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Cloud-based platform to enable autonomous container handling

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Abstract

Autonomous cargo handling can increase usage of the short sea in last-mile shipping which can reduce emissions and road traffic congestion. For commercial and logistical feasibility of autonomous operations, a connected digital solution is required where all stakeholders participate throughout the cargo lifecycle. The connected digital solution solves the challenges around cargo data flow and information sharing. A cloud-based experimental platform is designed and developed that provides cargo information management and sharing for autonomous container handling. The platform essentially enables autonomous operations and improves the efficiency of cargo flow from the origin to the destination, while keeping all stakeholders, actors, and systems in the loop.

Keywords: Automated terminal operations; connected and automated mobility; Sensoring and real-time information; Connected and automated multimodal mobility; Autonomous Cargo Handling

1. Introduction

As a result of positive changes in the global economy in the context of globalization, deregulation and liberalization in the last three decades or so, the port and shipping industry has called upon to face the new challenges and opportunities [1] by offering integrated transport centers and logistics platforms [2] - a few to mention. The new developments such as container terminals in the ports have to respond to the growth in containerized traffic and have the infrastructures adapted to increasingly large container ships [3]. This new maritime environment is expected to achieve economies-of-scale with a control of time, and this necessitates the optimization of container movements and flows [4]. Since the end of the period of the construction of industrial port zones in the 1990s in Europe, the container

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terminals have marked a new stage in the development of port areas by addressing the new problem of sea/territory flows [5]. Ports today have to meet the requirements of ship owners and mega stevedores [6], while the public budget allocated to them is decreasing and environmental and social criteria are becoming more stringent. On the other hand, the shipping industry is one of the major CO2 emitters in the world. Globally, it comprises about 2.5% of the world's total human-generated CO2 emissions [7]. Efforts are being made to increase shipping efficiency and reduce carbon footprint. This includes initiatives such as designing greener cargo ships, vehicles, and cranes. There are also efforts to make the whole operational process and supply chains better streamlined.

The EU is committed to a reduction in greenhouse gas emissions and it has set ambitious short and long-term targets [8]. The European Commission is supporting and funding different initiatives and projects to achieve these targets. One of the sustainability initiatives in cargo transportation is to reduce the growth of road transport in the last mile by increasing the utilization of narrower and smaller waterways, using the smaller ships known as feeder vessels. Waterborne transport is obviously cost-effective, environment-friendly and less pricey [9].

Nomenclature

CO2	Carbon Dioxide in context of global warming.
WP	Work Package
VCOP	Voyage and Container Optimizer Platform – The cloud platform under discussion in this document
BBO	Break Bulk Optimiser – Macgregor software solution for optimised arrangement of cargo in vessel
IT	Information Technology
API	Application Programming Interface
REST	REpresentational State Transfer
UI	User Interface
SAS	Software-as-a-service
AWS	Amazon web services – refers to Amazon Cloud

However, there are several challenges in utilizing smaller waterborne logistics compared to road transport. These include timeliness, the total time needed, frequency and flexibility of the operations, etc. The possible reasons for these problems are the small terminals being slow, lack of standardization and their exposure to out-of-date regulations.

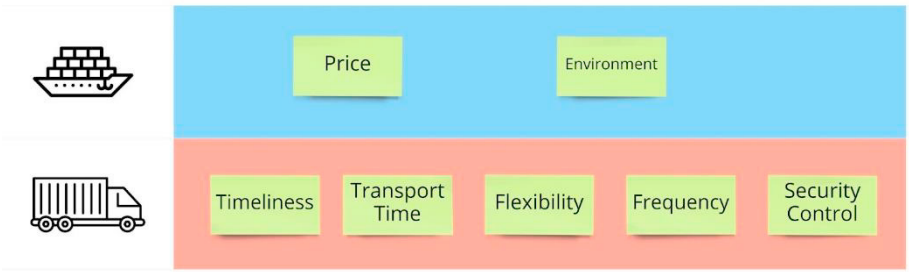

Fig. 1. Comparison of key advantages in road vs waterborne transport.

Cargotec's initiative on Advanced, Efficient and Green Intermodal Systems (AEGIS) is set to address such major challenges by duly considering the tasks such as logistics system redesign, green terminal and vessels, digital connectivity, policies, support and infrastructure.

Through this initiative, Europe's next-generation sustainable and highly competitive waterborne logistics system will be established, comprising more autonomous ships and automated cargo handling systems. Standardized cargo units and digital connectivity are key elements of this program.

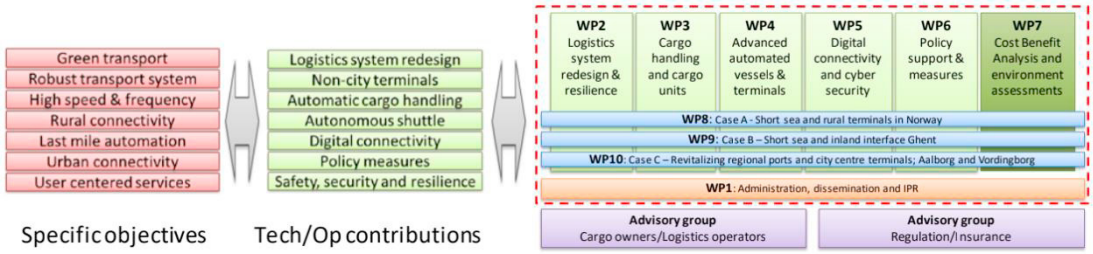

Fig. 2. Overview of Advanced, Efficient and Green Intermodal Systems Initiative.

2. Autonomous cargo handling in small ports

The scope of autonomy in cargo handing starts when the ship docks to the terminal and is ready for self-governing loading and unloading operations. The scope ends when the ship finishes the operation and is ready to sail. For the sake of simplicity, the demonstration was limited to container cargo while the technology expansion is done.

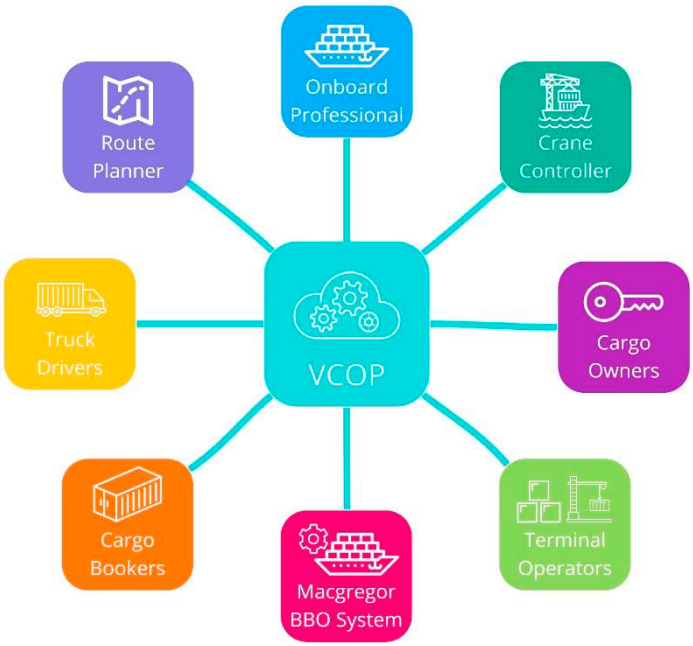

Fig. 3. Typical actors on Voyage and Container Optimization Platform (VCOP)

Autonomous container handling in this case needs an autonomous crane and connected intelligent systems, which are capable of loading and unloading containers autonomously with relevant safety and reliability standards. One of the challenges in accomplishing this is the information management of the cargo handling, such as providing information to the crane about the containers needed to be loaded and unloaded, container positions both on board and at the quay, container and cargo properties, quay map and the most efficient sequence of operations etc. To fulfill this broad set of information flow requirements, a neo-traffic management system is needed which keeps the track of the vessels, routes, terminals and is able to follow all the cargo as it moves around.

3. Voyage and Container Optimization Platform (VCOP)

The Voyage and Container Optimization Platform (VCOP) is a cloud-based experimental software platform, aimed at managing autonomous cargo handling. It is designed to manage the cargo flow from the origin to the destination

while keeping all stakeholders and actors in the loop. It combines the data and interactions from key actors involved in cargo handling and digitally manages the cargo flow.

VCOP was built on top of the AWS SaaS cloud platform inheriting key features such as security, scalability and reliability. This provides REST APIs to communicate with the IT infrastructure of the stakeholders so that ERP and CRM systems can be directly integrated with VCOP. In addition, it also provides a demonstration UI as a web application where different actors can view and interact with the platform.

VCOP not only enables the autonomous handling of containers but also keeps track of the ships, cargo and terminals. This enables the actors to continuously monitor the situation and provide updates to the system as the cargo and ship journey continues. A brief description of different actors' interactions with VCOP by using connected systems of the stakeholders and the benefits they get are presented here.

3.1. Shipping Operators - Route Planners

The ship operator manages the continuous route of the ship, which is also called a scenario. This includes adding port calls with estimated arrival and sailing times and planning the voyages which are unique sets of consecutive port calls in a scenario. These route changes are instantly visible to all other parties. For example, cargo bookers can see the routes while planning their container booking.

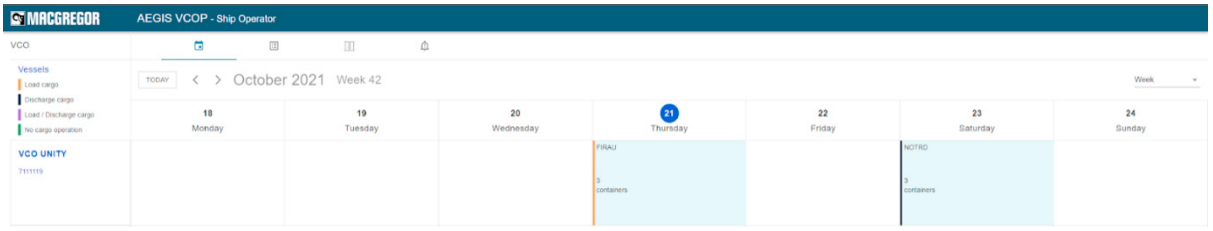

Fig 4. Ship Operator's interface to view, add and edit scenario

3.2. Cargo bookers

The Cargo booker is able to search different possible routes for containers using the VCOP platform. While this is similar to the flight booking system, the difference arises where the entered containers are put for review and optimization for the bay planners. The Cargo booker can view whether bay planners have accepted their containers, and they follow their container journey from origin to destination through the trucks, ports and ships.

3.3. Bay Planners - Onboard Professionals

The bay planner accepts or rejects the cargo entered by the bookers and performs the stowage plan. They go through the containers entered by the booker and forward them for cargo optimization. The VCOP optimizes the cargo using Break Bulk Optimizer (BBO). Once the stowage plan is ready, the updated status of the cargo is instantly visible to all relevant stakeholders. The major advantage of using BBO is that the stowage plan is automated; the bay planners do not need manual intervention for stowage planning. VCOP keeps the ship’s turnaround time to a minimum by providing an optimized sequence for loading and unloading.

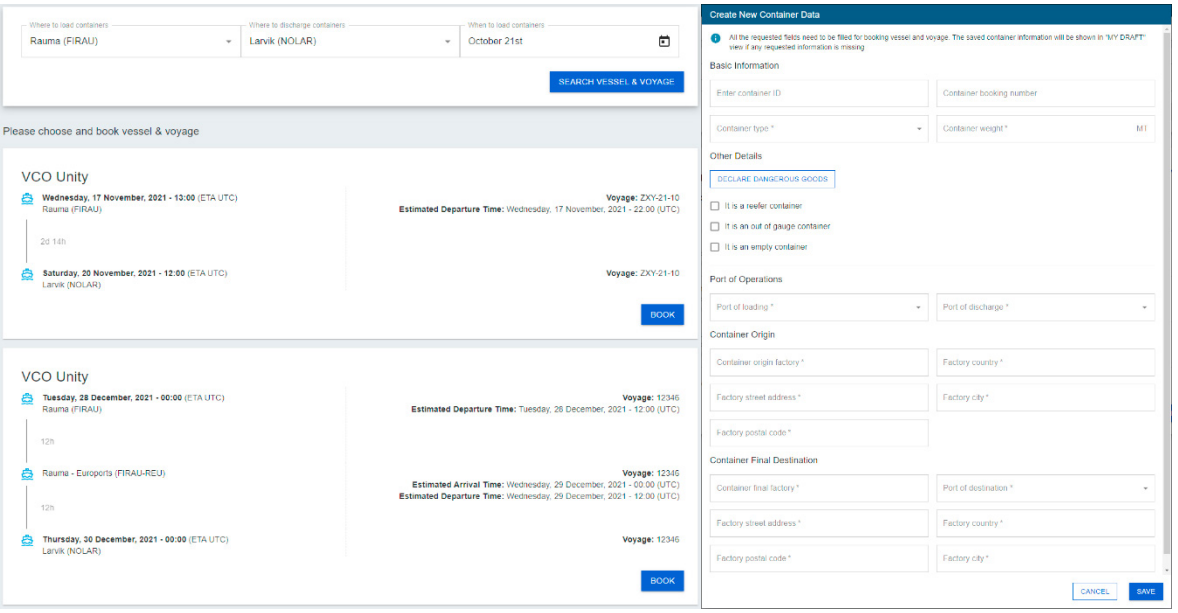

Fig 5. Cargo booker searching for a route (left) and container data entry form (right)

3.4. Terminal Operators

The VCOP cloud platform enables the Terminal Operators to follow the cargo and ships going through their terminals. They can check the availability of slots and assign or change container positions. They get notified if some information is missing for autonomous operations before the arrival of the ship. VCOP also works with Terminals which do not have any IT infrastructure. In that case, terminals are totally managed by VCOP with the help of ship operators and onboard professionals.

3.5. Crane and Ship

The crane and ship computers have live connections with the VCOP. They interact with the cloud platform throughout the autonomous cargo handling operations and take permission from the platform at key stages. The crane updates the status of individual jobs to the VCOP. This informs the crane which containers to handle, in which sequence, and what are their origin and target positions. Moreover, the crane gets the terminal and obstacle maps from the VCOP.

3.6. Truck Drivers

Truck drivers are notified to their mobile apps when jobs are created for them along with all relevant information like job address, terminal area position, container properties, etc... They are also obliged to update the system with the job progress.

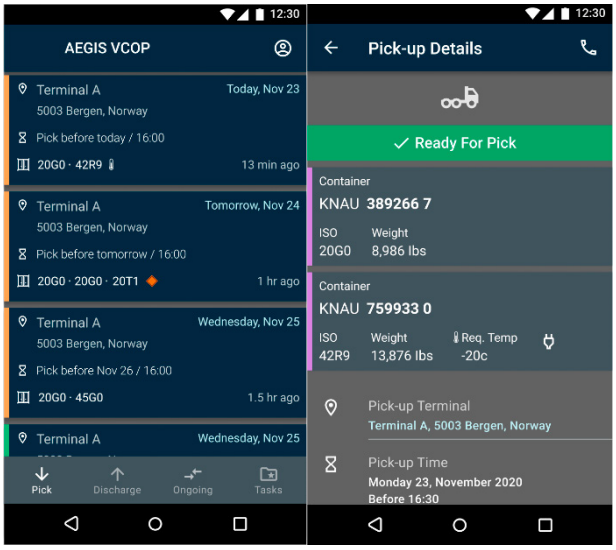

Fig 6. Example views of truck driver mobile application

4. Information flow and use case

A use case is presented where a shipping company maintains continuous routes of their ships, which are seen by cargo bookers to enter their cargo into the system. The bay planners accept this cargo information for stowage planning and if that goes well they can confirm the cargo booking. The booked cargo is seen by terminal operators to start preparation. Notifications to truck drivers can be dispatched as soon as cargo is available, who also keep the VCOP informed about the job status. When ships come to port for autonomous handling, the VCOP provides all needed information to start autonomous loading and unloading. Unloaded cargo once again generates notifications to the relevant truck driver. VCOP is aware of the cargo's location and status throughout its lifecycle.

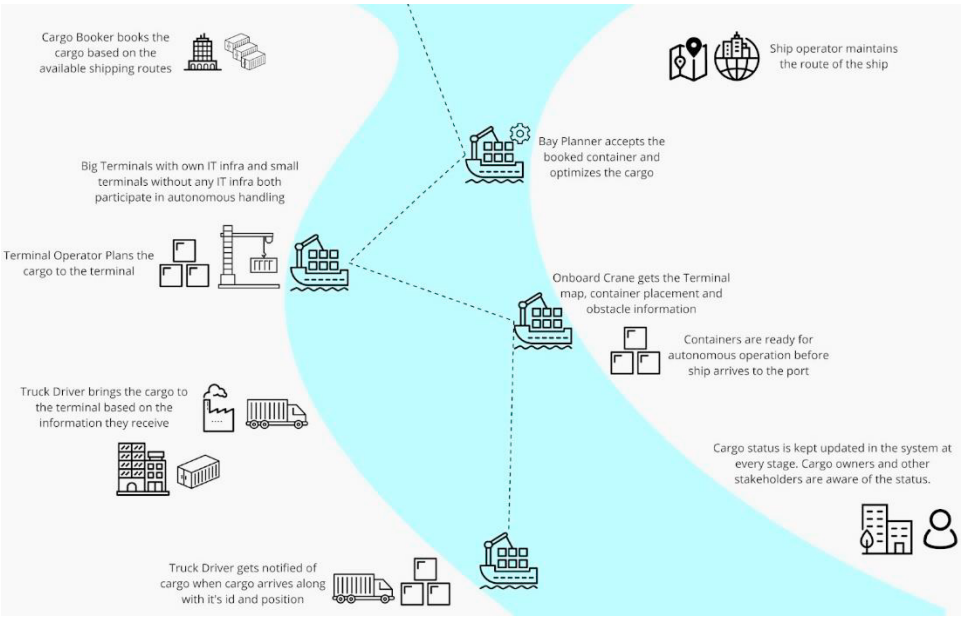

Fig 7. The role of different stakeholders in Voyage and Container Optimization Platform (VCOP)

5. Break Bulk Optimizer (BBO)

BBO is a sustainability initiative. This cloud-based application holds the complete cargo placement and integrity profile of the ship, along with the route of the ship in order to provide not only an optimized stowage plan but also an optimized loading and unloading sequence of operation. The VCOP UI and API users do not have to connect with BBO directly, however behind the scenes, BBO is a key part of the VCOP autonomous cargo handling solution.

6. Summary

The cloud-based experimental platform, VCOP, is inevitable for the management of autonomous cargo handling. It answers several major challenges posed by autonomous cargo handling, which makes it to be a key enabler for improving the utilization of short sea routes, hence reducing cargo emissions and achieving EU's sustainability goals. To further develop this platform and to make it adaptable for all stakeholders, continuous cooperation is needed between pilot stakeholders. The progress in platform development is critically dependent on the industrial and research collaboration, which has been fruitful, for example, through Horizon 2020 and Horizon Europe programs. Next actions are underway to make VCOP a viable option for embracing autonomous cargo handling in short sea transportation.

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