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Transport Demand and Traffic Engineering Scheme in The Street Space Reallocation Plan For The Future Tram Track

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ABSTRACT : Surabaya has plan to reactivate tram in several arterial streets which will cause car lane reduction. This research aims to enhance the traffic performance of several arterial streets in Surabaya after the reduction of street width due to street space reallocation for the future tram track. The modal split analysis in natural car and train or pulled scheme is compared to several vehicle restriction methods or push scheme which using data from car and motorcycle rider. From comprehensive computation, it is concluded that the insertion of tram track in the road space directly without any transport demand management will impact street performance to a more severe condition of traffic jam intersection. Therefore this research advising city government to apply restriction scheme to car and motorcycle by using high occupancy vehicle only scheme or pre paid area licencing scheme.

Keywords: *Vehicle Restriction, Tram, Surabaya, Traffic Engineering.*

1. INTRODUCTION

Surabaya has plan to introduce tramway using reactivation scheme. The right of way (ROW) is planned at center or median with maximised ROW class B if possible, means that the tram track is longitudinally separated from traffic, while crossing traffic is still have possibility at a certain designated places.

The problem adresses to the reduction of the width of the streetspace allocated to existing crowded traffic condition. Current condition of the lack of good public transportation system. Exhilarating the use of privat vehicle whether it is car or motorcycle. Without any vehicle restriction at city center, the street toward city center will remain full of privat vehicle, at least in the time when tram is still new.

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With traffic demand reduction schemes, there is some opinion of privat vehicle user whether they want to leave their car and move to tram and its feeder which can be calculated as privat vehicle reduction.

The goals of this paper are as follow:

- Analizing traffic performance at the rest of several streets with a part of street allocated for tram ROW without any demand restriction.
- Analizing traffic performance with several demand restriction technique applied at several streets above

2. LITERATURE REVIEW

Street performance and interchange performance calculation is the main issue and discussion in the Indonesian Highway Capacity Manual (Direktorat Jenderal Bina Marga, 1996), the formal and widely accepted by Indonesian traffic engineers.

Naweed and Rose (Naweed, 2015) discussed the issue of track position in traffic is about safety at mixed traffic configuration including conflict with vehicle, while Naznin et al (Naznin, 2016) stressed at pedestrian safety and accessibility.

Public transit in the city especially rail based is very robust in attract passenger i.e. London underground atrract 85% peak hour trips before application of road user charging as stated by Litman (Litman, 2006) Road user charging in London reduce car using by 20% at the early operation, hence car mode share is decrease from 12% to 10% of over one million trip at daily morning peak. It results 14% increase of bus passengers and 1% increase of metro passengers from current 85% metro mode share.

T&E (T&E, 2003) reported that bussiness group members felt that in overall the scheme impacted their bussiness positively. The majority (69%) felt charging had no impact, 22% reported positive impact, and 9% reported negative impact.

For better traffic performance a car vehicle reduction scheme should be applied, which includes expensive parking policy at city center, high occupancy vehicle only street, and road user charging. Schemes for reducing traffic by road pricing in Paris is considered by Kilani et al (Kilani,2014), in Lyon by Pronello and Rappazzo (Kilani, 2014), in Vienna by Dieplinger and Furst (Dieplinger, 2014), in Madrid by Di Ciommo and Lucas (Di Ciommo, 2014). Area licencing scheme or annual registration fees is mention by Seik (Seik, 1997) and Hensher and Bliemer (Hensher, 2014)

Stated preference survey is studied by Bourgeat, De Luca and Di Pace (De Luca,2015), and Satiennam et al (Sateennam,2015).

3. MATERIAL AND METHOD

The outline methodology can be summarised in Figure 1. Survey includes traffic counting from video recorded from Transportation Board of Surabaya for the existing analysis and as forecasting base. Street width is measured and tram track Right of Way is identified.

When tram is operated with its integrated feeder system, it is possible that a part of private vehicle riders will shift to tram. Therefore a stated preferences survey is conducted in order to know the natural changes of mode share after operation of tram.

Surabaya also prepares to adopt privat vehicle restriction scheme, whether it is area licencing scheme, congestion pricing or high occupancy vehicle only. The determination is

reducing traffic volume to cope the narrower street space alocated for traffic as a result of acquisition a part of the street by tram track. On the other side, these schemes also have impact in supporting public transport by increasing passengers moving from privat vehicle riders. For this reason a survey also conducted for asking opinion about what would privat vehicle riders plan when these schemes is applied.

Reactivation of Surabaya tram track at the first stage (Figure 2) consists of double track section for two way tram traffic and single track section for one way tram traffic. The double track sections consist of jl Raya Darmo and jl UripSumoharjo, while single track sections are as follows: jl BasukiRahmat, jl Embong Malang, jl Blauran, jl Bubutan, jl Indrapura, jlRajawali, jl Veteran, jl Pahlawan, jl Gemblongan, jl Tunjungan, jl GubernurSuryo, and jl Panglima Sudirman.

Tram track in Surabaya will be laid as a part of median depend on availability, and at the center of the street if there is no existing median. In major cases the track is separated from traffic with exception on two mixed traffic sections –jl Veteran and southern part of jl Pahlawan– due to narrow existing street.

The Right of Way (ROW) of the tram track is 4 meters width for each direction according to Basic Engineering Design. The application at median of jl Raya Darmo and jl Urip Sumoharjo with 6 meters distance between axis of the track enabling tree row and shelter inserted between the two tracks. On the other hand this configuration reducing the street more to produce more severe traffic condition in which careful analyze is a necessity. Existing condition is shown in Figure 3 and the tram position is shown in Figure 4.

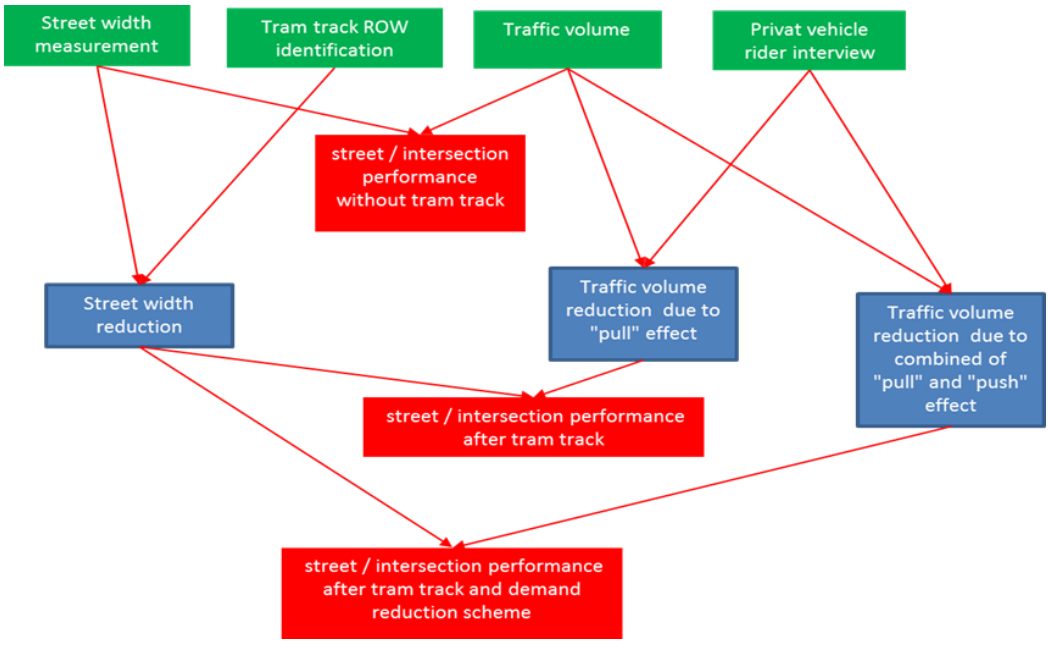

Figure 1. Flow chart of survey and analysis

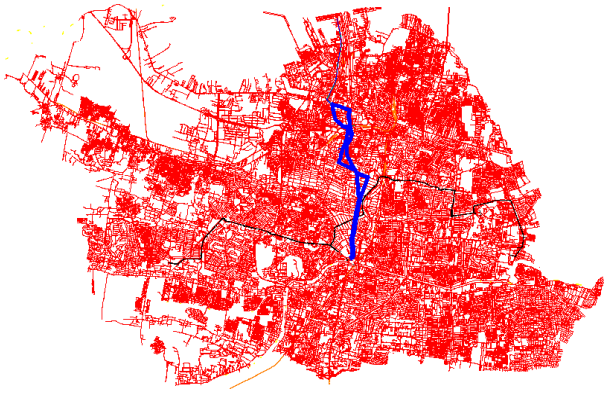

Figure 2. Tram track route plan stage 1

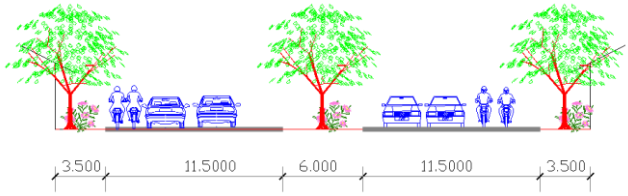

Figure 3. Current cross section of Raya Darmo street

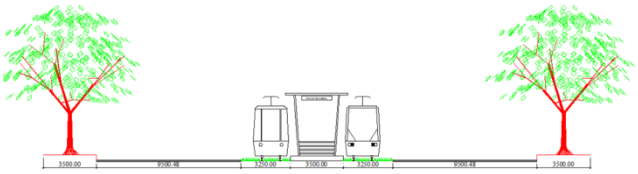

Figure 4. Double track position at median

In one way section at city center ROW of the tram is in the middle which reduces street with by 4 meters at the lane and 5 meters at tram stop section. Dedicated tram lane needs some abrubt at certain location enabling traffic to manouvre from left side to right side and vice versa. Existing condition is shown in Figure 5 and tram track position is shown in Figure 6.

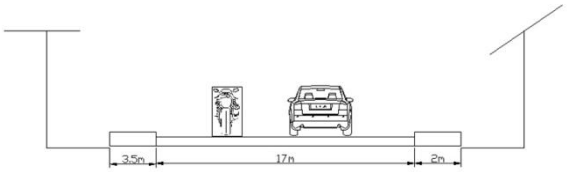

Figure 5. Current cross section of one way street

Figure 6. Single track position at steet center

Interview survey in Surabaya using stated preference method shows that tram with its feeder as a part of better public transport system will atrract29.44% ofprivat vehicle rider (Table 1). It cause reduction of traffic volume. This condition of demand reduction and the narrower street due to tram track acquisition resulting varries street performance.

Table 1. Stated preference of mode tram and feeder

Tariff Scenario	Respondent	Certainly taking public transit	Probably taking public transit	Hesitate in taking public transit	Probably not taking public transit	Certainly not taking public transit	Proportion of privat vehicle rider shift to public transit
Rp 10.000,- per hour	125	7	32	13	4	4	29.44
	Persentage (%)	5.6	25.6	10.4	3.2	3.2	
	Weight	0.9	0.7	0.5	0.3	0.1	
	Proportion of taking public transit (%)	5.04	17.92	5.2	0.96	0.32	

Survey had been conducted in Surabaya in 2014 with 125 respondent of privat vehicle user, and reported the opinion of respondence if there is schemes to reduce privat vehicle demand to the city center while a better comprehensive public transit is available (Table 2). The schemes include pay for intering city center or expensive parking scheme and high occupancy vehicle permit scheme. 24.8% of them would pay would pay, 5.6% want to follow car sharing, 4.8% keep their car with rerouting, while the majority 64,8% shift their mode to the better public transit.

Current condition of traffic and especially turning movement is surveyed using traffic count method on recorded visual data of Inteligent Transportation System of Transportation Office of Surabaya. This existing demand is used for performance benchmark of the condition and treatment after the tram track is applied. Street sections performance of existing (2015) condition is analized using Indonesian Highway Capacity Manual or MKJI in Indonesian and the result is shown in Table 3 (column 1). The red colour shows severe condition.

Tabel 2. Privat vehicle restriction and respondent opinion

Scheme choices	Respondent	Proportion
Pay scheme (ERP or expensive parking)	31	24.80%
Shift to the better public transit with comprehensive feeder	81	64.80%
Using car with minimum 3 passengers (accompanion with 2 others)	7	5.60%
Using privat car (rerouting)	6	4.80%
Total	**125**	**100.00%**

During the construction time the street has been narrowed already while traffic condition is expanded to 2017 without any reduction by shifting it to public transit. It is because the

tram has not been operated yet. Hence congestion is severed in several street as shown in Table 3 (column 2).

After operation of tram, 29.44% of privat vehicle user will change option to tram. Therefore traffic volume will be reduced and street congestion performance is increased and it is shown in Table 3 (column 3) as decrease of degree of saturation (DS)The decrease of DS, however, results a still high due to the narrower streetspace. A kind of solution is decreasing privat vehicle by using several schemes of restriction. The result is shown in Table 3 (column 4) which is increase street performance of traffic condition.

Column 5 and 6 shows the street performance of the year 2022, 5 year after tram operation, with and without transport demand management or privat vehicle restriction. It shows that privat vehicle restriction is very important tool for better performance of street traffic.If street performance shows a better performance with transport demand management (TDM) or privat vehicle restriction, the condition of intersection will be encountered after this.

The initial condition is 2015 with existing turning movement condition. Degree of saturation (DS) calculation shows that at existing condition some intersection is crowded as shown in Table 4 (column 1) an marked with red color.Column 2 of Table 4 shows the intersection condition in 2017 when tram track still during construction. The condition is more severe. Colomn 3 shows the increase of intersection performance when tram is in operation in 2017 with some privat vehicle user left their vehicle and use tram. It is obviously that intersection performance increase.

Table 3. Street performance of traffic condition at existing condition and after tram operation with TDM

Street Section	Most Peak Period	Degree of Saturation (DS)					
		2015 (Existing)	2017 (Construction)	2017 (Operation)	2017 (TDM)	2022 (Operation)	2022 (TDM)
Raya Darmo (South Section) - Northbound	Morning Peak	1.033	1.165	0.818	0.459	0.993	0.556
Raya Darmo (South Section) - Southbound	Morning Peak	0.535	0.603	0.424	0.237	0.514	0.288
Raya Darmo (South Section) - Southbound	Noon Peak	0.620	0.699	0.491	0.275	0.594	0.333
Raya Darmo (Mid Section) - Northbound	Morning Peak	0.774	0.872	0.613	0.343	0.743	0.416
Raya Darmo (Mid Section) - Northbound	Afternoon Peak	0.863	0.973	0.684	0.383	0.829	0.464
Raya Darmo (Mid Section) - Southbound	Afternoon Peak	0.708	0.798	0.561	0.314	0.679	0.380
Raya Darmo (North Section) - Northbound	Morning Peak	1.026	1.156	0.813	0.455	0.985	0.552
Raya Darmo (North Section) - Southbound	Afternoon Peak	0.971	1.094	0.768	0.431	0.931	0.522
Urip Sumoharjo - Northbound	Morning Peak	1.613	1.819	1.278	0.716	1.550	0.868
Urip Sumoharjo - Southbound	Afternoon Peak	1.777	2.003	1.407	0.788	1.707	0.956
Basuki Rahmat	Morning Peak	0.952	1.117	0.785	0.440	0.952	0.533
Embong Malang	Afternoon Peak	0.309	0.417	0.293	0.164	0.355	0.199
Blauran	Morning Peak	1.004	1.130	0.794	0.445	0.963	0.539
Bubutan (South Section)	Morning Peak	0.721	0.813	0.571	0.320	0.692	0.388
Bubutan (North Section)	Afternoon Peak	0.543	0.609	0.428	0.240	0.216	0.121
Indrapura	Morning Peak	0.679	0.908	0.638	0.358	0.773	0.433
Rajawali	Noon Peak	0.365	0.489	0.344	0.193	0.413	0.231
Veteran	Noon Peak	1.194	1.840	1.293	0.724	1.542	0.864
Pahlawan (North Section)	Noon Peak	0.549	0.588	0.413	0.232	0.493	0.276
Pahlawan (South Section)	Noon Peak	0.574	0.682	0.481	0.269	0.582	0.326
Gemblongan	Afternoon Peak	0.772	1.111	0.781	0.437	0.384	0.215
Tunjungan	Afternoon Peak	0.871	1.881	1.322	0.740	1.601	0.897
Gubernur Suryo	Morning Peak	1.074	1.497	1.051	0.589	1.277	0.715
Panglima Sudirman	Morning Peak	1.125	1.511	1.061	0.595	1.288	0.721

After transport demand management (TDM) means there is schemes of privat vehicle restriction applied in 2017, a significant decrease of traffic volume resulting significant increase of intersection performance.

The condition of 2022 with or without TDM is shown in column 5 and 6 respectively. It shows that TDM means privat vehicle restriction is very important.

4. RESULT AND DISCUSSION

The congestion still occured at two intersection eventhough restriction to the privat vehicle has been applied. The point is at Bubutan street and Veteran street.

It should be noted that at the two point tram track is at dedicated lane. It reduced street width significantly and reduce street performance. It is a possibility to change the dedicated lane to mixed traffic lane to increase streetspace width.

The mixed lane scenario is applied as well at two narrow street section – Veteran street and Pahlawan street (South section) – with good result. However, a tram stop at this section can significantly reduced the performance. Tram stop should be placed at the wider point of this section, as shown in Figure 7 (Veteran street) and Figure 8 (Pahlawan street)

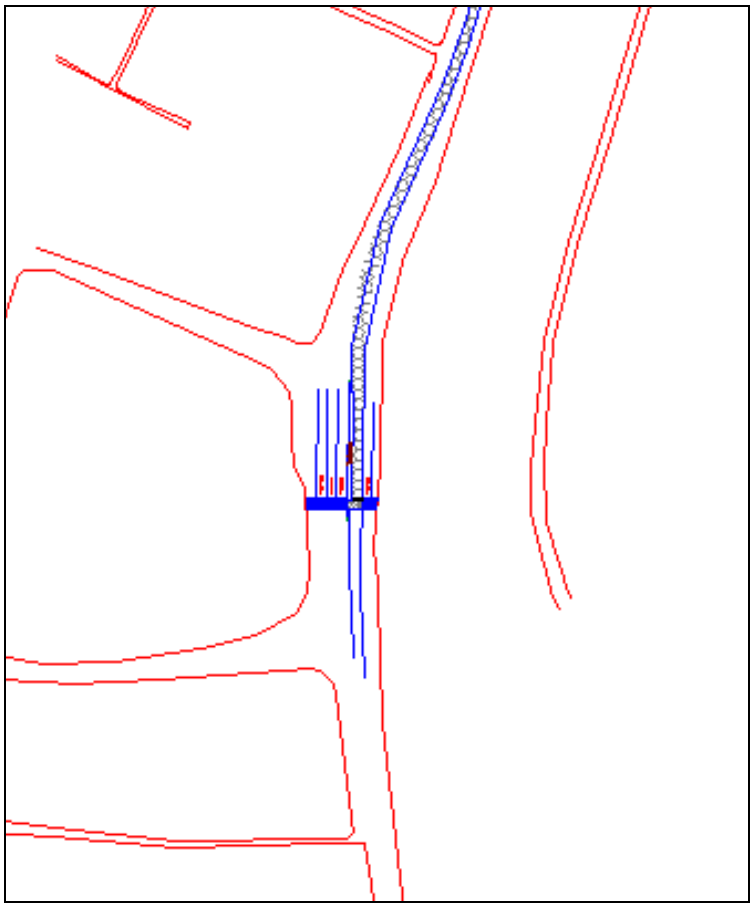

Figure 7. Placement of tram track at widest point of Veteran street

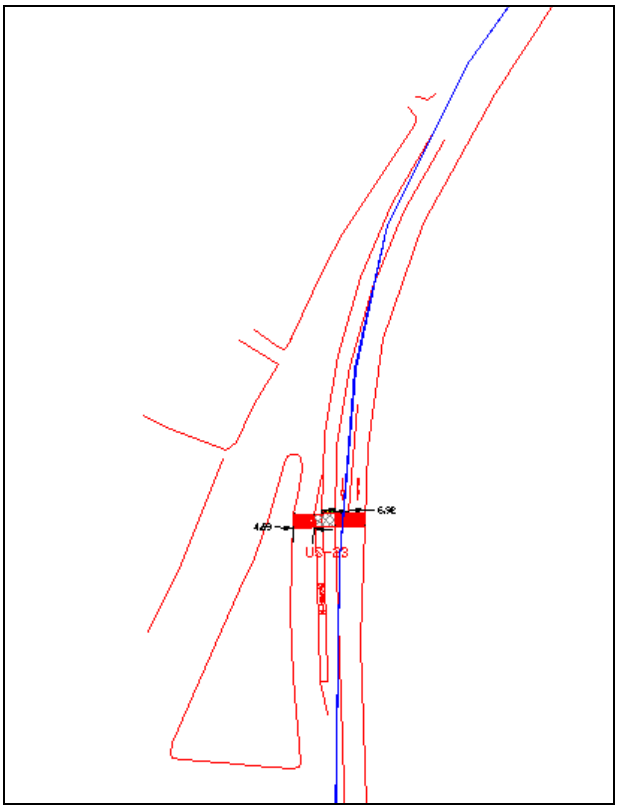

Figure 8. Placement of tram track at widest point of Pahlawan street

It is important to be noted that bicycle lane is occured at the southern half of the route. This bicycle lane should be moved to the wide pedestrian sidewalk with addition of clear marking and signing.

5. CONCLUSION

Analizing traffic performance at several streets with a part of street allocated for tram ROW without any demand restriction shows that intersection is the critical point of congestion. Therefore transport demand management (TDM) is a must.

Analizing traffic performance with several demand restriction technique applied at several streets along the tram route shows that some intersection is still congested. Therefore design still should be modified at the critical legs by change dedicated lane to mixed traffic, in which tram speed will be reduced at these points.

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