigh the potential risks. Not even the largest industry leaders have all the possible expertise in-house, and open interfaces enable a vastly expanded collaborative landscape for the benefit of terminal operators, independent developers and automation system providers alike.



AUTHORS



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Product Manager, Kalmar, has worked for Kalmar since 2007 in various sales and product management roles, all of which have had a strong automation focus. Over the years, Hannes has contributed to numerous successful Kalmar automation sales projects for customers across the globe with a focus on ECS software and crane automation systems. At the moment, his main task in the company is to look after the commercial product management of the Kalmar One automation system, which is the home of Kalmar Key open automation interfaces, too.



JARI HÄMÄLÄINEN

(Dr Tech.), Director, Automation, Kalmar, has been working nine years at Kalmar, leading service concepts, offering development, as well as product management and engineering teams in automation and software development. He also worked as the project director for the Kalmar AutoRTG product development. Nowadays his role is to lead automation for mobile solutions. He is a co-founder as well as a member of the executive council at TIC4.0. Before joining Kalmar, he made a distinguished career in the telecommunications and software industry. His 300 patents in 42 global patent families help smartphone users in their everyday business and pleasure.

ABOUT THE COMPANY

Kalmar, part of Cargotec, offers the widest range of cargo handling solutions and services to ports, terminals, distribution centres and to heavy industry. Kalmar is the industry forerunner in terminal automation and in energy efficient container handling, with one in four container movements around the globe being handled by a Kalmar solution. Through its extensive product portfolio, global service network and ability to enable a seamless integration of different terminal processes, Kalmar improves the efficiency of every move.

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KEEP IN TOUCH WITH US



NOTES



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