

# The Development of Demand Responsive Transport Services in Taiwan

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**Abstract:** Many people living in rural areas in Taiwan are restricted to access to the public transportation systems due to the insufficient transportation infrastructure services. For instance, most public transportation services are concentrated in central business districts (CBD) of the cities and they are usually fixed route services. In this case, the public transportation systems are inconvenient for elderly or impaired persons living in rural areas to utilize. Since the elderly population in Taiwan is estimated to be 2 million and approximately 9% of the population in 2018, it is necessary to develop and provide a flexible and cost-effective public transportation service to people living in rural areas. This study aims to establish a framework of demand responsive transport services (DRTS) in rural areas. According to the framework, some suggestions are recommended.

**Keywords:** Rural Area; Public Transportation Systems; Fixed Route Service; Demand Responsive Transportation Service; Framework.

## 1. Introduction

Public transportation is essential to the economy development of a country. In Taiwan, the public transportation services are concentrated in metropolitan areas, especially the bus services. From 1946, the bus service has played a prominent role with the economy growth in Taiwan. In 1996, the Taipei Mass Rapid Transit (MRT) started operation. It is a big milestone for the development of public transportation services in Taiwan. Moreover, the Kaohsiung Mass Rapid Transit started operation in 2008. It indicated that the public transportation services in metropolitans are much more convenient than before. Nowadays the single and simple transportation mode is changed into multiple transportation modes. In addition, the public transportation service has been changed from only bus service into multiple services including Mass Rapid Transit, Light Rail Transit, and bus.

In metropolitan areas, buses and MRT services are both fixed route transportation services. Therefore, the MRT services are easily replaced the bus services and become a major public transportation services because of their high mobility. The role of bus services should be reconsidered and their accessibilities need to be enhanced to promote their contributions to the transportation systems.

On the other hand, the public transportation services in rural areas are insufficient and rare because of low density of populations in rural areas and high difficulty of bus operations. In Taiwan, the population of elderly persons (more than 65 years old) is estimated to be 2 million in 2018<sup>[1]</sup>. Many of them are living in rural areas and only

depend on private transportation modes (automobiles and motorcycles) to achieve their trip objectives (medical or shopping trips) because public transportation services are not sufficient to them. The development of public transportation services in rural areas need to be reconsidered. Furthermore, the fixed route services of buses must be changed into another operation mode.

The purpose of this study is to develop an adequate framework of demand responsive transport services (DRTS) in rural areas in Taiwan. The research methods utilized in this study include literature review, data analysis, benefits and shortcomings analysis. Moreover, some conclusions and issues are discussed in the study for future development.

## 2. Literature review

In this section, the definition and research scope of DRTS, the introduction of counties who have advanced public transport systems, benefits and issues of DRTS usage are analyzed as follows.

### 2.1 Definition and research scope

The definition and research scope of public transportation is under the jurisdiction of the government. Government stipulates the fare that is obtained acceptance from the citizens. Public transport modes can be divided into mass transit and paratransit. Mass transit usually includes bus, mass rapid transit and railway transportation. Because the government usually focuses on the transportation demands of most citizens, the simple design such as fixed route, fixed schedule and standard fare is easily obtained acceptance from citizens.

Pratransit includes taxi, dial-a-ride, hail-a-ride and jitney. It is a supplementary transportation service when some citizens could not be served by mass transit service. The characteristics of paratransit services include flexible route, flexible schedule and higher fare level than that of mass transit. Sometimes it is also named flexible transport services (FTS).

The operation a mass transit mode uses a vehicle to carry mass passengers, and the capacity of bus is designed to carry 48 passengers. Because not all passengers get on a bus at one bus stop, it is vital to set up several or some bus stops along a bus route. If a bus can carry many passengers in one route, the operational cost which includes fixed cost and variable cost will be decreased.

The paratransit is another transport service when passengers could not use the mass transport service that provides fixed bus stops or schedules. The paratransit supplements the service gap which is not provided by the mass transit services. Some paratransit are named FTS or DRTS. The major characteristic of DRTS is to assist passengers who are inconvenient to travel from one location to another location by mass transit systems. In Taiwan, the Fu-kang bus service is one of DRTS serving elderly and impaired people in Taipei.

## 2.2 The background of DRTS

The SAMPO project of European Union from 1996 to 1997 is a DRTS project which applied the wireless communication technology to transportation demands in urban or villages. According to the results from the project, the efficiency and feasibility of DRTS is obvious. The study scope of this research includes six countries, Belgium, Finland, Ireland, Italy, Sweden, and Britain. The SAMPO project has some meanings described from Ambrosino et al.<sup>[2]</sup>: (1) Expanding the bus routes and bus stops, allow more passengers to ride bus; (2) The improvement of accessibility of terminals and rural areas; (3) The improvement of accessibility and mobility for elderly and mobility impaired persons; (4) The improvement of accessibility and service for students who live in a area with low density of population and housewives having no driver licenses; (5) Increasing utilization ratio of public transportation systems by promotion of service levels; (6) The promotion of economic activity in the region.

Castex et al.<sup>[3]</sup> indicated that if communication technology collocate with flexible demand responsive transportation, then the efficacy will be good. The function of DRTS is to provide a public transportation service to mobility impaired persons and people who live in low density areas. Moreover, the service routes and schedules of transportation service need to be flexible.

Chen et al.<sup>[4]</sup> studied whether Advanced Technology Transport Service(ATTs) and Advanced Transport Information System(ATIS) could improve the mobility of elderly and mobility impaired persons. Results of the

study showed that usage percentage of public transportation system will increase if the Advanced Transport Information System has been utilized. In addition, the in-home Advanced Transport Information System interests elderly and mobility impaired people, especially via telephone service.

## 2.3 The benefits and shortcomings of DRTS

DRTS is one of paratransit systems and its benefits include: (1) Transport area can be expanded; (2) It is convenient for elderly or mobility impaired persons; (3) Passengers responds well to transportation demand. The shortcomings include: (1) Appointments are required before riding; (2) Destination arrival time is uncertain; (3) The bus demand is decreased during off-peak periods; (4) The service will be insufficient as passengers increase unexpectedly.

## 2.4 The Development of DRTS in Taiwan

According to the article 3 of chapter 1 in "Rural Community Land Readjustment<sup>[5]</sup>", the term "rural community" means that the rural district designed by non-urban land use zoning under "Regional Plan Law", country village and aborigine village related laws. The rural community in the preceding paragraph shall be broadened its area for regional development or increasing public facilities if necessary. The scope is defined in article 2-1 of chapter 1 in "Enforcement Rules of the Rural Community Land Readjustment Act<sup>[6]</sup>". The "country village" and "aborigine village" stated in the first Paragraph of the Article 3 refer to the following land areas: (1) The total area is more than 0.5 hectares; (2) According to the household data, one area which has more than 15 households inhabited each year in the last five years; (3) The population shall be more than 50 persons each year.

There are no laws for DRTS or paratransit transport systems in rural areas in Taiwan. According to the goal of social welfare, the Fu-kang bus service in Taipei city is one of DRTS in Taiwan. Chen<sup>[7]</sup> collected the cases of Fu-kang bus service in Taiwan and stated some findings: (1) The identification of the transportation service area around each city; (2) All mobility impaired persons are service clients; (3) Most transportation services are for hospital, then school and work; (4) Each city government decides their fare and costs half or one third of the taxi fare in urban areas and costs fixed fare or free in rural areas. Most passengers in the city need to preorder the service and some of just-in-time service will be expected in urban areas. Passengers who live in rural areas or low density areas need to preorder the service 2days or 7 days ago. However, the DRTS is seldom in Taiwan.

## 3. The difficulties of rural DRTS development in Taiwan

Industrialization and manufacturing industry are the basis of Taiwan economic growth, and it leads Taiwan from a developing area to a developed area. The purpose of

many public constructions in Taiwan was to attract citizens' attentions, therefore they were built actively. For example, High Speed Rail (HSR), Taipei MRT, Kaohsiung MRT and SuHua Highway which is planned to be reconstructed are all public transportation constructions. However, the public transportation systems and constructions related to people's daily life are still insufficient. Figure 1 shows the utilization rate of public transportation. In the figure, we can find that the utilization rate concentrates in the northern Taiwan areas. The utilization rates in Taipei City (34.1%), Keelung City (29.4%), Taipei County (24.9%). Taoyuan County (4.2%), Taitung County (4.1%), Hualien County (3.0%), Chiayi City (2.5%). There are 23 counties, cities, and neighborhoods whose public transportation utilization rates exceed 10%, including Taipei City, Keelung City, Taipei County, and Taoyuan County. Others' public transportation utilization rates are lower than 10%. This also indicates that the public transportation systems in areas other than northern Taiwan are insufficient. In Figure 2, Taipei Municipality (100%), Kaohsiung Municipality (88.9%), Taichung City (67.9%), Chiayi City (47.3), Tainan City (44.1%), Shinchu City (40.1%) are high population density areas. On the other side, Taitung County (0.6%), Hualien County (0.7%), Nantou County (1.3%), Yilan County (2.1%), Chiayi County (2.9%) are low population areas. High public transportation utilization rate occurs in high population density cities. It implies that public transportation utilization rate is low in rural areas and private transportation modes such as automobiles and motorcycles are used frequently.

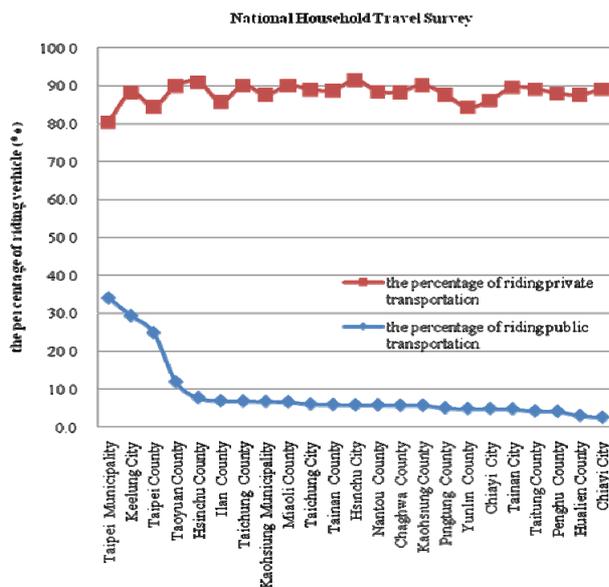


Figure 1. The percentage of riding public vehicle in Taiwan (2009) [8]

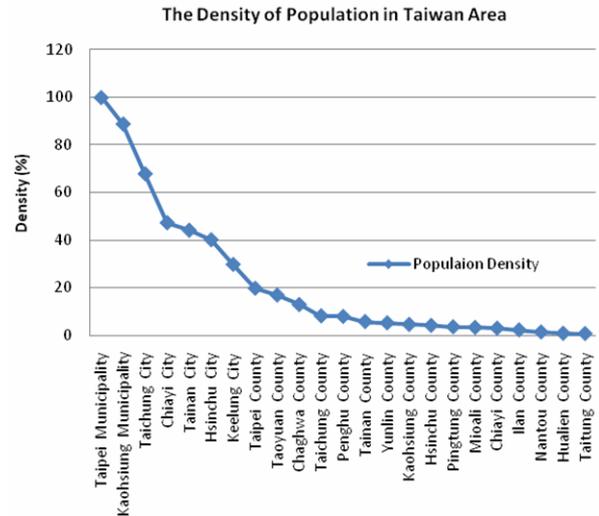


Figure 2. The density of population in Taiwan (2009) [9]

### 3.1 Public transportation demand

Because of the concentration of population distribution, public transportation system could be a good mode to provide effective mobility to commuters. In Taiwan's cities, approximate one hundred passengers per day use MRT systems. Taipei Municipality has the highest percentage of public ridership (see Figure 1).

However, in rural areas, the public transportation demand of commuters or inhabitants is also required every day. From Figure 1, the usage percentage of private transportation modes exceeds 90% in rural areas. Moreover, hiring taxi or carpool for long distance trips is necessary for some inhabitants. The potential demand of public transportation exists, but not very popular.

### 3.2 Public transportation supply

The concept of using public transportation is frail for inhabitants in rural areas because less population in these areas and public transportation systems are not been well planned at primary stage by government or public transportation operators. Therefore, it increases the advantages of private transportation usage. Under this circumstance, public transportation operators do not intend to invest public transportation services in rural areas.

### 3.3 Law

Some laws to promote the public transportation services in rural areas are needed. The laws in "Enforcement Rules of the Rural Community Land Readjustment Act" by the Ministry of Interior point out that traffic networks must connect with outer city and complete interior roadway systems, roadway landscape, roadway emergency facilities are important tasks.

### 3.4 Aging

Wang et al. predict that the population of 65 years and older will dramatically increase since 2008, thus Taiwan has gradually become an aging society. In this trend, the

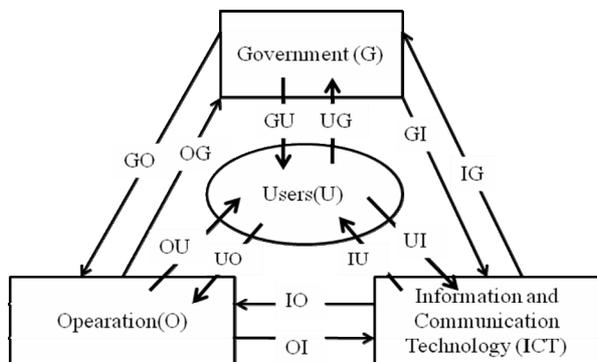
passenger transportation services need to be reviewed and planned seriously. Mutual coordinate utilization of public transportation happens in northern Taiwan because it has many resources. However, the related resources in rural areas are less. Hence the coordination and utilization of existed resources has become an urgent issue.

**Table 1. Forecasting the retired population over the age of 65 in Taiwan**

year	The percentage of population over the age of 65	The population structure of 65 age (%)		The population over the age of 65(thousand)	
		The age of 65-74	Over the age of 75	The age of 65-74	Over the age of 75
2008	10.4	56.9	43.1	1,365	1,032
2013	11.6	54.6	45.4	1,478	1,231
2018	14.7	58.3	41.7	2,028	1,452
2023	18.5	62.7	37.3	2,758	1,644
2028	22.5	58.7	41.3	3,147	2,215
2031	27.9	50.0	50.0	3,271	3,271
2041	34.0	45.3	54.7	3,399	4,111
2051	37.5	40.3	59.7	3,069	4,547

#### 4. The framework of DRTS in Taiwan

The previous studies in DRTS usually emphasize on the operational effectiveness and the promotion of advanced information and communication technologies. From business operators' point of view, profit is important when they are operating DRTS. However, transportation service is one of the public services. Their major mission is to serve general public, so the social welfare should be considered. To consider the trade-off, this study tried to develop a framework of DRTS in rural areas in Taiwan. The basic framework is shown in Figure 3.



**Figure 3. The framework of DRTS in rural areas in Taiwan**

In the figure, the core of the framework includes four parts. The first part is that the government (G) must re-think the real demands of the inhabitants and practice

it certainly. The second part is the ideal pattern and philosophy of operation (O). The third part is the users (U). Inhabitants should have confidence of the public transportation services. The final part is to promote the information and communication technologies (I).

Government needs to rethink how to promote DRTS and how to assist the operators (GO). The operators should choose adequate advanced information and communication technologies, DRTS systems, or dial-a-ride services for users (OI+IU), and continue to promote public transportation services to users (OU), then users are willing to choose public transportation services. Increasing usage of public transportation services is necessary. The more revenue the operators gain the less subsidy the government provide. On the other hand, the government needs to establish laws in "Enforcement Rules of the Rural Community Land Readjustment Act" for users (GU).

#### 5. Conclusions and suggestions

In this paper, we conclude some issues through literature review, data analysis of the percentage of public ridership, population density, DRTS development difficulties, and a DRTS framework. The conclusions and suggestions are summarized as follows.

- (1) The motivation of government
  - DRTS is one type of social welfares. The government needs to have a boarder vision and starts plans to provide DRTS for citizens in rural areas.
- (2) Confidence between the government and operators
  - To achieve a successful transportation promotion, the government and operators need to have confidence with each other and cooperate together.
- (3) Government department and law
  - The laws in "Enforcement Rules of the Rural Community Land Readjustment Act" need to consider boarder scope to concern with transportation systems. If these laws can be used to develop the information or telecommunications for public transportation services, it will be helpful to promote DRTS in Taiwan.
- (4) Inhabitants are conscious of using public transportation
  - The government and operators should provide inhabitants with more chances to use public transportation systems before they are conscious of the importance of public transportation services.
- (5) The operators should choose adequate information and communication technologies (ICT)

Because the public transportation users are usually inhabitants, elderly citizens and mobility impaired people, the operators need to consider the most appropriate type of information or communication technology that will be accepted. Most users like to use telephones to communicate each other, but the DRTS needs to be pre-ordered. Therefore, other appropriate communication

interfaces such as internet networks should be probably designed in the future.

## References

- [1] Wang L.et al., Analysis of population projections for Taiwan area: 2008 to 2056, *Taiwan Economic Forum*,2009,7(8).
- [2] Ambrosino, G. Boero, M., Eloranta, P.,Engels, D., Finn, B. and Sassoli, P. Flexible mobility solutions in Europe through cooperation between operators, it supplier and authorities. Proceedings of the 7<sup>th</sup> world congress on ITS, 2000,Italy.
- [3] Castex, E., Clavel, R. and Josselin, D., The role of technology in flexible demand responsive transport, presented in 10th International Conference on Applications of Advanced Technologies in Transportation (ICAATT), Athens Greece,15 pages.
- [4] Chen, W.H., Gross, F., Pecheux, K. and Jovan, P.P.,Model preference for ITS-enhanced ridesharing and paratransit services for disabled and elderly travelers, *Advanced in Transportation Studies*, 2005,Vol.5, pp.53-67.
- [5] Web of Ministry of the Interior R.O.C., Rural Community Land Readjustment. (<http://www.land.moi.gov.tw/law/enhtml/inquiriesdetail.asp?elid=45>)
- [6] Web of Ministry of the Interior R.O.C., Enforcement Rules of the Rural Community Land Readjustment Act. (<http://www.land.moi.gov.tw/law/enhtml/lawquery.asp>)
- [7] Chen, Y.A.,The planning of demand responsive transportation service for elderly citizen in rural area- a case study of Shigang township of Tainan, Master dissertation, Chung Hua University,2007.
- [8] Web of Ministry of Transportation and Communications R.O.C., utility rate of public transportation survey report, 2010. (<http://www.motc.gov.tw/mocwebGIP/wSite/1p?ctNode=454&CtUnit=313&BaseDSD=7&mp=1>)
- [9] Ministry of the Interior R.O.C. printed, Annual Bulletin of Statistics, 2009.