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THE ANALYSIS OF RIGHT-OF-WAY FOR DIFFERENT ROAD USERS IN CHINA: PASSING-PASSENGER-UNIT VERSUS PASSENGER-CAR-UNIT

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Abstract

Being a public resource, the roadway space was distributed between different road users based on the Passenger-Car-Unit (PCU) concept. However, this concept tends to under estimate the capacity of public transportation and non-motorized travel. To improve the traditional car-oriented design to become more human-oriented, this study proposed a Passing-passenger-unit (PPU) and the method to observe the PPU in roadway level and area level. The PPU data were collected for urban arterials and residential areas in China to test the method and to compare the right-of-way distribution at different types of locations. Results showed that the PPU revealed the true efficiency of the facility carrying passengers. Using PPU would tell a different story about the facility or system compared to using PCU. Additionally, using PPU to analyze the right-of-way for the roadway or community could offer guidance for improving pedestrian and bicyclist environment.

Keywords

Passenger-Car-Unit, Passing-Passenger-Unit, Passing-Passenger-Transport, Public Transit, Right-of-way

BACKGROUND

The passenger-car-unit is a basic metric used in transportation engineering and planning to assess traffic capacity on a roadway facility such as a road segment or an intersection. Using this metric, the efficiency of a transportation system was quantified by the number of vehicles. However, in China, non-motorized travel and public transportation are the two major modes for commuters. Measuring the roadway capacity by PCU would under estimate the capability of the public transportation and non-motorized vehicles, and even ignore the number of pedestrians. For example, in figure 1, the private vehicle and taxi took 63% of the traffic flow measured by PCU, and transit and non-motorized travel only took 34%. Using PCU as the only metric to guide the transportation system design would bring a vehicle-oriented system. As a result, the bus only lane and bike lane were denied by the designers.

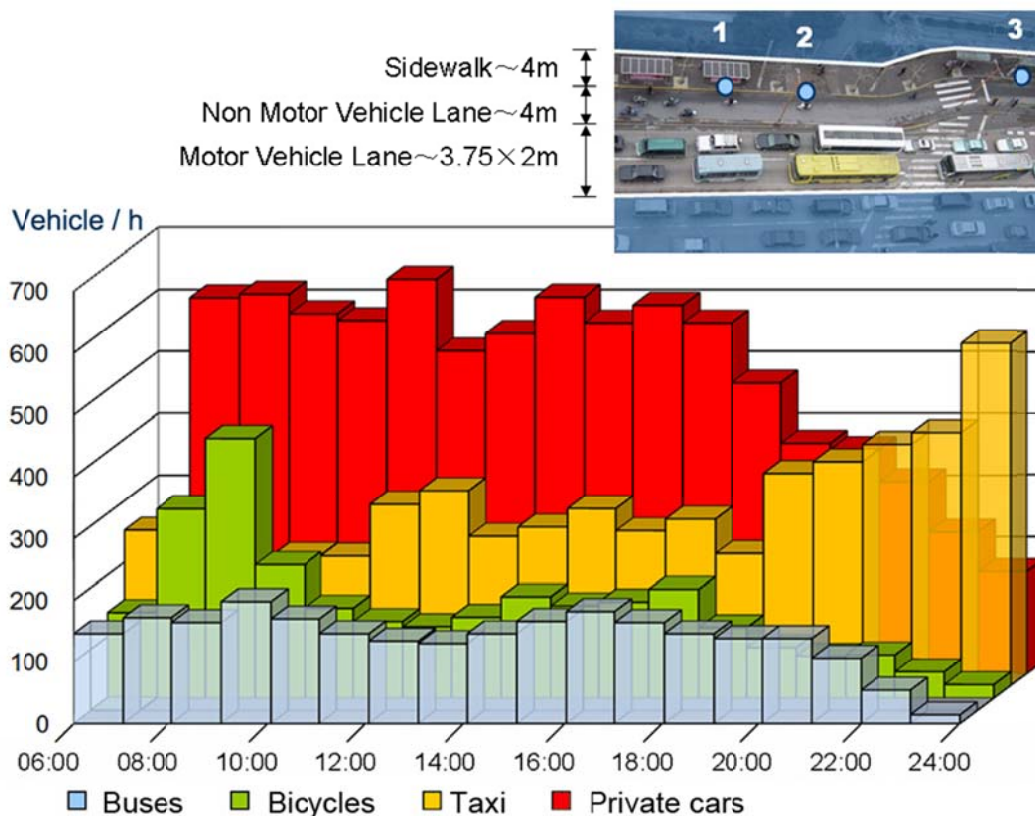


FIGURE 1 The PCU for different modes in south bound of Caoyang Road in different time of day. (PCU/Hour)

The equity and the accessibility of the transportation system have been the trend in the transportation planning. Ircha (1) suggested a set of equity-measuring variables and proposed a remedial operational measures. Randall (2) proposed the pedestrian connectivity to reduce the walking distance, increase pedestrian route directness to improve the walking environment around residential areas and schools. Southworth (3) developed the walk-ability as the parameter to evaluate the roadway design. Facing this trend, González-Guzmán (4) suggested that the road space should be reallocated from vehicles to public transport to diminish the number of private vehicles on the corridor.

In China, public transportation has been the focus of the development in cities and regions. Cheng (5) proposed the safety, accessibility, affordability, and universal design as the four equity parameters to assess transport diversity for promoting sustainability and quality of life. Taking Qingde City as an example, Zhang (6) compared the performance of various road space reallocation schemes and proved that the road-space-reallocation can help achieve equity and efficiency by improving mobility options for

non-drivers and encouraging travelers to shift from autos to more space-efficient modes. In order to shift from vehicle-oriented design to human-oriented design, this study proposed the passing-passenger-unit (PPU) as a metric to evaluate the ability of a roadway facility or system to serve passengers.

PASSING-PASSENGER-UNIT

This study proposed the Passing-passenger-unit (PPU) as a new metric to evaluate the ability of a roadway facility or system to serve people. PPU is defined as the passengers passing in a roadway space (such as a roadway section, an intersection, and a block) in a certain period of time. The passengers should be classified into pedestrians, riders, transit passengers, private vehicle passengers and drivers, and taxi passengers and drivers. We collected the PPU for Caoyang Road in the same time period and the data was shown in figure 2. Using PPU, the private vehicles and taxi vehicles only took 23% passengers, while transit and non-motorized travel took 77%. This is opposite to the conclusion when evaluating the efficiency using PCU. Considering the highest capability of transit to serve passengers, the bus lane should be considered in the design.

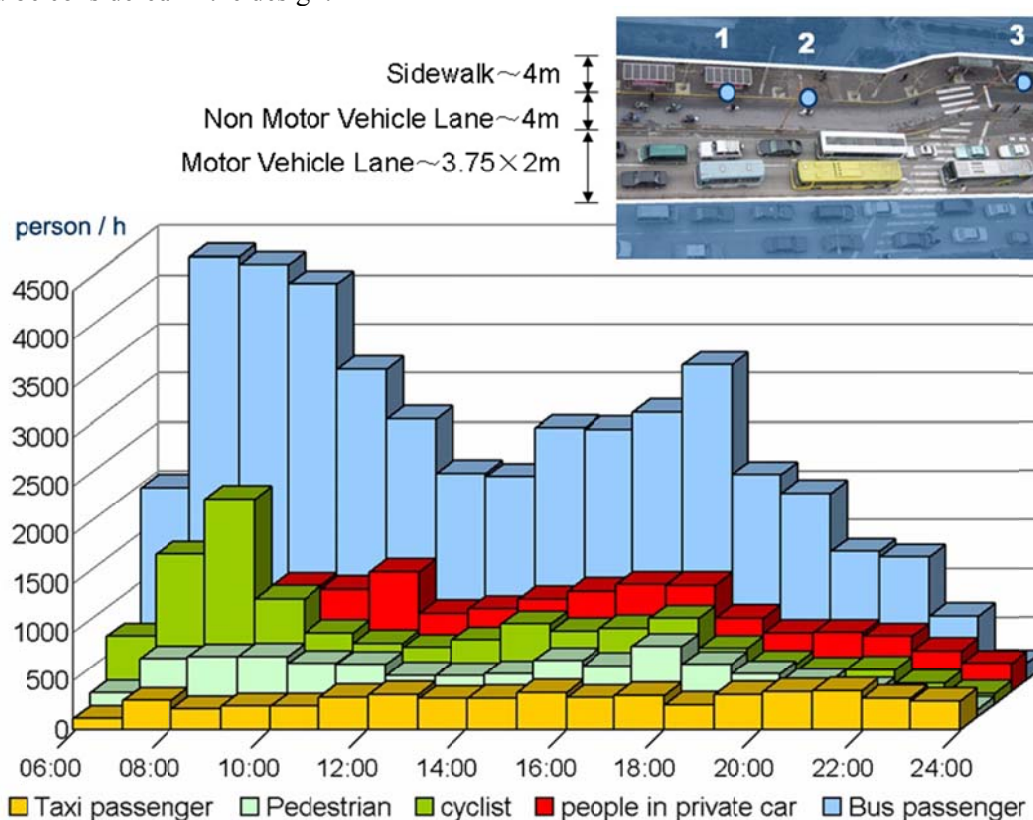


FIGURE 2 The PPU for different modes in south bound of Caoyang Road in different time of day. (Passenges/Hour)

OBSERVATION METHOD FOR PPU AND RIGHT-OF-WAY ANALYSIS

Roadway Segment PPU Observation

This study proposed a work flow collecting PPU in five steps.

Step 1, PPU observation

The number of pedestrians, bicycles, private vehicles, taxis, transit, and metros should be recorded by hour for the entire day, and labeled as Q_P , Q_{Bike} , Q_A , Q_T , Q_{Bus} , Q_M . Sample the average occupation

rate for private vehicles, taxis, transits, and metros for each hour, and labeled as C_A , C_T , C_{Bus} , C_M . Using Q_i , C_i to calculate the number of passengers passing a given section or intersection.

Step 2, passing passenger transport (PPT)

Record the license number on the plate, arriving and departing time for targeted vehicles and pedestrians, calculate the velocity of bicycles, private vehicles, taxis, transit, and metros, V_A , V_T , V_{Bike} , V_M , V_P , V_{Bus} . Then calculate the PPT using the V_i , PPU_i .

Step 3, the level of the environment

Collect the sustainability indices such as roadway area per person L_{Pi} , carbon emission per person P_{Pi} , energy consumption per person E_{Pi} , tax and fees per person D_{Pi} .

Step 4, comfort level of passengers

Collect the pedestrian accident hot spots, rider accident hot spots and the spatial distribution. Collect the data for Space required by different modes in square meters per person S_{Pi} , temperature T_{Pi} , air quality A_{Pi} and noise level N_{Pi} .

Step 5, right-of-way reallocation based on PPU

Considering the PPT and environment indices, personal comfort level, propose the reallocation of right-of-way for the given roadway segment at a specific time.

PPU and Right-of-Way Analysis for Commuter Corridor in Beijing

The Jingtong highway in Beijing connects the CBD area to the satellite city Tongzhou. There are 10 lanes in two directions. In 2013, the first lanes in the two directions were all designated for transit bus use only in the morning and evening peak hours. In order to evaluate the effect of the bus lane, a PPU survey was taken on January 11, 2013. The results were shown figure 3 and table 1.

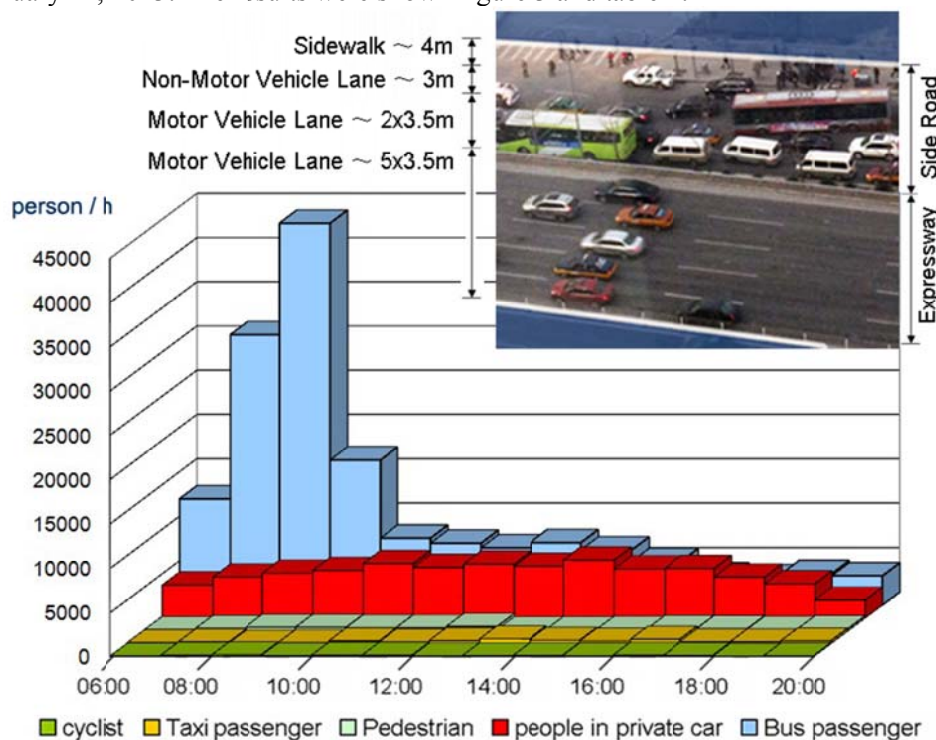


FIGURE 3 The PPU for different modes in Jingtong Highway in different time of day. (Passenges/Hour)

TABEL 1 PPT and Environment Indices for Jingtong Highway (8 am-9 am)

Indices		Private vehicle s	taxis	buses	metro s	pedestria ns	bicycli st	total	Unit
compositio n	① PC U	76%	5%	18%	—	—	1%	4767*	Vehicle
	② PP U	10%	0.2 %	88%	—	0.4%	0.9%	48842*	Person
	③ PP T	2%	0.1 %	97.5%	—	0.1%	0.3%	212000 0*	person•k m
environme nt	④ L_p	52	122	1.5	1.4	154	27	8.7	M ²
	⑤ P_p	1.8	0.8	0.06	0.03	0	0	0.08	Kg
	⑥ E_p	1.2	2.6	0.02	0.07	0	0	0.14	L
	⑦ D_p	5	3	0.4	2	0	0	0.9	RMB
Personal comfort level	⑧ VP	8.9	9.8	48	32	4.8	15.3	43.5	km/hour
	⑨ SP	1	0.9	0.27	0.16	1.2	1.5	0.35	M ²
	⑩ TP	22	19	12	16	2	2	12.8	° C
	⑪ AP1	57	96	138	169	457	471	133	mg/m ³
	⑫ NP2	68.5	69.8	74.8	71.5	77.4	77.7	74.1	db
	⑬ MP 3	15	26	0.8	2	0	0	2.1	RMB

The total passengers entering the CBD was 234000 (metro not included). The bus carried 66%, while the number for the private vehicle was 30%, taxi and non-motorized travel 2%. In morning peak hour from 8:00 am to 9:00 am, in the CBD bound, the private vehicle took 76% PCU, and the bus took 18% PCU. But if measuring in PPU, the number for the private vehicle was only 10%, and the number for the bus was 88%. In addition, if consider the PPT, the private vehicle took only 2% while the bus took 97% of the passenger transport. According to the PPT evaluation, the buses on Jingtong highway should have the priority in right-of-way.

Based on the environment evaluation, the personal space need, carbon emission, energy consumption for bus passengers was only 2.9%, 3.3%, 1.7% of the private passengers. And those numbers for the pedestrians and bicyclists were even close to 0.

Respect to the personal comfort level, the biggest problem is the crowds in the buses and metros. In the morning peak hour, the personal standing space in buses or metros was less than 0.1 m². The second problem was the pedestrians and bicyclists were easier to be exploded to the emission and bad air than the private passengers. In winter, the PM_{2.5} in the private vehicle was 57 mg/m³, but in buses, bike lanes and sidewalks, the number could be 138, 457, and 471 respectively.

COMMUNITY PPU OBSERVATION AND RIGHT-OF-WAY ANALYSIS

Community PPU Observation

Step 1, key point PPU observation

Select the key points in the community, such as key intersection and roadway segment. Then collect the PPU in the same way in roadway observation.

Step 2, PPU characteristic collection

Classify the PPU into different groups based on age, gender, and job, and labeled in different colors in the map, as shown in figure 4.

Step 3, PPU spatial distribution

Using 10 persons a point or 100 persons a point to draw the PPU points on the map.

Step 4, right-of-way analysis based on PPU

Evaluate the right-of-way considering the PPU composition in different time of day and the personal environment indices. Then propose the right-of-way plan for a given community at a certain time.

Residential Community PPU Distribution and Right-of-way Analysis

In Beijing, a lot of communities were developed in the bicycle generation. As a result, the parking space was far from enough in those old communities. But at the same time, the private vehicle ownership was over the housing unit by 30%. A lot of vehicles were taking space from pedestrians and bicyclists. This study conducted the PPU observation in Songyuli community in Beijing, and the results were shown in figure 4.



FIGURE 4 PPU composition and distribution in Songyuli community in Beijing.(100 person per point)

On the roads around the community, there were 89000 passengers in total per day. 36% were bus passengers, 28% pedestrians, 15% bicyclists, and 18% private vehicle passengers. 0.4% of the drivers used the on street parking space. In the community, the PPU was 58000 persons per day, with 56.7% pedestrians, 28.8% bicyclists, 14% private vehicle passengers. 0.5% of the drivers used the on street parking space. The PPU distribution was shown in figure 5. According to the PPU distribution, the pedestrians and bicyclists should have the priority of right-of-way both inside and outside the community. However, the 0.4% drivers outside the community and 0.5% drivers inside the community pushed the pedestrians and bicyclists out of the sidewalks and bike lanes into the vehicle lanes by parking on the sidewalks or bike lanes.



FIGURE 5 PPU distribution in different times of day inside and outside the Songyuli community. (10 persons/point)

Moreover, the distribution of PPU was changing at different times of day. Figure 5-a ~ 5-d showed the distribution in four typical time periods. On Wusheng Road, buses, pedestrians, and bicyclists contributed the highest PPU in the morning and evening peak hours. Accordingly, in this time period the on street parking should be forbidden. In detail, the majority of PPU on Wusheng Road in the morning peak hour was bicyclists, so the “on street parking” time should be 20 pm to 7 am. On the contrary, Songyu Road had the lowest PPU for bicyclists in the whole day, so the “on street parking” time could be 19 pm to 8 am. This study was used to guide the improvement of the design in Songyuli community. Accordingly, besides the “on street parking” time limit, the bike lanes were painted as shown in figure 6-a. And the roads inside the community were painted as pedestrian priority lanes, shown in figure 6-b.



a. bike lanes on the roads outside the community b. Pedestrian priority lane inside the community
FIGURE 6 The improvements on the roads inside and outside the Songyuli community.

CONCLUSIONS AND DISCUSSIONS

This study proposed the PPU as a metric to assess the efficiency and capability of a roadway facility or system to serve road users. The methods to collect the PPU and to analyze the right-of-way for the roadway segment level and community level were developed. One highway segment and one residential community in Beijing were analyzed to test the methods. Results showed that the PPU revealed the true efficiency of the facility carrying passengers. Using PPU would tell a different story about the facility or system compared to using PCU. Additionally, using PPU to analyze the right-of-way for the roadway or community could offer guidance for improving pedestrian and bicyclist environment. In general, the PPU was the key metric which can change the angle of the designers and planners to look at the transportation system from the vehicle-priority to the human-priority. The next step of this study was to use the suggested indices in the methods to develop a model to evaluate the right-of-way.

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REFERENCES

- 1 Ircha, M. C., and M. A. Gallagher. Urban Transit: Equity Aspects. *Journal of Urban Planning*, Vol (111), 1985, pp. 1-9.
- 2 Randall, T. A. and B. W. Baetz. Evaluating Pedestrian Connectivity for Suburban Sustainability. *Journal of Urban Planning*, Vol (10), 2001pp.1-12.
- 3 Southworth, M. Designing the Walkable City. *Journal of Urban Planning*, Vol (131), 2005. Pp. 246-257.
- 4 González-Guzmán, C. A. and C Robusté. Road Space Reallocation According to Car Congestion Externality. *Journal of Urban Planning*, Vol (137), 2011, p. 281-290.
- 5 Cheng M.F., and H. Cheng. Implications of Transport Diversity for Quality of Life. *Journal of Urban Planning*, Vol (135), 2009, pp. 13-18.
- 6 Zhang X, J. Chen, W. WANG, and D. Jiang. Efficiency and Equity Comparison of Urban road space Reallocation Schemes. In proceeding of ICTE, 2009.