

Initial planning of monorail development in Medan

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Abstract. Medan City is the third largest city in Indonesia after Jakarta and Surabaya. With a total area of 265.10 km² and a population of 2.1 million people, it is proper that Medan City has operated a mass transportation system, which can accommodate the needs of the city movement. The current transportation system is dominated by a paratransit that has a capacity of 12 passengers. In fact, the data released by Ditlantas Poldasu and the Department of Transportation of Medan City shows that in 2013 the total number of passenger vehicles is 408,877 units, 99% of which are private vehicles, and there are only 1580 public transport. Planning the bus as a public transportation system in the city of Medan who tried to integrate it with the surrounding cities until now has not been done. One of the problems is the overlap of the bus route with existing public transport routes. This raises resistance from organda as an association of public transport operators located in the city of Medan. Bappeda Medan City in the Year 2014 has done the initial planning of monorail development in Medan City. The results of the study show that economically monorail development is feasible to be implemented and does not compete directly with the existing public transport system. This happens because 90% of monorail routes are in median ring road Medan City, which predicted the next 20 years will experience a large loading.

1. Introduction

The use of private vehicles became one source of congestion that occurred in almost all areas of Medan. Therefore, this monorail feasibility study examines the utilization of monorail transportation as one means to improve the performance of the Medan City road network.

There have been various studies showing the transportation problems and public transportation system in Medan City. Joewono et al., In 2007 has explored the problem and advised Medan to have a sustainable Transportation system. Medical et al, in 2011 also conducts research on travel time reliability in the main segments of Medan City. In the study showed a large buffer time and congestion, which is dominated by bad or very bad category [1].

The general concept of Medan City road network as stated in Medan Urban Spatial Plan of 2007-2016 shows there are 2 road ring roads that serve the movement in the outskirts of Medan City, and will become the main traffic movement path of Medan city. Figure 1 below shows it



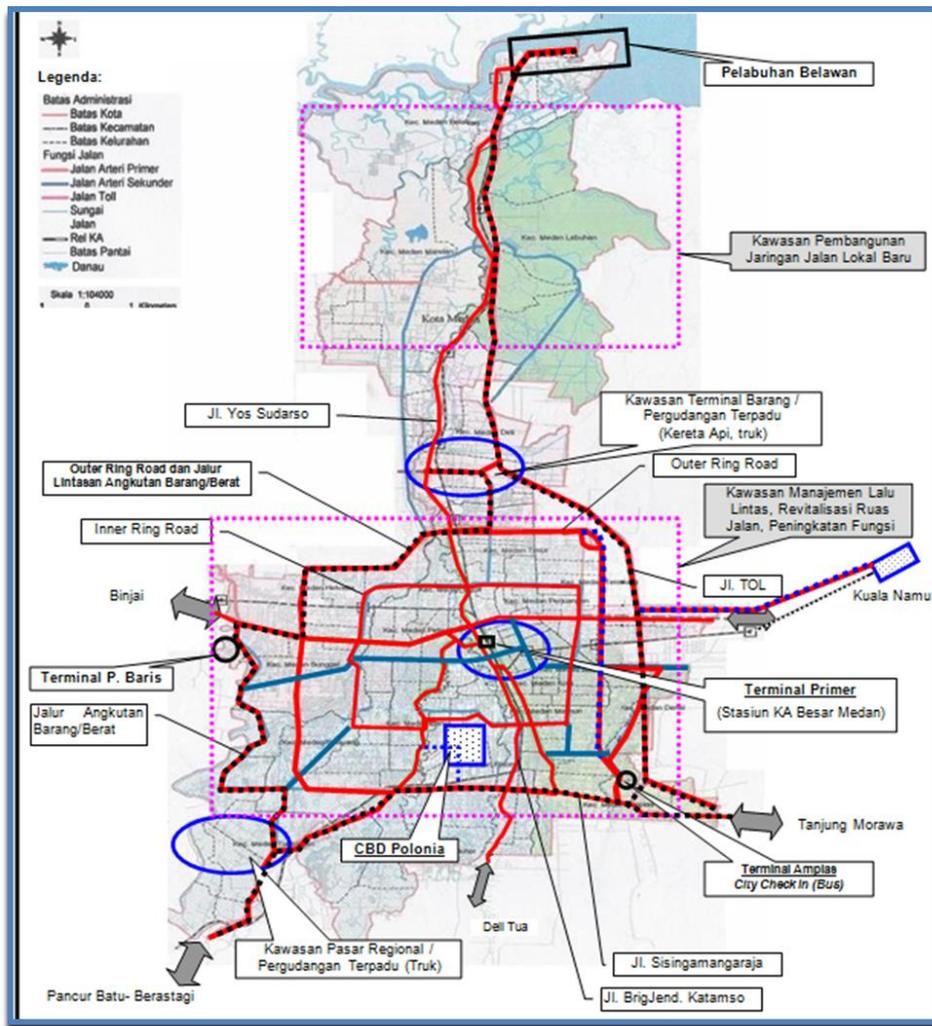


Figure 1. The map of main road Infrastructure on Medan, Indonesia; Existing and Plan

The study of road network Masterplan in Medan City in 2013 shows the need for Medan city trip in 2028 as shown in figure 2 below.

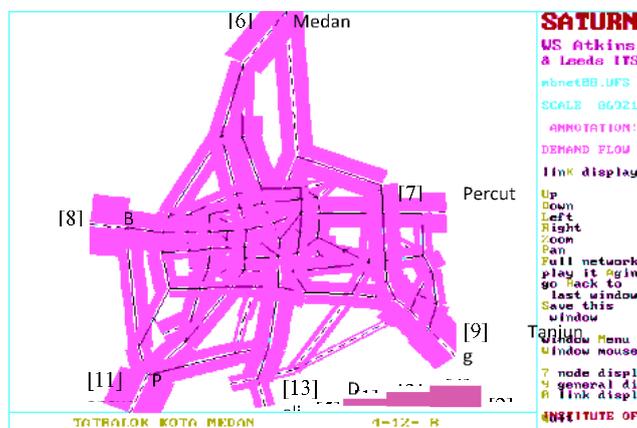


Figure 2. Future Demand Flow estimation at Medan City on 2028

To serve the inter-city movement around Medan City such as Binjai City, Lubuk Tanjung Morawa, Pancur Batu, Belawan, and Deli Serdang, Trans Mebidang rail and bus modes have been planned and some have been operated. However, although it has been planned since 2005 the two modes of transportation cannot be fully operated, because in addition to coordination between the city and district governments that are less good, there are routes that overlap with the existing mode of public transportation in each city / district in its path. This raises the resistance of public transport operators in the city and district areas in its path [2].

Especially for the city of Medan of Figure 2 shows that there will be demand movement of vehicles in the ring road of Medan, especially on the outer ring road. This has not been accommodated in the planning of public transportation system either Medan City or Mebidangro Transportation system (the upcoming megapolitan of Medan, North Sumatra Province).

Therefore, it is necessary to plan to accommodate the movement with mass transportation system in accordance with the needs and conditions of the Medan city. The condition of the city of Medan in the suburbs, especially the west and south is still in the development and development phase which relates to the network of ring road with a wide median (6 meters). While in the east and north are areas that have been built, but generally have a median that separates the direction of movement of the vehicle.

The results of discussions conducted by the government are chosen monorail mode that is more in line with the city of Medan because:

1. Have their own separate road network with existing road
2. Has a small turning radius, compared with other rail modes
3. Routes can be constructed on the road median so that it will greatly reduce the cost of land clearance.

2. Route Choice

The development of alternative corridor of monorail of Medan city, in this study, conducted with three main considerations, namely:

1. Existence of existing public transport service (operating or planned) as the main priority to be developed
2. Existence of activity centres in Medan City and its surrounding area and future development plan
3. Transportation network development plan, in accordance with the document of regional development plan

Based on the above considerations, there are several aspects of the criteria to be considered in the determination of this monorail corridor are:

1. Aspect of Spatial Planning
 - A. Corridor Monorail to follow the development of the city of Medan as contained in the RTRW Medan.
 - B. The corridor is adjusted to the existing ROW if the corridor crosses the existing road segment
 2. Transport Aspects
 - A. The monorail is organized by not placing it on an existing or planned public transport route.
 - B. The monorail corridor must be integrated with other public transportation, thus synergizing the operational of Medan city transportation system.
 3. Environmental Aspects
 - A. The monorail corridor does not cross the city location that has been designated as a cultural preserve and a city conservation area.
 - B. The monorail corridor as far as possible does not reduce the existing green open spaces [4].
- There are 5 pieces of route that will be planned, which has the potential to be developed that is:

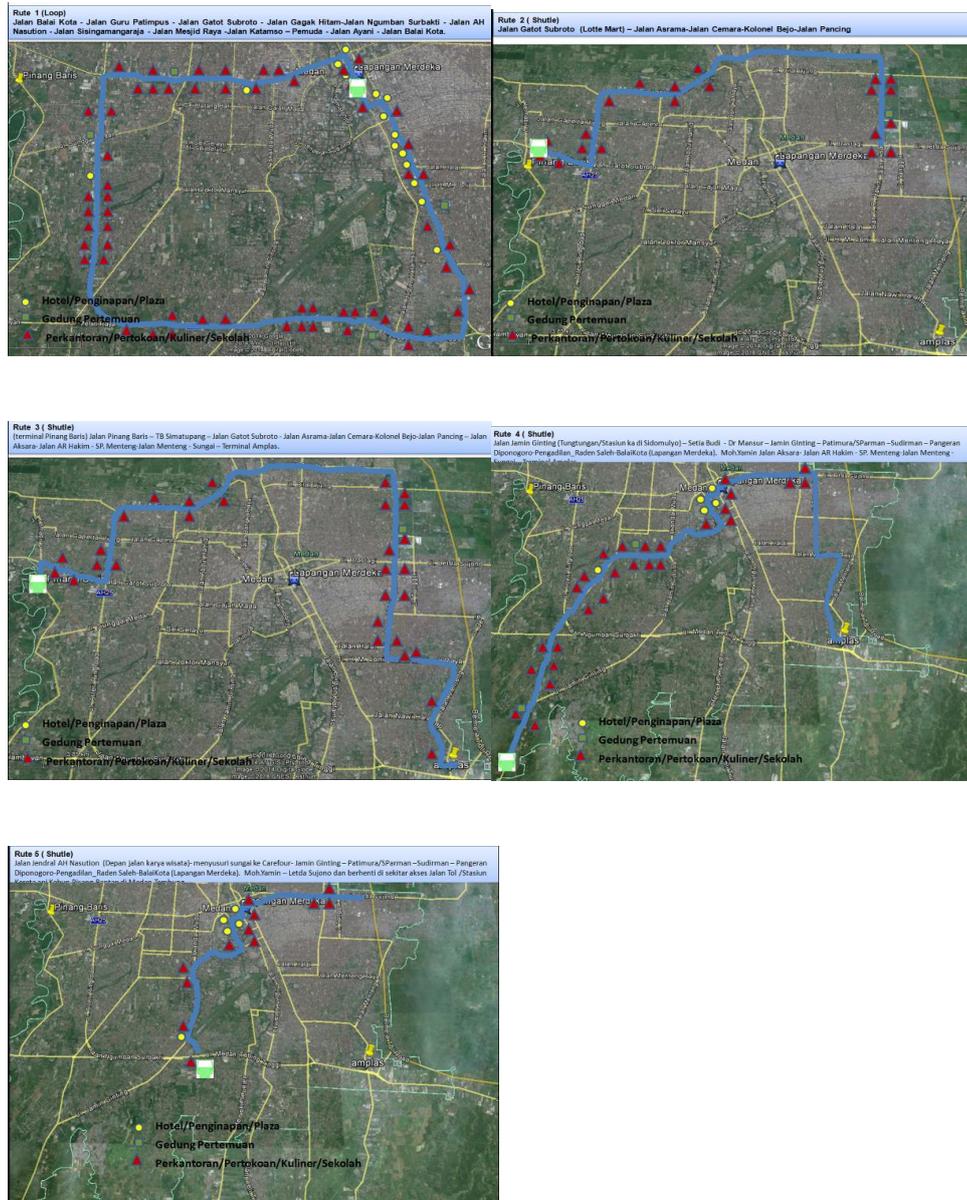


Figure 3. 5 Selection of terrain monorail route

The 5 routes above are divided into 2 types namely commuter and shuttle. Route 1 is a monorail with commuter operational type, where the route form is a circle type, so the monorail operation will rotate throughout the day. Routes 2,3,4 and 5 are monorail routes with shuttle type (Shuttle). This indicates that monorail operations will be conducted back and forth.

To see the potential passengers who will ride the monorail, then conducted a survey by down to the 5 monorail routes, with a potential record of the generation or attraction of passengers. Some examples of building sites that will provide the generation and attraction of passengers that will significantly affect the filling of the monorail are:

1. Hotel / Lodging / Plaza Location.

Hotels, inns and plazas provide attractions to visitors or guests who come to the location of the building. Hotels and inns usually have peak time on weekends, Saturday and Sunday, while for Plaza, activities usually start during the day at 10, and peak occurs during the afternoon, especially on weekends.

2. Meeting Building

The meeting hall has very specific characteristics of the generation and attraction, where activity on the building usually does not occur routinely, but the quantity of movement it generates will greatly affect the surrounding transport network.

3. Offices

The office building provides great potential for generation and attraction monorail usage. This is because the peak of traffic that occur in the morning and afternoon happen every day, as well as with special treatment people who work full time in an office (enter at 8 or 9 and return home at 16 or 17), will choose the monorail as their transportation choice because it is practical and has a reasonable level of comfort.

4. School / university

School buildings or universities have a kind of attraction in the morning, where at that time both schoolchildren and students will enter the school area. For schooling, the end of school time that occurs usually during the day, will be a traffic generation that affects the transportation needs at that time. Usually the amount of demand for public transportation ends school time is greater than the need for public transportation in the morning.

For the university, although the peak of the traffic takes place in the morning, the traffic generation is not at the same time, because the end of a lecture has different times. But in general, the largest rise of the university area is when the end of campus activities that coincided with the end of office administration service hours.

5. Shops

The shopping district will be a traffic generation starting from noon, where shopping activity begins, and will move up during the afternoon and evening.

6. Culinary

The culinary area has the traction of traffic during the day, and has the greatest traffic attraction in the afternoon and evening. The size of the attraction and the rise of traffic in the culinary region depends on how much and how many culinary offerings there are in the region.

To assess which monorail route will be a priority, an assessment of the 5 routes will be performed. Assessment criteria are based on technical reasons that can be compared on those routes. For the weight of each of the criteria can be seen in Table Below.

From the table, we can see that there are 5 criteria in terms of assessment for the 5 monorail routes are:

- Integration of Monorail Mode route with Bus Mode,
- Integration of Monorail Mode route with Railway routes
- Integration of Monorail Mode with TOD
- Potential of Traffic Generation and Pickup
- New station should be built [5]

Table 1. Below shows the amount of values assigned to each criterion (bus integration, railway integration, TOD integration, potential for generation and pull and the need for new stations to be constructed), based on the conditions of each route on the ground.

As an example; The assessment on a route based on the criteria of integration with the bus will be based on whether the route is much in tandem with the planned bus route set by the government. The more monorail routes are tangent to the bus route (thereby allowing the integration of modes), the value of the route is getting better. A route that has a path with at least 6 bus routes will have very good criteria. Preferably if the route is tangent to 1 or 2 bus routes, it will have an unfavourable criterion [7].

Table 1. Route characteristic

	Route 1	Route2	Route 3	Route4	Route 5
Length of Track (km)	25.8	18.8	28.2	29.9	14.5
Road Path	Jalan Balai Kota - Jalan Guru Patimpo - Jalan Gatot Subroto - Jalan Gagak Hitam-Jalan Ngumban Surbakti - Jalan AH Nasution - Jalan Sisingamangaraja - Jalan Mesjid Raya - Jalan Katamsa - Pemuda - Jalan Ayani - Jalan Balai Kota.	Jalan Gatot Subroto (Lotte Mart) - Jalan Asrama-Jalan Cemara-Kolonel Bejo-Jalan Pancing /William Iskandar (Stasiun Angkot)	(terminal Pinang Baris) Jalan Pinang Baris - TB Simatupang - Jalan Gatot Subroto - Jalan Asrama-Jalan Cemara-Kolonel Bejo-Jalan Pancing - Jalan Aksara-Jalan AR Hakim - SP. Menteng-Jalan Menteng - Sungai - Terminal Amplas.	Jalan Jamin Ginting (Tungtungan/Lauch/S tasiun bis) - Setia Budi - Dr Mansur - Jamin Ginting - Patimura/SParman - Sudirman - Pangeran Diponogoro - Pengadilan_Raden Saleh-BalaiKota (Lapangan Merdeka). ,Moh.Yamin Jalan Aksara- Jalan AR Hakim - SP. Menteng-Jalan Menteng - Sungai - Terminal Amplas.	Jalan Jendral AH Nasution (Depan jalan karya wisata)- menyusuri sungai ke Carefour- Jamin Ginting - Patimura/SParman - Sudirman - Pangeran Diponogoro - Pengadilan_Raden Saleh-BalaiKota (Lapangan Merdeka). Moh.Yamin - Letda Sujono dan berhenti di sekitar akses Jalan Tol /Stasiun Kereta api Kebun Pisang-Bantan di Medan-Tembung
Width of Road (m)	14-18	8-16	8-16	10-16	14-16
Number of Trip Generation & Attraction	At Least 185 location	At Least 117 location	At Least 191 location	At Least 156 location	At Least 74 location

Table 2. Criteria and value of each condition

Criteria	Weight (%)	Value for Each Condition				
		Very good/ Very Much (5)	Good (4)	Moderate (3)	little (2)	least/ none (1)
Integration to Bus Route	20	>6	5-6	4-3	2-1	0
Integration to Train Stasiun	20	>3	3	2	1	0
Integration to TOD (plan)	20	>3	3	2	1	0
Potential Generation / Attraction	20	>180	140-180	100-140	60-100	<60
Number of Station to Be build	20	0	0	1	2	3

Table 3. Priority of the route

	Route 1	Route2	Route 3	Route4	Route 5
First Station	Central train Station	Pinang Baris /Bus Station	Pinang Baris /Bus Station	Tuntungan /Train station (plan)	Tanah Kosong di jalan AH Nasution
Last Station	Central train Station	Willien Iskandar Angkot Station	Amplas/Bus Station	Trasin Stasiun Kebun Pisang (plan)	Trasin Stasiun Kebun Pisang (plan)
BRT Connection	1,2,3,6,7,(8,9)	1,2,4,6,8	1,2,4,6,8,9	5,7,1,4,2	7,5,4,2
Plan of Nearest TOD (RTRW)	a,l	a,k	a,k	a,d,l	a,d
Weight (%)	20	13	16	18	13
Priority	1	5	3	2	4

From the table above, Route 1 becomes the first choice of construction of this monorail followed by route number 4. It is based on the highest value that the route has. The route with the highest value, because it is considered to have access and infrastructure support more adequate than the other routes.

3. Feasibility Study

For feasibility analysis, conducted with reference to various possibilities of monorail operation of Medan city. For economic feasibility analysis is developed by assuming the operation of the monorail is purely by the Government for public service.

There are two types of feasibility reviewed in this study, which are economic feasibility and financial feasibility. Scenarios of both types of feasibility can be seen in the table below.

Table 4. Economic Feasibility Scenario

Economic	Information
Scenario 1	<ul style="list-style-type: none"> ▪ Full monorail operations are divided into 2 (two) operating segments: Routes 1 and 2. ▪ Do the overall construction (Do Maximum), which includes: elevated building, signal system, station, including the purchase of facilities for operational purposes. ▪ Revenue from tariff and reduction of public expenditure.

Tabel 5. Financial Feasibility Scenario

Finance	Information regarding financial scenario
Scenario 1	<ul style="list-style-type: none"> ▪ Full monorail operations are divided into 2 (two) operating segments: Routes 1 and 2. ▪ Purchase of new facilities for operational purposes. ▪ Revenue is obtained from passenger tariff revenue, tariff = Rp. 10,000, flat ▪ All financing is done by the private sector.
Scenario 2	<ul style="list-style-type: none"> ▪ Full monorail operations are divided into 2 (two) operating segments. ▪ Purchase of new facilities for operational purposes. ▪ Revenue is obtained from passenger tariff revenue, tariff = Rp. 10.000, - ▪ The initial cost of purchasing facilities and infrastructure procurement is entirely funded by the government
Scenario 3	<ul style="list-style-type: none"> ▪ Full monorail operations are divided into 2 (two) operating segments. ▪ Purchase of new facilities for operational purposes. ▪ Revenue is obtained from passenger tariff revenue, tariff = Rp. 25.000, - ▪ The initial cost of purchasing facilities and infrastructure procurement is entirely funded by the government

The estimated benefit component with the surplus consumer approach in this study was derived from the reduction of transportation costs in the presence of monorail operations. Some of the benefit components that have been undertaken by several studies (DJM Consulting & ECO Northwest, Seattle, WA, 2002) are as follows:

Table 6. Quantified and Non-Quantified Benefit Analysis

<i>Value of Travel Time Savings by Riders</i>	Q
<i>Parking Saving</i>	Q
<i>Reduces auto Operating/Ownership Cost</i>	Q
<i>Reliability</i>	Q
<i>Road Capacity for drivers</i>	Q
<i>Reduction in Bus Related Accidents</i>	Q
<i>Reduction in Auto Related Accidents</i>	Q
<i>Increased comfort and amenities</i>	NQ
<i>Impact on Urban form/Development near station</i>	NQ
<i>Community Pride</i>	NQ

Notes: Q=quantified; NQ=Not Quantified.

Source: Benefit-Cost Analysis of the proposed Monorail Green Line, 2002

Table 7. Calculation of Monorail Feasibility Parameters for various occupancy ratios and discount rates.

Economic Indicator	Discount Rate			
	8%	12%	20%	25%
Net Present Value (NPV)	(5,721,743,659,655)	(7,502,357,369,105)	(7,100,553,012,076)	(6,518,764,860,913)
Benefit Cost Ratio (BCR)	-0.403245032	-0.13310037	-0.0197902	-0.007249738
Economic Internal Rate of Return (EIRR)	0			

Occupancy Ratio 1/2				
Economic Indicator	Discount Rate			
	8%	12%	20%	25%
Net Present Value (NPV)	69,545,486,941	(4,857,931,747,594)	(6,249,248,445,610)	(6,003,850,821,326)
Benefit Cost Ratio (BCR)	1.008196287	-0.380774524	-0.07763022	-0.034511463
Economic Internal Rate of Return (EIRR)	8.031			

Occupancy Ratio 3/4				
Economic Indicator	Discount Rate			
	8%	12%	20%	25%
Net Present Value (NPV)	5,860,834,633,536	(2,213,506,126,083)	(5,397,943,879,144)	(5,488,936,781,739)
Benefit Cost Ratio (BCR)	1.725665726	-0.705206658	-0.174499386	-0.089030824
Economic Internal Rate of Return (EIRR)	10.35			

From the calculation and analysis of economic feasibility, in terms of benefits generated when the occupancy rate of 1/2 the largest NPV value of Rp. 69 Billion at a discount rate of 8% (Current Interest Rate of Bank Indonesia (SBI)). Meanwhile, the value of BCR at the discount rate is 1.00. Based on Table 7 the Economic Internal Rate of Return (EIRR) amounted to 8.031%.

From the above calculation when the occupancy rate of 3/4 the largest NPV value of Rp. 5,860 Trillion at discount rate of 8% (Current Interest Rate of Bank Indonesia (SBI)). Meanwhile, the value of BCR at the discount rate is 1.72. Based on Table 7 the economic indicators of interest rate return - Economic Internal Rate of Return (EIRR) is equal to 10.35%.

Conclusion

1. The study of the monorail route shows that there are two monorail routes that have the potential to be developed in Medan City.
2. The first route is a route that begins at Medan railway station on Lapangan Merdeka that has a circular trajectory of Medan, crossing the streets of the protocol and ending back at the big station. (Looping).
3. The second route is the route that begins / ends from the station to the terminal Amplas by crossing the path Setia Budi, Dr Mansur and Lapangan Benteng and Lapangan Merdeka. This route also crosses Mohamad Yamin, Aksara and AR Hakim roads up the Menteng road. The operation of this route is shuttle.
4. From the results of the above study, it can be concluded that the monorail is economically feasible to be built.

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