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A Study of Efficiency Regarding Port Operations on a Passenger Ferry

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ABSTRACT: While revising their "Ship Energy Efficiency Management Plan" [SEEMP] the crew of a roll-on/roll-off [Ro-Ro] passenger ferry in Norway discussed new measures for energy saving. One suggestion was to lower transit speed by reducing idle dwell time in port. The concept was to arrive just in time to handle all cargo before departing. On short distances a couple of minutes would make a noticeable impact on transit speed. A speed reduction leads to lower fuel consumption which has both economic and environmental benefits. Although port operational efficiency has been studied by maritime researchers for some amount of time, there exists a limited supply of literature dealing with passenger ferries and their cargo handling in port. It was therefore necessary to gather more information before implementing this measure in the ferry's SEEMP. An observational field study was carried out by one of the navigators, where different variables related to cargo handling in port was measured. Throughout the field study it was discovered that the ferry had idle time in port on several occasions. Among the factors that were discussed it was recommended that transit speed should be reduced by 0,5 knots to save fuel. The results were then summarized in this article and distributed with the intent of sharing our experiences.

1 INTRODUCTION

The shipping industry is responsible for a large portion of the worlds greenhouse gas [GHG] emissions. According to IMO the emissions increased from 977 million tonnes in 2012, to 1076 million tonnes in 2018 [1]. As of 2018, shipping is responsible for 2,89% of the global anthropogenic emissions. To handle rising GHG emissions from shipping, IMO has implemented several measures. One important measure is the Ship Energy Efficiency Management Plan [SEEMP] which is mandatory for all ships above 400 GT. It was adopted as an amendment to MARPOL Annex VI at MPEC 62 in 2011 [2]. The SEEMP is an operational measure that fosters fuel efficiency on board ships. It consists of goals for energy saving, measures that should be followed and how to monitor energy usage in daily operations. Typical measures for energy efficiency are speed optimization, weather routeing and efficient use of ship equipment [3]. The SEEMP is usually developed by the crew of each vessel and thus specified for its operation. Furthermore, the document should be revised on certain intervals, for example when experiencing extensive changes to daily operations.

Most passenger ferries in Norway are required to create a SEEMP and implement energy saving measures. For years the ferry operators in Norway have strived towards lowering emissions and reducing the cost of operations. Economic rewards in combination with strict government regulations have fostered company policies demanding efficient ferry operations. Tough competition between shipping companies in combination with increasing fuel prices puts pressure on operating personnel to reduce unnecessary expenses. On the other hand, this has also led to an exciting development in the industry of ro-ro passenger ferries. New ferries are built with other energy carriers besides marine diesel oil [MDO] and liquid natural gas [LNG], such as electric [4] and hydrogen power [5]. Autocross and autonomous sailing are also in the making [6], both providing more energy efficient operations.

2 BACKGROUND

The crew of a passenger ferry in Norway were discussing possible changes to the ships SEEMP. The ferry operator encouraged new ideas and challenged crew members to implement these energy saving measures. Among several suggestions, port efficiency was highlighted as a possible energy saving area. Studies on container shipping has shown that more efficient port operations have led to less fuel consumption because of speed optimization [7]. On this particular connection it was widely known that the ferries had idle time during port operations. The next section will present the ferry and the connection in detail.

2.1 *MF Glutra*

The crew worked on MF Glutra as seen on figure 1, which is a ro-ro passenger ferry that runs on LNG. The ferry was delivered in 2000 from Langsten Yard and later modified in 2010 at Remontowa in Poland. MF Glutra has IMO number 9208461 and it is built as a monohull, aft-bow symmetrical vessel with one Schottel STP 1010 azimuth thruster in each end [8]. The ferry operated on the Molde-Vestnes connection as part of E39 in Norway during this field study.

Figure 1. MF Glutra viewed from starboard side, arriving in port during normal operation [8].

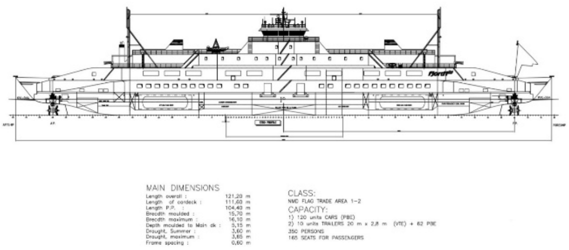

Figure 2.General arrangement and main dimensions of MF Glutra [8].

MF Glutra is designed to transport maximally 120 car equivalent units [CEU] and 350 passengers as presented in figure 2. CEU is a standard reference unit for 4,3m long vehicles [9, p. 30] used by The Norwegian Public Roads Administration. Furthermore, figure 3 presents a loading condition with 120 cars and a loading condition with 10 trailers and 62 cars. This is meant as an illustration to how the lanes are organized. The main deck also includes two designated spaces for dangerous cargo in each end, as well as evacuation zones and walkways. All large vehicles are placed on this deck while the side house deck is used for cars. Notice that trucks are meant to be stowed in the two lanes close to the centreline, to maintain stability.

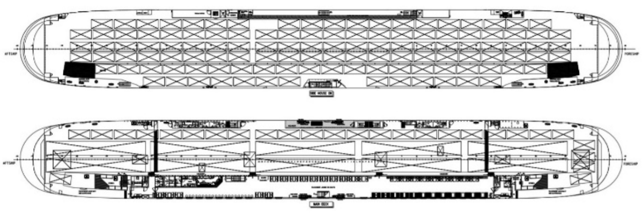

Figure 3. Different loading conditions as seen from above, where squares represent a vehicle. Side house deck is not displayed on the bottom half [8].

2.2 *Molde-Vestnes connection*

This connection is the 4th largest in Norway measured in cargo transported annually [10]. Molde-Vestnes is part of E39 and at the time of this study is operated by 4 ro-ro passenger ferries from Fjord1, each with a capacity of 120 CEU. The distance from each port is approximately 6,5 nautical miles and with a transit speed of 12 knots the voyage should take 37 minutes. Dwell time is usually 8 minutes, but the ferries can adjust arrival time without economic repercussions from the government. Similar to other connections, there are major traffic variations during the day.

Most navigators on this connection chose to sail with a transit speed of 12 knots to avoid delays in port. One major reason for this is that the schedule is quite strict making it harder to reduce possible delays by increasing vessel speed. Furthermore, a delay on one ferry could cause delays on the other ferries considering that each port has infrastructure to handle just one ferry simultaneously.

2.3 *Dwell time and fuel efficiency*

Dwell time has an impact on the other phases of operation for a passenger ferry. However, the extent varies depending on the ferry and the connection. Ro-ro passenger ferries are an essential part of the Norwegian road network with 133 active connections [10] across a series of fjords, channels and straits. In total, these connections transport over 34.000.000 CEU yearly [11]. In recent years, the ferry operators have met increasing and stricter demands concerning emissions, punctuality, and operational reliability. Depending on the region, authorities will demand economic redress from shipping companies that do not uphold these regulations.

Ferry connections in Norway are quite diverse. Some connections are maintained by multiple ferries while other connections require just one. Timetables, crew size, ferry design and equipment on board differs across the ferry fleet. Tourism or major traffic variations also induce a seasonal increase in ferries on specific connections.

Although there are some differences, the operation is similar. Ferry operations are split in different phases as shown below [12, p. 3]:

1. Ferry arrives at dock and keeps itself in place using its propulsion equipment/mooring.
2. Hatches and doors open which let the vehicles and passengers off the ferry.
3. Ferry personnel guides waiting vehicles and passengers on-board the ship.
4. Hatches and doors close.
5. Ferry undocks from the current harbour and starts transiting to the next one.
6. During transit and docking/undocking ferry personnel takes care to follow the International Regulations for Preventing Collisions at Sea (COLREGS) to avoid any collision.

When sailing between ports, ferries have three distinct phases. These are acceleration, transiting and retardation. Depending on the connection, some ferries also use the propulsion equipment to position the ship along the pier during cargo handling. These phases have a great influence on each other as exemplified in figure 4.

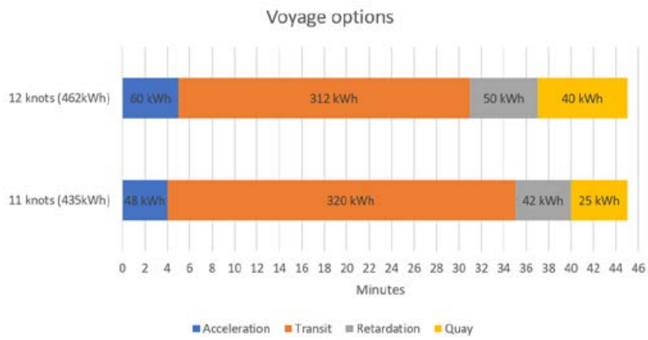

Figure 4. Voyage options for MF Glutra [8].

The information in figure 4 is gathered from MF Glutra when sailing on the Molde-Vestnes connection. Although the vessel operated on LNG, it is natural to use the term kWh when discussing energy efficiency. This is because the ferry operator standardized kWh as the unit for energy consumption in their vessel fleet. The integrated automation system will therefore display kWh on all ferries, for all types of energy carrier used for propulsion. Kilowatt-hour (kWh) is a well-established measure of energy consumption and consists of the SI-unit Watt, multiplied with 1000 (kilo) and 1 hour.

Four different phases are shown with the corresponding energy consumption during normal operations. The total amount of time for one voyage is 45 minutes and this cannot be exceeded. If the ferry accelerates to 12 knots, it will need approximately 5 minutes and 60 kWh during calm weather. When accelerating the consumption per minute is identical in both cases but reaching 11 knots is achieved faster. Transiting in 12 knots would require more energy per minute, but the destination is reached faster. Thus, the consumption is almost identical. The retardation phase is a little bit longer when sailing in 12 knots because the vessel needs longer time to reduce speed. Here the power demand is estimated to be at 500 kW to maintain proper steering. Naturally the last phase in quay is shorter when sailing in 11 knots, but the total energy consumption for the whole voyage is lower. Notice that the ferry uses its propulsion to position itself along the pier, and that power demand is estimated at 300 kW. Reducing dwell time while still handling all cargo within the timetable would therefore be a positive measure for energy efficiency. Based on the example in figure 4, optimizing transit speed benefits the ferry operator. However, it is difficult to estimate the proper transit speed because terminal time is uncertain. In essence, estimating terminal time in port is crucial to save fuel during other phases of operation. The reason why is further explained in figure 5 below.

Figure 5. Combined power demand on the propulsion equipment at different velocities [8].

Figure 5 is copied from the ferry's SEEMP. It shows how the power demand is affected by vessel speed. Although vessel speed is affected by several factors, such as wind, current, growth or loading condition [13], the propulsion system is the main cause for velocity. The propulsion equipment requires power from the main engines, which in turn consumes fuel. Depending on the engine, fuel consumption is described as having an exponential correlation with engine load on most ships [14].

On the other hand, reducing speed to a bare minimum is not profitable either. Conventional marine engines usually work most efficiently between 70-90% load [15]. The key theme here is therefore to reduce speed if it is fuel efficient.

To summarize, terminal time has a great effect on the other phases of ferry operations. In theory there could be potential economic and environmental benefits to be gained through careful planning of every voyage and terminal operation. Adapting a vessel speed that provides sufficient time for unloading existing cargo as well as loading new cargo would be more effective than what is practiced today on some connections.

3 FIELD STUDY

Hoping to be able to reduce transit speed and save fuel, it was necessary to observe cargo handling in port. What needed to be uncovered was how much idle time the ferry experienced and how much the traffic varied. Loading and unloading efficiency was also observed. The specific research questions were formulated like this:
– How long is the dwell time?
– How long time is spent on equipment handling?
– How efficient is the unloading?
– How efficient is the loading?
– How long is the idle time?

To answer these questions a field study was organized. An observational field study falls within the category of descriptive quantitative research [16, p. 154] where a phenomenon is described as it is while interfering as little as possible. All crew members were told to act as normal during these observations.

3.1 *Data gathering*

The first research question was to observe total dwell time. This is the period between vessel movement dedicated for cargo handling in port. In other words, terminal time starts the moment the ferry has positioned itself alongside the pier and reached a speed of 0 knots. Terminal time ends when all hatches and doors are closed, and the ferry starts embarking. This definition is chosen because the on-board Ship Performance Monitor (SPM) also applies this definition. Dwell time was registered from the ship SPM on the bridge. All navigators were told to sail with 12 knots speed over ground during transit.

Upon arrival the navigator stood on the bridge with a stopwatch. This was used to measure unloading and loading of vehicles. Equipment handling was also measured by stopwatch. This includes handling of gates, hatches and doors when arriving and embarking. This is a fixed value that does not change.

To measure efficiency the crew also requested traffic logs for the observations. These were provided by the ferry operator. Finally, idle time had to be observed. This was done by taking the dwell time for each observation and subtracting the time spent handling cargo or equipment.

When planning the field study, it was necessary to establish how many observations were needed and a timeframe. The SEEMP had to be finished in November. It was therefore decided that the observations were conducted in October and that we aimed for as many as possible. The observations would be done at different times of day when the author was available.

3.2 *Molde ferry terminal.*

Every observation was made in Molde, as shown on figure 6. When vehicles are unloading, they use a road consisting of two lanes that travel unobstructed for approximately 300 m. Here it reaches an intersection. During heavy traffic this could lead to slower unloading and a possible traffic jam. The two lanes that are assigned for unloading combines into one lane near the intersection. Unloading vehicles must therefore merge as efficiently as possible to avoid congestion. Vehicles waiting to embark are stowed on the three lanes in the upper half of the figure. In the end it should also be mentioned that pedestrians are physically separated from vehicles using designated walkways. These two groups are handled simultaneously but still unaffected of each other.

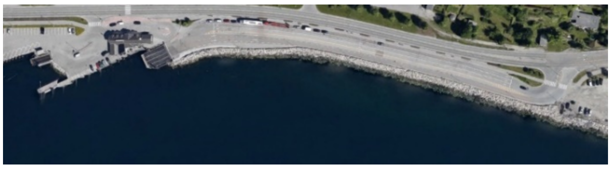

Figure 6. Molde ferry terminal [17].

3.3 *Unloading phase*

Figure 7 presents a detailed description of unloading in port. Shortly before arrival the visor in the stern is lifted in upright position. When the ferry is carefully positioned alongside the pier, the able seaman (AB) will adjust the linkspan's height depending on tidal waters using a remote control. When the front of the linkspan rests on the ferry's stern loading shelf, the AB will open the loading ramp. Finally the automatic gate will open, indicating that unloading can safely commence. AB will decide which lane is unloading first. On MF Glutra the ramp is quite wide and therefore it is possible to unload two lanes simultaneously. Pedestrians walk on a passenger walkway, sheltered from the vehicles.

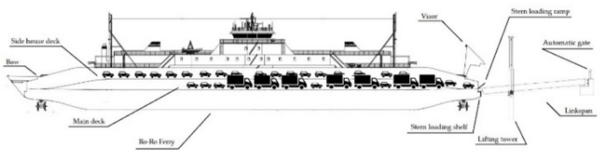

Figure 7. Overview of cargo handling operations on MF Glutra.

Unloading operations on passenger ferries are regulated in Norwegian law [18] and company procedures [8]. It states that drivers must follow crew instructions and that vehicles only move when a signal is given. Figure 8 illustrates an unloading operation where the AB has just finished choosing which vehicles unload first.

Figure 8. Unloading vehicles in Molde ferry terminal.

There are several situations that can arise when unloading. Some ferries have had a heeling angle so large that it could not unload [19], others have experienced tidal waters that restrict heavy vehicles from unloading [20]. Some cars fail to start, some drivers are asleep during unloading or some are not even present in their cars. All these situations lead to longer terminal time, although they are out of control for the crew.

3.4 *Loading phase*

When the ferry is completely empty, loading starts. This phase is also regulated in law. It states that vehicles might only drive onboard on signal and that they follow the queue of which they arrived on the quay. An exemption here is if stability or other factors makes this impractical. There are also some vehicles with priority, such as buses and emergency services on the job. The AB must place vehicles according to the stowage plan. Emergency zones must be unobstructed, and the passenger tally must be reported to the bridge before departure.

Figure 9. Loading and stowing vehicles in Molde ferry terminal. Designated area for dangerous goods is thoroughly marked on the deck, using red paint.

In this phase it is only possible to load one lane at a time as illustrated on figure 9. There are also some scenarios that can lead to longer loading time, for instance cars that park in the evacuation zone and must be moved. Furthermore, there is a risk of collision between vehicles and passengers or crew members.

3.5 *Limitations*

Although this method is believed to be reliable, there are some limitations that affect the results. One problem is related to sea-level fluctuations caused by tides. During high tide or low tide, some large vehicles tend to drive slower to reduce the risk of material damages underneath the car. To some extent, this limiting factor could also be applicable when there are lots of heavy trucks stowed near the perpendiculars, providing an unwanted forward trim during unloading. Figure 10 provides an example of this limitation where two heavy trucks are placed in the bow. Unfortunately, these factors have not been accounted for in this study. A different limitation is related to capacity problems on the port facility during unloading. When a fully loaded ferry unloads all vehicles at once, there is a potential risk of traffic congestion present.

Figure 10. Example of one limitation where heavy cargo is placed in the bow, potentially slowing down unloading operations.

Another limitation is associated with the complexity of port operations. This method does not necessarily cater for the diversity of driver characteristics, where some might accelerate faster than others or maintain a higher speed during loading or unloading.

These factors are hard to cater for and as a result the observations cannot be viewed as undisputed facts but descriptions of a trend. Although there are some limitations to this study, they have been deemed not severe enough to invalidate the results. The study was therefore completed, knowing about these limitations.

4 RESULTS

The result of the study is presented in the following pages. It was conducted 36 observations in Molde ferry terminal, between the 2. of October and 30th of October 2020. There are certain gaps between the dates, but this is due to the working schedule of the author. Furthermore, the time of day is not the same for each date. This is because the observations were conducted by the author while performing other work related tasks. Sometimes it was not feasible to conduct an observation. If any inconsistencies were present, such as a car failing to start, the observation would be deleted from this study.

Equipment handling was measured at 45 seconds. This includes opening or closing hatches, handling the gate and linkspan. These seconds are already accounted for in the idle time column in table 1 below. Information about registered traffic during loading and unloading on these dates was provided by the ferry operator. The cargo for both loading and unloading is presented using CEU, which is a standard reference unit for vehicular cargo, as mentioned in chapter 2. The time column show the next scheduled departure from Molde.

Table 1 show that there are several observations that have long periods of idle time. One exemption is observation 36 which exceeded the timetable by 36 seconds. The most important figures from table 1 are presented in table 2 below.

Table 1. Registered traffic during the observational study.

DT – Dwell time; CU – CEU Unloaded; TU – Time unloaded
CL – CEU Loaded; TL – Time Loaded; IT – Idle time

	Date	Time(LT+1)	DT	CU	TU	CL	TL	IT
1	02.10.20	14:00	480	65,15	133	63,89	249	53
2	02.10.20	17:00	470	81	171	35	149	105
3	02.10.20	18:30	465	85,33	185	17,23	64	171
4	02.10.20	20:00	483	17,55	38	16,93	61	339
5	19.10.20	09:30	477	10	31	19,6	72	329
6	19.10.20	11:00	445	30,11	67	21,52	60	273
7	19.10.20	12:30	491	27,58	65	13,74	43	338
8	19.10.20	14:00	435	19,74	50	12,30	51	289
9	19.10.20	15:30	444	37,82	56	19,24	76	267
10	19.10.20	17:00	487	34,15	66	25,65	77	299
11	19.10.20	18:30	490	10,91	24	13,82	46	375
12	20.10.20	09:30	456	24,68	41	30,02	98	272
13	20.10.20	11:00	420	11,53	25	11,23	39	311
14	20.10.20	12:30	434	27,89	56	17,59	56	277
15	20.10.20	14:00	456	35,70	85	55,34	193	133
16	20.10.20	15:30	477	39,18	92	21,23	80	260
17	20.10.20	18:30	456	18,23	53	4	16	342
18	22.10.20	09:30	454	24,5	39	27,23	95	275
19	22.10.20	12:30	489	41,16	75	22,55	72	297
20	22.10.20	15:30	411	41,79	93	50,61	179	94
21	22.10.20	18:30	434	41,91	72	26,97	70	247
22	23.10.20	09:30	454	22,05	44	31,16	114	251
23	23.10.20	15:30	467	45,17	93	68,25	257	72
24	23.10.20	18:30	487	70,06	140	16,09	62	240
25	26.10.20	09:30	454	17,9	19	27,55	84	306
26	27.10.20	09:30	421	48,55	75	16,08	41	260
27	27.10.20	12:30	489	14,8	40	9,825	28	376
28	28.10.20	09:30	456	28,51	60	14,84	55	296
29	28.10.20	12:30	485	43,97	89	18,55	47	304
30	28.10.20	15:30	498	43,48	83	35,68	105	265
31	28.10.20	18:30	434	18,30	47	11,45	32	310
32	29.10.20	09:30	411	30,44	65	21,82	88	213
33	29.10.20	12:30	453	27,05	59	8,627	30	319
34	29.10.20	15:30	421	22,44	47	31,83	129	200
35	30.10.20	12:30	456	49,11	94	39,2	122	195
36	30.10.20	14:00	482	56,68	134	80,25	339	-36

Table 2. Key figures.

	Dwell time	Idle time
Shortest observation	411 seconds	53 seconds
Longest observation	498 seconds	376 seconds
Average observation	458,94 seconds	247,69 seconds
Least efficient observation	23,10%	
Most efficient observation	88,95%	
Average efficiency	45,98%	

As shown in table 2, there are large differences between the observations. Efficiency describes the idle time as a portion of the total dwell time for each observation. This is further illustrated in figure 11.

Figure 11. Port efficiency

Figure 11 compares idle time and dwell time for each observation in the field study. Notice the fluctuating results for idle time in port. Dwell time also deviates from the goal of 8 minutes, but not substantially.

Table 3. Key figures from the study

	Unloading	Loading
Longest observation	185 seconds	339 seconds
Shortest observation	19 seconds	16 seconds
Average observation	72,38 seconds	93,86 seconds
Most efficient observation	1,06 sec/CEU	2,53 sec/CEU
Least efficient observation	3,10 sec/CEU	4,26 sec/CEU
Average efficiency	2,10 sec/CEU	3,44 sec/CEU

Table 3 highlight essential data from the loading and unloading phases of the operation. There is a gap between longest and shortest observation. This indicates major traffic variations in port. The average loading observation seems to take longer time than unloading. This is bolstered by the efficiency calculations, where seconds spent handling one CEU is presented.

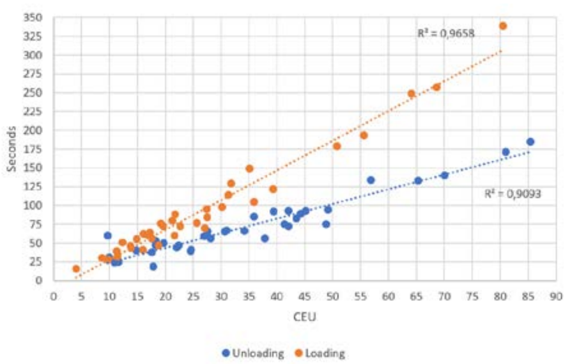

Figure 12. Results from observations with a corresponding trend line for each operation.

Figure 12 exhibit cargo handling data from every observation. Although there are some deviations, there seems to be a somewhat linear trend line for both operations. These lines visualize the general pattern and direction of the data. As seen above, both lines rise with an increase in CEU, albeit the loading line has a marginally steeper growth. The trend lines have values of R^2 close to 1, which indicates high level of reliability. Lastly there are no extreme values that differ greatly from the other data in figure 12. These observations suggest that loading is slower and less efficient than unloading. In addition, the observations vary for similar amount of cargo.

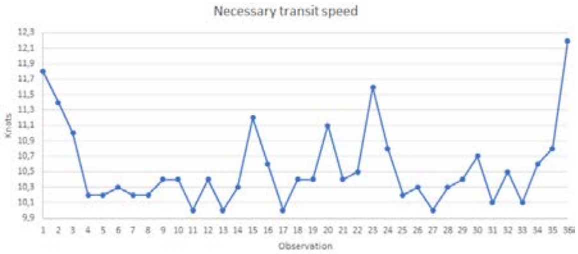

Figure 13. Necessary transit speed for each observation.

The figure above presents the necessary transit speed that the ferry should have sailed to avoid idle time in port. Calculations are based on information from the ferry's SEEMP [8]. The traffic fluctuations lead to great differences between each voyage.

To summarize, the data gathered from the field study seems to be sufficient to answer the research questions. There are several interesting findings that will be discussed in the upcoming chapter.

5 DISCUSSION

In this section the results of the observations will be discussed. As mentioned earlier the scope of this study was to learn more about port operations on a ferry. The goal was to uncover measures to optimize cargo handling in port, thus saving energy and implementing this in the ferry's SEEMP.

There are a number of interesting factors that should be addressed in this study. Table 1 in the previous chapter presented the total dwell time for each observation. As mentioned earlier in this article, the navigators tried to keep total dwell time at 8 minutes (480 seconds). It was assumed that this would be difficult, considering that the ship handling is not automated, except using autopilot during transit. External factors such as wind, current, visibility or ship traffic would make it difficult to arrive precisely. It is also possible that navigators manoeuvre differently and needs an uneven amount of time to berth. These factors would most likely explain why dwell time varies, although not significantly. In any case, this information in itself is interesting because the study was performed by different navigators. Considering that all were told to sail in 12 knots, their dwell times differ. A recommendation would be to learn from each other and collectively become adept at ship handling. Navigators should also prioritize consistency to ensure positive results over time.

The next factor is related to cargo handling. Apparently the traffic varies tremendously, both for unloading and loading. As presented in table 3, there is a gap between longest and shortest observation for both situations. Most observations were made for 55 CEU or less, and no observations include an empty deck or a fully loaded ferry. Unfortunately, this makes it very hard to predict necessary dwell time in port. A speed reduction would only be applicable if total dwell time is sufficient to complete cargo handling. Delays would lead to less disposable time for the upcoming voyage. In most cases it would be necessary to increase transit speed, thus diminishing any fuel savings from the previous voyage.

Furthermore, it is important to discuss the unloading and loading efficiency. Table 3 presents how many seconds is spent handling one CEU. Again, there is a significant difference amidst the most efficient and least efficient observation. As mentioned above, this study focused on observing cargo handling as it was usually performed. For this purpose, the only registered variables were time and amount of cargo. Placement of vehicles on the deck, how many lanes were used and how close vehicles were stowed was all decided by the deck department. Identifying the cause might therefor be difficult, but it is not unlikely that the deck department could improve their consistency and learn from each other.

Another cause might be that drivers have different driving styles. Drivers that accelerate quickly and maintain a relatively high speed would benefit overall port efficiency. Cargo handling could also be affected by meteorological and oceanographic factors. Sea level-fluctuations create a heeling angle on the linkspan when loading and unloading cargo. Drivers tend to slow down when the linkspan has a steep angle. Efficiency could be further decreased in poor visibility, such as heavy rain, darkness and fog. Finally, strong winds in combination with waves create a rolling motion along the ferry's longitudinal axis and a pitching motion along the transverse axis. Cargo handling in these conditions is often less efficient, but it was not included in this study and therefor hard to define precisely.

A major part of the observations shows that unloading is faster than loading. This is logical, considering that the ferry can unload two lanes simultaneously while loading just one lane. During loading, vehicles must also be sorted out and placed on designated spots, while unloading do not have to cater for this. On the other hand, traffic congestion on the road network in Molde often reduce unloading efficiency.

The previously mentioned topics are interesting, but the most important factor in this study is related to idle time. The last column in table 1 shows the idle time for each observation. It is very interesting, because all but one observation shows relatively large amounts of idle time. The average efficiency is 45,98%, but the range is from 23,10% to 88,95%, as presented in table 2. At first glance this indicates possibilities for fuel saving. However, cargo handling is not the only operations conducted in port. In addition the crew use this time to dispose of garbage, maintain cargo handling equipment, change crew or receive packages. Navigators should therefore not focus solemnly on cargo handling when planning to reduce idle time in port.

What this study fails to highlight is the passenger perspective. Reducing transit speed to save fuel would mainly benefit the ferry operator. Even though the ferry does not correspond with other public transportation, it is not unlikely that passengers would have a negative reaction towards increased travel time. Tickets also cost the same, no matter how fast the ferry sails. Navigators should therefore determine what is most important, predictability for passengers or fuel savings for the ferry operator. There is a noticeable difference between 43 minutes and 36 minutes voyage time if you travel with a ferry.

Throughout this discussion, several topics have been commented upon. It has been established that the ferry has idle time in port when sailing in 12 knots during transit. Considering that the traffic fluctuates it is not realistic to have zero idle time in port. Focus should therefore be given to uncover appropriate idle time, without experiencing delays.

Figure 13 showed the necessary transit speed that should be sailed to avoid idle time for each voyage. For the majority of the observations, it would not be necessary to sail with 12 knots. On another hand, it is hard to identify one fixed speed for all voyages. A recommendation would be to reduce the usual speed but adjust it if needed. If transit speed was reduced to 11,5 knots, this would reduce dwell time to 6,5 minutes and the total consumption would be 446,83 kWh. These numbers are based on data from the SEEMP and not sea trails. 33 of 36 observations would still have idle time, but the fuel savings would be noticeable, estimated at 3,8% reduction from 12 knots. Most likely the passengers would not react on such a small speed adjustment. Furthermore, the deck department should investigate why efficiency for both loading and unloading varies. If they find ways of optimizing their task, maybe port operations could be further lowered. This goes for the navigators as well. One way to further optimize operations would be to reduce the range in dwell time. There might be ways to share experiences and find the best possible route between ports.

It should also be discussed how applicable this information is to other ferries. Most likely, some of this is relevant to others. However, connections with fixed arrival and departures would not benefit from better port efficiency. This also applies to connections with bus correspondence at certain times or electric ferries that need to recharge batteries while in port. Most ferries that do not fall into aforementioned categories would probably benefit from this study.

6 CONCLUSION

The main objective of this study has been to learn more about cargo handling in port on a passenger ferry. As mentioned earlier in this article, efficient port operations lead to a lower necessary transit speed. A speed reduction has both an economic profit as well as an environmental gain. To achieve more efficient port operations, a series of observations were conducted on a passenger ferry in Molde.

The field study resulted in some interesting findings. It was discovered that the dwell time varies, even though navigators were told to sail with 12 knots speed over ground. This indicates a possibility for improving overall efficiency. To some extent, this is also applicable to the deck department. Cargo handling efficiency varies, but it is uncertain if this is related to the actions of the deck department or external factors. This should be studied further but a recommendation would be that the crew share experiences and focus on consistency in their work-related tasks. Better manoeuvring and faster cargo handling would bolster overall efficiency and generate room for reduced transit speed.

Furthermore, it was uncovered that there are large traffic fluctuations on this connection. This makes it hard for crew to predict necessary dwell time for each voyage. As a result of this, navigators have usually sailed with 12 knots speed over ground to avoid delays in port. The observations indicate that this speed is too excessive. A recommendation would be to sail in 11,5 knots during transit, but increase speed if necessary, during periods of high traffic. This would lead to increased fuel efficiency and should be included in the ferry's SEEMP.

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