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Setting of operating patterns of crossing transportation on the sei Selari-Air Putih route in Riau province

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Abstract: Sei Selari Ferry Port is a port located in Riau Province that serves the Sei Selari-Air Putih Passage. *Load Factor* at Sei Selari Ferry Port has reached the maximum limit so research is needed to improve the quality of service and safety of crossing transportation service users. The methods used in this research are *Load Factor* analysis, analysis of the suitability of minimum service standards for ship operations, analysis of ship requirements, and scheduling analysis. The technique used in this research is the saturated *sampling* technique because it uses the entire population (ship) as a research sample. Based on the results of the *Load Factor* calculation analysis, the average *Load Factor of* passengers and vehicles is 10% and 98.5% and the minimum service standards for ship operations have not been met by not matching the ship's departure time with the available schedule. There are differences from the *Existing* conditions, which are obtained from the results of the analysis of ship requirements and optimal ship scheduling, causing a difference between the applicable operating pattern and the analysis plan. The analysis results are calculated based on the number of trips and the number of ships according to the needs of service users. There is a difference between the *Existing* conditions and the results of the analysis, where the ideal number of ships is in accordance with the needs but it is necessary to increase the number of ship trips to 27 trips/day according to the needs of service users.

Keywords: *Crossing transportation, Load factor, Operation pattern, Scheduling.*

1. Introduction

Transportation is a process that involves the movement of people, goods, or services. Transportation has an important role in the economic growth and infrastructure development of a country. To increase the economic level of a country, a good transportation system and infrastructure are needed. Infrastructure and transportation systems that need attention are ports. Ports as water transportation infrastructure, play an important role in the economic development and infrastructure of the country. Riau is one of the provinces that has a role in economic development in water transportation.

The Sei Selari-Air Putih route based on the analysis results has reached a density of 98.5% of the maximum vehicle load factor. Therefore, it is necessary to add ships that operate evenly to implement an optimal schedule on the route. Ship scheduling is carried out based on Load Factor with the number of ships being 4 ships and the number of trips being 24 trips/day so that the operating pattern created can be optimal and does not exceed capacity. According to PM No. 66 of 2019, the Minimum Service Standard permitted is only a Load Factor of 60%

Based on the results of the data survey, it is known that the average service speed of ships on the Sei Selari-Air Putih route has not met the minimum Service Standards for ship operations, which is a minimum of 10 Knots. A speed of 10 Knots is not possible because it is influenced by strong currents and also to avoid the accumulation of ships at the pier because the distance of the route is not too far. Ship Service Speed Data for 15 days.

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The operational efficiency of a ferry is the ability of the ship and its associated systems to provide optimal transportation services with minimal resources, without compromising the quality or safety of the service. The following are some important aspects that affect the operational efficiency of a ferry. Time management includes arranging departure and arrival schedules to suit the needs of passengers and goods. Reducing waiting times at ports with efficient loading and unloading processes, such as the use of automation technology. Cargo Capacity A ship operating at full capacity is more efficient than a ship operating below optimal capacity. A balance between the number of passengers, vehicles, and goods must be made to maximize the use of ship space.

This research is still a continuation of previous research which only discussed the pattern of vehicle arrangements on ships, but in this research, it is a pattern of arrangements at the ship crossing.

Management Center which has a function as supervision and control, it is very necessary to regulate ships so that ships are safe. Safe, comfortable until they reach their destination according to the Minister of Transportation's mandate and avoid zero accidents

Riau Province is known as one of the high natural resource producing regions in Indonesia. Riau has abundant oil and gas reserves. This is certainly very strategic to be utilized as a province that moves with water transportation to support economic mobility. One of the influential crossings is the Sei Selari-Air Putih crossing.

The Sei Selari-Air Putih crossing is the only crossing that connects Sungai Pakning Sub-district on Sumatra Island with Bengkalis Sub-district on Bengkalis Island. This route plays a vital role in ensuring the smooth mobility of the population and the distribution of goods and services between the two regions. As the main link, this route not only facilitates transportation access, but also strengthens economic, social and cultural interactions between the communities in the two sub-districts. As in general, crossing transportation service performance problems are often encountered in the operation of a port, as is the case at the Air Putih Crossing Port, Bengkalis Regency. Where with the existing ferry service schedule, which is every 40 minutes, there are still frequent queues of ships in the berth pool because they have to wait for ships that have not finished carrying out activities at the dock or are still loading and unloading vehicles is one of the consequences of inappropriate port operation management at the Air Putih Ferry Port and has an impact on the dissatisfaction of service users or ship passengers with existing ferry transportation services. This is the basis for the need to analyze the operating pattern on the track to ensure the safety and comfort of service users. Therefore, the authors conducted research related to the pattern of operations on the Sei Selari-Air Putih track which will be outlined in "Setting of Operating Patterns of Crossing Transportation on The Sei Selari-Air Putih Route in Riau Province ".

2. Method

Vehicle and passenger load factors are used to measure the efficiency of vehicle capacity utilization. The use of load factors is essential in various transportation contexts, such as planning, operational management, and performance evaluation of transportation systems. Here are some of the main reasons for their use:

2.1. Operational Efficiency

1) Vehicles: Load factors indicate the level of vehicle capacity utilization, for example, how much space is used compared to the total capacity of the vehicle. By knowing the load factor, transportation operators can optimize fleet utilization to reduce operational costs.

2) Passengers: Load factors for passengers describe the ratio of the number of passengers to the seating capacity or available space. This helps determine whether a particular route or schedule is meeting passenger demand or is overcrowded.

2.2. Capacity Planning

Load factor helps in future capacity planning. With load factor data, operators can determine whether to add vehicles, increase capacity, or rearrange travel schedules.

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2.3. Performance Evaluation

Load factor is a key performance indicator (KPI) in the transportation industry. High values indicate good efficiency, while low values can indicate wasted capacity or the need to improve route and schedule management.

In the Regulation of the Minister of Transportation No. PM.62 of 2019 concerning minimum service standards for ferry transportation. Every ferry that operates is required to comply with the uni regulations.

2.4. Load Factor Analysis

Carry out the calculation of Passenger and Vehicle Load Factor in March 2024 by using Equation

a. Analysis of Conformity of Minimum Service Standards for Ship Operations
   1) Operation Schedule
   2) Ship Service Speed
b. Analysis of Determining the Ideal Number of Ships
   The calculation of the Ideal Number of Ships includes the number of ship departure frequencies, ship sailing time, ship berthing time, Round Trip Time, and Trip Capability.
c. Ship Scheduling Analysis
   In determining ship scheduling, Headway time or departure between ships is required.

3. Results and Discussion

3.1. Load Factor Analysis

The following Load factor calculation based on the equation obtained the results of loading capacity and used capacity can be seen in the following table.

Table 1.
Of passenger load factor calculation results.

No.	Ship name	Used capacity		Available capacity		Load factor	
		Unload	Load	Unload	Load	Unload	Load
1	KMP. Bahari Nusantara	2104	1786	31200	31500	7%	6%
2	KMP. Persada Nusantara	1882	1514	16150	16150	12%	9%
3	KMP. Swarna Putri	1918	1547	12648	12896	15%	12%
4	KMP. Mutiara Pertiwi II	150	733	4056	4056	4%	18%
5	KMP. Permata Lestari I	495	1931	6318	6318	8%	31%
6	Permata Lestari III	462	1986	8424	8424	5%	24%
7	KMP. Teluk Singkil	961	1776	17334	17334	6%	10%
Total		7972	11273	96130	96678	8.3%	11.7%
Average						10.0%	

Table 2.
of vehicle load factor calculation results.

No.	Ship name	Used capacity		Available capacity		Load factor %	
		Unload	Load	Unload	Load	Unload	Load
1	KMP Bahari Nusantara	82365.44	86148.48	110164.08	111223.35	75%	77%
2	KMP. Persada Nusantara	80328.76	77748.7	82228.2	82228.2	98%	95%
3	KMP. Swarna Putri	87818.69	84013.37	65643.12	66930.24	134%	126%
4	KMP. Mutiara Pertiwi II	23372.62	20494.39	23278.06	23278.06	100%	88%
5	KMP. Permata Lestari I	57314.38	59720.43	57137.4	57137.4	100%	105%
6	KMP. Permata Lestari III	51588.97	53057.78	55021.2	55021.2	94%	96%
7	KMP. Teluk Singkil	54571.49	61771.42	52128.36	52128.36	105%	118%
Total		437360.35	442954.57	445600.42	447946.81	98%	99%

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Based on Table 4.21, the average *Load Factor* based on 1 month survey data of loading and unloading of each ship is 98% and the average arrival *Load* Factor is 99%. The average vehicle *load factor* on the Sei Selari-Air Putih track is 98.5%.

a. Analysis of Conformity of Minimum Service Standards for Ship Operations

3.2. Schedule Fulfillment

PM 62/2019 concerning Minimum Service Standards for Crossing Transportation discusses the operation of the ship. Ship operators must carry out the schedule as set, therefore an analysis is needed regarding the time of delay in ship departure can be seen in Table 3 below.

Table 3.
Average delay time of over 15 days.

No.	Ship name	Ship delay time (Minutes)
1	KMP. Bahari Nusantara	7.4
2	KMP. Persada Nusantara	8.4
3	KMP. Swarna Putri	8.0
4	KMP. Mutiara Pertiwi II	7.4
5	KMP. Permata Lestari I	11.2
6	KMP. Permata Lestari III	7.7
7	KMP. Teluk Singkil	8.3
Average		8.3

Based on the results of a survey conducted at the Sei Selari Ferry Port, it can be seen that the average departure time of the ship on the Sei Selari-Air Putih track still has departure hours that are not in accordance with the set schedule with the highest delay time obtained by KMP. Permata L estari I because the ship is the oldest ship. The average departure time of all ships is more 8.3 minutes or 8 minutes 18 seconds from the established operating schedule.

3.3. Ship Service Speed

Analysis of ship service speed is carried out through data collection survey activities by recording ship speed on the Sei Selari-Air Putih track which is carried out for 15 days. Based on the Minimum Service Standards for Ship Operations, the ship's service speed must be carried out in accordance with what is determined. This is a benchmark for the fulfillment of sailing time. Regular ships must meet a minimum service speed of 10 knots and express ships must meet a minimum service speed of 15 knots. The average speed can be seen in Table 4.

Table 4.
Average ship speed March 2024.

No.	Ship name	Ship service speed (Knots)
1	KMP. Bahari Nusantara	6.9
2	KMP. Persada Nusantara	7.0
3	KMP. Swarna Putri	6.9
4	KMP. Mutiara Pertiwi II	7.0
5	KMP. Permata Lestari I	6.0
6	KMP. Permata Lestari III	6.8
7	KMP. Teluk Singkil	6.9
Average speed		6.8

Based on the results of the data survey, it is known that the average service speed of the ship on the Sei Selari-Air Putih track has not met the minimum Service Standards for ship operations, which is at least 10 Knots. Speed of 10 Knots is not possible to do because it is influenced by strong currents and

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also avoids the accumulation of ships at the dock because the distance of the track is not too far. Ship Service Speed Data for 15 days can be seen in attachment 6.

3.4. Ideal Number of Ships Analysis

Ship frequency calculation is used to determine the number of trips needed in one day to serve crossing transportation. This frequency calculation is calculated based on the number of passengers and vehicles. The frequency of ship departures is determined from the number of transportation requests, namely the number of passenger and vehicle transportation requests:

1) Ship Departure Frequency Based on Number of Passengers

The following is the calculation of the frequency of ship departures based on the number of passengers using the equation

$$FK = \frac{11273}{31 \text{ x } 0.9 \text{ x } 75\% \text{ x } 164.3}$$

$FK = 3.3$ trips/day rounded up to 3 Trips

So, from the calculation of the frequency of ship departures based on the number of passengers at the Sei Selari-Air Putih crossing is 3 trips.

2) Ship Departure Frequency Based on Number of Vehicles

The following is the calculation of the frequency of ship departures based on the number of vehicles using the equation

$$FK = \frac{442954.57}{31 \text{ x } 0.9\text{x } 75\% \text{ x } 783.01}$$

$FK = 27$ trip/day

So, from the calculation of the frequency of ship departures based on the number of passengers at the Sei Selari-Air Putih crossing is 27 trips / day.

3) RTT *(Round Trip Time)*

a) *Sailing Time*

The distance of the Sei Selari-Air Putih Passage is 4.5 Miles with an average ship speed of 6.8 Knots so that the calculation of travel time can be seen in the equation

$$ST = \frac{s}{v} = \frac{4.5}{6.8} = 40\ Menit$$

The results of these calculations can be seen in Table 5 below

Table 5.
Ship sailling time.

Trajectory	Trajectory distance (Miles)	Speed average (Knots)	Sailing time
Sei Selari-White Water	4.5	6.8	40 Minutes

3.5. Lay Over Time

Based on the results of a 15-day survey at the Sei Selari ferry port, the average docking time is 45.9 minutes or rounded up to 46 minutes with the following equation and the survey results can be seen in Table 1.

LOT = Inbound Maneuver Time + Unload Time + Load Time + Outbound Maneuver Time

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Table 6.
Lay over time data.

No.	Date	Maneuvers (Minutes)		Unload	Load	Docking time	Lay over time
		Come	Depart	(Minutes)	(Minutes)		
1	March 01, 2024	4.7	5.6	10.7	21.9	32.6	42.9
2	March 02, 2024	4.4	8.0	10.8	20.1	30.9	43.3
3	March 03, 2024	8.2	6.8	13.7	17.8	31.5	46.5
4	March 04, 2024	7.2	8.6	11.5	17.4	29.0	44.8
5	March 05, 2024	7.3	7.3	12.0	22.1	34.1	48.7
6	March 06, 2024	5.6	8.5	14.9	17.0	31.9	46.0
7	March 07, 2024	4.5	8.9	11.8	20.2	32.0	45.3
8	March 08, 2024	5.1	7.1	12.8	24.5	37.3	49.5
9	March 09, 2024	6.0	6.0	10.3	20.1	30.4	42.4
10	March 10, 2024	3.5	8.0	14.9	18.1	33.0	44.5
11	March 11, 2024	7.6	7.4	14.9	21.5	36.4	51.4
12	March 12, 2024	4.6	6.8	12.0	16.8	28.8	40.2
13	March 13, 2024	7.7	9.7	10.5	17.9	28.4	45.8
14	March 14, 2024	5.4	6.0	13.2	23.2	36.4	47.8
15	March 15, 2024	3.2	7.0	14.6	24.0	38.6	48.8
Average		5.7	7.4	12.6	20.2	32.7	45.9

3.6. Ship Round Trip Time

Round trip time is the length of *round-trip* transportation from one point to another. RTT calculation is obtained from the following equation

$RTT = (40\ Minutes + 46\ Minutes)\ x\ 2$

$RTT = 172\ Minutes$

3.6.1. Ship's Ability to Travel Per Day

The ship's trip capability is based on the port operating time which operates for 17 hours or 1020 minutes. Trip capability can be calculated with the following equation:

$$KT = \frac{1020\ Menit}{172\ Menit}$$

$$KT = 6\ trip/Kapal$$

3.6.2. Calculation of Ideal Number of Ships

The calculation of the ideal number of ships is obtained from the following equation.

$$Jumlah\ Kapal\ yang\ Optimal = \frac{29}{6}$$

$$Jumlah\ Kapal\ yang\ Optimal = 4\ Ships$$

3.6.3. Load Factor Ship Departure Plan

After knowing the frequency of ship departures on the Sei Selari-Air Putih track, the load factor of the planned vehicle can be found so that it can be seen whether the load factor is in accordance with the planned load factor of 70%. The following is a *load factor* prediction based on the number of trips and the current ideal number of ships:

$$LF = \frac{442954.57}{31\ x\ 27\ x\ 0.9\ x\ 783.01}$$

$$LF = 75\%$$

3.6.4. Ship Scheduling Analysis

Determination of ship departure and arrival schedules must first determine the *Headway* (ship

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departure time span) using the following equation:

$$Headway\ Time = \frac{1020\ Menit}{27\ \text{trip/hari}}$$

$$Headway\ Time = 37.7\ \text{dibulatkan menjadi}\ 38\ Menit$$

Based on the survey results obtained *layover time* data then to make scheduling can be calculated using the following analysis with the preparation of the schedule can be done by considering the port operating time and current conditions. Therefore, the analysis and preparation of departure and arrival schedules on the Sei selari-Air putih route can be seen in the following table:

Table 7.
Previous analysis result.

No.	Analysis result	Time description
1	*Layover time*,	46 Minutes,
2	*Headway*,	38 Minutes,
3	Operating time at port	1020 Minutes,
4	Travel time	40 Minutes,

With the ship departure operation time starting at 07.00 WIB, it can be calculated as follows:

a. Ship departure time = 07.00 am
b. Arrival Time = (2 x *Running Time* + *Layover time)*
= (2x40 Minutes) + 46 Minutes
= 80 Minutes + 46 Minutes
= 126 Minutes
= 2 Hours 6 Minutes
c. Arrival Time = Departure + 2 Hours 6 Minutes
= 07.00 am + 2 hours 6 minutes
= 09.06 AM

4. Conclusion

a. The Sei Selari-Air Putih trajectory based on the results of the analysis has reached the maximum limit with an *average passenger load factor* of 10% and an average vehicle *load factor* of 98.5%. Therefore, it is necessary to add ships that operate evenly to apply an optimal schedule on the track.

b. The operational condition of the ship based on the minimum service standard of ship operation on the Sei separallel-Air Putih crossing ship there are still ships that have not met the schedule with an average *departure delay of* 8.3 minutes with the highest delay rate obtained by KMP. Permata Lestari I is because it is the oldest ship on the track. And on the track has a speed of 6 to 7 knots where the speed is affected by the strong current, preventing buildup at the pier and saving fuel.

c. The number of *ships* set at the Sei Selari Crossing Port is appropriate in meeting the needs of service users in terms of service and safety. Based on the results of the analysis, the ideal number of ships is 4 ships that operate within one day of the existing 7 ships.

d. Ship scheduling is carried out based on the *Load Factor* with the number of ships *which is* 4 ships and the number of trips is 24 trips/day so that the operation pattern made can be optimal and does not exceed capacity.

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