Digitalising terminal operations

Akiko Shinozaki and Kim Hock Teo, Yokogawa, Japan, explain how digitisation can be used to improve and optimise operations and maintenance.

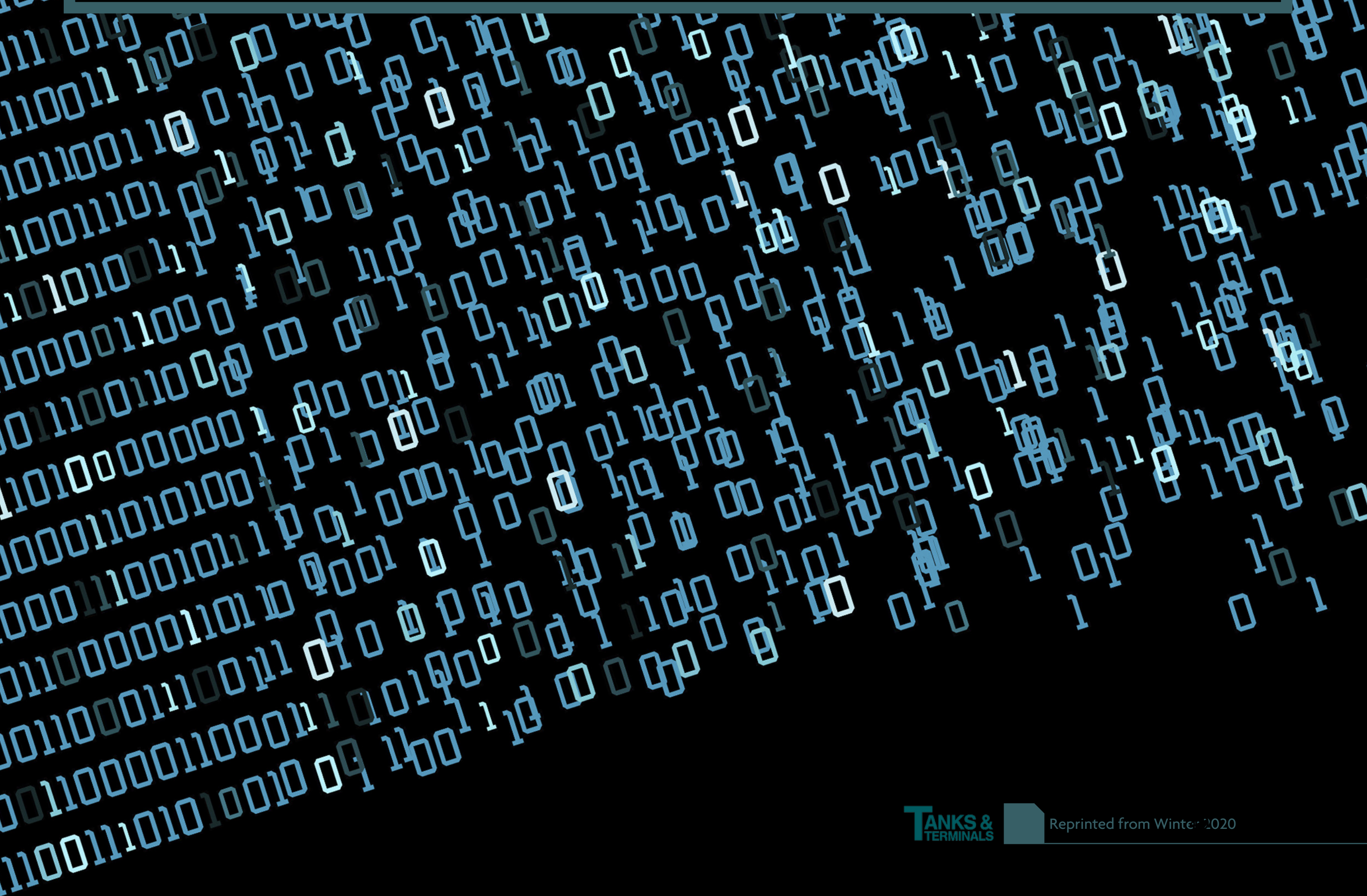
Advancements in automation systems have greatly benefitted the control and monitoring of tank and terminal facilities. Starting with the introduction of the distributed control system (DCS) in the 1970s, there has been a transformation of terminal operations from field-centric to centralised control and monitoring, substantially improving operational safety and efficiency (Figure 1).

Most industry participants are fully aware of the benefits this digital transformation has delivered, and this trend is now undergoing another major step change. In the next wave of digitalisation, the massive amounts of operational data collected and stored by automated systems – as well as new digital technologies such as machine learning and artificial intelligence – will be leveraged to create systems capable of autonomous terminal operation.

This article will define the term 'autonomous terminal' and will look at other aspects of digital transformation.

What is an autonomous terminal?

The recent COVID-19 pandemic has highlighted the importance of business and global supply chain resilience. Autonomous terminals address these and other challenges by reducing the need for human intervention during normal operations. By digitalising all major operations, an autonomous terminal improves agility for quicker response to market



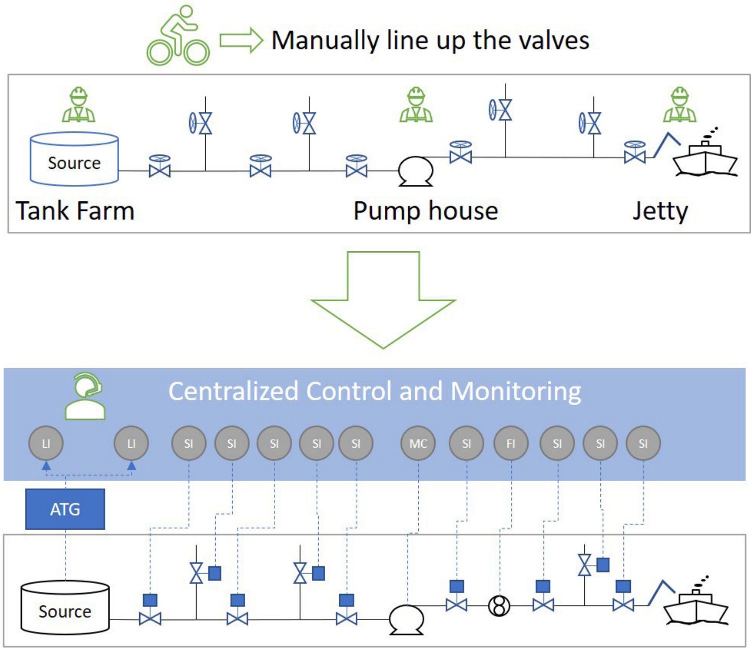


Figure 1. Terminal operations have progressed from manual to automated operations.

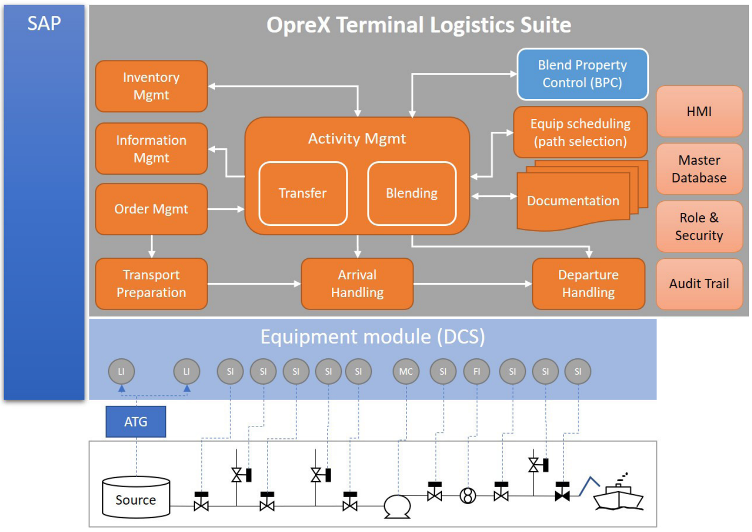


Figure 2. The components, capabilities, and systems shown in this system architecture diagram can be used to digitalise the operations of an autonomous terminal.

demands and regulations, such as the new bunkering fuel specifications required by the International Maritime Organization (IMO 2020).

While modern terminals have acceptable safety records due to the implementation of safety instrumented systems and tank overflow protection schemes, avoidable incidents still occur. Because terminals deal with flammable and hazardous materials, any incident has potentially serious consequences, and may even result in loss of the facility's operating license. Common causes of incidents include piping and pump leaks, human error, fires from lightning strikes, etc.

Modern systems can automate most operating procedures, however, the instructions to carry out certain procedures still come from the operator, which may not always result in the safest or most efficient operation.

Typical terminals will execute dozens of concurrent operations. Operators select the most suitable resources at the start of each task and usually will not revisit their selections during execution, even if better options become available after the task has started. A better approach is to dynamically search for the optimal allocation of resources during task execution.

An autonomous terminal is one with the knowledge of its capabilities and limitations, and the ability to work with operators to provide maximum operational safety and efficiency. A simple example of such collaboration is dealing with alarms. Different operators address the same alarm in various ways, while an autonomous terminal can analyse and learn the differences among them, and then suggest recommended steps to be consistently followed by all operators.

In addition to intelligent alarm handling, an autonomous terminal can:

- Optimise execution of customer orders without operator intervention, including coordination with other terminals with overlapping coverage to maximise distribution efficiency.
- Automatically exchange information with business partners such as port authorities, transport agents, ship captain, customers, etc.
- Perform self-diagnostics of terminal assets by analysing data provided by smart sensors and instruments in real time, in coordination with digitised historical maintenance records.
- Adapt to and learn from terminal dynamics to provide operational advice for improving safety and efficiency.

Digitalised execution

Figure 2 illustrates the operation of a fully digitalised terminal to deliver the capabilities that have been listed, along with other benefits.

Key successful factors for sustainable digitalisation are:

- Integration with business domain – tight integration with the business domain, either directly with an enterprise resource planning system or through an oil account system using web services, for seamless exchange of information.
- Scalable and flexible architecture – almost all terminal projects are developed over many phases, and even for mature terminals there is a constant need to fine tune services and enhance efficiency. Traditional monolithic software solutions present significant challenges in adapting to these constant changes. The system architecture depicted in Figure 2 enhances scalability

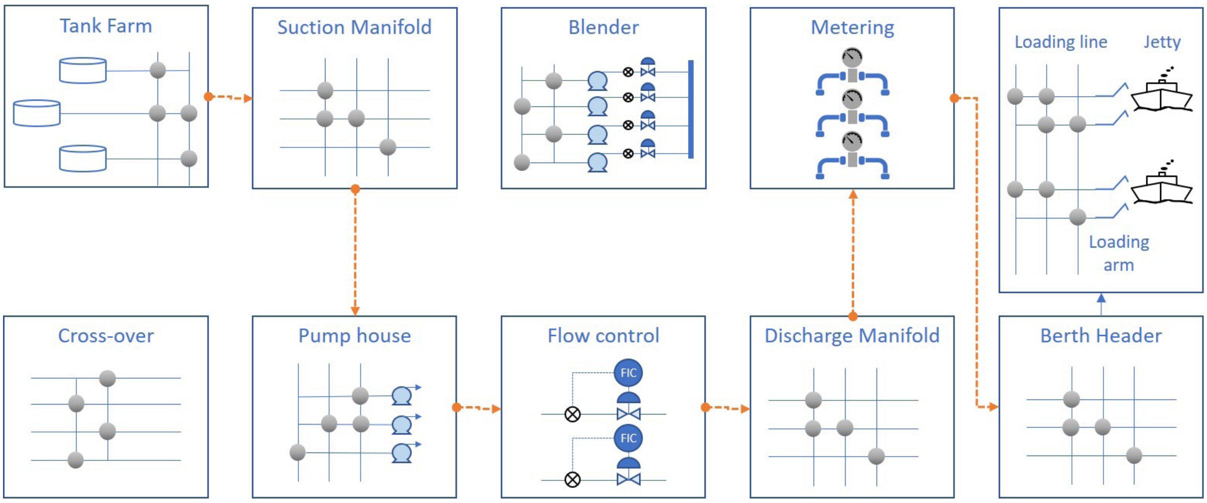


Figure 3. Breaking terminal operations into manageable modules allows for automated and optimised path generation.

and flexibility. Large and complex software programs are broken into smaller modules, each of which can be upgraded individually, with new modules added as needed, all without interrupting ongoing operations.

- Online dynamics path management – traditional approaches generate all the paths between sources and destinations, a complex effort even with the help of automation systems. The path generated is then transferred to online software for operator selection. The major difficulty with this approach comes from varying actions by different operators. This and other challenges can be addressed by modularising the terminal to group similar assets into equipment modules, as shown in Figure 3.

Path management between sources and destination is selected online dynamically, with maps stored online and paths generated dynamically based on asset availability. By grouping the assets into modules, it becomes a more straightforward task to update the database for only those elements modified, unlike the offline generation method where any small change may affect hundreds or thousands of paths.

Digitalised exchange

Terminals are part of a larger business ecosystem involving customers, local authorities, and business partners such as shipping agents, ship pilots, and others. In most terminals, exchange of information within the ecosystem is not fully digitalised, with phone calls, emails and spreadsheets the most common communication tools.

These communications can be greatly improved by using a digitalised information exchange (Figure 4), e.g. to implement optimum jetty scheduling with minimum demurrage.

When information is provided in real time, the right decisions can be quickly made to provide the most efficient utilisation of resources.

Figure 5 illustrates a digitalised system for jetty scheduling, with the shipping schedule planned by logistics

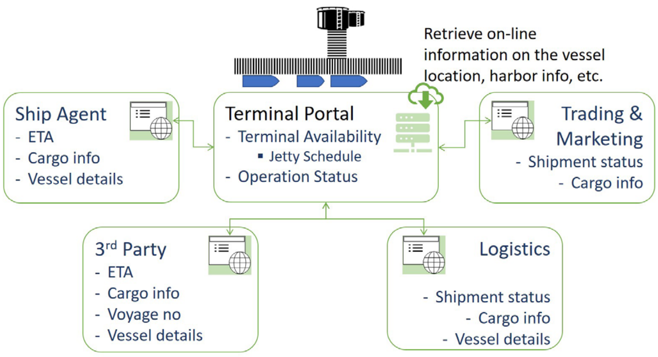


Figure 4. This diagram depicts a fully digitalised system for information exchange among all the parties affecting terminal operation.

as the driving input. With real time digital exchange of information, the logistics department – as well as the trading and marketing departments – have visibility regarding jetty availability, providing dynamic capability for better decisions. This type of digital exchange significantly improves inter-department collaboration, along with terminal agility for responding to rapidly changing markets.

With a digitalised jetty scheduling system, demurrage is minimised by optimal utilisation of jetties through the use of real time information regarding asset status, product availability, ship laytime, and other factors.

Digitalised asset maintenance

Most terminal maintenance is scheduled manually based on a calendar or on the hours of asset operation, with little or no use of diagnostics software.

A better approach is predictive maintenance using a rule-based engine to automatically discover issues based on diagnostics, and to then schedule maintenance action based on an automatic ticket system (Figure 6).

Digitalised asset maintenance improves asset availability and reduces maintenance manpower requirements by prioritising asset issues, automatically generating tickets for corrective actions, and closing

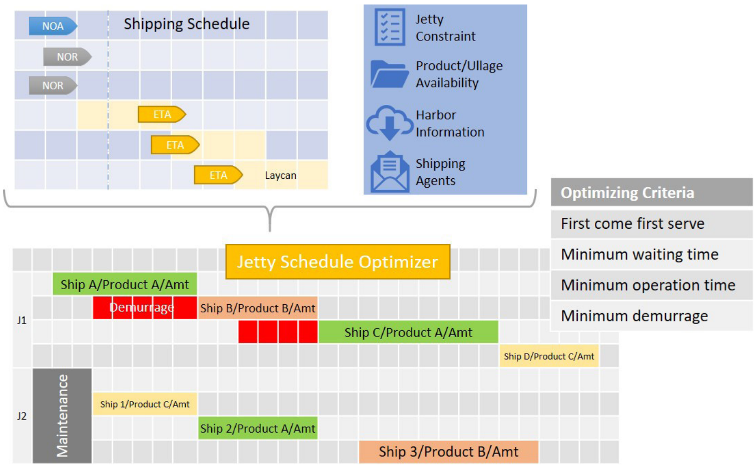


Figure 5. Digitalising jetty scheduling optimises operations.

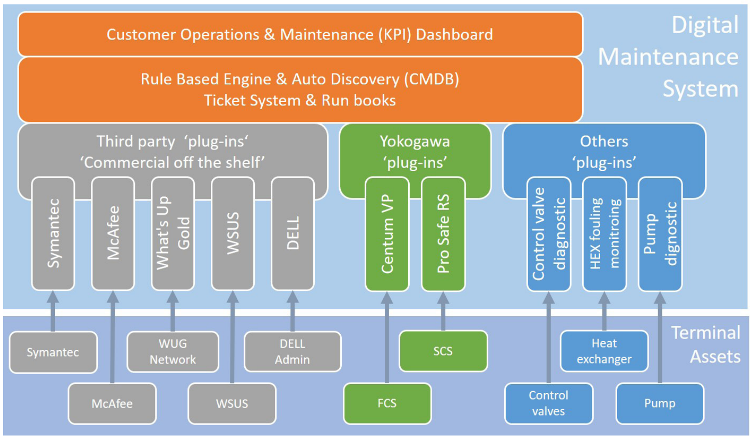
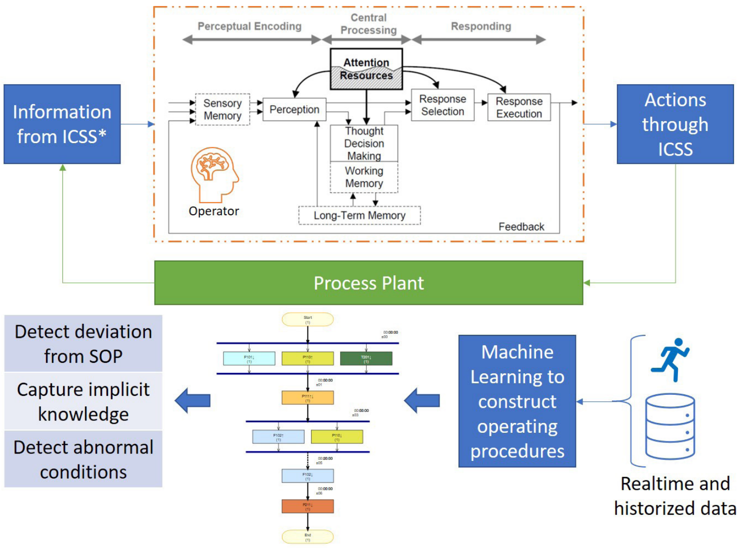


Figure 6. This digitalised maintenance system can be used for predictive maintenance.



ICSS: Integrated Control & Safety System

Figure 7. Knowledge capture from a plant or facility's best operators can be used to generate improved standard operating procedures.

tickets when an issue is resolved. This particular system originated from close collaboration between Yokogawa and the National Association of Manufacturers, with the first revision targeting only instrumentation assets, but has since expanded to cover other assets.

There are two major sources of raw information for diagnostics, device data delivered via digital communication networks, and process data delivered via OPC, with both used together for best results. This type of system simplifies asset monitoring through the use of smart diagnostics and helps plant personnel prioritise corrective actions based on asset health.

Dynamic adaptation

Yokogawa has applied machine learning to reconstruct the operating procedures for a process plant based on archived information stored in the integrated control and safety system. Although this project was carried out for a process plant, the lessons learned are applicable to terminal operations, as well as many other types of industrial facilities. The objective of this project was to update the company's standard operating procedure (SOP) because the existing one was out of date and often not used by operators (Figure 7).

The algorithms employed to generate the new SOPs were effective, with results exceeding end user expectations by capturing the implicit knowledge of the best operators.

This project provided insight into interpreting operator actions based on external events. The company has since applied these algorithms to other applications, such as detecting operator corrective actions to recover from alarm conditions.

The next phase of development is applying dynamic adaptation algorithms to terminals to proactively provide advice and recommend operator actions for safer and more efficient operation.

Conclusion

Many aspects of terminal operations are often directed by operators based on experience and judgement. This frequently results in inconsistent and non-optimal operations, with greater risk of incidents.

Automating actions – and advising operators regarding their best course of action – with digitalised systems and making better use of data results in improved and consistent operator actions. These digitalised systems can also be used to shift maintenance from reactive to proactive, reducing downtime and maintenance costs. T&T