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Just in time vessel arrival system for dry bulk carriers

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Abstract

Cargo conveyance onboard dry bulk carriers is contemporarily often affiliated to preoperational waiting times, which may affect the income situation of stakeholders and the sustainability of the sector. Therefore, repetitively occurring waiting problems, potentially paired with port congestion phenomena, indicating that just in time (JIT) arrival potential for a distinct or a combination of reasons has not been realised, can be frequently identified. Undesired increment of waiting times and development of port congestion is frequently responded to by an array of measures. JIT arrival concepts, vessel arrival systems (VAS) and virtual arrival (VA) agreements thereby do not strive to eliminate waiting times but facilitate their sensible transformation into additional navigation time. In practice, VAS applications may, however, only enfold their inherent sustainability potential within closely defined delimitations. At the same time, JIT mechanisms and VA agreements may lack acceptance due to impracticability or missing alignment to underlying trade requirements. Therefore, fair but environmentally inefficient arrival mechanisms like the first come first serve (FCFS) concept remain widely applied. As a remedy, a VAS has been conceptualised by diverting from a static to a dynamic time-, distance- and speed JIT concept wherein these parameters are defined by predicted berth and cargo operation availability. A circular based Reporting Line furnished with the functions attributable to the place where line up positions are customarily allocated is fluctuating in correspondence to the time to go until the nearest berthing opportunity becomes available. The concept does not only provide for a dynamically shifting line and corridor to obtain an often highly valued line up position, but for the distance and conditions where under a vessel is going to arrive JIT. The FCFS concept interwoven with unbiased allocating of line-up positions is being retained as an integral part while VA applications are supported.

Keywords: Just in time, Vessel arrival system, Dry bulk, Green shipping, Decarbonization

Introduction

The world fleet capacity exceeding 2.1 billion DWT, with about 0.9 billion DWT thereof attributable to dry bulk carriers, in 2021 shows a growth trend (UNCTAD 2021). Recently, the bulk shipping sector has experienced faster growth than the overall shipping sector, which is reflected by the increase of its share from 36% in 2010 to 43% in 2020 (UNCTAD 2021).

Consequential to the growing importance of the dry bulk sector, an exploration of how environmental sustainability in general and exhaust emissions, in particular, can be addressed appears not only necessary but also promising.

The undertaking of commercial shipping as derived demand solely exists to facilitate trade (Stopford 2009). The transportation underlying sales contracts are thereby likely to create a root cause for various operational challenges while trade- and shipment processes concerning individual dry bulk cargoes may substantially differ. For example, dry bulk cargoes are commonly procured under free on board (FOB) and potentially numerous times resold before or during transit under cost insurance freight (CIF) or cost and freight (CFR), terms (Senss et al. 2018). Moreover, unlike liner shipping, where often myriads of shippers' contract carriage under standard terms, bulk cargoes are conveyed under individual voyage, consecutive voyage, trip time, time charter agreements and contracts of affreightment.

Consequentially, when green shipping solutions are conceptualised, dry bulk-related just in time (JIT) arrival mechanisms need to be addressed differently from those concerning other maritime subsectors (Senss et al. 2021).

The potential concerning the coordinated JIT navigation and arrivals appears to be significant. King (2011), for example, estimated that approximately 8% of the dry bulk carrier fleet had temporarily been in anchoring and, therefore in waiting position during the years before 2010, which he attributed to numerous factors relevant to port operation.

Even though certain ports or specific terminals are more prone to it, port congestion appears not to be constrained to particular world regions and is, therefore, seen as a global maritime problem. It thereby creates far-reaching adverse economic or environmental issues, including increasing air pollution near port cities (Canbulat 2021; Canbulat et al. 2015).

To address this problem, a VAS became operational in 2010 at the Australian port of Newcastle, the terminal part of the hunter valley coal chain (HVCC), (PANSW 2019).

Even though the operation of the VAS at Newcastle might be seen as a contribution toward the mitigation of greenhouse gas (GHG) emissions and other pollutant substances, the reason for introducing the VAS has been a severe nautical incident. According to the port authority of New South Wales (PANSW) (PANSW 2021), the VAS was implemented due to an event where a dry bulk cargo ship, the MV Pasha, anchored in the vicinity of Newcastle, ran aground due to severe weather.

The associated issues of waiting time avoidance, port congestion and JIT arrival have been addressed by a multidisciplinary approach, for instance: investment in capacity enhancement/ throughput augmentation (in relation to conveyance to/ from the terminal, stock holding, cargo handling) and organisational/ managerial measures (i.e., to carry out work during times that were initially considered work free, by improved berth allocation, quay crane scheduling and -planning).

As the shipping industry has been identified as a sector that is accountable for a considerable GHG- as well as sulphur oxide- (SOx), nitrogen oxide- (NOx), and particular matter (PM) emissions, modern technologies have entered the industrial sector. Even though energy efficiency measures (EEM) have generally gained momentum in the industry, the field, which may be described as the coordination of commercial operation (voyage realisation), still offers substantial unutilised potential.

While the thereto underlying reasons might be multi-layered, the main barriers preventing an augmented exercising of EEM are likely related to the Principal/Agency- and Split Advantage Problem as described by Rehmatulla and Smith (2015). Aside from monetary aspects, long-established and well-tested trading practise with arrival timing, compliance to dedicated timelines, and prescriptive speeds may be seen as reasons for the lack of applied EEM. Consequentially stakeholders involved in maritime conveyance and well prepared to support existing or initiate their EEM are often prevented from doing so.

Also, the commercial aspects of freight earning and demurrage generation in relation to port congestion should not be underestimated; hence, voyage duration affects not only the profit- and expense situation of ship operating- and chartering entities via inclined fix- and variable cost elements. And while fixed cost elements associated with insurance, manning and classification are expressible in daily rates, variable cost elements, including those concerned with energy utilisation, may vary in relation to geographical allocation, seasonality, and fuel pricing. In consequence, operating expenditures tend to incline with prolonged waiting times, and freight rates and/or demurrage rates might be adjusted to retain a sustainable income expressed by the time charter equivalent (TCE). Contrary to freight earning, which is set, the extent of demurrage payable by the charterers, to remunerate the person who charters the vessel out, if time in excess of the contractual Laytime is needed to service a vessel, may thereby considerably fluctuate. Whether the exact agreed Laytime will be consumed, times in demurrage incurred, or dispatch money becomes payable by the person who charters the vessel out, can only be vaguely assumed due to the operation of various choices. Nevertheless, the concepts of demurrage and dispatch are commonly extended to sales contracts and, therefore, to the relations of (FOB) sellers and -buyers (as voyage charterers).

Under Grain Trade Australia's contractual framework, for example, an array of terms of similar meaning, including those stipulating the consummation of Laytime, is contained, both in the GTA Voyage Charter Ausgrain 2015 (GTA 2015) and the GTA FOB Contract No. 1 -Grain and Oilseeds in Bulk (GTA 2018). Moreover, whilst a certain threshold rate is not to be exceeded, the demurrage rate stipulated under the GTA FOB Contract No. 1 (GTA 2018) shall be in alignment with the relevant rate stated in the underlying CP. It might therefrom be deduced that exposure to demurrage does equally extend to trading in commodities and the sales of goods while, as indicated by Grain Corp's Bulk-Wheat and Non-Wheat Port Terminal Service Agreement (GrainCorp 2016), a conveyance of demurrage expenditures into the logistic chain may not incur normally.

Therefore, even though the findings may not be generalised concerning exporting and importing of dry bulk cargoes, it might be presumed that terminal operation may not necessarily be directly affected financially by temporary port congestion. Excessive, persistent port or terminal congestion may exert pressure on terminal's, port's, region's or country's competitiveness, leading to commodity price discounting or service providers' substitution.

In the following, a condensed literature review is provided to depict alternative concepts, inherent potential and barriers associated with uni-, bi- and multilaterally coordinated speed alignment and arrival timing. Subsequently, an alternative VAS is being conceptualised to address the research gap, and the likely entailed effects are illustrated and evaluated by means of a theoretical exercise.

Literature review

The phenomena of port congestion, avoidance of undesired waiting times, and JIT arrivals have been separately and jointly addressed. The distinct approaches may be broadly categorised into terminal operation/ throughput improvement, vessel prioritising, tonnage demand and supply alignment, as well as the transformation of identified potential waiting time into time for speed alignment.

By focussing on terminal throughput augmentation, Bierwirth and Meisel (2010) emphasised the extensive literature addressing berth allocation- (BA), quay crane scheduling- and quay crane allocation.van Vianen et al. (2012) dedicated their research to the efficient intra-terminal movement of coal by reviewing the working practice of a distribution terminal that serves laden ocean-going bulk vessels and distributes the commodity predominantly using smaller vessels and trains. The proposed method first evaluates vessel-specific requirements "Order Input" and then the existing or projected infrastructure and operation conditions "Network" to comprise "Sets" that remain amendable to reflect the continuing operation (van Vianen et al. 2012). Without supplementing computational results, the authors indicate that reductions concerning cargo operation time, agglomerated waiting time for vessels awaiting cargo operation and energy usage can be generated by applying the proposed method. These reductions are likely mirrored by lesser demurrage and energy expenditures (van Vianen et al. 2012).

Singh et al. (2012) developed a model, "Capacity Expansion Planning Model CEPM", that derives ideal cost solutions for coal supply from the stages of inland transportation sourcing until and including the shipment of the commodity. The model recognises that a cost reduction can be achieved through refined utilisation of existing or investment in supplementing assets (Singh et al. 2012).

While the said model has been implemented into the hunter valley coal chain (HVCC) operational routine, Singh et al. (2012) emphasise its inherent aspects of certainty and realism regarding arrival patterns and cargo details.van Asperen et al. (2003) simulated the arrivals of vessels to a customer-owned terminal consisting of four berths with different characteristics used for importing and exporting raw materials, semi-finished and fined chemical products. Three different arrival scenarios were selected to ascertain values: the number of vessels waiting to be served, the waiting accumulated and the distribution of stock levels associated with the facilitating tank construction (van Asperen et al. 2003). The concept presented by van Asperen et al. (2003) depicts that BAP/ arrival planning can be of concern to stakeholders involved in the processes of cargo procurement and shipment. BAP/ arrival concepts may not only be decisive for reducing emissions or expenditures as demurrage but be furthermore utilised to determine layouts of berthing, reception and storage facilities. BAP/arrival mechanisms may perform as viable tools when investment decisions are to be made. Fararoui and Black (1992) developed a berthing prioritisation model that focuses on socio-economic implications and the public in terms of financially quantifiable exposure deriving from temporary situations of port congestion. A "hierarchical multi-objective approach" is applied to allocate berthing arrangements for individual vessels and associated voyages based on their specific delay expenditures that are deemed to provoke detrimental and measurable effects on the national economy (Fararoui and Black 1992). The approach provides an interesting inside aspect of delay that clearly extends beyond commercial and regional public interests but does not provide an applicable solution hence trade specific- and legal requirements are not recognised.

Tengku-Adnan et al. (2009) researched the effects of cargo parcel sizes and ship age profiles on port congestion with reference to Australian coal loading chains to minimise demurrage expenditures and strengthen their ports' strategic positions. Their underlying idea hereto is that vessels' age profiles potentially provoke detrimental effects on the cargo handling rates while smaller cargoes to be lifted may lead to faster turnaround times (Tengku-Adnan et al. 2009). They compared and contrasted their defined categories "newest ship first, the smallest ship first", as well as the combination of both with the FCFS concept and found that, in the absence of objecting factors, their developed concept tends to resolve the problem of port congestion more appropriately (Tengku-Adnan et al. 2009).

Robinson (2007) investigated the restructuring of the Dalrymple Bay Coal Terminal as part of the Goonyella coal chain from a "public utility" into a commercially driven private entity that its customers own entirely. The introduced concept utilises shipping quotas that are determined for each calendar month and individual customers with remunerations payable to the terminal whether or not the contracted amount of cargo has been shipped (Robinson 2007). The predefined monthly terminal throughput, the alignment of supply and demand with unused capacities tradeable between the shareholders, considerably reduces the extent of vessels arriving and awaiting cargo operation (Robinson 2007). The findings attribute to the substantial financial saving potential inherent to reduced waiting time while additional fuel-saving potential from navigation speed adjustment to arrive JIT is not considered.

In contrast to the above-depicted contemplations of how vessel idle times prior to being served by a terminal and port congestion may be avoided by applying enhanced simulation tools, streamlining operational processes, prioritising vessels berthing windows (i.e., to avoid payment of demurrage), distributing vessel arrivals or aligning /converging supply and demand for tonnage for a dedicated period the following discussed publications focus on JIT arrivals.

Even though it may be argued that JIT arrivals do not mitigate port congestion when defined as misalignment of supply of and demand for tonnage, arrival timing can play a vital part in materialising sustainability potential.

Rosaeg et al. (2010) proposes an innovative concept that allocates the ranking position of a vessel in the port lineup in accordance with its computed Estimated Time of Arrival ETA by utilising its inherent speed characteristics. To ensure that fairness amongst the participants is exercised and speed values can be relied upon, Rosaeg et al. (2010) suggests that index values should be derived from standard certificates. Inherently, where the "Standardised ETA—SETA" and the requested arrival time fall apart, the resulting period might be used for intentional speed reduction. While various operational challenges may occur, Rosaeg (2010) argues that the inherent common contract duty of pursuing a voyage with due or utmost dispatch can prevent speed adaption measures. The SETA method, however, appears to be a suitable relief from commercial and compliance pressures to arrive at the earliest possibility at a port to gain a favourable lineup position.

Alvarez et al. (2010) addressed the inefficiency of the FCFS arrival concept as being substantially dependent on requirements not to delay navigation deliberately and to comply with the terminal operational layout. Under their method "Global Optimization of Speed Berth and Equipment Allocations" (GOSBEA), vessels are awarded their lineup positions at a dedicated static distance from the destination port. This renders further navigation at due dispatch speed obsolete (Alvarez et al. 2010). From the time the lineup position is allocated, the vessel is urged to comply with speed recommendations which should frequently lead to speed decrement in congestion situations. Alvarez et al. (2010) mathematically compared their method with the FCFS and SETA methods and found indications that enhanced EE can be best achieved by the GOSBEA and secondly by the SETA concept.

As an example, concerning sustainable utilisation of resources by transforming potential waiting time into a time of navigation, the mandatory Newcastle VAS (NVAS) shall be sketched here. The said VAS thereby partially resembles the formerly discussed GOSBEA concept even though the Notified Arrival Time establishes the lineup.

The port of Newcastle; an exemplary case

The trade layout: dimensions

The Port of Newcastle (PON), while let to a binational, Australian- Chinese infrastructure entity for a period of 98 years in 2014 (Heaver 2021), might, in terms of throughput, be described as a nationally leading port (PANSW 2020). Even though dominated by coal exportation, "grain, alumina, fertilizer and ore concentrate cargoes" are also conveyed via its facilities (PANSW 2020).

The annual trade reports for 2014–2020, published by the PON (2022), thereby depict that approximately 95% of the cargo in MT handled by the terminals within Newcastle Harbour has been related to coal exportation. The throughput of said commodity group to destinations which are predominantly allocated within the East- and Southeast Asian Regions thereby represents 95% of the total hunter valley coal chain's coal shipments (HVCCC 2021).

The total weight of exported coal via PON thereby reached approximately 163.8 MT during July 2019–June 2020 financial year (PANSW 2020). In total, 1813 (165.3 MT) dry bulk carriers engaged in coal exportation were serviced during the calendar year 2019 (PON 2020).

Terminal layout

Coal exportation through the PON comprises more than one hundred grades of thermal and coking coal shipped via Port Waratah Coal Services (PWSC) and Newcastle Coal Infrastructure Group (NCIG). Vessels within a range of 25,000 DWT and 210,000 DWT are commonly serviced by PWCS (PWCS 2019), while the NCIG, which does not provide for a maximum servable DWT, states that vessels up to 300 m LOA (max depth at berth 16.2 m, channel depth 15.2 m, max sailing draught 15.2 m + tide − 10% UKC, max beam 50.0 m) can be handled by them (NCIG 2018). Therefore, while distinct berths tend to service different tonnage segments and cargo sizes, the coal handling entities at PON are capable and prepared to load coal cargoes to an array of vessels comprised of the Handysize-, Handymax-, Supramax-, Ultramax-, Panamax- and Capesize tonnage segments.

Vessels' sea passages

With the assumption of Newcastle being the geographical centre of the trade, fronthaul distances to ports within the main importing regions commonly, even though not exclusively, exceed a threshold of 4,000 nm. Satellite Position as well as AIS status information gained from FleetMon.com, JAKOTA Cruise Systems GmbH, (data provided on 10.06.2021), Rostock, Germany, further indicates that backhaul voyages to Newcastle are often pursued under ballast conditions. This emphasises only a marginally pronounced market for bulk cargoes to be conveyed from East-/ Southeast Asia to the Eastern Shores of Australia.

VESSEL's approach, arrival and waiting situations

Where tonnage to load at the PON is not sourced locally or regionally but drawn from the East and Southeast Asian regions, vessels appear to navigate towards the Australian East Coast at speed levels above the speed required for their actual berthing time. Following periods of comparatively fast navigation, relative slow steaming is often applied, which is later substituted by alternating periods of drifting and repositioning that represent idle time. Before inbound navigation and docking, vessels commonly shift to coastal areas where they anchor, per the VAS rules, generally not longer than 48 h.

Furthermore, as indicated by AIS status data, vessels with a distance of more than 10 nm off the coast often claim not to be under command. A reason hereto might be seen in ship operators intending to reduce fuel consumption and expenditures even if that may entail nautical safety hazards.

NVAS layout and operation

According to the Port Authority of New South Wales (PANSW 2021), substantial emission-related savings have been identified in comparison with earlier operation periods and competing ports. Concerning the preceding operation practice, the fuel consumption and the emission of greenhouse gases (GHG) declined by abt. 18% (PANSW 2021). Compared to voyages of similar design, air emissions under NVAS governance are likely to be 13.2% less, while significant savings are attributed to anchoring (29.2%) and staying at berth (50%), (PANSW 2021).

The NVAS' predominant operational aim is to reduce the anchoring time of individual vessels to a maximum duration of 48 h (NCVTS 2019); hence said undertaking is commonly perceived as potentially dangerous in terms of safety and environmental preservation.

A Berth Notification Form is required to be submitted to the VAS 14 days before an intended arrival (GBRMPA 2013) by any vessel planning to participate in the mandatory system. Based on the vessel monitoring by port authorities, which commences after the Berth Notification Form has been submitted, each vessel will be given a "7 Day Notified

Arrival Time" (NCVTS 2019), which also establishes its lineup position while its berthing time may differ.

The port authority, either at the same time or at a later stage, informs the vessel about its "Estimated Time of Loading" (ETL); it is thereby essential that the maximum waiting time at anchor is to be observed (NCVTS 2019).

Aside from visible improvements concerning the traditional FCFS mechanism, speed alignment and fuel-saving potential may not be entirely realisable where the ETL can only be reached at a velocity below a sensible threshold. Correspondingly, a vessel may be required to drift or anchor elsewhere to resume navigation later to meet the NVAS' participation conditions. In essence, environmental and/or safety concerns may not necessarily be entirely resolved but transferred to places where less control is exercised and/or less assistance in an emergency is provided. It might also be of concern that solely vessels' ETA, which can be artificially influenced by unnecessarily elevated engine performance, are decisive for berthing prioritisation. Furthermore, a consideration of implied sustainability improvements such as the usage of less pollutant fuel and/or the loading or discharging of comparatively few consignments etc. is also absent.

Vancouver port

The implementation of VAS in general and specifically those dedicated to the conveyance of dry bulk cargoes appears not to have gained momentum until recently and is confined to the NVAS or applications that have not been publicized. However, interest in the NVAS and its underlying methodological approach has gained recognition due to the need to manage port congestion. Heaver (2021), for example, emphasises the urgent requirement for a VAS to be instated at the Port of Vancouver to address export-oriented bulk cargo flows via commodity-specific terminals by referring to the NVAS. The need for anchor management, waiting time mitigation, and JIT navigation facilitation has also been publicly highlighted by Tansport-Canada (2021). Hence the intended operating methodology and framework have not yet been revealed it may be reckoned that the implemented system will, in certain aspects, resemble the NVAS.

Californian ports

A novel "*queuing system*", predominantly for container ships, has recently also been introduced at the US West Coast Ports of Los Angeles, Long Beach and Oakland (Gard 2022a). Vessels are thereby assigned with berthing priorities in correspondence to their ETAs to their destinations (referred to as Calculated Time of Arrival) (CTA) upon departure from their Last Port of Call (LPOC) to facilitate JIT arrivals, enhancement of coastal air quality and navigational safety (Gard 2022a) (PMSA 2022). Vessels are now further required to abstain from a defined spatial zone named Safety and Air Quality Area (SAQA) that extends between 50 and 150 nm in the seaside direction until at least 72-h prior to their anticipated times of berthing (Gard 2022a; PMSA 2022). Before the SAQA, vessels were vested with berthing priorities upon their intersecting of delimitations which for LA and Long Beach were allocated 20 nm and for Oakland 80 nm off the coast (Gard 2022a; PMSA 2022). To a limited degree, the implemented *"queuing system"* shows resemblance to the SETA concept defined by Rosaeg (2010).

Aside from comprehensive schemes as applied at Newcastle or Californian ports or intended to be applied at Vancouver that directly influence or prescribes voyage speed, approaches also exist that only address specific congestion factors. Naudé (2016) emphasises that the port of Paranagua/Brazil tends to award berthing preference to vessels that are required to handle fewer consignments than their similarly dimensioned competitors. Handling of multi-consignment cargo parcels may be perceived detrimental concerning vessel turnaround times. This is also depicted by Naudé (2016), who reckons that 30% of the time with grain loading at Paranagua (Brazil) can be attributed to excessive utilisation of separate consignments. Therefore, aspects promoting greening in the maritime sector should be considered when lineup positions are allocated.

Research gaps

The research aim may be described as to find a viable way to leave a well-operating interlinked system of commercial, logistical and legal involvements intact. At the same time, sensible background processes are adjusted to facilitate a materialisation of speed alignment/JIT potential. More specifically, the research strives to elucidate whether sophisticated static lineup allocation, for instance, applied by the NVAS, can be further elaborated into a dynamic system where the merits of the situation define arrival timing, speed choice and vessels' lineup positions. Subsequently, to address the highlighted research gap, an alternative VAS is conceptualised as well as the likely entailed effects illustrated and evaluated by employing a theoretical exercise.

Even though several arrival mechanisms have been developed, relatively few have been initiated as they may contravene the concept of self-determined commercial undertaking by maritime stakeholders. Certain mechanisms, for instance, seem to focus on idealistic aspects as to prioritise vessels in accordance with their inherent environmental performance and are, for example, interrelated with their building dates (Tengku-Adnan et al. 2009), the effects on the national economy (Fararoui and Black 1992), the exposure to demurrage (Tengku-Adnan et al. 2009). Furthermore, where VAS designs recognise operational and commercial requirements, the determination of lineup positions and arrival timing may be constrained by static elements. Under the NVAS in the example, the point in time to define the arrival time and lineup position is statically prescribed by the Notified Time of Arrival. The proposed approach aims to scrutinise how commercial/operational necessities and limitations, as well as dynamic actual port congestion aligning arrival mechanisms, may converge. Hence a predictable and fair allocation of berthing- and cargo handling windows in correspondence to the underlying framework is deemed decisive, the impartial long-applied FCFS still seems to be well suited. A significant detrimental effect thereby remains the absent transformation of waiting periods into the time available for speed reduction, which affects fuel consumption and harmful emissions and so forth.

Higher EE in voyage realisation requires substantial, feasible and commercially acceptable changes. The importance of such a paradigm shift is also supported by, for instance, Heaver (2021), who emphasises that addressing port congestion, waiting time avoidance and JIT navigation, that has often only been considered as a by-product in relation to GHG emissions mitigation, is tending to form an independent area of research. A multidisciplinary-oriented comprehensive towards port congestion-directed research appears promising; hence, positive JIT navigation coupled effects are likely to extend beyond direct fuel and emission savings (Heaver 2021).

The urgent need for JIT navigation has also been specifically highlighted by the IMO (2020b) and has been addressed within its interdisciplinary *JIT Arrival Guide* (IMO 2020a). According to the IMO (2020b) and Heaver (2021) the absence of JIT arrival concepts is likely attributed to predominantly commercially imposed and difficult barriers. Heaver (2021) further underlines that JIT navigation induction and facilitation are more likely prevented by stakeholders' behaviour than by unsophisticated technical components and processes. Behavioural aspects are also mentioned within the IMO's JIT arrival guide as reasons to initially focus on the utilisation of JIT navigation inherent in EEM within the container (liner) shipping sectors and to address bulk shipping at a subsequent stage.

Poulsen and Sampson (2019), who directed research on the implementation of VA invoke that substantial risks are likely to associate with uncertainty and default. Extensive complexity and feasibility issues and the risks associated with defaulting with contractual terms are likely to hinder a wider uptake of VA agreements; hence they are unlikely to be sufficiently compensated and rewarded by JIT-attributed cost savings (Poulsen and Sampson 2019). Their work thereby supports a view that JIT arrival inherent savings are subject to carefully weighing against an array of parameters that in relation to dry bulk shipping, embraces aspects of certainty and compliance in correspondence to Laydays, shipment, delivery and fulfilment periods. We further identified demand for research whereby stakeholders' requirements, embracing compliance to statutory obligations and contractual terms, demand for fair, unbiased and reliable berthing prioritisation are to be addressed to ensure the EEM can, to their greatest potential, be materialised.

The GOSBEA and SETA concepts as underlying theoretical frameworks to answer the urgent need for JIT navigation facilitation may thereby not allow exerting EE potential to the most comprehensive extent.

Under SETA-based systems, energy-saving potential may not be fully materialized due to inefficiencies provoked by navigating vessels whose ETAs/CTAs, due to comparatively elevated speeds, incur earlier in relation to their competitors. Berthing priority may be awarded to a more distant but at higher speed operating vessel than the vessel closer to the destination but operating at a slower speed.

A substantially more distant vessel that is being allocated with an only marginally earlier CTA due to a high speed will intrinsically be awarded berthing priority, indicating that elevated voyage speeds are promoted. Consequently, vessels departing from LPOC closer to the destination but navigating at lower and, therefore, presumingly more energy-efficient speeds are prejudiced. Any speed reduction for them might become problematic if their speed to arrive JIT falls below a feasible minimum value (incl. but not limited to nautical, technical, safety and security imperatives). Concerning the container services, voyage realisation intentions are verifiable against published schedules and therefore, VAS administrators might be able to revoke ETA' that have been intentionally preponed to gain earlier berthing times. However, complex, concerted and independently derived speed and arrival timing decisions are vital to the functioning of dry bulk ship operation. The applicability of SETA-based arrival schemes might therefore be limited.

While, under the NVAS and the GOSBEA concept, berthing priorities are determined according to predefined static time or distance to go to the destination, a dynamic situation response is being discarded. JIT navigation may thereby be initiated at excessively late timing without fuel and emission savings.

Furthermore, under the SETA, GOSBEA and NVAS's concepts,'ETA' to destination, which are decisive for berthing prioritisation, might be intentionally influenced and preponed. Whether an ETA corresponds to the actual intended arrival time of a vessel's master may not be ascertainable. Potential issues may also arise if formerly allocated berthing priorities based on estimated arrival times are allowed to be challenged by the vessels entering into the system later. A vessel which is closer to the destination and which might have already adapted its speed to arrive JIT might be forced to decelerate further its speed, whereby a minimum speed is not to be undercut.

Barriers to JIT navigation and potential remedies

While promising mechanisms to enhance JIT navigation-based EE exist, their uptake as formerly depicted appears less constrained by technical aspects and stakeholders' willingness than by trade, shipment, conveyance or delivery-related risks of default and indemnification. In addition, the three-dimensional relationship spanning between sales agreements, CP and BL' as negotiable documents is not to be underestimated, and the stakeholders' reasonings are to be explored.

Default situation

Sales contracts not only are causative for the procurement of maritime conveyance but are likely to draw delimitations concerning JIT arrival mechanisms; hence associated factors might become decisive for defaulting with obligations.

Breaches of obligations may particularly become detrimental when cargoes, under voyage charter, have been or are intended to be remarketed under string contracts. The consenting to JIT navigation by the person to whom the BL has been issued may not suffice. Furthermore, a party who may even be unaware of deviations from what is to be expected under the BL and CP and who is thereby becoming unable to comply with sales or other contractual terms may face exposure to liquidated damages or even suffer from contract repudiation. Deliberate but inexcusable delays and deviations, even though not causing damage to the other party and made or consented to with good intentions, might be construed against a party which is also mirrored by, for instance, Gard P&I Club Rule 34 xi.

"Rule 34 Cargo liability.

1. The Association shall cover the following liabilities when and to the extent that they relate to cargo intended to be or being or having been carried on the Ship:

    a. liability for loss, shortage, damage, or other responsibility arising out of any breach by the Member, or by any person for whose acts, neglect or default he may be legally liable, of his obligation properly to load, handle, stow, carry, keep, care for, discharge or deliver the cargo or out of unseaworthiness or unfitness of the Ship.

Provided that unless and to the extent that the Association in its discretion shall otherwise decide, the cover under this Rule 34.1 does not include:

xi. liabilities, costs and expenses arising out of a deviation or departure from the contractually agreed voyage or adventure, which deprives the Member of the right to rely on defences or rights of limitation which would otherwise have been available to him (GARD 2022b)."

An owner may, due to delay or deviation, not be able to invoke further the operation of a (charter contract) *"exception clause"* in his favour (GARD 2013).

Furthermore, ship operators, charterers, and further parties, as those to whom rights and duties under a CP have been conveyed, may assume risks in connection with the vessel's port stay if they initiate or consent to JIT navigation which becomes causative for postponed or foregone berthing and cargo handling opportunities.

Statutory and contractual frameworks

Definition of dispatch

Among a list of behavioural barriers that are to be seen as causes for the limited implementation of JIT arrival mechanisms as invoked by the IMO (2020b), Poulsen (2019) and Heaver (2021), the concepts of dispatch are of paramount importance. Underlying thereto, subject to freight paying voyage charter agreements, the persons who charter a vessel to another commonly agree to be load ready within a predefined period and to convey the contracted cargo to a place of destination at an implied performance level. In consequence, the (head) charterers, those to whom the CP has been assigned, and those who can rely on BL terms may expect that contracted services will be rendered as defined. A minimum SOG is not demanded, but it can be expected that the voyage(leg) is going to be pursued with reasonable efforts to comply with said performance level. The English Common Law concept of reasonable dispatch and the often contractually implemented obligations to undertake the voyage at due dispatch provide the thereto underlying basis. **A charter agreement may only be avoided on the ground of breach of reasonable dispatch if its purpose has been entirely lost, while demanding damages from the owners might be the only recourse for charterers where a contract can still be fulfilled** (Bennett 2015).

Conferment of duties and rights

The overarching requirement to confer obligations and rights throughout the chain of maritime and commercial involvements shall, in correspondence to frequently used INCO terms, be explored. As they commonly define place and time of possession, property and risk transfer, said terms further regulate by whom distinct conveyance stages are to be arranged and paid for. Their utilisation in relation to dry bulk transportation appears thereby to be primarily constrained to the general terms Free on Board (FOB), Cost and Freight (CFR), and Cost Insurance Freight (CIF), while derivates thereof may suit specific trades and purposes.

Subject to FOB (export) terms, the seller of merchandise is, under the INCO terms 2020, at the duty to deliver the said at his own expense on board, where the risk passes to the buyer by whom transportation has to be arranged and paid for. As underlined by Griffin and Day (2003), the buyer is "legally" being contemplated as the shipper.

The sellers of merchandise are responsible for procuring shipment and transportation of the said to the named port under CFR terms, while under CIF terms, they are further entrusted with arranging and paying for corresponding transport insurance. These terms and derivates thereof are also vital to the well-functioning of commodity trades and have been widely adopted to facilitate (re)sales of goods in transit or those that remain to be shipped.

An intertwined, coordinated, and concurrent operation of FOB and CFR/CIF-based sales contracts concerning an individual cargo is commonplace, which reemphasises the necessity to confer rights and obligations under the CP during maritime transportation.

A carrier, who is to act as agent for and on behalf of an unknown party, whose intentions cannot be ascertained, has to comply with the contract terms and, if doing otherwise, as consenting to speed changes (decrements) demanded by charterers, may act without authority.

Remedies

However, the said instated hindrances to JIT navigation can be remedied by CP incorporated *Virtual Arrival VA, Sea Traffic Management and Just in Time Arrival Clauses* (BIMCO 2013b, 2018, 2021b) or alike as produced by the BIMCO (2021a). Subject to their specific wordings, carriers are allowed to comply with (head) charterers' speed or arrival instructions and therefore to reduce their navigational performance below a value that reflects the lower band of Reasonable/ Due/ Utmost dispatch speed. A deviation from the performance bandwidths would thereby not be considered in breach of dispatch requirements, which is affirmed by the relevant BIMCO clause wordings. According to said BIMCO clauses, the charterers further promise to keep the carriers covered against claims brought against them by a third party due to noncompliance to dispatch rules.

Another common instrument to prevent situations of conflict arising in relation to deviation from dispatch concepts is the conveyance of CP terms intentions into BL' by the express incorporation. A person demanding delivery of a consignment under such BL at the destination port may not be able to invoke that dispatch conform speed has not been applied where the CP allows agreeing on or otherwise adapting a reduced speed.

In addition, vessels are required to adhere to relevant governing rules, including those made by the port state authorities, as illustrated at the Port of Newcastle. An integration of or reference to CP terms and/ or rules regulating vessel' arrival- or berth allocation processes into sales contracts might also be practised, as demonstrated under the Standard Coal Trading Agreement SCoTA (GlobalCoal 2011).

Proposed method

A novel flexible reporting line (FRL) arrival mechanism to address port congestion is proposed, which strives to combine the advantages of a dynamic lineup allocation with the FCFS arrival concept by transforming predicted waiting into navigation time.

Thereby the misleading term port congestion hence literally comprising all facilities within a port, shall be construed as being congruent to the terminal or, more appropriately, berth congestion. Furthermore, the contemplated method herein is confined to single berth infrastructures even though, in practice, a terminal with multiple (un)loaders and a common quayside may be flexibly divided into berths of varying dimensions.

Method imperatives/theoretical framework

A vessel with a berthing priority (lineup position) during pursuance at speed in correspondence to the Requested Time of Arrival (RTA) provided by the VAS administrator is deemed compliant to reasonable/due/utmost dispatch. At the moment of prioritisation, manifested vessels' ETA to destination shall be construed as the time arrived for laytime consummation, provided the vessel would then have been ready to commence cargo operation. A vessel shall retain its berthing priority irrespective of vessels that may gain their berthing priority at a later stage but can claim an earlier ETA to destination. Destination ETAs are to be calculated by using a commonly applied speed and shall only be amended where cargo operation would be prevented for any reason, including cargo (operation) unavailability or where a vessel's inherent maximum speed lies below the common speed. By using a common speed, vessels are aimed to be demotivated to establish preponed Destination ETAs based on artificially elevated performance. Hence the FRL VAS shall be responsive to dynamically changing situations, the VAS corridor, by allowing vessels to gain their berthing priorities, establish their ETAs, receive and observe their RTAs, is deemed to fluctuate. To retain a dynamic situational response, time-wise amendments to berthing allocations, whether provoked via incoming traffic or terminal throughput changes, are without delay to be corresponded by FRL outreach (re)determination.

By applying contractual adaptions, specifically where the initial parties to a charter contract consent to FRL VAS facilitated JIT navigation, subsequent CP or BL holders and other third parties shall be prevented from alleging noncompliance to reasonable/due or utmost dispatch.

Method layout

The dynamically aligning FRL mechanism inherently comprises threefold effects: immediate, take away, and future indirect (primary, secondary and tertiary) sustainability aspects. Immediate effects are materialised by the vessel, which is being allocated to the nearest available berthing/servicing window NABSW. Take-away effects relate to those vessel(s) which do not gain the NABSW but become allocated with lineup positions (and which situation-depending may be enabled to further reduce their speed below ASPEED actual). Future -indirect effects are those which are consequential to vessel operation. It is the hypothesis that JIT speed alignment does not solely affect the current voyage but subsequent vessel operation, including but not limited to safety, maintenance, fuel consumption, emission and profit concerns.

A clear focus is nevertheless placed upon fuel consumption and consumption differentials as they are likely causative or tightly interwoven with GHG emissions, air pollution, sensible utilisation of natural resources and health concerns. A design emphasise is set onto the parameter speed through the water (STW); hence machinery performance

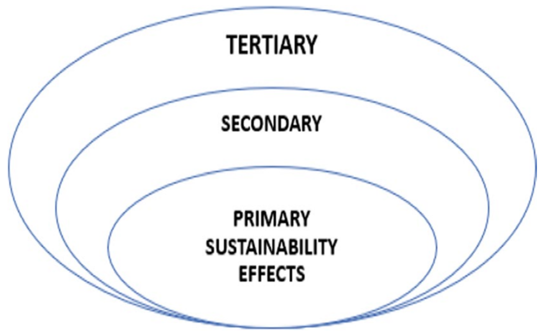

Fig. 1 Levels of sustainability

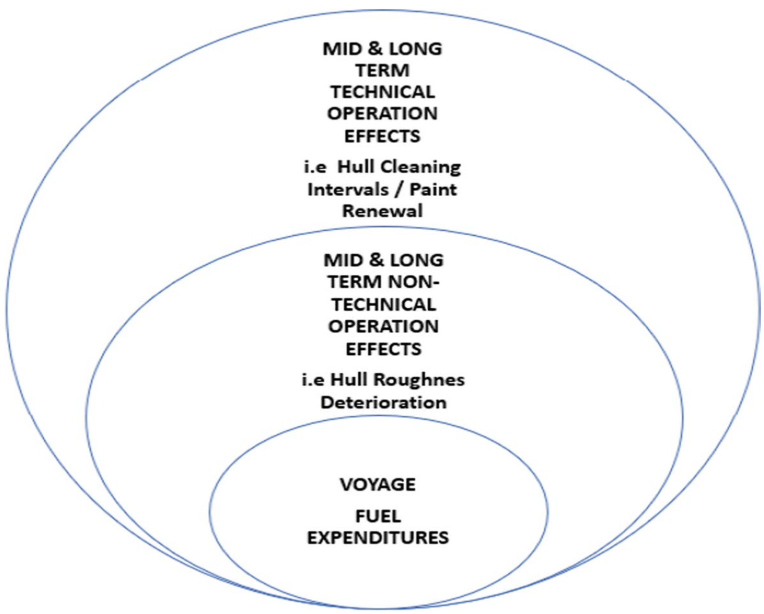

Fig. 2 Direct, mid, and long-term JIT arrival mechanisms effects

and fuel consumption are directly interrelated with an object's relative motion through a surrounding medium. Among other aspects, said relative motion/friction influences the degree of the hull- and propeller roughness and, therefore, biofouling (Uzun 2019; Uzun et al. 2018).

The effects and added value(s) likely affected by FRL VAS-based arrival mechanisms might be visualised from two distinct points of view (Figs. 1, 2).

The basic method

Contrary to the enhanced concept version, which operates on an array of sensible velocities to reach the focal point (FP) JIT, the approach speed (ASPEED) hereunder is perceived as a sensibly chosen constant. Thereby the said, ideally, is to reflect technical-, operational- and further concerns, including but not limited to steerability, incomplete fuel combustion, fuel usage, biofouling and security issues, including potential exposure to piracy activities.

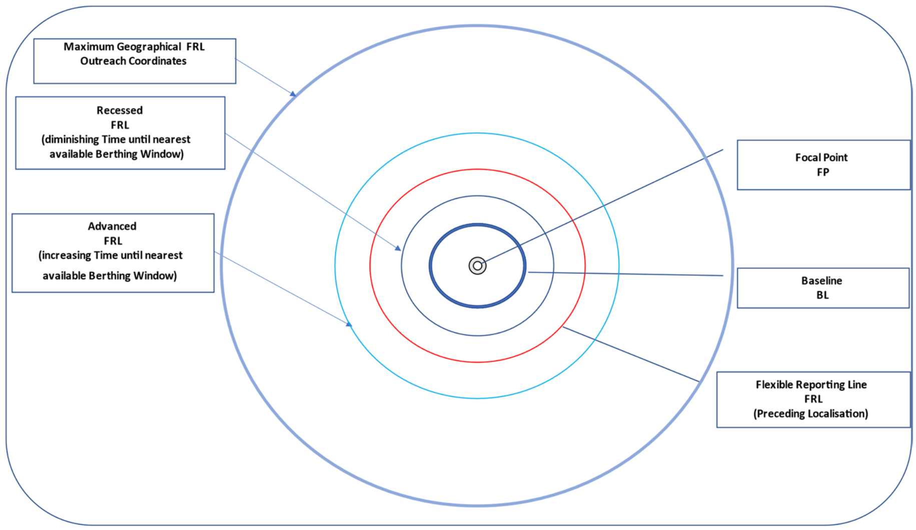

Fig. 3 FRL VAS—basic model elements

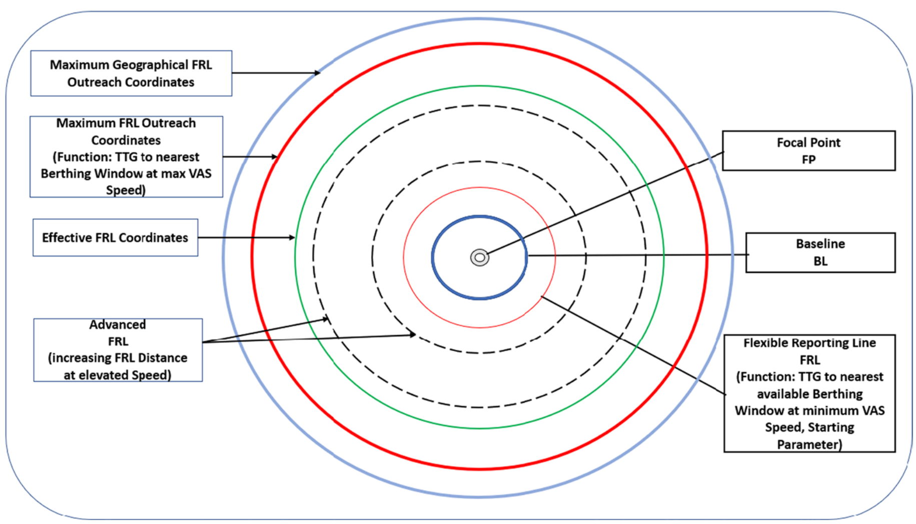

Fig. 4 FRL VAS—enhanced model elements

Based on frequent or continuous comprehensive situational (re)assessment, the changing distances of the FRL from the Base Line (BAL)/FP are to become active with either immediate effect or by reaching the nearest FRL adjustment timeline. The corresponding FRL coordinates may thereby either expire at a set pre-announced timeline/by lapsing of a pre-announced period or, where appropriate, by a subsequent event or circumstance-driven redetermination of the FRL (Fig. 3).

The enhanced method

The enhanced version operates on the basis of an array of sensible speed choices to materialise the JIT arrival potential corresponding to each situation. In this case, less extensive but early initiated speed reduction at comparatively high velocity is deemed to be more effective than one at a slower speed (Fig. 4).

Method/model: systematic layout

FRL initial determination At the geographical centre of the model, a Baseline (BAL) of a defined distance from the Focal Point (FP) (infrastructure/customary waiting area/ pilot boarding ground/fairway buoy) is to be established, with the FRL oscillating from the said in correspondence to the computed radius that reflects each congestion situation. Under the default situation of berthing on arrival, the FRL and the BAL are compatible and therefore equally distant from the FP. However, as the prevailing and forecasted infrastructure throughput and vessel arrival situations fluctuate throughout the operation period, the FRL is aligning its distance from the BAL/FP. To determine the distance BA–FRL, the prevailing and forecasted infrastructure performance in alignment with the tonnage to be serviced must be ascertained and computed to an agglomerated period that identifies the Nearest Available Berthing/ Servicing Window.

The said period, subject to potential reservations, is then to be transformed into a distance in accordance with the simple formula

$$\boldsymbol{s} = \boldsymbol{v} * \boldsymbol{t}$$

where s stands for distance (nautical miles), v for velocity (nautical miles/h) and t for time (h).

FRL (Re)determination The distance of the FRL from the BAL/FP retains its validity only until the next vessel(s) arrive to/into the FRL (corridor) and/or until amendments are provoked by changes to the terminal throughput (there might be more than one vessel registering at the same time). Hence, an increasing amount of identified time to go (TTG) until the NABSW advances the FRL seaward; the opposite movement towards the BAL reflects diminishing time (presuming a static velocity to apply).

FRL (Re)determination process The initial determination of the FRL-FP distance (ADISTANCE min) by utilising the minimum approach speed (ASPEED min) may however not suffice to register one or more vessels due to an absence of registrable tonnage. Therefore, it may become necessary to further advance the FRL sector by applying a speed that is to be gradually inclined (ASPEED actual) until one or more vessel(s) can be registered. Where successfully registered, the respective vessel(s) become furnished with their (predicted) berthing/servicing windows and berthing priorities while the FRL coordinates are concurrently redetermined. However, advancing the FRL corridor is to be stopped where the employed speed ASPEED actual is equal to ASPEED max. If no vessel can be registered, a continuous terminal operation may not be maintained while the FRL is deemed to remain in said position until the following situation (re)assessment/ FRL (re) determination has been made.

Vessel registration Each VAS participating vessel that is being identified in the FRL corridor but has not been previously registered experiences a status change by becoming a registered vessel furnished with a semi-persistent lineup position (provided the indicated latest time of arrival (LTA), as a direct derivate of ASPEED actual, allocated by the VAS administrator, can be physically complied with).

Vessels which are unable to correspond to a NABSW or an allocated berthing and cargo handling window might be superseded by other vessels that can respond to those allocations more appropriately. Thereby interruptions to an efficient utilisation of port and terminal infrastructures are aimed to be avoided.

ASPEED actual illustrates the present to the (valid) FRL actual and its embracing corridor corresponding speed. ASPEED min represents the lowest adaptable speed, while ASPEED max depicts the most elevated utilisable speed.

Multi vessel registration

Hence the determination of the FRL corridor only refers to the first registering vessel to arrive JIT simultaneously registering ships may be able to exert enhanced fuel savings in comparison.

Where the FRL (corridor) has attained its maximum (ASPEED actual equals ASPEED max), the fuel-saving potential of the vessel to correspond to the NABSW may be well exceeded by those vessels that are registering simultaneously. On the contrary, if the speed required to arrive JIT is less than the minimum speed adaptable by the concerned vessel, waiting on route or near the FP appears unavoidable, and sustainability potential is lost. Equally decisive parameters might be the geographical distance between the registering vessels and the port, and the time difference between their respective Requested Times of Arrival (RTA).

Therefore, an intrinsic objective under the FRL VAS is to recognise and register vessels at the earliest opportunity and extend the FRL corridor to the individual situation reflecting maximal sensible outreach.

JIT arrival facilitation A clear distinction is to be made concerning the allocation of a lineup based on LTA and RTA. The latter, derived by the port or terminal and directly corresponding to actual berth accessibility and cargo operation availability, prescribes arrival timing and navigation speed and functions as a direct JIT arrival facilitator.

FRL correction and augmentation Where a direct approach to the FP from the initially computed FRL intersected position or vessel's position at the moment of registration is prevented or otherwise influenced, corrections are to be applied. These reflect deviations from the direct track caused by physical or administrative barriers, speed advancement or delay effects caused by, for instance, Traffic Separation Schemes (TSS), Inshore Traffic Zones, areas of shallow water and operation of currents, wind, waves, and swell (Figs. 5, 6).

Hence for each relevant position, the shortest passage to the FP is to be initially determined the deviation in nm is to be subtracted from the distance stretching directly between the initial FRL intersected geographical position and the FP. An augmented FRL coordinate is being inbound placed while the augmented FRL is being locally recessed.

In relation to a vessel's intersected position, the extent of deviations from the direct track to the FP is to be added to reflect the remaining navigational distances. By estimated speed advancement and delay effects refined, the augmented coordinates create a situation

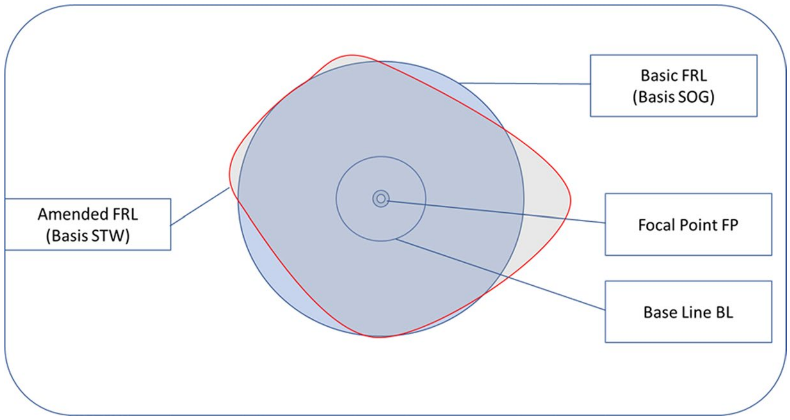

Fig. 5 Terms describing the effects exerted by speed advancement and -delay

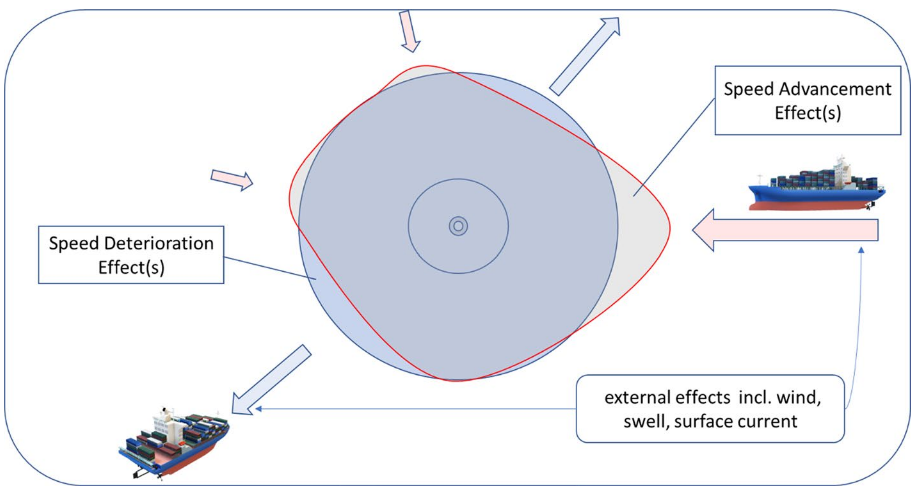

Fig. 6 The effects of speed advancement and delay caused to FRL definition

of equal conditions for vessels to compete for an identified NABSW based on a common approach speed. SOG used for the definition of the FRL and STW demanded from the vessel are therewith of equal value. Based thereon, vessels' 'Destination ETA' are to be computed and subordinately verified against their Best ETA.'Best ETA' are to be construed in alignment with the vessel's inherent steaming abilities.

Where a vessel's 'Best ETA is deemed to incur before the vessel's destination ETA', that latter shall prevail and be further used. Where a vessel's 'Best ETA' is deemed to incur beyond a vessel's 'destination ETA', the 'Best ETA' shall prevail and be further used. The refined ETA is to be verified against the earliest cargo (operation) readiness, whereby the Laydays begin paired with actual cargo availability, shall be decisive. The finally augmented ETA shall be construed as being decisive for berthing prioritisation (Fig. 7).

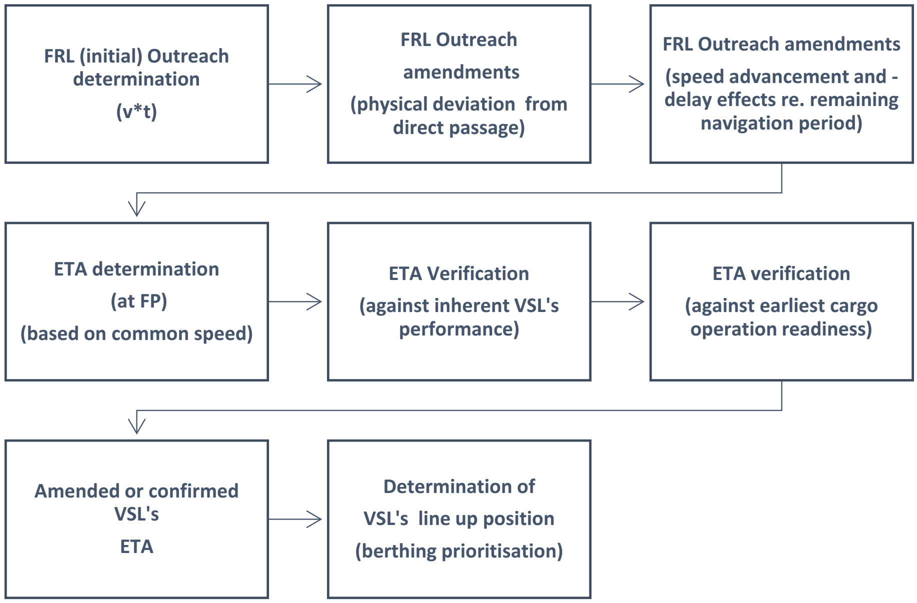

Fig. 7 The process of FRL outreach- and lineup definition

The review of the method

VAS compliance aspects

As indicated by PANSW, while stating that they only provide an opinion, a NOR, based on prior performances, shall be tendered at the same time when a vessel's notified time of arrival (NAT) is allocated. Whether such notice shall be the final or to be affirmed by the vessel's actual arrival has not been addressed. Similarly, references to NOR tendering, being an arrived ship and the consummation of laytime, are absent from the wordings of the BIMCO "Just in Time Arrival Clause for Voyage Charter Parties 2021, Sea Traffic Management (STM) Clause for Voyage Charter Parties 2018, Virtual Arrival *Clause for Voyage Charter Parties 2013"*. The BIMCO-drawn clauses solely demand that time saving resulting from the difference in the vessel's ETA/CTA and RTA shall be remunerated on the basis of an agreed daily rate. The underlying idea thereto appears to reduce potential laytime consummation for the charterers, facilitate fuel cost savings, and remunerate owners for forgone opportunities of consuming laytime.

The dilemmas of missing certainty and being inclined to favour either owners' or charterers' interests might be sketched by two contravening approaches. Intrinsic to the PANSW's opinion, the acceptance of a NOR by the charterers during navigation may discard themselves from the possibility of avoiding the charter on the basis of a vessel's arrival beyond the contractual Laycan. Furthermore, navigation risks normally attributed to owners may be conveyed to the charterers at an early stage, which contravenes the doctrine of voyage stages.

Baughen (2009), for example, differentiates the obligations under voyage charters into the four owners' or charterers' specific segments, the positioning leg, loading port stay, cargo-carrying leg and discharging port stay. During the navigational legs, the owners are required to pursue their navigation with reasonable dispatch while the charterers assume responsibility for arranging for a place to load or discharge and for cargo operations (Baughen 2009). The requirement that cargo operation is undertaken within "reasonable time "is commonly substituted by agreeing on Laytime (Baughen 2009).

The BIMCO-drawn clauses, on the contrary, appear to privilege the charterers; hence vessels are required to tender their valid NOR by arriving at the destination, whether it might be the named port or berth (potentially subject to a WWWW clause). Said undertaking, subject to periods during which a tendered notice may not be deemed received, may collide with owners' most natural interests to tender valid NOR at the earliest opportunity. Therefore, by complying with charterers' arrival instructions, owners may discard themselves of arriving at an, for them, effective time that may affect the commencement of Laytime consummation.

The above passages imply that the treatment of arrival timing, being an arrived ship, consummation of laytime and the tendering of NOR' is not without ambiguity, and a clear legal position may still be shaped. From a predominantly commercial point of view, the absence of clear guidance as to how anticipatory and actual notices and thereof arising issues are to be dealt with may hinder the uptake of said clauses and JIT concepts.

A framework needs to be developed to clearly distinguish between time-position stamps upon which a vessel shall establish its estimated/calculated operation readiness and when/where a vessel shall be deemed to be an arrived ship to establish actual operational readiness. The first referred to shall thereby be amendable to reflect effects that would have led to pre-or postponed arrivals to the destination.

We, therefore, propose submissions of anticipatory NOR during navigation to the port, and of final NOR, subject to actual load readiness, upon arrivals at the named destinations. Anticipatory notes shall establish theoretic arrival times as if the vessels had proceeded with their navigation performance that manifested during a standardised period before being advised with their CTA. The noticing of anticipatory NOR by the charterers or their agents shall not be construed as the acceptance of a NOR. Only a validly, at the named place, tendered NOR shall establish the fact of being an arrived ship, terminate the navigational and commence the port stay segment.

At a port of loading, an effective NOR as being commonplace, subject to further conditions, shall serve as a precondition to deliver a vessel into her charter. Thereby the CTA to the destination, subject to amendments, shall remain without effect where a vessel does not fulfil the criteria of being delivered into the charter.

Irrespective of the previously mentioned, where JIT navigation has been hindered by circumstances that would not have affected a vessel's navigation if it had proceeded with reasonable or due dispatch or any other agreed performance consequential delay shall be borne by the charterers. Thereupon the CTA shall still be used for laytime consumption aspects.

It may also be included in a CP to ensure that, from the moment of being allocated with a lineup position and an RTA and while adhering to subsequent PA' and or charterers' instructions, a vessel shall be deemed compliant with the relevant charter contract stipulations and with reasonable/due dispatch.

Reasoning and legal cases

Acceptance of a NOR which is common to be tendered at loading and discharging ports, while only prescribed by the Common Law for loading operations, is systematically perceived as acknowledging charterers' commercial control over a vessel. Therewith, including but not limited to laytime consummation, an unnecessary early NOR acceptance may disadvantage the charterers; hence it acknowledges that the preceding navigation leg has ended, and the port stay has begun. The Common Law is therefore cautious that certain preconditions for the valid tendering of NOR are duly observed.

In Christensen v Hindustan Steel 1971 (The Maria LF) (1971), it has been stated that a ship to initiate the consummation of laytime is required to, having accomplished the respective navigational segment, be ready to undertake cargo operation and be arrived at its destination (Baughen 2009). Where a Notice of Readiness is to be submitted, such notice is not to be tendered in anticipation of the circumstance of being an arrived and ready vessel but only when the conditions are fulfilled (Baughen 2009).

Whether an anticipatory notice may be validated by becoming an arrived and ready vessel has been addressed in the case T.A Shipping Ltd v Comet Shipping Ltd 1998 (*The Agamemnon*), where an advanced notice had been tendered at a place different as stipulated in the CP (Kempson and Wagland 1998). While the CP stated that under circumstances of an unavailable berth, the vessel is to proceed to the destination as close as permitted, the NOR had been tendered at a distance in excess of 150 nm from the port (Kempson, 1998). On appeal, it has been held that the vessel has had the opportunity to proceed closer to port to await berthing at a designated place near to it, and therefore, hence the NOR had been given too early, and at the wrong place, it had not been effective (Kempson and Wagland 1998). The anticipatory notice did not become effective by the vessel's subsequent arrival at the port's anchorage, and therefore, laytime consummation did not commence prior to the moment at which cargo operation began (Kempson and Wagland 1998).

The ruling of the *Agamemnon* case implies that courts may not be prepared to define a place *"as near as she may proceed"*, which is often referred to in CPs as 'too generously'. The approach is understandable as it is an intrinsic element of voyage charters for owners to bear navigational risks and to fulfil their contractual navigational obligations.

In the case *Oldendorff & Co. v Tradax Export S.A. 1973 (The Johanna Oldendorff)*, it has been established that the term port as a place of delivery may not be literally but widely construed. The Johanna Oldendorff arrived at the "Mersey Bar" from which she later navigated to the port to be cleared and to which she returned to await berthing (Szteinduchert 2017). Even though the waiting ground had been within the administrative port limits, the charterers argued that the vessel had not arrived. The court held that the vessel was placed within the port limits and at the instantaneous disposition of the charterers (Szteinduchert 2017). She was considered to be an arrived ship (Szteinduchert 2017). The charter had been concluded on port terms and incorporated a WIBON clause which emphasises that the vessel had been required to be within the delimitations of the port to tender an effective NOR (HoL 1974).

In the aftermath of this leading case, whether a place of waiting is to be seen as within the area of a port is not necessarily decided in accordance with geographic definitions but by the control exerted over a vessel by charterers and administrative (port) organisations. The applied pragmatism in the case of Johanna Oldendorff still provides guidance for contemporary disputes, even though each case is required to be assessed in accordance with its merits. Ought to the case's importance, we like to refer to the judges' reasoning in more depth. While Lord Reid upheld that a vessel, to be an arrived one, has to have attained a place within the delimitations of a harbour and is to be at the instantaneous disposal of the charterers, Lord Diplock introduced the below test.

A vessel is then likely an arrived ship where/when it

1. attains a position at which it is being furnished with berthing prospects in relation to its place in the arrival queue
2. is being in reach of the charterers in relation to merchandise handling and the reachability of a distinct place to undertake such handling
3. is situated at a place from which it can navigate to the place of merchandise handling upon receiving instructions from the charterers without incurring substantial operational delay concerning the berth that became accessible

Viscount Dilhorne emphasised that while the area of a port shall include those places where a vessel customarily awaits berthing, a vessel shall not be treated as arrived if, due to instructions by the port authority, the vessel must await berthing outside port areas. Arrival in an area defined by the relevant administrative organisation that may be somewhat away from the actual port, shall satisfy the precondition to be an arrived vessel (Viscount Dilhorne).

The BIMCO's "*Laytime Definitions for Charter Parties 2013*" (BIMCO 2013a), which are commonly referred to dry cargo chartering, show commonalities with the reasonings given in the case of the *Johanna Oldendorff*. This might be of assistance in pragmatically addressing JIT-related research questions.

> *"Port shall mean any area where vessels load or discharge cargo and shall include, but not be limited to, berths, wharves, anchorages, buoys and offshore facilities as well as places outside the legal, fiscal or administrative area where vessels are ordered to wait for their turn no matter the distance from that area. (BIMCO 2013a)"*

In *Federal Commerce and Navigation Co. Ltd. v. Tradax Export S.A.* 1977 (*The Maratha Envoy*), the vessel, which had been contracted on the basis of a port CP, was advised by the charterers not to pursue its navigation to the port of Brake, which is situated at the river Weser (Szteinduchert 2017). Instead, it was agreed that the vessel should have waited at a customary and suitable waiting place, approximately 25 nm in the seaward direction from the said port. The vessel nevertheless proceeded to the Port of Brake several times to tender NOR'. The House of Lords ultimately ruled that the voyages to the port were *"voyages of convenience",* and therefore, the vessel, by tendering NOR before returning to the waiting place, did not become an arrived vessel (Szteinduchert 2017).

The decision formerly derived in the *Johanna Oldendorff* case has, in fact, not been questioned. If the CP had not prescribed that the vessel shall not navigate to the port if the berth was not available, the decision by the court might have been different.

The ambiguity as to whether a vessel shall be deemed an arrived ship is also addressed and likely remediable by the incorporation of a WIPON clause.

In *Navalmar UK Limited v Kale Made Hammadeler Sanayi Ve Ticaret AS 2017 EWHC 116 (Comm) (The MV Arundel Castle), the vessel* had, due to the unavailability of the loading berth, been advised by the PA to anchor at a position indicated by them (Szteinduchert 2017). The printed text of the GENCON 94 CP clause 6 and clause 15 of Recap stated that:

> *clause 6*
> *"If the loading/discharging berth is not available on the Vessel's arrival at or off the port of loading/discharging, the Vessel shall be entitled to give notice of readiness within ordinary office hours on arrival there…Laytime or time on demurrage shall then count as if she were in berth…(Szteinduchert 2017)."*
> *clause 15 of Recap*
> *"(Notice of Readiness) to be tendered at both ends even by cable/telex/telefax on vessel's arrival at load/dish ports within port limits. The [notice of readiness] not to be tendered before the commencement of laydays (Szteinduchert 2017)."*

While the fixture recap solely referred to the port as the place where a valid NOR is to be tendered and hence the stipulations therein shall prevail when there are inconsistencies with other terms, the ship owners were not in the position to claim that the NOR had been validly tendered (Szteinduchert 2017).

In response, the ship owners tried to invoke that their vessel was within the port when the NOR had been tendered (Szteinduchert 2017). Their attempt had, however, been rebutted by the Commercial Court, which stated that it was not clear whether the area at which the vessel waited was part of the port as its delimitations could not be clearly defined (Szteinduchert 2017). The vessel that stayed less than one nautical mile from an area that had been considered to be within the limits of the port was not entitled to demurrage paid by the charterers (Szteinduchert 2017).

In Glencore Grain Ltd. v Flacker Shipping Ltd (C) case *(The Happy Day), where* the vessel had been voyage chartered from the Black Sea to South Asia, an anticipatory NOR had been tendered due to tide-related navigational constraints. Even though the preponed NOR had not been effectively tendered, no further actual NOR had been submitted (Kempson and Wagland 1998). While the charterers did not decline the receipt of the invalid NOR, they subsequently argued that, since no valid NOR has been given, Laytime has not been consumed and therefore, they are entitled to receive dispatch money (Kempson and Wagland 1998).

By applying the following reasoning, the court came to the conclusion that laytime shall have been consumed as if the vessel had tendered a valid NOR (Kempson and Wagland 1998).

If a vessel's master has tendered an advanced but ineffective notice and the charterers were aware of the subsequent actual readiness, the notice may still be given effect (Kempson and Wagland 1998). Of importance, the charterers did not decline the received notice, nor did they demand a newly issued effective NOR, nor did the absence of an effective NOR influence cargo operation (Kempson and Wagland 1998). An ineffective notice might therefore be given effect by the acts and omissions of the charterers.

Findings

The Common Law appears to give room to individual contractual stipulations which are reflected by insertions into contracts as to when and where a NOR is deemed to be effectively tendered, a vessel is delivered into the charter and laytime consummation to commence or pause. A precondition hereto is that a vessel is to be seen as an arrived ship and that impliedly the port stay segment had begun and its preceding navigation segment ceased. Nevertheless, even though anticipatory notices might be treated as validly tendered, NOR submissions are not required, or destination terms are widely construed, English Common Law rulings seem not to have addressed specific JIT arrival issues under voyage charter regimes. To our knowledge, there are no specific legal cases, for example, listed in the law repository Westlaw Edge UK by Thomson Reuters, that thematise the aspects of being an arrived ship, consummation of laytime, tendering and accepting of NOR in the light of JIT navigation.

The following questions may also be employed to approximate the described problem, which has not been answered by reviewing past and contemporary cases sought in the litigation.

1. Shall the port term only apply to static places at which a vessel is idle, or may the term be construed as embracing areas a vessel is navigating through? (JIT navigation is nothing else than a form of spending idle time)
2. Might a navigational passage under JIT navigation through national and international waters be deemed subject to the control of the relevant port authorities or its agents? (incl. the VAS operator)
3. Might advice and instructions given under voluntarily applying VAS' be construable as orders given by the port or their agents in the meaning of the Johanna Oldendorff case?

However, presuming that those questions could have been positively answered, it remains to be responded whether an estimated arrival time established through an anticipatory notice or by a CTA awarded by the port administration can be utilised to set the beginning of laytime counting.

The absence of relevant cases does however not necessarily imply that viable solutions to deal with JIT navigation under voyage charter conditions have not been found nor that disputes have not arisen and sophistically addressed. A reason thereto may be seen in tradition and in the tendencies of owners and charterers to try to resolve their disputes outside courts confidentially and in a more commercial-minded and balanced way. Consequentially, the Common Law may lack occasions to develop in the field. The well-established NVAS may, however, be seen as an indication that viable solutions are achievable for the concerned parties.

From a commercial point of view, an array of aspects that is even to be contemplated for standard port calls without the influence of JIT mechanisms may often be perceived as an array of vagaries. It is therefore clearly understandable that, as a matter of prudence, contracting on the basis of vague or commercially not sufficiently approved terms is commonly avoided by owners and merchants.

In the attempt to circumvent potential issues that could arise from changes in operational behaviour concerning the status of being an arrived ship, we like to introduce a further and alternative notion. Hereunder a vessel shall become an arrived ship by reaching a stipulated destination as defined in the *Johanna Oldendorff* case.

The value of time that has elapsed between the CTA and the Actual Time of Arrival (ATA) to the destination and to, which we like to refer to as Negative Grace Time, shall be subtracted from the ATA subject to time advancements and delays that would have been incurred if the vessel had navigated at its planned or reasonable dispatch speed whichever should be applicable.

The material difference to the common application of various forms of Grace Time is that the earliest possible commencement of Laytime counting is not referred to as a point in future but in the past. Contrary to our initially proposed notion, there would no commitments by the charterers be required in relation to additional notices of readiness during the navigational stage. The corresponding navigational risks that remain are clearly attributed to the owners. Regarding loading operations, subject to individual agreement, there may be less likely issues regarding the avoidance of the charter contract where the laydays/laycan cannot be met by the owners. Whether the notion would align with the scope of the Common Law framework remains equally to be tested.

Application/adaptation alternatives

An (augmented) acceptance of the FRL VAS arrival method might potentially be achieved where the recommended speed and timing parameters are formalised or otherwise supported by a relevant authority. In particular, where recommended speed and/or timing parameters are construable as compliant with due dispatch, commercial and legal issues that presently obstruct the employment of private JIT and VA agreements might be remedied.

Nevertheless, by the operation of the FRL VAS, owners and charterers shall not be deprived of discarding speed or timing advice and adapt an elevated velocity according to their individual needs (i.e., to gain time required for repair, maintenance or cargo hold preparation). Therefore, designed as a non-mandatory arrival mechanism, the VAS' port limits may retain their genuine validity for vessels departing from a localisation bounded by the BAL and the FRL and where owners do not opt to participate in the scheme (vessels departing from within the FRL corridor may equally be furnished with an LTA and a lineup position as part of the standardised FRL redetermination process).

Theoretical case study description and application

As a comprehensive case study comprising real and simulated values has not yet been made, the preliminary results of a theoretical exercise are depicted. In order to compare and contrast fuel savings which are perceived as route cause for CO2 and harmful substances emissions, two distinct arrival mechanisms (FCFS and static VAS) have been selected for benchmarking. A general-purpose Panamax Dry Bulk Carrier, which has 80,000 DWT capacity, and which correlates with a customary DWT segment within the bandwidth of the PON's coal terminals, is selected for the case study.

The performance benchmarking at the present stage is only referred to the estimated fuel consumption under the distinct arrival mechanisms and directly attributable to propulsion by the main engine.

Situation description/scenery setting

Due to continuous situation assessment, a berthing opportunity NABSW, for the next registering vessel has been identified in 12 days (RTA: 01/01/2020 00:00) on 20/12/2019 00:00. Following the said identification, the initial FRL outreach is being defined by multiplying the TTG to NABSW and corresponding RTA with the minimum safe and sensible navigation speed utilised by the FRL VAS (ASPEED min). Hence no unregistered but qualified vessel could be identified, the FRL outreach is being inclined by utilising a gradually increased speed value ASPEED actual. Two similar unregistered vessels marginally distant from each other have been recognised at a distance of 2,880 nm from the FP/ destination port by employing ASPEED actual of 10 nm/h. It is hereby assumed that speed advancement and/or deterioration do not apply or that their total amount is equal to zero. Therefore, Speed over Ground (SOG) and STW are deemed to be identical. Through the process of registration, the first, marginally closer to the FP positioned vessel, is being allocated with the NABSW, which is deemed to correlate with its RTA to the FP. From the moment of registration, the 1st vessel starts proceeding with 10 nm/h (STW, SOG) to the FP to arrive JIT. Concerning the second, marginally more distant registering vessel, an RTA has been identified exactly 14 h after the first vessel's RTA (RTA 2nd VESSEL: 01/01/2020 14:00:00).

Assumptions/limitations for the case

The following enlisted assumptions in Table 1 have been made to relate the estimation and benchmarking of results to operational practice as well as to create a level playing field by common underlying conditions.

Findings and discussions

The displayed findings are solely assumptions; therefore, behaviour evaluation and result benchmarking are still intended to be made.

As anticipated, the estimated consumptions of HFO/IFO for propulsion for the 1st and 2nd vessels appear to be most substantial under the governance of the traditional FCFS mechanism. With great distance, the 2nd highest consumption of fuel is attributed to the static VAS mechanism, followed by the consummation of fuel under the FRL VAS mechanism. Results of the case application are presented in Table 2.

1st vessel

Corresponding to a distance of 2880 nm and coinciding with the moment the NABSW of the 1st vessel and the RTAs for the 1st and 2nd vessel have been known, the fuel consumption for the 1st vessel is estimated to be 421 tons under the FCFS, 215 tons under the static VAS and 196 tons under the FRL VAS mechanism.

The fuel-saving potential for the 1st vessel compared with the traditional FCFS mechanism, therefore, amounts to 206 tons under the static VAS and 225 tons under the FRL VAS mechanism.

Table 1 Theoretical exercise assumptions

	Vessel/voyage characteristics	External effects
General conditions/assumptions	Equal dimensions and technical details	(Nautical) Speed advancement and -delay effects are deemed not to apply for any route (total value of wind-, sea-, swell and current effects are deemed to be equal to zero, SOG equal STW, DOG equal DTW)
	Equal awareness concerning berth availability (NABSW)	(Administrative) Speed advancement and -delay effects are deemed not to apply for any route (i.e. absence of speed limitations concerning TSS)
	Equal distance to FP when awareness of NABSW is gained	(Physical obstruction) Speed advancement and -delay effects are deemed not to apply for any route (i.e. absence of shallow water areas, narrow passages)
	Common Due Dispatch (DD) Speed	Distance Increments of any nature (i.e. by island, off shore structures etc.) are deemed not to apply for/ to any route
	Potential main engine utilisation to i.e. respond immediately to hazardous situations while adrift or at anchor is not taken into consideration	
	Utilisation of distillate fuels for the operation of auxiliary engines is not taken into consideration	
	Minimum safe and sensible navigation speed is deemed to be 9.0 nm/h	
FCFS mechanism	Continuous Due Dispatch (DD) Navigation	
Static VAS mechanism	Notified Time of Arrival (term adapted from NVAS), 7 days	
	Prior to Notified Time of Arrival continuous DD speed applied	
FRL VAS	1st. Vessel's RTA deemed to be equal to the NABSW (JIT arrival)	

The difference attributable to the fuel consumption by the 1st vessel under the static VAS and the FRL VAS appears thereby to be about 19 tons.

Concerning speed alignment to arrive at the FP/ destination port JIT, it has been identified that the 1st vessel is able to adapt its velocity from DD speed to ASPEED actual of 10 nm/h ab initio from the moment of registration (2880 nm distant from FP). On the contrary, under the static VAS mechanism, the 1st vessel is to navigate at a DD speed of 14.5 nm/h until the Notified Time of Arrival (7 days prior to ETA FP) is obtained (2436 nm distant from FP). Thereby the navigation speed is instantly declined from 14.5 to 9.5 nm/h.

2nd and more vessels

Equal to a distance of 2880 nm from the FP and coinciding with the moment the RTA for the 1st and 2nd vessels have been known, the fuel consumption for the 2nd vessel to arrive JIT 14 h after the RTA of the 1st vessel is estimated to be 421 tons under the FCFS, 199 tons under the static VAS and 176 tons under FRL VAS mechanism.

Table 2 Comparison of results for the theoretical exercise [Fuel prices excerpted from Ship and Bunker on 12th October 2021 for the same date (S&B 2021)]

Vessel arrival mechanism	Unit/format	First vessel			Additional vessel		
		FCFS	Static VAS	FRL VAS	FCFS	Static VAS	FRL VAS
Requested time of arrival (RTA)- for 1st vessel (NABSW)	dd/mm/yy/hh/mm	01/01/2020 00:00			01/01/2020 14:00		
Distance to go (DTG)	nm	2880			2880		
Due dispatch (DD) Speed	nm/h	14.5			14.5		
First come first serve (FCFS) Speed	nm/h	14.5			14.5		
Static VAS							
Static VAS, speed prior to be awarded with notified arrival time	nm/h		14.5			14.5	
Static VAS, speed subsequent to being allocated with notified arrival time	nm/h		9.5			9.0	
Speed to meet requested time of arrival (RTA)				10.0			9.5
Fuel consumption for propulsion (i.e HFO/IFO 380)	ton	421	215	196	421	199	176
Fuel consumption differential (i.e HFO/IFO 380) (basis FCFS mechanism)	ton		206	225		222	245
Fuel consumption differential (i.e HFO/IFO 380) (basis static VAS mechanism)				19			23
Fuel price	USD/ton			528			
Fuel expenditures	USD	222,288	113,520	103,488	225,385	106,574	94,222
Fuel expenditures differential (basis static VAS mechanism)	USD			10,032			12,351

While the fuel consumption attributable to the 2nd vessel is equal to the fuel consummation of the 1st under the FCFS mechanism, the reduction of fuel consumption for the 2nd Vessel under the static VAS mechanism appears to be substantial but less significant

Fuel Specs	Pricing Basis	Procurement Date	Difference	Procurement Date	Difference
		12. October 2021	USD	10. May 2022	USD
MGO	Global Average Bunker Price	758.3	230.3	1275.3	545.8
IFO 380		528.0		729.5	
VLSFO		642.0	114.0	958.0	228.5

Fig. 8 Fuel prices excerpted from Ship and Bunker on, 26/05/2022 (S&B 2021)

than under the FRL VAS mechanism. Therefore, the second vessel's most extended fuel-saving is clearly attributed to the FRL VAS.

While the fuel expenditures concerning the above desktop study have been confined to Main Engine for propulsion, they do not solely depend on the amount of fuel saved but on fuel specifics and prices.

For instance, IFO 380 fuel-consuming vessels (using scrubber techniques) are less benefitting from fuel savings than similar vessels which are required to consume very low sulphur fuel (VLSFO) to comply with the IMO 0.5% sulphur emissions cap that applies to vessels navigating beyond emission control areas (ECA). Wider savings may even accrue if JIT navigation is undertaken within the IMO (2018) defined Emission Control Areas like the Baltic Sea area; the North Sea area; the North American area (covering designated coastal areas of the United States and Canada); and the United States Caribbean Sea area (around Puerto Rico and the United States Virgin Islands) where vessels are required to observe a sulphur cap of 0.1%. To comply with the sulphur cap, vessels might be required to consume comparatively expensive Marine Gas Oil (MGO).

To illustrate the quantitative effects of fuel quality and -procurement timing, a reference has below been sketched to the Global Average Bunker Price for the first half of October 2021 and May 2022. The savings if fuels other than IFO 380 are consumed might therefore be higher than those mentioned in the desktop study (Fig. 8).

Conclusions and future works

The exercise is clearly indicating that to varying degrees, EE potential, without abandoning the underlying ideology of the FCFS concept, may be exerted by transforming potential idle into navigation time via JIT arrival mechanisms. Thereby an early definition of berthing prospects via RTA, particularly concerning the FRL VAS mechanism, paired with speed alignment at the earliest opportunity (ideally at maximally extended FRL) is desirable.

Therefore, any VAS may strive to permit JIT navigation to be undertaken with(in) sufficient time/distance and scope to reduce speed. Essentially, the earlier but less pronounced speed reduction is to be given preference over more extensive but later initiated adjustment. Hence under static VAS mechanisms, notified times of arrival are strictly allocated a set number of days prior to estimated times of arrival (ETA) vessels are required to proceed with due dispatch (speed) until being furnished with them. In a case where the speed required to arrive JIT would be less than the sensible navigation speed (ASPEED min), only the latter may be pursued, idle times not prevented, and EE enhancement potential forgone.

Since under static VAS arrival mechanisms, empirical-based time spans are employed to obtain Notified Times of Arrival JIT- speed alignments are to be seen as compromises and less as individual responses. The dynamically aligning FRL (corridor), delimited only by its maximum geographical outreach, to the contrary, is responding to each situation assessment. An abrupt decline of speed preceding a comparatively short JIT navigation period may there successfully prevented where the FRL (coordinates) have been advanced to their maximum outreach.

However, whether the FRL VAS arrival mechanism's sketched potential can be exerted under actual operating conditions must be tested. The ability to reliably predict terminal operation and nautical conditions, including but not limited to the effects of wind, sea, swell and current, may perform, aside from other constraints, as an inherent application boundary.

Irrespective of the previously mentioned immediate propulsion concerned fuel-saving, the operation of either arrival mechanism may also embrace indirect and less visible effects.

These include, for instance, the consumption of fuels during navigation periods and idle times as well as grounding, collision, security and health risks entailed by navigation, drifting and anchoring.

The JIT navigation entailed effects and thereto attributed benefits, guided by the criteria to whom and when they are likely to aggregate, are here distinguished into voyage specific, future relevant, commercial (owners, charterers, third party specific) and public benefits.

Unlike fuel consumption attributable to propulsion, fuel consummation during idle times, which embraces aspects of immediate responsiveness to navigational hazards, generation of electricity and boiler operation, is complex and to be assessed by the merits of each voyage. To prevent navigational hazards such as collision or grounding risks to materialise, propulsion might, for example, be maintained while at anchor or adrift in correspondence to vessel proximity to other vessels, infrastructure and shallow water areas, sea-state, wind direction and force. Fuel(cost) savings may also accrue in relation to electricity generation and whether, for example, shaft generators during navigation instead of auxiliary engines during idle times are utilisable. Thereby, the amount of fuel (per electrical power unit) and the price difference between the utilisable fuels are decisive.

Further JIT-related (cost) savings may relate to hull smoothness, port disbursements, waste heat recovery, prevented damages to cargo and avoidance of uneconomic operation. An ability to pursue navigation without incurring idle times may also provoke less direct voyage-specific benefits as reflected by less insurance premium payable where damage to cargo has been prevented.

While ship owners may share benefits, voyage charterers may also directly benefit from JIT navigation without entering into a sharing agreement where insurance premiums payable for elevated risks (i.e., piracy risks) are concerned. Hence security risks tend to evolve with: entering the proximity of coastal areas, speed reduction or immobilisation, charterers might be able to reduce the insurance premium payable if the vessel can remain outside a high-risk area and/ or maintain navigation.

Hull and propeller smoothness deterioration by biofouling due to idle time duration and water temperature may affect vessel operation and fuel consumption profiles. Increased surface roughness is likely to entail an elevated consumption of fuel, to maintain the desired STW, or a speed loss (STW) if the engine performance is set. Fuel expenditures or navigation time increase, and the TCE for a vessel affected by biofouling may be lower than for a vessel which is free from biofouling. Furthermore, performance deviations from contractually agreed parameters, as under time charter contracts, may be a reason for consequential speed or performance claims and loss compensation payable to charterers. The BIMCO, in its *"Hull Fouling Clause For Time Charter Parties 2019 (*BIMCO 2019*)",* facilitating notes is pointing out that under the (English) Common Law, a carrier is obliged to ensure that his vessel is kept in *"a thoroughly efficient state throughout the charter period".* If conditions cannot be complied with the carrier becomes liable for indemnification.

Oliveira and Granhag (2020) underlined that commercially viable underwater cleaning may not be permitted in each country due to harmful substance depletion and augmented species migration. The BIMCO substantiates the view in its facilitating notes concerning their *"Hull Fouling Clause For Time Charter Parties 2019 (*BIMCO 2019*)"*. Herein, it has been highlighted that while underwater hull cleaning may not be permitted within each territory, vessels may only be allowed to arrive at territorial waters if there is no traceable biofouling on parts of their hull.

JIT navigation not only reduces carbon and other harmful emissions but also may lead to an increment in navigational safety and security.

Even though our conceptualised VAS will likely improve commercial, environmental, and further performance indicators, a critical view in relation to derivable fuel consumption savings is required.

The estimated propulsion-related fuel consummations herein have been derived by applying the admiralty rule, which is based on the presumption of a constant cubic relationship between VSL speed (STW) and fuel consumption. The admiralty rule, referred to and utilised by leading governmental and industrial institutions such as the BIMCO and IMO to ascertain fuel consumption, is recognised as a standard procedure (Merkel et al. 2022). Merkel et al. (2022) criticise that fuel consumption savings derived by applying the admiralty rule might be exaggerated when the adapted speed allocates significantly below the design speed. Therefore relatively exact fuel consummation values are only derivable by applying the admiralty rule in the comparative vicinity of the design speed (Merkel et al. 2022). Corresponding to an increasing delta between design- and reduced speed, the exponential relationship between speed and fuel consumption appears less significant (Merkel et al. 2022). Fuel reduction by adapting a speed below 10 nm/ hour appears to be likely insignificant or absent, more fuel may even be consumed on the grounds that navigational periods are timewise extended (Merkel et al. 2022).

The FRL speed bandwidth may not exclusively be delimited by nautical and technical constraints but by a systematic threshold speed that allocates beyond our presumed minimum FRL speed. Hence a technically feasible but below said threshold value allocated speed is likely to generate additional fuel consummation the FRL minimum speed may require redefinition to correlate with the threshold value.

To avoid uneconomic JiT navigation speeds, an even more stringent focus might be set on advancing the FRL to the largest possible extent, applying speed reductions at comparatively elevated speeds and exerting speed reduction throughout an extended period.

Challenges exist not only in relation to the choice of the mathematical model to ascertain fuel consumption but to the recognition of factors influencing the corresponding computational results. Inefficiencies concerned with the ascertainment of fuel savings aside from barriers imposed by sales- and transportation agreements related contractual duties have been identified as JIT navigation implementation barriers.

The researches of Li et al. (2022), Du et al. (2022a), Du et al. (2022b) however suggest that those inefficiencies are remediable and that findings of satisfactory accuracy to support JiT navigation can be derived. The publication of Li et al. (2022) which forms part of a series of interlinked works with Du et al. (2022a) and Du et al. (2022b), scrutinises the accuracy of fuel consumption assessments subject to combined voyage report- and meteorological data. Du et al. (2022a) addressed the research question of whether further accuracy improvements can be gained by combining voyage reports- with meteorological- and additional AIS data. Du et al. (2022b) extended the research by replacing voyage reports- and AIS data with geographical time—position stamps incorporating sensor data.

Structured data sets were in each part of the research series processed via a defined array of machine learning algorithms with tree-based algorithms found best suited. According to Li et al. (2022) supplementing voyage record based data with predicted geographical positions specific meteorological data does not lead to substantially improved assessment accuracy. The work of Du et al. (2022a) further illustrates that a combination of AIS- and meteorological- with voyage report data does lead to a moderate improvement of assessment accuracy in comparison with the results derived by Li et al. (2022). A substantial gain concerning assessment accuracy in comparison with the findings of Li et al. (2022) and Du et al. (2022a) may however be gained by combining meteorological and sensor data. An essential element appeared to be the selection of the best suited machine learning algorithm which is mirrored by the author' findings that enlist for container VSLs of 8100 to 14,000 TEU capacity range systematic errors of 0.5 to 4.5 tons fuel per day (Li et al. 2022; Du et al. 2022a, 2022b). Fit errors between 0.52 and 0.75 tons per day have thereby been identified for applications where sensor data has been involved (Du et al. 2022b).

The assessment accuracy requiered to sophistically distribute fuel cost savings, as consented by Li et al. (2022), Du et al. (2022a, b) may already be achieved by using traditional voyage report data whereby a combination of data sources can be beneficial. According to Li et al. (2022), Du et al. (2022a, b), a concerted arrangement of readily available data in combination with their processing by suitable machine learning algorithms is already permitting to facilitate VA application. To place a future emphasise on remedying the barrier effects imposed by commercial routines, bounded rationalities, contravening interests, and traditional rules is therefore essentially required.

Even though the relations between JIT arrival undertakings/ mechanisms and the referred aspects remain to be researched, it is hoped that the conceptualised FRL VAS mechanism might benefit sector greening. As a continuation of the present work, a sophisticated model is intended to be developed to (re)model and compare actual and simulated voyages to gain clarity concerning the efficiency of selected arrival mechanisms. The aspect of potential deviations from a presumed constant cubical relationship between speed and fuel consumption not to overestimate fuel savings shall be taken into consideration.

Abbreviations

ADISTANCE	Approach distance
ADISTANCE min	Approach distance attributable to minimum approach speed
ADISTANCE actual	Approach distance attributable to actual approach speed
ADISTANCE max	Approach distance attributable to maximal approach speed
ASPEED	Approach speed
ASPEED min	Approach speed, minimal
ASPEED actual	Approach speed, actual
ASPEED max	Approach speed, maximal
ATA	Actual time of arrival
ATIME	Approach time
BA	Berth allocation
BAP	Berth allocation problem
BAL	Base line
BL	Bill of lading
CFR	Cost (and) freight
CIF	Cost freight (and) insurance
CP	Charter party
CTA	Calculated time of arrival
ECA	Emission control area
EE	Energy efficiency
EEM	Energy efficiency measures
ETA	Estimated time of arrival
ETL	Estimated time of loading
FCFS	First come first serve
FOB	Free on board
FOC	Fuel oil consumption
FP	Focal point
FRL	Flexible reporting line
GTA	Grain trade Australia
GHG	Greenhouse gas
GOSBEA	Global optimization of speed berth and equipment allocations
HVCC	Hunter valley coal chain
HVCCC	Hunter valley coal chain coordinator
IFO	Intermediate fuel oil
IMO	International maritime organisation
JIT	Just in time
LTA	Latest time of arrival
LPOC	Last port of call
MGO	Marine gas oil
NABSW	Nearest available berthing/servicing window
NCIG	Newcastle coal infrastructure group
NOx	Nitrogen oxides
NVAS	Newcastle vessel arrival system
PA	Port authority
PANSW	Port authority of New South Wales
P&I	Protection & indemnity
PM	Particular matter
PON	Port of Newcastle
PWCS	Port Waratah Coal Services
RTA	Requested time of arrival
SAQA	Safety and air quality area
SCoTA	Standard coal trading agreement
SETA	Standardised ETA
SOG	Speed over ground
SOx	Sulphur oxides
STW	Speed through water
TCE	Time charter equivalent
TTG	Time to go
VAS	Vessel arrival system
VESSEL	Vessel
VLSFO	Very low sulphur fuel

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Author contributions
The research had been undertaken by AS and OC, supervised by OT, commented, and reviewed by DU and SAG. Each author read and approved the final manuscript.

Availability of data and materials
The authors herewith declare that data used during their research is available from them on request.

Declarations

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