# Feasibility Study of Application of PRT at a Tourism Island

Mingming Dong
Faculty of Maritime and Transportation
Ningbo University
818 Fenghua Road, Ningbo, China
888.d666@163.com

Pengjun Zheng
Faculty of Maritime and Transportation
Ningbo University
818 Fenghua Road, Ningbo, China
pjzheng@gmail.com

***Abstract*—This paper deals with public transportation in tourism areas. A survey was carried out in Putuoshan, a famous scenic area in Zhejiang Province. By carefully analyzing the current transportation situations using the data collected, a new public transport---PRT, was proposed and feasibility of application was studied. The impacts of the PRT were evaluated using a microscopic PRT simulation model – Hermes. Simulation results showed that it is feasible to use this system, and some of its advantages were evaluated. Suggestions on the application of the system were discussed.**

***Keywords-PRT (personal rapid transit); tourism areas; transportation survey; feasibility study.***

## I. INTRODUCTION

It is commonly acknowledged that tourism plays an important role in a country's economy. At the same time, public transportation is of crucial importance to scenic areas. Currently, the main means of mass transportation in scenic areas is bus. Buses, convenient as they are, cannot offer a good service level. For instance, tourists usually have to wait a long time before aboard a bus, people have different destinations may have to take the same bus because of fixed routes [1]. It may also be the case that emissions from buses cause degradation of the environment at scenic areas.

PRT (Personal Rapid Transit) is a public transport system that uses small automated vehicles running on a fully segregated guide-way and with off-line stations (e.g.Lowson, 2003; Lowson, 2005; Cottrell, 2008). The vehicles can run directly from origin to destination with no intermediate stops. PRT represents an automated transport system that has evolved from the point of view of a public transport operator rather than an automobile manufacturer [2].

The primary objective of PRT is to provide an alternative PT (public transport) system that is demand responsive which is particularly attractive to users because it offers minimal waiting times and a travel experience that is very close to travelling by private car or taxi.

When compared to mass public transport systems, PRT may have a lower capacity, since a public transport vehicle can increase its occupancy during peak hours. From the user's point of view, compared with traditional public transport, the PRT offers better comfort, lower waiting time, higher travel speed, no need to plan routes or transfer from one vehicle to another. From the community point of view, the PRT offers very low energy consumption, high reliability and safety, non intrusive infrastructures and the possibility to build a dense network requiring very short walking distances from and to any point [3].

In this paper, feasibility of application of PRT at tourism areas was investigated, a series of simulations were conducted upon the Putuoshan PRT using a microscopic PRT simulation model---Hermes. The simulations are intended to study the feasibility when applying the PRT system at tourism areas (Putuoshan is a typical scenic area).By carefully analyzing the data collected, and by comparing those data with the current situation, it is demonstrated that PRT system can provide high quality and efficient public transportation in tourism areas.

## II. TRAFFIC SURVEY AT PUTUOSHAN

Putuoshan (Zhejiang) is one of the most famous Buddhist mountains in China. It is a small island covering an area of 12.5 square kilometers. It is one of the major tourist attractions in China.

### *A. General Information*

Tourist volume of Putuoshan in 2009, 2010 and 2011 are illustrated in table 1. It is clear that the tourist volume is growing steadily. Meanwhile, there is a growing demand for public transport.

A traffic survey was conducted on Oct.12---Oct.18, 2012 between 6.00 and 20.00 at Putuoshan. Questionnaires on the use of public transportation were handed out to random tourists. Individual waiting time at public transport stations was recorded at selected sites. The traffic and pedestrian flow were surveyed with the help of local administration staff. In total, 292 questionnaires were collected.

Site selection is a very important issue in traffic surveys. In this survey, a selection of all the major sites was considered in order to provide the breadth of information required. The main criteria are as follows:

- Major traffic attractions( the quantity of tourist volume)
- Current bus stations

Mainly based on these two criteria, six sites were chosen: Matou(Nantianmen)、Zizhulin、Pujisi、Fayusi、Fanyingdong、Suodao(Fodingshan).For the sites selected, detailed site visits were conducted and photographs were taken. A detailed description was made for each site, with such information as geometry (sketch map of the site), traffic volume and public facilities etc.

Published by Atlantis Press, Paris, France.

TABLE I. TOURIST VOLUME OF PUTUOSHAN IN 2009,2010 AND 2011

| Season / Year | Jan.-Mar. | Jan.-Jun. | Jan.-Sep. | Jan.-Dec. |
|---|---|---|---|---|
| **2009 (thousand)** | 936.2 | 2035 | 3014.5 | 3785 |
| **2010 (thousand)** | 1024.5 | 2619.7 | 3835.1 | 4784.2 |
| **2011 (thousand)** | 1292.4 | 2899.1 | 4185.2 | 5196.7 |

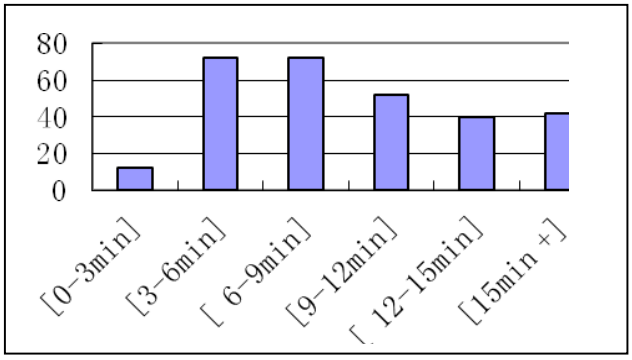
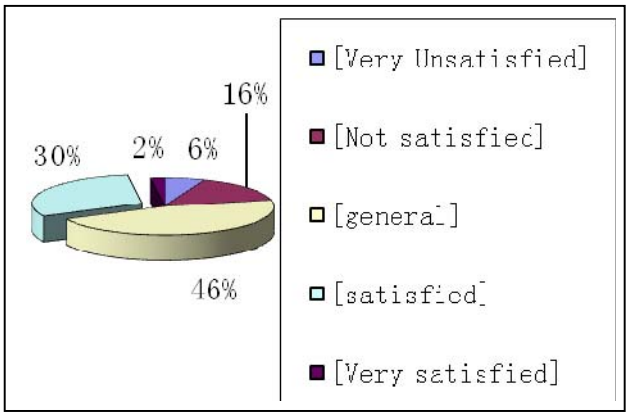



Figure 1. Distribution of individual waiting time according to questionares

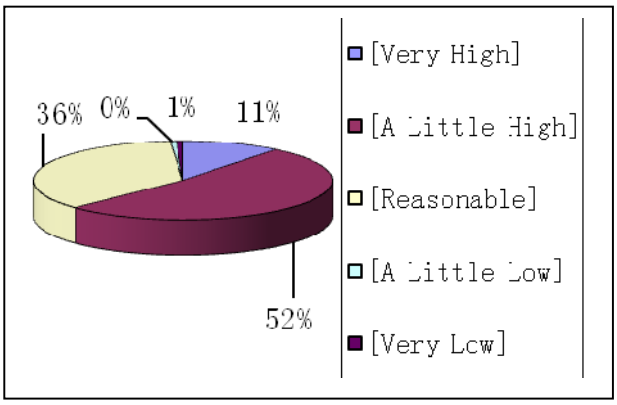
### B. *Survey results*

The number of male and female asked was 143 and 149 respectively. Most tourists (49.32%) are between 19 and 35 years old. Most tourists came for sightseeing (41.78%) or pilgrimage (36.64%). Individual waiting time at stations were also investigated, the results are showed in figure 1.There are two types of vehicles which provide public transportation service to the tourists. The total number of buses is 53, each has a capacity of 23. Some run on fixed routes while the others run according to real time dispatch. The number of the small vehicle is 8, with a capacity of 5---6 seats.

Public opinion about the bus services are show in figure 2, almost half of the tourists think that the current system is not very good (**a**). Many tourists also complain about overcharge (**b**), and long waiting time.




**a.** Satisfaction with bus service




**b.** Ticket Price

Figure 2. Public opinions on the current system

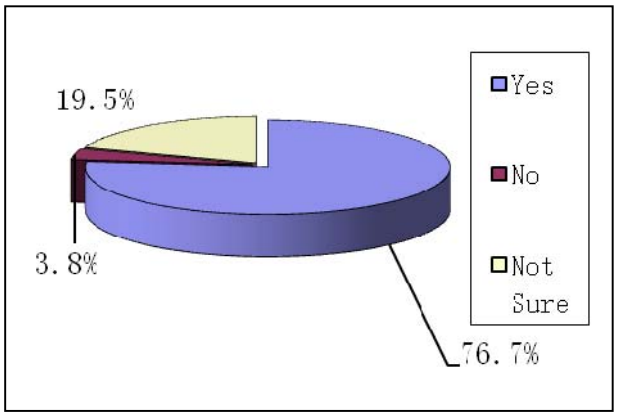



Figure 3. Are you willing to take the PRT system?

To find out the tourists' attitude towards a Putuoshan PRT, the following question was asked: if the PRT system is applied as a public transportation, will you use the system? The results are shown in figure 3. According to the questionnaires, only 3.8% are unwilling to use the system. Many tourists believe that the new system will provide enhanced service level such as shorter waiting time and comfort.

## III. SIMULATION

In order to examine the feasibility of applying PRT in Putuoshan, simulations were conducted. By comparing the new PRT system with the current public transportation system, some of its advantages were investigated. The simulations were conducted upon a microscopic PRT simulation model – Hermes, as it allowed the implementation of a demand program to simulate different demand inputs. Additionally, Hermes has the functionalities necessary to model PRT networks with different system specifications.

Firstly, a proper Putuoshan PRT network was designed, the fundamental rule is to cover the same service area. A PRT network which covers all major tourist attraction sites is shown in Figure 3, this scheme was chosen from a number of

design options considering total length of network, operational efficiency and impacts on environment.

The total guideway length is 7115 meters, with 86% of online guideway, that is 6149 meters. The system has 10 stations and 2 depots.

Since safety approved and commercially available PRT systems now offer speeds of 40-45 kph at headways of 3-4 seconds [4], The basic settings used for the simulations are:

- Vehicle speed 11m/s (39.6 km/h), which is believed to be close to the speed of the current buses on average.
- The minimum headway between PRT vehicles is 2 seconds, which is believed to be practical technically, and is able to accommodate the demand profile proposed in this investigation.

Secondly, different simulations which use different demand programs were conducted. All together, three demand programs were tested, i.e. low demand (demand 3), medium demand (demand 2), and high demand( demand 1). The high demand program is show in table 3.

When the headway between vehicles is set, the capacity of the system is also determined. Ideally, Since the headway of this system is set for 2 seconds, it has a maximum capacity of 1800vph, and the high demand program is based on this (table 2). A little modification is also made based on real time observation. A high demand program was used to simulate the peak time traffic while a low demand program was used to simulate the off-peak time traffic. In the simulation, a low demand is set to have a capacity of 60vph based on real time observation. A medium demand, which has a capacity of 120vph based on observation, is also simulated.

Figure 4. The PRT network of Putuoshan.

## IV. FEASIBILITY ANALYSIS

Service levels for pubic transportation in Putuoshan based on bus and PRT were compared in terms of waiting time, journey time.

### *A. Comparison of Average waiting time*

Since the observation of individual waiting time is mainly conducted at the Pujisi station, the comparison of the current public transportation in terms of individual waiting time with that of the PRT system discussed above is mainly focused at the Pujisi station, namely, station 3 in the PRT system. The comparison of average waiting time between the PRT and that of the current one is shown in figure 5(station 3).

At peak times, the PRT system can reduce the average waiting time by 47.98%, and there is a 60.53%, 65.47% decrease of average waiting time at medium and low demands respectively. It is clear from the simulation results that the application of PRT in scenic areas(Putuoshan) can significantly reduce passenger waiting time at stations(Pujisi), and thus improve PRT operation and level of service overall.

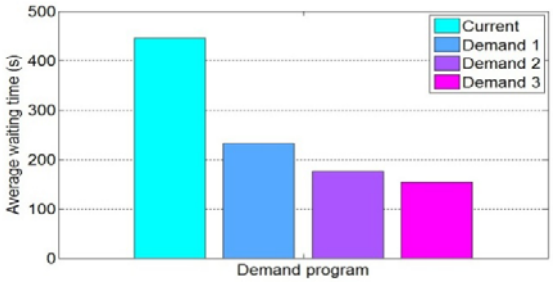



Figure 5. Average waiting time under different demand programs

### *B. Comparison of journey time*

Journey time is determined by design speed (with the synchronous control system used in HERMES, congestion is not possible on the track [2]). On average, it took 660s to go from Pujisi to Suodao using the current tour buses, while the simulation results showed that it took 286s, 327s, 370s under demand 1, demand 2 and demand 3 respectively using PRT system. It took 300s to go from to Pujisi to Fayusi using the current tour buses, while the while the simulation results showed that it took 240s, 154s, 136s under demand 1, demand 2 and demand 3 respectively. In both cases, journey time using PRT is about half of that using buses.

## V. CONCLUSIONS

Currently, the major public transportation means at scenic areas in China is tourist buses, and public service level in terms of public transportation is low. Take Putuoshan for example, it is clear that according to the questionnaires, lack of capacity, long waiting time, high ticket price have become the main issues for tourists. On the other hand, the current public transport system poses a great threat to these areas since they are very environmental-demanding.

PRT is a demand-responsive transportation service where vehicles are dispatched in response to demand in real-time.

Published by Atlantis Press, Paris, France.

Several simulations were conducted using the microscopic PRT simulation model – Hermes. Several demand programs were conducted based on previous data (statistics collected by the Administrators of Putuoshan).

Simulation results showed that the application of the system in Putuoshan can significantly reduce the waiting time for tourists. Journey time can also be reduced due to its nonstop features.

The application of the PRT system at scenic areas can bring many benefits, the major advantages are listed as follows:

- Enhanced public services, such as shorter waiting time, more comfortable space. Simulation results revealed a significant reduction in average waiting time.
- More environmental friendly and do less harm to the surroundings.

Therefore, it is feasible and should be the priority to apply PRT system at scenic tourist areas.

## ACKNOWLEDGMENT

We would like to give special thanks to the Administrators of Putuoshan. They are very patient during the survey, and offered useful suggestions about the design of the system. The work was supported in part by National Natural Science Foundation of China (No. 61074142) and Disciplinary Project of Ningbo under grant B01342104900.

## REFERENCES

[1] Kjell Dahlström: General Transport System foundation (2010).

[2] Pengjun Zheng, David Jeffery, and Mike McDonald: Development and Evaluation of Traffic Management Strategies for Personal Rapid Transit.

[3] Robbert Lohmann, Luca Guala: Introducig PRT To The Sustainable City.

[4] Ingmar J. Andreasson: Extending PRT Capabilities (2008).

[5] Peter J. Muller, P.E.: Improving Transportation Requires a New Solution, P.6.

[6] J. E. Anderson: Questions and Answers following a presentation on High-Capacity Personal Rapid Transit (2007).

[7] Sinclair Knight Merz: Daventry PRT Scoping Study

[8] Hengning Wu, Acroscape: Why We Need a New Mode of Surface Transportation, P.2.

TABLE Ⅱ A HIGH DEMAND BETWEEN STATIONS (VPH)

| Station | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | sum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 0 | 200 | 400 | 200 | 200 | 200 | 200 | 100 | 50 | 50 | 1600 |
| **2** | 150 | 0 | 100 | 200 | 200 | 300 | 200 | 200 | 50 | 50 | 1350 |
| **3** | 100 | 100 | 0 | 250 | 200 | 200 | 200 | 200 | 150 | 150 | 1550 |
| **4** | 200 | 100 | 100 | 0 | 200 | 200 | 300 | 200 | 50 | 50 | 1400 |
| **5** | 100 | 100 | 100 | 100 | 0 | 300 | 200 | 200 | 50 | 50 | 1200 |
| **6** | 300 | 100 | 200 | 100 | 100 | 0 | 200 | 200 | 150 | 150 | 1500 |
| **7** | 300 | 100 | 200 | 100 | 100 | 100 | 0 | 300 | 50 | 50 | 1300 |
| **8** | 300 | 200 | 200 | 100 | 100 | 200 | 200 | 0 | 50 | 50 | 1400 |
| **9** | 100 | 100 | 50 | 50 | 50 | 100 | 50 | 100 | 0 | 50 | 750 |
| **10** | 100 | 100 | 100 | 50 | 50 | 100 | 50 | 100 | 50 | 0 | 700 |
| **sum** | 1450 | 1100 | 1450 | 1200 | 1250 | 1700 | 1600 | 1600 | 700 | 650 | 12750 |