JTUS, Vol. 02, No. 9 September 2024
E-ISSN: 2984-7435, P-ISSN: 2984-7427
DOI: https://doi.org/

Journal Transnational Universal Studies

Feeder–Line Concept Development For Public Transportation Network In Urban Area Based On O-D Matrix And Performance Evaluation

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Abstract

The management of the public transport network system is very important because it affects the future of the city and supports the activities of the community in travelling and movement. This research aims to develop a feeder-line concept on the public transport network based on O-D Matrix and Operational Performance Evaluation. The research method used is the operational performance standard indicator approach based on the Directorate General of Land Transportation SK 687/AJ.206/DRJD/2002 and the O-D Matrix method in determining new route recommendations. This research uses secondary data as well as primary surveys to assess operational performance. The results show that the level of operational performance of public transport in the research area there are still several routes below the standard with a total of routes operating from D1 to D8 of which 75% of the routes are in good condition and the other 25% of the routes have substandard assessment results with a total value of ≤18. Thus, it is recommended that rerouting to be carried out on routes whose operational performance is still below standard, namely routes D7, and D8 based on the characteristics of the feeder-line concept to BRT Corridor 2.

Keywords: Feeder-Line, O-D Matrix, Operational Performance.

INTRODUCTION

Public transportation is an important component in supporting the mobility of people in urban areas. According to (Tunjungsari et al., 2019), public transport is a type of transport that carries passengers on the road in mixed traffic conditions which provided by public or private operators in a certain number of routes or groups. Public transport consists of two types, the first is trunk (main) route transport, which serves the mobility and hinterland of an area with large vehicles and the route passes through the central activity area (Karim et al., 2023). The second is feeder route transport, or a supporting network of trunk routes that connects generation areas or suburbs to activity centers (Musthofawi et al., 2023).

According to (Afriza & Manullang, 2017), feeder line are public transport services that use small-capacity vehicles for lower density areas. In line with that, (Steijn, 2014) explains that a feeder is a means of transport that serves areas of the city that are not reached by the main transport system or BRT transit. This idea is also corroborated by (Herdiana & Firdaus, 2021), who considers feeders as a way to connect areas that are not served by the main mode of transport such as buses.

In research that has been conducted by (Tangphaisankun et al., 2009) stated that mass transit in developing countries needs to introduce the feeder concept as a mass transit system, where the aim is to integrate paratransit systems into urban transport. On the performance of bus services in the research area, it is mentioned that there is a need to consider paratransit services starting from the strategy of paratransit facilities that should be provided and facilities in connection from the feeder to the main transport service to reduce the difficulty of switching passenger (Harry Yulianto et al., 2018).

Cirebon City is one of the strategic areas by connecting two provinces, namely West Java and Central Java, making it a transit city for people travelling between regions. With existing development causes the need for movement and travel to be very high (Gusleni, 2016). Cities public transport currently operates two types of modes, namely *angkutan kota (angkot)* and BRT Corridor 2. But until now the condition of public transport in the city of Cirebon is still less than optimal causing a decrease in the effectiveness and efficiency of the urban transport system. This is evidenced by urban transport research that has been conducted by (Rizka & Hariani, 2023) that the average load factor value of the actual conditions of route D6 in Cirebon City is 45%. This shows that the operational performance for route D6 is still not optimal with the lack of passengers transported on route D6. While the Trans Cirebon BRT research has been carried out previously on BRT Corridor 1 by (Sugiyanto et al., 2023) mentioned that there are indicators that do not meet performance standards, namely load factor, service time, waiting time, and passenger seat comfort, from these indicators concluded that the operational system on BRT Corridor 1 is not good enough so that it stops operating.

In a study conducted by (Sutrisni & Setiono, 2014) the stage of handling transport problems on the performance of the Surakarta City road network movement patterns required identification in the form of the Origin-Destination Matrix. The 2013 O-D matrix estimation was obtained from processing the priority matrix with traffic data, and calibrated using the generation and attraction model with an analysis method that produces the amount of generation and attraction in 2025. With this result, the total number of hourly movements is 55,074.29 smp with an increase of 3.3% per year.

One of the analysis of the operational performance of transport can be used to generate the effectiveness of public transport in service and satisfaction of the use of public transport, a previous study (Atmaja et al., 2017) To renew the public transport service system in Surakarta City, an efficient and sustainable public transport system needs to be planned. Based on the standard operational indicators that have been analysed there are still routes that are not optimal in terms of service according to operational standards. It is still necessary to integrate between the route network with other types of transport with attractive routes so that passengers feel safe and satisfied with the services of the public transport system in Surakarta City.

With literature review of previous research that aims as a reference and comparison or a differentiator for this research, where the research aims to study and develop all urban transport network systems in Cirebon City based on the O-D matrix and operational performance evaluation, based on the feeder-line concept between angkot and BRT Corridor 2. With this research, it is hoped that the public transport network system in the city of Cirebon will be able to increase more efficient and sustainable mobility. So that the operational performance of public transport is more optimal, both from several points of view, namely regulators as planners and supervisors, operators as public transport service providers, and also the public who are consumers or users of these public transport services.

METHODS

Location and Object of Research

The study was located in the Cirebon City area, Indonesia. Covering routes passed by routes from D1 to D8 and BRT Corridor 2 in the urban area of Cirebon City.

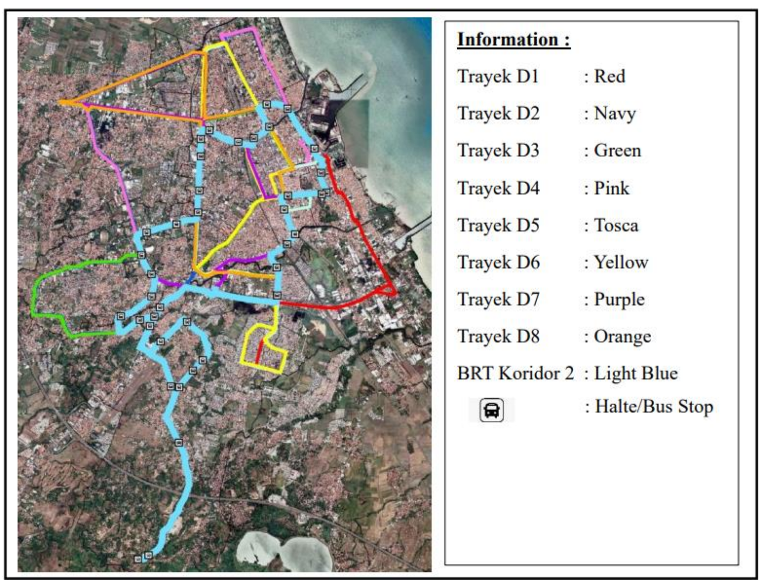

Figure 1. Research Location Map

Data Collection Methods and Sources

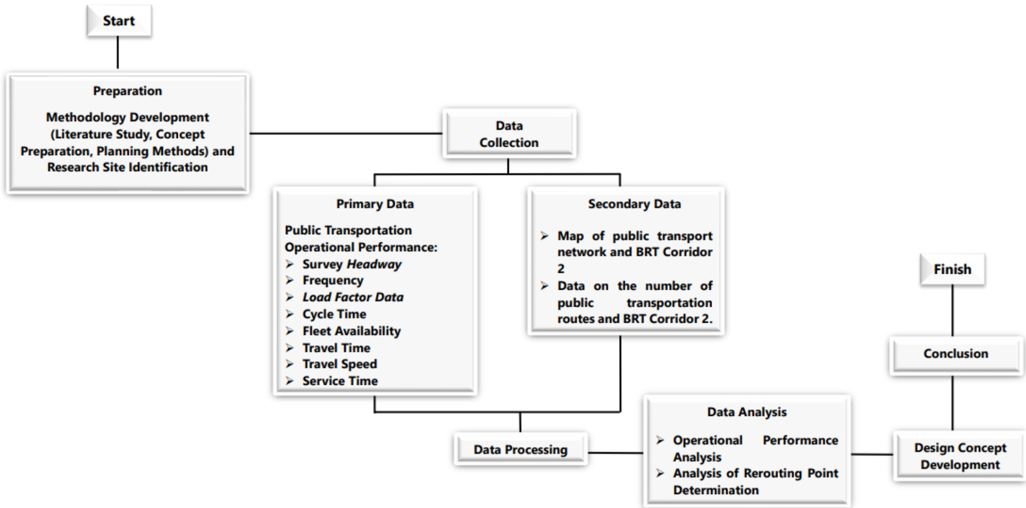

Figure 2. Research Flow

The research method used is quantitative research by collecting data. The data required is in the form of primary data with field surveys as data collection method in the form of headway surveys to support frequency data, the number of fleets (availability), also the load factor survey by recording the number of passengers in the vehicle in each segment, cycle time and travel time surveys, and travel speed surveys. While the secondary data needed are public transport network and BRT Corridor 2 maps, the number of public transport routes and BRT Corridor 2. This secondary data is obtained through the Cirebon City Transportation Office (*Dinas Perhubungan Kota Cirebon*). The survey results are used in data processing and analysis using the O-D matrix method and operational performance evaluation, as well as providing recommendations from the analysis results.

Operational Performance Standards

Parameters that can be done to determine the operational performance of public transport are headway, frequency, availability, travel time, travel speed, cycle time, and load factor. This research uses standard operational performance indicators of urban public transport and Bus Rapid Transit based on the Directorate General of Land Transportation SK 687/AJ.206/DRJD/2002.

Table 1. Urban Public Transport Performance Standards

No	Services Indicator	Unit	Assessment Standard		
			Bad (1)	Performance Standards for Urban Public Transport Moderate (2)	Good (3)
1	Peak hour load factor	%	>100	80-100	<80
2	Off-peak load factor	%	>100	70-100	<70

No	Services Indicator	Unit	Assessment Standard		
			Bad (1)	Performance Standards for Urban Public Transport Moderate (2)	Good (3)
3	Travel speed	Km/Hour	<5	5-10	>10
4	Headway	Minutes	>15	10-15	<10
5	Travel time	Minutes/Km	>12	6-12	<6
6	Service time	Hours	<13	13-15	>15
7	Frequency	Vhcl/Hour	<4	4-6	>6
8	Waiting time	Minutes	>30	20-30	<20
9	Number of active vehicle	Unit	<82	82-100	100

Source: Directorate General of Land Transportation 2002

Table 2. Performance Standards for Urban Public Transport

Criteria	Total Value
Very Good	>24
Good	18,00 – 24,00
Moderate	12,00 – 17,99
Bad	<12

Source: Directorate General of Land Transportation 2002

Standard indicators of public transport performance on BRT Corridor 2 were obtained based on secondary survey results.

Table 3. Performance Indicators of Public Transport Based on Director General of Land Transportation

No	Criteria	Value
1	Load Factor	70%
2	Headway time	
	a. Average	5-10 Minutes
	b. Maximum	10-2- Minutes
3	Passenger waiting time	5-10 Minutes
4	Vehicle frequency	4-6 Vehicle
5	Service time	13-15 Hours/Day
6	Travel time	
	a. Average	60-90 Minutes
	b. Maximum	120 Minutes

Source: (Sugiyanto et al., 2023)

RESULTS AND DISCUSSION

Public Transport Network Data

Based on the Decree of Walikotamadya/KDH TK.II Cirebon Number: 05 of 1997 there are about 10 codes of city transport routes operating in the city of Cirebon, namely D1 to D10, but the D9 and D10 routes are no longer operating, judging on the passenger interest in using the two routes, this is due to the area or route passed is not strategic. So, what is studied in this research is only on routes D1 to D8 as city transport routes. Whereas in the Decree of the Mayor of Cirebon City No. 551/Kep.52-DISHUB/2023 that Cirebon City has Bus Rapid Transit Corridors 1 and 2, with the route of BRT Corridor 1 starts from Dukuh Semar Terminal and ends at Pesantren Rd., Cirebon City, while the BRT Corridor 2 route starts and returns at the same point, namely Harjamukti Terminal. However, currently BRT Corridor 1 has been closed or is no longer operating, due to the lack of passengers who ride so what operates now is only BRT Corridor 2.

From the condition of public transport in Cirebon City which has two types of transport, namely BRT and angkot, research was conducted to analyze and evaluate the operational performance system on both types of public transport, by making routes D1 to D8 as feeders that can reach residential areas and connect with BRT Corridor 2.

Currently the routes and route lengths owned by public transport in Cirebon City are routes D1 to D8 and BRT Corridor 2 as listed in table 4 below.

Table 4. Public Transport Routes

Route Type	Rute	Distance (Km)
D1	Term. Dukuh Semar - Jl. Elang - Jl. Rajawali - Jl. A. Yani - Jl. Kesunean - Jl. Yos Sudarso - Jl. Cemara - Jl. RA Kartini - Jl. Wahidin - Jl. Slamet Riyadi - Jl. Diponegoro - Jl. Samadikun - Jl. Sisingamangaraja - Jl. Kantor - Jl. Syarif Abdurakhman - Jl. Kesunean - Jl. Kalijaga - Jl. A. Yani - Perumnas Selatan - Perumnas Utara - Jl. Dukuh Semar.	22,80
D2	Term. Dukuh Semar - Jl. Pangeran Drajat - Jl. Kesambi - Jl. Nyimas Gandasari - Jl. Pekiringan - Jl. Pekalipan - Jl. Pulasaren - Jl. Merdeka - Jl. Benteng - Jl. Sisingamangaraja - Jl. Samadikun - Jl. Diponegoro - Jl. Slamet Riyadi - Jl. Wahidin - Jl. Tuparev - Jl. Brigjen Dharsono - Jl. Perjuangan - Jl. Majasem - Jl. Kanggraksan - Jl. A. Yani - Jl. Dukuh Semar.	20,20
D3	Term. Dukuh Semar - Jl.Elang - Jl. Rajawali - Jl. A. Yani - Jl. Kanggraksan - Jl. Kalitanjung - Jl. Pelandakan - Jl. Majasem - Jl. Perjuangan - Jl. Brigjen Dharsono - Jl. Pemuda - Jl. Dr. Cipto - Jl. RA Kartini - Jl. Karanggetas - Jl. Pekiringan - Jl. Petratean - Jl. Pulasaren - Jl. Lawanggada - Jl. Kesambi - Jl. Pangeran Drajat -Term. Dukuh Semar.	15,60
D4	Term. Dukuh Semar - Jl. Elang - Jl. Rajawali - Jl. A. Yani - Jl. Kanggraksan - Jl. Kalitanjung - Jl. Evakuasi - Jl. Brigjen Dharsono - Jl. Tuparev - Jl. Wahidin - Jl. Slamet Riyadi - Jl. Diponegoro - Jl. Samadikun - Jl. Sisingamangaraja - Jl. Syarif Abdurakhman - Jl. Pasuketan - Jl. Pekiringan - Jl. Pekalipan - Jl. Lawanggada - Jl. Kesambi - Jl. Pangeran Drajat - Term. Dukuh Semar.	15,68
D5	Term. Dukuh Semar - Jl. Elang - Jl. Rajawali - Perumnas Selatan - Jl. Rajawali - Jl. Kutagara - Jl. Jagasatru - Jl. Pekawatan - Jl. Pulasaren - Jl. Merdeka - Jl. Kebumen - Jl. Pasuketan - Jl. Pekiringan - Jl. Petratean - Jl. Pulasaren - Jl. Lawanggada - Jl. Nyi Mas Gandasari - Jl. Pangeran Suryanegara - Jl.	15,08

Route Type	Rute	Distance (Km)
	Sukalila Selatan - Jl. Siliwangi - Jl. Slamet Riyadi - Jl. Wahidin - Jl. Dr. Cipto - Jl. Pangeran Drajat - Term. Dukuh Semar.	
D6	Term. Dukuh Semar - Jl. Pangeran Drajat - Jl. Kesambi - Jl. Nyi Mas Gandasari - Jl. Tentara Pelajar - Jl. Dr. Cipto - Jl. Wahidin - Jl. Slamet Riyadi - Jl.Siliwangi - Jl. Karanggetas - Jl. Pekiringan - Jl. Pekalipan - Jl. Lawanggada - Jl. Kesambi - Jl. Pangeran Drajat - Perumnas Selatan - Perumnas Utara - Jl. Elang - Term. Dukuh Semar.	20,70
D7	Term. Dukuh Semar - Jl. Pangeran Drajat - Jl. Kutagara - Jl. Jagasatru - Jl. Lawanggada - Jl. Nyi Mas Gandasari - Jl. Pangeran Suryanegara - Jl. Sukalila Selatan - Jl. Siliwangi - Jl. Kartini - Jl. Wahidin - Jl. Raya Pilang - Jl. Kedawung - Jl. Tuparev - Jl. Dr. Cipto - Jl. Pemuda - Jl. Brigjen Dharsono - Jl. A. Yani - Term. Dukuh Semar.	20,20
D8	Term. Dukuh Semar - Jl. Pangeran Drajat - Jl. Dr. Cipto - Jl. Tuparev - Jl. Kedawung - Jl. Raya Pilang - Jl. Wahidin - Jl. Kartini - Jl. Siliwangi - Jl. Karanggetas - Jl. Pekiringan - Jl. Petratean - Jl. Jagasatru - Jl. Kutagara - Jl. Pangeran Drajat - Jl. Rajawali - Jl. Elang - Term. Dukuh Semar.	16,30
BRT Corridor 2	T. Harjamukti - Jl. A.Yani - Jl. Kanggraksan - Jl. Jend. Sudirman - Jl. Angkasa Raya - Jl. Katiasa - Jl. Pramuka - U Turn Jl. Pramuka (Cadas Ngampar) - Jl. Angkasa - Jl. Angkasa Raya - Jl. Jend. Sudirman - Jl. Kalitanjung - Jl. Evakuasi - Jl. Brigjen Dharsono - Jl. Pemuda - Jl. Dr. Cipto - Jl. Tentara Pelajar - Jl. Sukalila Selatan - Jl. Siliwangi - Jl. Veteran - Jl. Sisingamangaraja - Jl. Benteng - Jl. Merdeka - Jl. Pulasaren - Jl. Kutagara - Jl. Pangeran Drajat - Jl. Rajawali Raya - Jl. A. Yani (T. Harjamukti).	30

Transport Operational Performance Analysis

The assessment of transport operational performance on angkot routes D1 to D8 and BRT Corridor 2 can be seen from the comparison of existing transport data assessment parameters. The assessment of transport operational performance is based on the 2002 Directorate General of Land Transportation service standards.

Headway

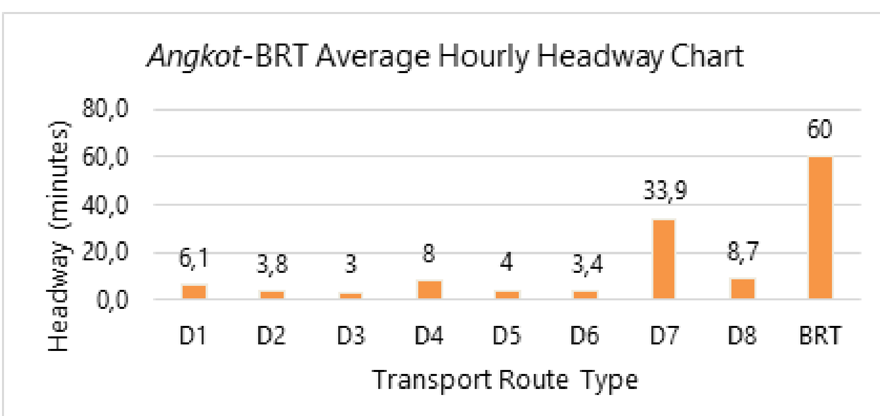

Figure 3. Headway

From the results of the analysis, the average daily headway value of route D3 is 3 minutes. It can be said that it is very easy to get public transport for route D3. While on route D7 the average headway owned is 33.9 minutes. These results show that the quality of the operational performance standards based on the Directorate General of Land Transportation in 2002 is still not optimal. On BRT Corridor 2, the average daily headway is 60 minutes. It can be said that the operational performance of BRT Corridor 2 is still not optimal because of the large headway value.

Frequency

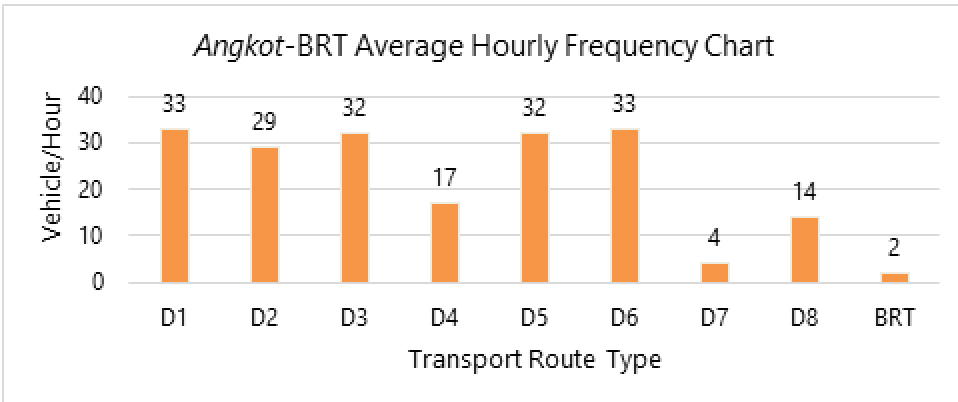

Figure 4. Frequency

Based on the frequency analysis results in figure 4, the operational performance standards of routes D1 and D6 have the highest average frequency level, which is 33 vehicles/hour. This is caused by several factors, such as faster public transport travel times due to minimum transport stops waiting for passengers and more routes in operation. Meanwhile, the average frequency of BRT Corridor 2 has a very low value of 2 vehicles/hour. This low frequency can be caused by the lack of a fleet to operate.

Fleet Availability

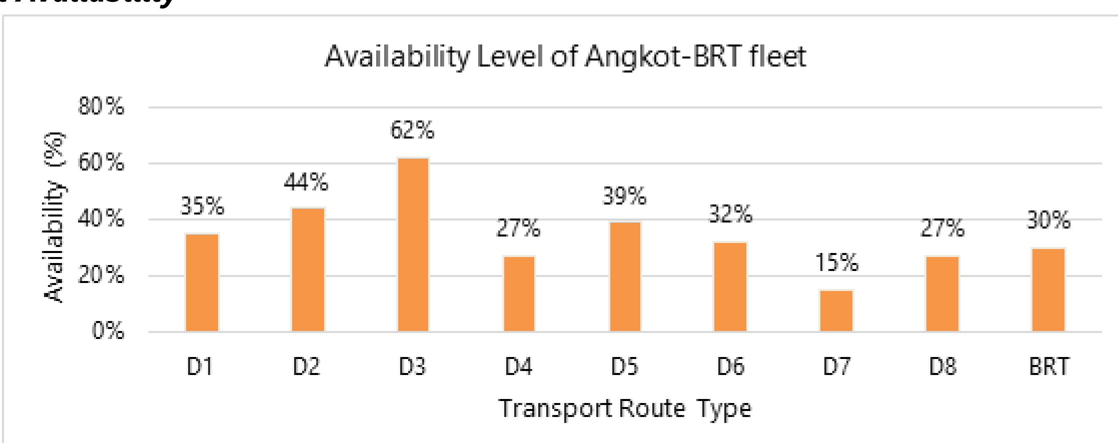

Figure 5. Fleet Availability Rate

Based on the percentage of availability of the operating fleet in figure 5, route D3 has high percentage value, which is 62%, which means that this percentage has met the operational performance standards based on the Directorate General of Land Transportation in 2002. Meanwhile, route D7 has the lowest value, which is 15%. This can be seen from the current public transport situation during peak hours, public transport operates more because there are many passengers, but during off-peak hours, most public transport stops for a break. The availability of the BRT Corridor 2 fleet has a percentage value of 30%, this shows that the average percentage value of BRT Corridor 2 is still less than ideal to fulfil its operational performance.

Service Time

The average service time of all routes starts and end is between 06.00-18.00 or for 12 hours of service a day. In this case the route from D1 to D8 still has a poor quality of service time. Where good service time, according to the Directorate General of Land Transportation in 2002, which is at least 15 hours of service. While the service time owned by BRT Corridor 2, which is 13 hours of service a day between 06.00-19.00, this service time according to the Directorate General of Land Transportation in 2002 is said to meet the requirements in the operational performance standard indicators.

Travel Time

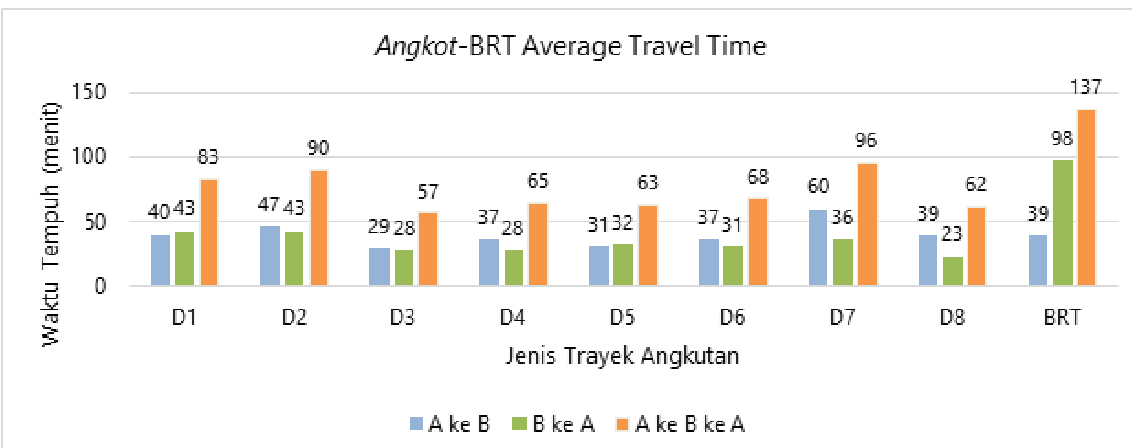

Figure 6. Travel Time

Based on Figure 6, route D7 has the longest travel time, which is 1.6 hours in one round. This can be influenced by drivers during peak and off-peak hours, tending to wait for passengers in potential areas. While the travel time of BRT Corridor 2 is 137 minutes or 2.3 hours in one round. This is because the length of the existing route travelled is 30 km. As for other factors of BRT Corridor 2, because there is a stopping time of 30 minutes in one round.

Travel Speed

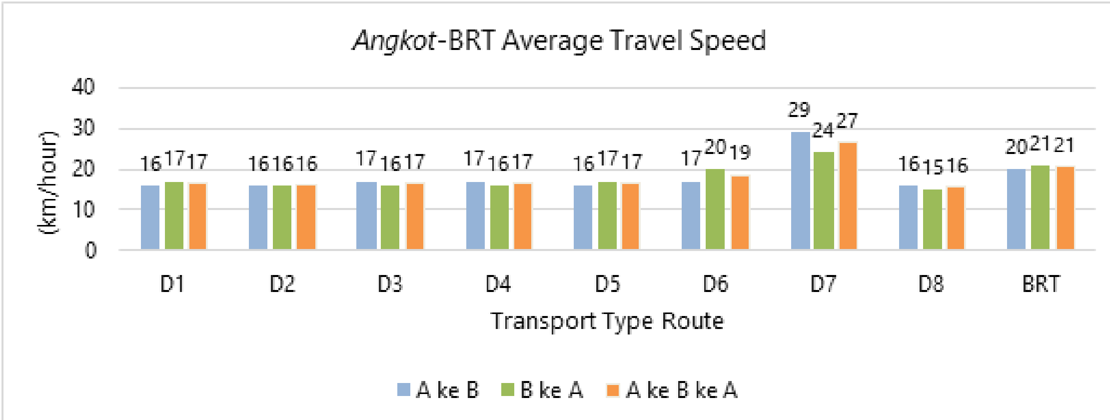

Figure 7. Travel Speed

Route D7 has the highest travel speed, which is 27 km/hour. Meanwhile, BRT Corridor 2 has a travel speed of 21 km/hour. From the results of the analysis, it can be concluded that the factor that affects the speed of travel is high or low due to changes in travel time. Although in the existing conditions, the route of each route has the same length the travel time is different, so it will affect the travel speed.

Cycle Time

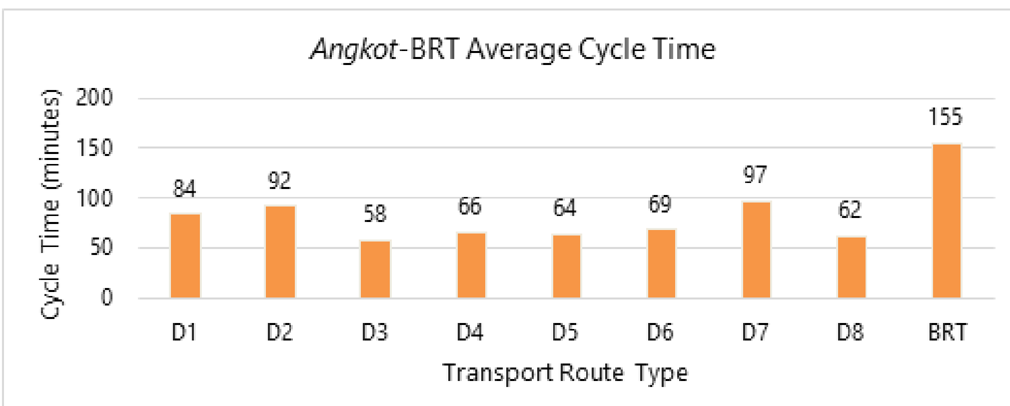

Figure 8. Cycle Time

Based on the results of the cycle time analysis, route D7 has the highest average cycle time, which is 1.6 hours. This is not much different from the travel time of route D7 where the factors that influence the high cycle time of route D7 are related to the driver who will wait and look for passengers. On BRT Corridor 2, the average cycle time is 2.6 hours.

Load Factor

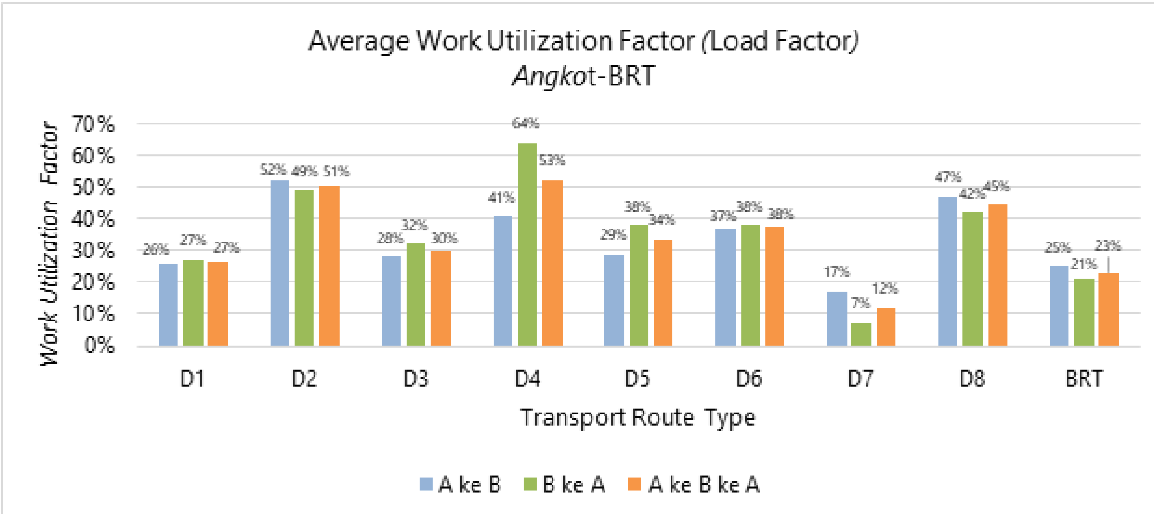

Figure 9. Load Factor

The highest load factor is on route D4 at 53%. Based on the analysis, this can occur because some of route D4 passed are quite good, during peak hours where the number of passengers on route D4 is quite dense. Meanwhile, the BRT Corridor 2 load factor is 23%. Based on the Directorate General of Land Transportation standards in 2002, the load factor value <70%, is very good because there is no need to be crowded. But other factors, this will be detrimental to the driver because the available seats are not full, thus reducing income.

Operational Performance Evaluation

In BRT Corridor 2, the analysis results that have been compared with the standard operational performance indicators, only meet some of the requirements of the Directorate General of Land Transportation in 2002, namely in the analysis of travel speed and service time. In this case, BRT Corridor 2 is still less than optimal in the operational performance system according to the standard.

Table 5. BRT Corridor 2 Operational Performance Standards

BRT Corridor 2 Operational Performance Standards				
No	**Indicators**	**Service Standard**	**Value**	**Description**
1	Load Factor	70%	27	Not Eligible
2	Headway	5 - 10 Minutes	60	Not Eligible
3	Frequency	4 - 6 Vhcl/Hour	2	Not Eligible
4	Bus Travel Time	60 -90 Minutes	137	Not Eligible
5	Passenger Waiting Time	5 - 10 Minutes	30	Not Eligible
6	Bus Travel Speed	10 - 30 Km/Hour	21	Eligible
7	Service Time	13 - 15 Hours/Day	13	Eligible

Based on the results of the analysis that has been done and then compared with the indicators of the operational performance standards of the Directorate General of Land Transportation in 2002, that on city transport routes D1 to D8 obtained the results that route D7 have the lowest total value, then route D8, both routes still do not meet operational performance standards.

Table 6. Operational Performance Standards for Routes D1 to D4

No	Indicator	Unit	Route D1			Route D2			Route D3			Route D4
			Amount	Value	Category	Amount	Value	Category	Amount	Value	Category	Amount Value Category
1	Headway	Minutes	6.1	3	Good	3.8	3	Good	3	3	Good	8 3 Good
2	Frequency	Vhcl/Hour	33	3	Good	29	3	Good	32	3	Good	17 3 Good
3	Fleet Availability	%	35	1	Bad	44	1	Bad	62	1	Bad	27 1 Bad
4	Service Time	Hours/Day	12	1	Bad	12	1	Bad	12	1	Bad	12 1 Bad
5	Travel Time	Hour	1,4	3	Good	1.5	3	Good	1	3	Good	1.1 3 Good
6	Travel Speed	Km/Hour	17	3	Good	16	3	Good	17	3	Good	17 3 Good
7	Cycle Time	Hour	1.4	3	Good	1.5	3	Good	1	3	Good	1.1 3 Good
8	Load Factor	%	27	1	Good	51	1	Bad	30	1	Bad	53 1 Bad
	Total	Value		18	Good		18	Good		18	Good	18 Good

Table 7. Operational Performance Standards for Routes D5 to D8

No	Indicator	Unit	Route D5			Route 06			Route 07			Route 08		
			Amount	Value	Category	Amount	Value	Category	Amount	Value	Category	Amount	Value	Category
1	Headway	Minutes	4	3	Good	1.4	1	Good	11.9	1	Bad	8.7	3	Good
2	Frequency	Vhcl/Hour	32	3	Good	33	3	Good	4	2	Moderan .	14	)	Good
3	Fleet Availability	%	39	1	Bad	32	1	Bad	15	1	Bad	27	1	Bad
4	Service Time	Hours/Day	12	1	Bad	12	1	Bad	11	1	Bad	12	1	Bad
s	Travel Time	Hours	1	3	Good	1.1	3	Good	1.6	2	Moderan .	1	1	Good
6	Travel Speed	Km/Hour	17	3	Good	19	3	Good	27	3	Good	16	3	Good
7	Cycle Time	Hour	1,1	3	Good	1,2	3	Good	1.6	2	Moderan c	1	1	Bad
8	Load Factor	%	34	1	Red	18	1	Bad	12	1	Bad	45	1	Bad
	Total	Value		14	Good		14	Good		13	Moderat .		10	Moderat .

The table above explains that the lowest route weight value is on routes D7 and D8 with moderate categories. While on routes D1, D2, D3, D4, D5, and D6 have a value of 18 which falls into the minimum limit of the good category. Based on this, it can be concluded that the operational performance of public transport in Cirebon City is mostly in the position of the minimum limit of the good category so that it can be considered not optimal. In addition, when viewed in terms of passenger transport, it can be concluded that public interest in the use of public transport is very low and can affect the sustainability of public transport routes in the future. Looking at the results of the operational performance evaluation, the routes that need to be rerouted are routes D7 and D8 which have the lowest values by considering the potential pull and generation as well as the existing conditions of the public transport network operating today. This can maximise the quality of transport performance, both in terms of passengers and driver operators who will feel the positive impact of making public transport in Cirebon City a sustainable transport network with a well-operating performance system.

Recommended Transport Network Route Design

In determining the direction of the rerouting point as a route design recommendation can be done by determining the potential passenger demand, which is presented based on the Origin-Destination Matrix table. Where the origin-destination matrix or O-D Matrix data used is based on the results of surveys, interviews, and on roads conducted by the Cirebon City Transportation Office and STTD Bekasi cadets in 2022. The method in this matrix is a method with generation restrictions and a method with pull restrictions.

Table 8. Total Generation Demand and Attraction Movement for Each Zone

No	Ad	Pi
	Attraction	**Generation**
1	Pekiringan (33452)	Pekiringan (40657)
2	Pekalipan (28060)	Pekalipan (31386)
3	Kesambi (23756)	Kesambi (25704)
4	Larangan 2 (20469)	Sunyaragi 1 (22105)
5	Kalijaga 1 (21294)	Drajat (20878)
6	Karyamulya 2 (24346)	Kecapi, Larangan 1 (20613)
7	Sukapura 2 (22076)	Larangan 2 (22582)
8		Kalijaga 1 (24135)
9		Kalijaga 2 (19308)
10		Harjamukti 2 (19080)
11		Karyamulya 2 (28021)
12		Sukapura 2 (30645)

Sumber: STTD Bekasi cadets, 2022

The origin-destination movement pattern shown in Table 7, shows that the most movements as a generation zone are zone 1 (Pekiringan) with 40657, zone 2 (Pekalipan) with

31386, zone 3 (Kesambi) with 25704, zone 4 (Sunyaragi 1) with 22105, zone 8 (Drajat) with 20878, zone 16 (Kecapi 1, Larangan 1) by 20163, zone 18 (Larangan 2) by 22582, zone 20 (Kalijaga 1) by 24135, zone 22 (Kalijaga 2) by 19308, zone 24 (Harjamukti 2) by 19080, zone 26 (Karyamulya 2) by 28021, and zone 28 (Sukapura 2) by 30645. Meanwhile, zones with potential as pull zones are zone 1 (Pekiringan) with 33452, zone 2 (Pekalipan) with 28060, zone 3 (Kesambi) with 23756, zone 18 (Larangan 2) with 20469, zone 20 (Kalijaga 1) with 21294, zone 26 (Karyamulya 2) with 24346, and zone 28 (Sukapura 2) with 22076.

By using the feeder concept on the city transport route as a feeder transport on BRT Corridor 2, the main thing for determining the design is that the coverage of the rerouted route must have the potential for high passenger demand, which is located in areas that have community trip generation, where the distance between the point of origin of the trip and the destination of the trip has a route that is not too short and not too long (Suraharta & Ananda, 2020).

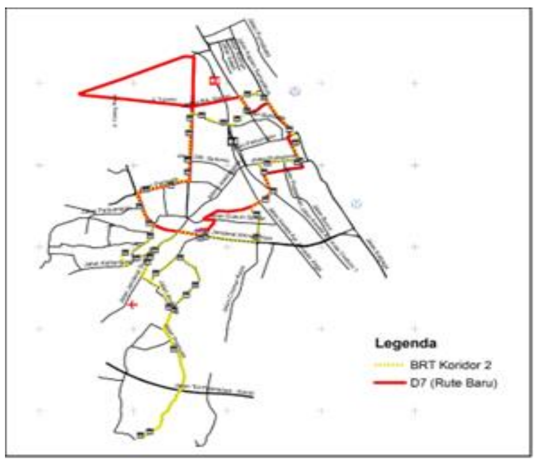

Figure 3. a) and b) Route D7 Before and After Rerouting

The following are some comparative route designs between the old route and the new route recommendations based on operational performance analysis and origin-destination matrix analysis on routes D7 and D8. In the picture, inside the green square box, there is a route point that has been changed.

The normality test is a test that is carried out with the aim of finding out whether the results of the available value data are normally distributed or not. This testing process was carried out using IBM SPSS Statistic 26 which obtained the following results.

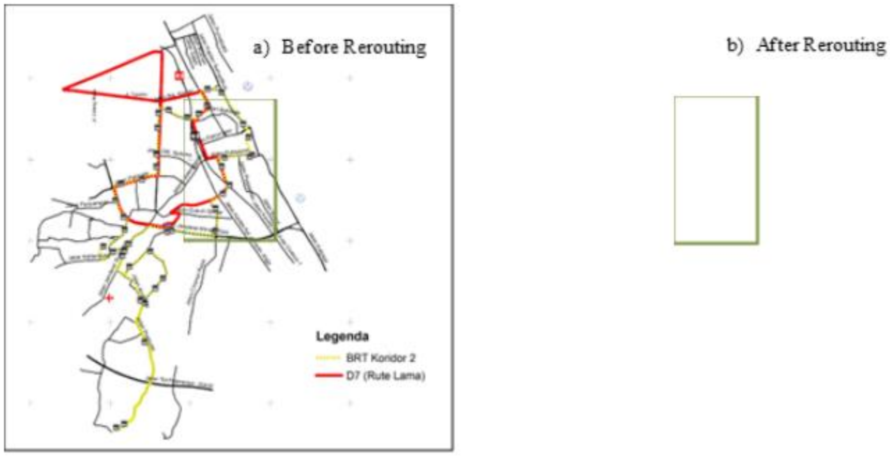

Figure 4. Route D7 Before and After Rerouting

Figure 4 explains the condition of the D7 route before and after rerouting. There are several things that are done in route changes, namely:

1. Moving routes that pass through Siliwangi Rd. to Kalibaru Selatan Rd. and Benteng Rd. This is done because on Jalan Siliwangi there are already several routes that pass through the road section. So as to reduce the amount of competition, the route was moved.
2. By moving the route of Siliwangi Rd. to Kalibaru Selatan Rd. and Benteng Rd., it is expected to increase the potential for generation, because the area is included in the generation zone category so that it has the potential to increase transport demand. The normality test is a test that is carried out with the aim of finding out whether the results of the available value data are normally distributed or not. This testing process was carried out using IBM SPSS Statistic 26 which obtained the following results.

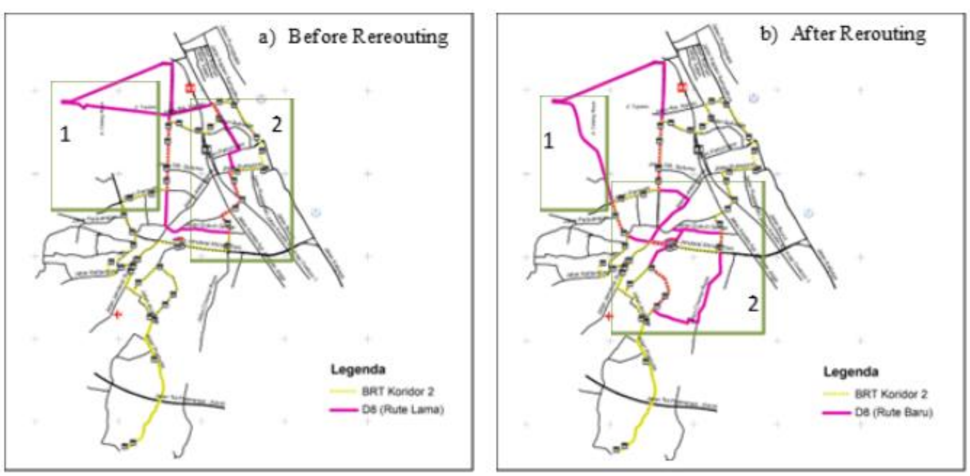

Figure 5. a) and b) Route D8 Before and After Rerouting

n Figure 5 above explains the condition of the D8 route before and after rerouting. There are several things done in route changes, namely:

1. There are two comparison boxes between the old route and the rerouting, where

   a. The first box is to move the route that passes through Tuparev Rd. to Brigjen Dharsono Rd. This is done because on Tuparev Rd. there are already several routes that pass through the road. So as to reduce the amount of competition, a new route was created.
   b. The second box moves the route from Siliwangi Rd. to Pangeran Drajat Rd. to Kesambi Rd. to Kanggraksan Rd. and continues through Angkasa Raya Rd., Pramuka Rd. to Ciremai Rd.
2. By moving some of the old routes to the recommended routes that have high generation potential, it is expected that the D8 route will increase its passenger.

Recommendations from this research were made with adjustments to the characteristics of the feeder as according to (EMBARQ India, 2013 in (Herdiana & Firdaus, 2021) that in the regional aspect according to EMBARQ India, feeder characteristics must connect the settlement node area to the main corridor. The route in the figure is the result of the rerouting recommendation design using the development of the feeder-line concept, where the physical operation of the feeder is integrated with the trunk line (BRT) connecting potential areas with perpendicular paths that aim to provide direct access to the trunk line (BRT) route.

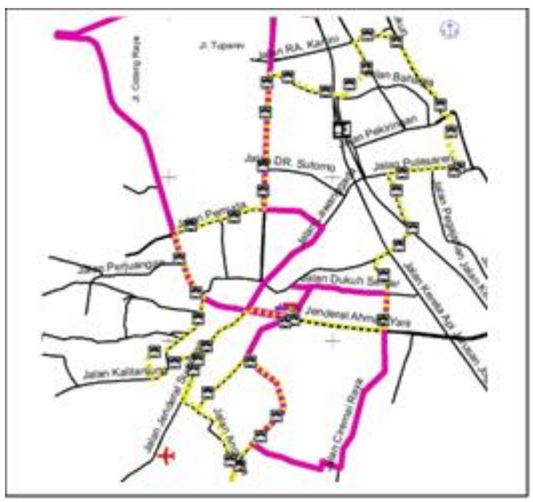

Figure 6. Feeder Characteristics on the New Route D8

In Figure 5 the route characteristics owned by route D8 are loop routes or circular routes where the terminal and final destination return at the same point. On the characteristics of the feeder-line concept, route recommendations are made where the latest route of route D8 as a feeder to BRT Corridor 2 reaches residential areas with the highest generation potential based on the origin-destination matrix in Table 7, this relates to the feeder concept from the ITDP Indonesia report source that the feeder system can connect potential areas connected to the main line stops with areas that have a high level of potential generation to the main service, namely BRT Corridor 2 (Indonesia, 2019).

The new route recommendations for routes D7 and D8 leads to BRT Corridor 2 stops, where the D7 route passes 16 stops with a perpendicular path between route D7 and BRT Corridor 2. While on route D8 which has a perpendicular path with BRT Corridor 2, it passes 11 stops. This aims to place the city transport feeder route in the generation areas that lead to the main corridor. So that the transfer of routes to the generation zone is one of the services required in conducting the feeder-line concept. And one of the reasons on which the rerouting recommendation is based, because the current condition of paratransit in Cirebon City is on city transport as a feeder not as the main corridor that delivers passengers directly to the pull zone. So that the routes between feeder transport and the main corridor do not overlap too much and make public transport in Cirebon City a well-integrated transport.

CONCLUSION

First, the operational performance of public transport in Cirebon City is still below the standards set by the Directorate General of Land Transportation in 2002. Out of the eight routes (D1 to D8) operating, 75% or six routes are in good condition, while 25% or two routes have substandard assessment results with a total score of ≤18. Second, the analysis reveals that the development of the public transport network system in Cirebon City is influenced by two main factors: the standard of transport operational performance and passenger movement patterns. As a result, the study recommends rerouting certain routes, specifically D7 and D8. For route D7, the recommendation is to change the path from Siliwangi Rd. to Kalibaru Selatan Rd. and Benteng Rd. For route D8, the suggested changes include altering the route from Tuparev Rd. to Brigjen Dharsono Rd., and from Siliwangi Rd. to Pangeran Drajat Rd., Kesambi Rd., Kanggraksan Rd., and finally to Ciremai Raya Rd. This research is limited to determining the rerouting of the transport network based on the OD Matrix and operational performance without reducing the number of routes currently in operation. However, the determination of transport routes could also consider other factors, such as the level of route overlap, operator profits, user perceptions, and more. Therefore, to achieve better rerouting results and to establish an integrated public transport network, further research could include these additional considerations. Additionally, it may be beneficial to reduce the number of routes to better align public transport provision with the needs of the community in the study area.

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