Just-In-Time Bunkering Operations
19/09/2022

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The process of a bunkering operation, the activity of supplying a ship with fuel oil, is a crucial, complex and frequent activity in ports all around the world. This important port activity involves coordination and planning amongst the Port Authorities, the Ship Agents, the Bunker Suppliers, the Shipowners, the Vessel's crew, the Surveyors and the Laboratories. The volatile and always changing maritime environment adds complexity to the bunkering operations and hinders the actor's plans due to the number of variables to be considered and the lack of reliable real-time data. Moreover, the 'first come, first served' rule followed in ports all over the world nowadays contributes to port congestion and GHG emissions.

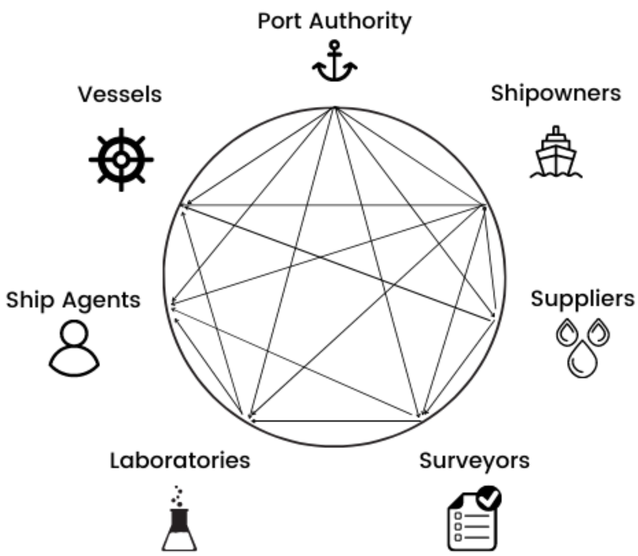

Figure 1. Bunker stakeholders.

The present use-case proposes to eliminate this rule in favor of Just-In-Time bunkering operations. In this new model, ships would receive an optimised Estimated Time of Arrival (ETA) so they can arrive at anchorage maintaining the optimal ship operating speed when the conditions in port ensure that they will receive the fuel according to the optimised ETA.

Impact

By reducing port congestion through better planning of bunker operations, the vessels wait less time and burn less fuel which in turn creates a virtual cycle of reduced GHGs. It has been estimated that the solution could potentially optimize the waiting time within the port (1,850,000h/year, globally), reduce fuel consumption and GHG emissions (1,282,050 tons CO2/year, globally), reduce costs (2,590M€ globally), increase safety, and reduce the risk of maritime pollution. Furthermore, by increasing the efficiency of the operation in the port, this solution would impact the reputation of the port, promoting local and regional economic growth.

Relevance

In the last decades, decarbonisation has become a pressing issue for the maritime sector. More recently, in April 2018, the International Maritime Organization adopted the Initial Strategy for the reduction of GHG emissions from shipping. This policy framework sets key ambitions, including cutting annual greenhouse gas emissions from international shipping by at least half by 2050, compared with their level in 2008, working towards phasing out GHG emissions from shipping entirely and reducing the carbon intensity of international shipping.

The planning integration in bunkering operations would contribute to global maritime decarbonisation, providing automated and optimal bunker schedules and impacting positively the bunker actors in ports all around the world. The presented use-case contributes to AIPlan4EU objectives and brings AI planning to the maritime industry in a new and innovative way, while creating a bridge for future innovations. Likewise, the solution would facilitate the achievement of the objectives proposed by the European Union through its Emission Trading Scheme (European Emission Trading Scheme (ETS)) and the European Green Deal.

1 Context

The process of a bunkering operation, the activity of supplying a ship with fuel oil, is a crucial, complex and frequent activity in ports all around the world. Every year, 300 million tons of fuel oil are supplied to vessels globally, valued at USD 225B[1]. This important port activity involves coordination amongst the Port Authorities, the Ship Agents, the Bunker Suppliers, the Shipowners, the Vessel's crew, the Surveyors and the Laboratories.

To carry out the bunkering operations efficiently and safely, critical data such as the Vessel's ETA (Estimated Time of Arrival), Fuel Type & Quantity requested, Hose Connection dimensions, Pump Rate, Tank Capacity etc. need to be reliably interchanged. Furthermore, today, bunkering operations in ports follow the "first come, first served" rule. This means that ships sail to their bunker port, only to find out that they need to wait upon arrival to be supplied because e.g. the bunker barge needs to load the fuel oil, the pilot is not available, or there is another vessel with higher priority in front of them. This results with vessels waiting outside the port at anchorage for many hours, days even, in case of bad weather.

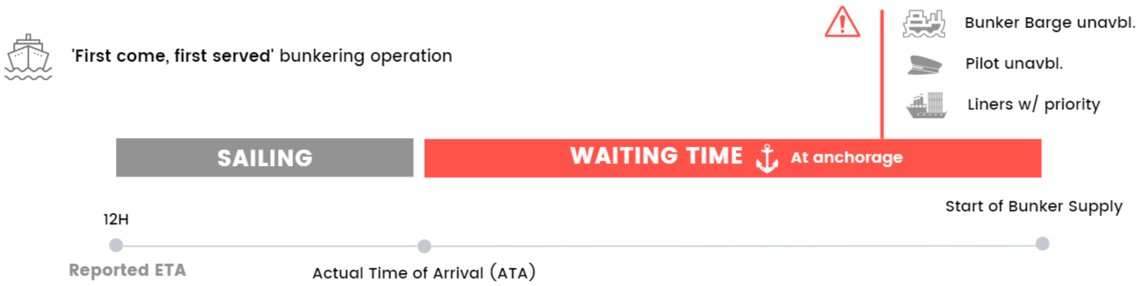

Figure 2. Example of today's bunkering operation.

The volatile and always changing maritime environment adds complexity to the bunkering operations and hinders the actor's plans due to the number of variables to be considered and the lack of reliable real-time data. This, paired with the 'first-come, first served' mode of planning for bunkering operations, causes errors and inefficiencies that contribute to increased GHG emissions in the port areas, higher risk of oil spills, wasted financial costs and reputational damage. Bunkering operations today display many disadvantages and can be improved significantly from an environmental, economic, and safety perspective.

Table 1. Challenges of today's bunkering operations.

Area	Challenge
Operational	Process inefficiencies, administrative burden, lack of quality data, absence of transparency, need of multilevel checks, poor business intelligence.
Economic	Financial loss, cost of dealing with pollution, reputational damage, decreased port performance.
Environmental	Pollution of the environment (air pollution (GHG), risk of oil spills, paper-use, courier of documents).
Societal	Health and safety risks, damaged port-city relationship.

[1] An average price of USD 750 per metric ton of fuel oil has been used in this calculation. Source (13-Sep-22): https://shipandbunker.com/prices.

2 Planning Application

It has been measured and, on average, a vessel spends 1.85h of idle time[2] waiting at anchorage to start the planned operations. This results in wasted fuel burn, increased GHG emissions, financial costs, congestion in the port, and reputational damage for the bunker actors.

In the Just-In-Time bunkering operation, ships would receive an optimised ETA so they can arrive at anchorage maintaining the optimal ship operating speed when the availability of: 1. **pilot**, and 2. **bunker barge** is ensured.

Based on the optimisation of both **schedules**, the pilots and the suppliers/bunker barges, and considering other variables such as the vessels level of priority and the weather, the planning integration would provide an optimised ETA to the ship, which would also help optimise the bunker schedule for the port. In this scenario, the optimised ETA is communicated 12h before arrival to the ship, thereby enabling the Master to take a decision to optimize the ship's speed (see Figure 3).

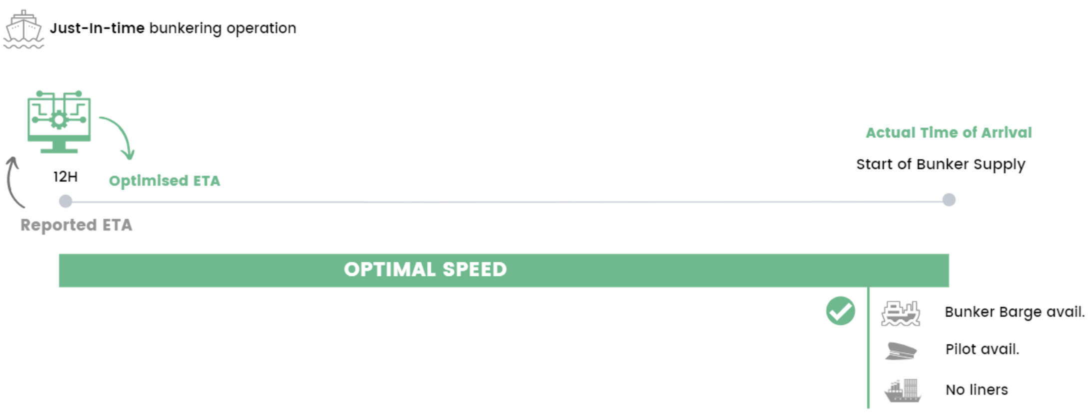

Figure 3. Example of a Just-In-Time bunkering operation.

A 12-hour notice is proposed:

- To manage expectations and start with a realistic window.
- As it will already have a significant effect on emissions (see impact) and reduce anchorage time.
- As reliability and accuracy of ETD (Estimated Time of Departure) of the ship is sufficient 12 hours before arrival.
- As weather and water level predictions are already accurate enough 12 hours in advance to enable planning of the nautical services.

The planning will be triggered by the Ship Agent upon introduction of the reported ETA from the vessel or when there are relevant disturbances to the schedule e.g., important weather phenomena or the arrival of a vessel with priority. Based on the optimised schedule, when the ship reports its ETA 12h before arrival, the software will return the optimised ETA. Today there is little trust by shipowners in port planning, and a 12-hour notice can already prove that arriving just-in-time will not jeopardize the priority of the ship in the queue.

Figure 4. Planning and execution.

[2] Lind, M., Lane, A., Bjørn-Andersen, N., Ward, R., Michaelides, M., Sancricca, M., ... & Theodossiou, S. (2018). Ships and Port Idle Time: Who are the Culprits?

3 Impact

3.1 Business Impacts

By eliminating the idle time of ships, Just-In-Time bunkering operations result in a huge impact on the productivity of the port and its ecosystem of players. Thanks to the optimised scheduling, vessel masters can adjust their speed to arrive at port at the right time to start the bunkering operation, decreasing the waiting time at anchorage. This decreases the overall economic cost for the Shipowner as bunker consumption and berthing time decreases as well. The solution will also eliminate the risk of unfulfilled charter parties due to port delays.

Table 2. Economic impact of optimised planning for shipowners.

Annual Vessel Idle time eliminated globally (h)	Annual Operational costs saved globally (M€)
1,850,000	2,590

Annual calculations considering 100% of market share and:
- A vessel's average idle time of 1,85h.
- 1,000,000 port calls annually globally (global estimate calculated considering a total fuel market of 300M tons and an average lift of 300 tons/bunker call).
- Average Operational cost for a shipowner of 1380€/h considering the cost/h of carrier (1.335€/h), bulker (1.254€/h) and tanker (1.552€/h)[3].

3.2 Other Impacts

The Just-In-Time bunkering operations have a positive impact on the environment and society at large. The improved planning helps eliminate unnecessary movements and maneuvers, thus decreasing the fuel oil consumed inside the port area and the CO2, SOx, and NOx emissions. Additionally, the reduction of waiting time at anchorage can in itself result in additional potential benefits:

- Less congestion and traffic in the anchorage areas
- Reduced risk of accidents, collisions and oil spills.

Table 3. Environmental impact of Just-In-Time Bunkering Operations.

GHG Emissions	Annual Tons saved globally
Marine Diesel Oil saved (MGO)	407,000
CO2 emissions saved	1,282,050
NOx emissions saved	23,081
SOx emissions saved	558

Calculations based on Table 2 figures and the emission factors for CO2 (3.15tn CO2/tn of MDO), NOx (0.057 tn NOx/tn MDO), and SOx (0.001 tn SOx/tn MDO)[4].

Moreover, just-in-time bunkering operations will minimize the port's environmental impact on the cities surrounding it, decreasing the negative effects on the ecosystems and the health of the local communities surrounding the port.

[3] Sander van der Meulen; Tom Grijspaardt; Wim Mars; Wouter van der Geest; Adriaan; Roest-Crollius & Jan Kiel (2020). Cost Figures for Freight Transport – Final Report. Netherlands Institute for Transport Policy Analysis (KiM), Zoetermeer, April 2020, p. 47.
[4] IMO (2020). Fourth Greenhouse Gas Study 2020.

4 Measures of Success

The following success metrics should be used to measure the success of the planning integration for Just-In-Time bunkering operations:

Table 4. Success metrics.

S/N	Key performance indicator	Definition	Target
KPI 1	Idle time saved	The waiting time spent at anchorage saved for a vessel before the bunkering operation starts	From 1.85h to 0h
KPI 2	Bunker Barge idle time	The waiting time saved for a bunker barge between supplies in back to back operations.	<1h

To release the solution to the actors the following criteria must be met:

- The AI plan should ingest data in **real-time** to provide an updated schedule of bunkers available to all the bunker actors once the action is triggered, as defined in section 2.
- The planning integration should allow ships to reduce the idle time and ensure that they receive the bunker upon arrival at port.
- The deviation of the prediction should be less than 15 minutes considering the optimised ETA provided and the actual time of bunkering.