- 1 A Mobile Application Survey in Bangkok Metropolitan Region
- $\mathbf{2}$ Jetpan WETWITOO <sup>a\*</sup>, Masaru KOMORI <sup>b</sup>, Naohiko HIBINO <sup>c</sup>, Hisao UCHIYAMA <sup>d</sup>, 3 Atsushi FUKUDA<sup>e</sup> 4  $\mathbf{5}$ <sup>a,b</sup> Creative Research and Planning Co., Ltd., 1-20-22 Ebisu, Shibuya-ku, Tokyo 150-0013, 6  $\overline{7}$ Japan 8 <sup>a</sup>*E-mail: j wetwitoo@crp.co.jp* <sup>b</sup>*E*-mail: komori@crp.co.jp 9 <sup>c</sup> National Graduate Institute for Policy Studies, 7-22-1 Roppongi, Minato-ku, Tokyo 106-8677, 10 Japan; E-mail: hibino@grips.ac.jp 11 <sup>d</sup> Tokvo University of Science, 2641 Yamazaki, Noda, Chiba, 278-8510 Japan; E-mail: 12uchiyama@rs.noda.tus.ac.jp 13<sup>e</sup> Nihon University, 7-24-1 Narashinodai, Funabashi, Chiba 274-8501, Japan; E-mail: 1415fukuda.atsushi@nihon-u.ac.jp 16 17Abstract: Travel survey in Bangkok Metropolitan Region (BMR) has been constantly 18 conducted since 1990 on an interview basis. Recent technology enabled a GPS-based travel 19survey to be conducted via a smartphone application. With this method, travel information 20can be obtained more precisely compared to interview-based survey as travel location can be 21instantly obtained from GPS tracker and other travel information can be recorded immediately 22after the completion of the travel. This study is the first large-scale pilot survey on the 23GPS-based travel survey in BMR, covering 308 samples in 10-days consecutive study period.  $\mathbf{24}$ Based on the unique survey data from mobile application survey, travel characteristics in 25BMR such as modal shift and time/day travel fluctuation can be presented. Problems found 26during the survey period and directions for future implementation are also discussed. 2728Keywords: GPS, Mobile Application, Travel Survey, Bangkok 2930 31**1. INTRODUCTION** 3233

In the Bangkok Metropolitan Region (BMR), the urban railway master plan has been 34formulated and reviewed several times since the 1990s. While the development of major 35 railway routes in BMR has been reached to a certain prospect, the Thai government considers 36 that there are still some issues on the existing master plan. An official request was made to 37 The Japan International Cooperation Agency (JICA) for the assistance for the formulation of 3839 the second master plan, so-called "M-MAP2". During the course of this study, the issue regarding the difficulties in conducting a household travel survey, so-called, Home Interview 40 Survey (HIS), has been raised. The HIS has been continuously conducted from 1995 until the 41latest survey conducted in 2013. However, many limitations from HIS has been reported. One 42of the most distinguish limitations from HIS is that HIS has been conducted only on one day, 43and the interview has been conducted without considering the difference of travel pattern in 44each day of week. In other words, each sample will be interviewed at different days of week. 45With this aggregate data utilized, the result of analysis could be strongly affected by the 46 fluctuation of trip characteristics. The lack of spatial data is also one of the issues in HIS. 47

<sup>\*</sup> Corresponding author.

Typically, the location of origin and destination of each trip will be asked in HIS. However, it is difficult to define the exact coordinate in practice. It is also possible to ask the route information during the interview. However, the data such as path and time spend on each section is still difficult to obtain in practice.

With these limitations in HIS, the travel survey based on mobile application survey 52(hereafter, mobile application survey) has been proposed by JICA study team as an alternative 53method to HIS. This pilot survey primarily aims to give an example of the mobile application 54survey in Bangkok and provide discussion for further actual implementation. The mobile 55application survey can be conducted with a smartphone at any time under a very simple 56operation. The data can be easily collected in multiple days so limitation in survey period in 57HIS could be solved by applying mobile application survey. So, in this paper, the first issue 58which we want to highlight is the trip characteristics during weekdays and weekends, which is 59still lagging in HIS data, can be analyzed. Any sample can start the trip recording with GPS 60 turned on, then he/she can change the mode of transportation from the application once he/she 6162 made a transfer to the new mode. Then, the sample can finish the trip recording from the application, and then fill the additional information such as trip purpose, fare, and lateness. 63 With GPS turned on, coordinate and time of the sample can be easily collected through GPS 64 65 server. Thus, the limitation of spatial data in HIS can be supported by GPS data from mobile application survey. Other trip data such as sample attribute, trip origin and destination, trip 66 67 purpose and mode of transportation can be obtained from mobile application survey as well.

However, the second issue which we want to highlight in this study is the limitations in 68 mobile application survey. The major disadvantage in mobile application survey is a sample 69 bias toward smartphone user as smartphone penetration is still limited in senior people and 70 71low-income people. Furthermore, by considering the cost to collect the data per head, HIS 72could be relatively cheaper as mobile application survey requires a training process, especially when targeting the sample who is not familiar with smartphone operation. In terms of total 73cost, it is still difficult to compare the total cost between HIS and mobile application survey at 74this moment as the scale of mobile application survey conducted in this study is still relatively 75smaller than the interview-based travel survey such as HIS. 76

In terms of past studies, Shen and Stopher (2014) provide an extensive review of 7778GPS-based travel survey and its methodology. In Japan, this survey method is widely known as "probe-person survey". Several implications such as in Japan (Hato et al., 2006), Australia 79(Stopher et al., 2007), The Netherlands (Bohte and Maat, 2009), USA (Chen et al., 2010), and 80 81 Singapore (Cottrill et al., 2013). In Thailand, GPS technology was utilized in several travel studies, including Tipagornwong (2003), Ishizaka and Fukuda (2004) and Tongsinoot (2017). 82 However, all three studies utilize the GPS data from probe taxis in Bangkok so the robustness 83 of trip characteristics is still limited when compared to the GPS data taken from the individual 84 travelers. 85

86 Furthermore, there has been a long discussion of the possibility to obtain travel survey 87 data based on the mobile phone data from the service provider. Instead of conducting a travel survey, travel data is obtained by purchasing data from a service provider. However, this 88 method is still difficult to be implemented in practice due to two issues. First, since only GPS 89 90 data can be obtained from this method, additional algorithm is needed to process the trip characteristics. The current artificial intelligent used to estimate the trip characteristics such as 91 mode of transportation, trip purpose, fare is still not 100% accurate. Second, issues regarding 92personal information and privacy are strongly regulated in many countries, including Thailand 93as well. Table 1 compares the advantages and disadvantages from HIS, mobile application 94survey, probe-based survey, and data from mobile phone service operator from four aspects; 95survey period, sample size, availability of spatial data, and availability of trip characteristics. 96

7
1

Table 1. Comparison between HIS and mobile application survey

~	1			
Survey HIS		Mobile Application	Probe-Based	Data from Service
Aspect	1115	Survey	Survey	Operator
Survey period	<ul> <li>Difficult to increase survey period due to the nature of an interview</li> <li>Only 1 day, day of week collected depends on survey conductor</li> </ul>	<ul> <li>Easier to increase survey period than interview-based survey because data is collected through mobile application</li> <li>In this study, 10 days consecutively</li> </ul>	• Easier to increase survey period than interview-based survey because data is collected through a GPS device	• Survey is not required
Sample size	• Easier to increase sample size from interview	• Difficult to increase sample size as training to sample is required	• Difficult to increase sample size as training to sample is required	• Depends on the budget
Spatial data	• Can be obtained indirectly through additional analysis	• Can	be obtained directly fro	om GPS
Trip characteristics (mode, trip purpose, fare, etc.)	• Can be obtained directly from interview• Can be obtained directly from the record in the application (if the application is designed so that the users must record their trip information)•		<ul> <li>Depends on the survey design</li> <li>If the user is not required to report the trip characteristics, the additional algorithm is needed.</li> </ul>	• The additional algorithm is needed to process the trip characteristics.

Comparing to the past studies in Thailand and abroad, the unique characteristics of our 99 study can be described into two points. First, unlike some studies which applied techniques 100 and algorithms to define travel detail such as modal choice and trip purpose, our study 101 requires samples to define trip information directly into the trip diary in the mobile 102application. Second, as the main target is for the actual implementation at the metropolitan 103 level, so our sample size of 308 is considerably high compared to other studies. Larger sample 104size enabled us to analyze the trip characteristics with higher robustness as shown in section 1051063.

- 107108 2. METHODOLOGY
- $\frac{108}{109}$

## 110 2.1 Sample Criteria and Recruitment

111

In order to achieve the preferred age distribution, the samples are recruited from various method such as an introduction from the recruitment staff, recruitment from social media and from recruitment websites. There are three main criteria in the selection process. First, the sample must be working in Bangkok CBD. Second, the sample must be living inside BMR. Residential locations of each sample are shown in Figure 1. Third, the sample must be a smartphone user, with Android OS version 5, 6 or 7. Once their participation is confirmed, their basic information, including name, home address, workplace address, mobile phone



 $121\\122$ 

Figure 1. Distribution of the residential locations

# 123 2.2 Survey Activity

124

125 During the course of the survey period, each sample is required to collect their trip 126 information from the following procedure:

- $127\\128$
- Each sample must record every trip information they made during the survey period of 10 days
- 130 The trip information can be collected through mobile application by
- 131 1. Press "Start" at the beginner of the trip
- 1321322. The trip will always start with walking. Select other modes of transportation when133transferring to the new mode
- 134 3. Press "End" at the destination
- 135 4. Then select the trip purpose
- 136 5. Finally, indicate the fare, in case of using public transportation.
- 6. After completing the trip recording, indicate the availability of time-constraint and information of trip lateness through the trip diary.
- If there are any technical issues; for instance, a device freezes or the trip is not recorded;
   it should be informed to the administrative team as soon as possible.
- The sample should leave the comments for short trips/abnormal activities



#### 

# **2.3 Survey Schedule**

Table 2.	Survey	schedule

No.	Date of Survey	Survey Period	Sample Number
1 <sup>st</sup> Survey	May 17, 2018 (Thu) – May 26, 2018 (Sat)	10 days	111 Samples
2 <sup>nd</sup> Survey	May 24, 2018 (Fri) – June 2, 2018 (Sat)	10 days	87 Samples
3 <sup>rd</sup> Survey	Jun 3, 2018 (Sun) – Jun 12, 2018 (Tue)	10 days	110 Samples

## **2.4 Survey Item**

Table 3. Survey items

Items	Source	Reference				
Travel time and location	GPS log	Day, Day of week, Time, Latitude, Longitude; every one second				
Trip distance	GPS log	Estimated from trip location				
Trip purpose	Main user input	Work, Private, Business, Pick up, Other, Go home				
Mode of transportation	Main user input	Walk, MRT/BTS/ARL, Air con Bus, Non-air con Bus, Office Bus, Van Bus, Car, Taxi, Motorcycle, Motorcycle Taxi, Songthaew, TukTuk, Railway, Boat, Bicycle, Other				
Fare [baht]	Main user input	In the case of public transit				
Time limitation	Optional question in Web Diary	on Yes, in case if the sample must arrive at the specific time, su as meetings				
Arrive early/late	Optional question in Web Diary	<sup>n</sup> In case if there is a time limitation, this question will show up				

#### 152 **3. SURVEY ANALYSIS**

153

In this section, general analysis and the analysis of commuting pattern will be presented. Unlike the usual travel survey which conducted only one day in weekday and weekend, application survey can collect the data cover the whole week. It is expected that the analysis can provide better accuracy on the difference between weekday and weekend. Furthermore, this data can be further analyzed on the specific day of week or time of day which enable us to discuss the policy implication in more detail.

160

## 161 **3.1 Data preparation**

162

# 163 **3.1.1 Data Screening**164

After the data collection period, several problems during the data collection were reported. The case where the sample forgot the press "End" button or the case of unavailability of the GPS signal is among the top problems found. This creates many unrealistic data so the following criteria are applied to screen unrealistic data out from the analysis. The following criteria a-e are applied with the main analysis where around 75% of samples are left after screening. The criteria a-g are applied only with trip rate analysis and around 64% of samples are left after screening.

- a. Trip distance less than 50km will be considered
- b. Trip distance more than 500m will be considered
- 174 c. Trip average speed less than 60km/h will be considered
- 175 d. Trip average speed more than 1km/h will be considered
- e. Trip travel time less than 3 hours will be considered
- 177 f. A trip within the trip chain which has no "go home" trip purpose trip will be screened out
- 178 g. A "go home" trip purpose trip without trip chain (only go home trip) will be screened out
- 179

#### 180 **3.1.2 Representative Mode**

181

182In a single trip, multiple transportation modes can be recorded. Thus, for the analysis, the representative mode of each trip has to be set. Generally, there are two methods to define the 183representative mode. In the first method, the representative mode will be assigned to the mode 184185which accumulates the longest travel distance in such trip. While in the second method, the mode priority is set based on the capacity and characteristics of mode. In each trip, the mode 186 with the highest priority will be assigned as a representative mode regardless of the distance 187 or travel time spend on such mode of transportation. Although the discussion of whether 188 which method is more rational is still ongoing, this study applies the second method as this 189survey is a part of urban railway master plan. In other words, a higher priority to the mode 190191 with the highest transport capacity such as railway will be given, as ordered from top to bottom in Table 4. 192

193

## 194 **3.1.3 Mode Grouping**

195

196 Since there are so many modes of transportation in Thailand, for simplicity, similar modes of 197 transportation will be grouped together as follows.

- 198
- 199
- 200

		1 0
Priority	Surveyed mode	New grouping
1	State Railway of Thailand (SRT) Trains	Dail
2	Urban Rail (BTS, MRT, ARL)	кан
3	Air-Conditioned Bus and BRT	Aircon Bus
4	Non-Air-Conditioned Bus	
5	Van	Bus & Van
6	Personal Car	
7	Taxi	Car
8	Motorcycle	Taxi
9	Motorcycle Taxi	Motorcycle
10	Song Taew	Davatransit
11	Tuk Tuk	
12	Office Bus	
13	Boat (Express, River Crossing)	
14	Bicycle	Other
15	Walk	
16	Other	

Table 4. Transport mode grouping and priority

201

#### 203 3.2 General Analysis

204

208

In this section, some examples of basic analysis on the trip characteristics are presented. With mobile application utilized, several unique trip characteristics such as speed, time distribution, and day distribution can be analyzed as follows:

#### 209 (1) Trip Count by Distance

210 A higher share of the short distance trip is observed in this survey.



- 211
- 212
- 213
- $\begin{array}{c} 214\\ 215 \end{array}$

Figure 3. Trip Count by Distance

#### 216 (2) Trip Count by Fare

There is a high proportion of the trip within the fare range of 0-29 baht, which is within the range of bus, or metro with 2-3 stops.



219 220

Figure 4. Trip Count by Fare



Trip rate does not vary across the day of week. From this, it can be implied that Bangkok people tend to go out even on the weekend. The total average trip rate is 2.49 trip per day.





- 220
- 226
- $\begin{array}{c} 227\\ 228 \end{array}$

#### 229 (4) Trip Count by Speed

Based on the average speed measured by GPS, most of the trip lies within the range of 10-20 km/h. Total average speed is 19.43 km/h.



233

232

Figure 6. Trip Count by Speed

234

## 235 (5) Trip Distance by Trip Purpose

236 Considering the trip distance by purpose, going to work and go home trips show the longer 237 trip distance than other trip purpose.



- $\begin{array}{c} 240\\ 241 \end{array}$
- 242
- 243

#### 244 (6) Trip Distance by Mode

Considering the trip distance by mode of transportation, trip distance characteristics for rail, bus, and car seems to be quite similar in weekday. While on weekend, car is usually used for



249

Figure 8. Trip Distance by Mode

## 250 (7) Trip Purpose

251 There is a higher share of going to work and go home trips in weekday. While on holiday, a

252 higher share of private trip is found.



253 254

Figure 9. Trip Purpose



On the weekday, the morning peak hour share is between 7-9 AM and is higher up to 12%. The evening peak which is between 17-19 AM shares around 10%. On holiday, the peak hour is less concentrated. Instead, the noon peak is observed as people tend to depart or arrive for a private trip around 12-13 PM.





Figure 10. Distribution of Departure Time and Arrival Time

#### 262 (9) Departure Time by Trip Purpose

When considering departure time by trip purpose, the peak hour share of going to work purpose trip is around 25-30% which is considerably high value. This could reflect the current traffic congestion during morning peak hour in Bangkok. Transportation Demand Management (TDM) strategies might be needed to alleviate this. In this chart, business trip in holiday has been excluded because of the low sample size. The result of arrival time distribution is quite similar to departure time with around one-hour lag distribution.





Figure 11. Distribution of Departure Time by Trip Purpose

#### 271 (10) Modal Share by Trip Purpose

When focusing on going to work trip purpose, the share of railway user is significantly higher on the weekday. Furthermore, when compared to other trip purpose, the share of public transport user (rail and bus) in go to work trip purpose is rather higher than others. A higher share of car user is found in private and go home trip.



276

277

Figure 12. Modal Share by Trip Purpose

#### 278 (11) Late/Early Arrival

From the optional question in web diary, holiday trip tends to be more punctual than weekday trip. Similarly, trip in weekday shows a higher tendency of being late.



281 282

Figure 13. Late/Early Arrival Distribution

#### 283 **3.3 Commuting Trip Analysis**

284

Apart from the general trip analysis shown in section 3.2, data taken from the mobile application survey enable us to analyze the trip characteristics in further details. In this section, the analysis specific for commuting trip, including travel time analysis and commuting modal shift analysis, and will be presented.

## 289 (1) Main Screening Criteria

290 Commuting trip (in this survey, recorded as "go to work trip purpose") with unrealistic travel 291 pattern will be screened out before analysis. Multiple commuting records in one day will be 292 targeted as the unrealistic commuting trip. If it is obvious that those multiple commuting 293 records are in the separate trip chain (i.e., one trip in the morning, another trip in the evening), 294 all records will be taken. However, if those multiple commuting records are in the same trip 295 chain, only the longest trip distance record will be selected as a representative and other 296 records will be discarded.

## 297 (2) Commuting Travel Time by Mode

298 Commuting with highway-based modes such as car, motorcycle, and bus in weekday requires 299 more commuting time than on holiday. On the contrary, commuting with rail requires more 300 travel time than highway-based modes, yet, on average, there is less difference in travel time



301 between weekday and holiday.





- $\frac{304}{305}$
- 306

307

308

Figure 14. Average Commuting Travel Time by Day of Week by Mode

#### 309 (3) Screening Criteria for Modal Analysis

Next, the commuting modal shift analysis will be presented. In this analysis, the main 310 commuting mode and the alternative mode will be determined and analyzed. The main mode 311of commuting is assumed as the mode that sample uses 50% or more during the survey period. 312The next frequently used mode is assumed as the first alternative mode. However, if there is 313no commuting mode that shares 50% or more, such sample will be discarded from this 314analysis. Due to the difference commuting trip characteristics found in the previous analysis, 315only weekday commuting trip is considered. Screening criteria can be summarized as shown 316 317 below.

#### 318 (4) Commuting Modal Shift

In this analysis, the main commuting mode and their alternative modes will be presented. 73% of sample commuting with car and motorcycle as the main mode only use their main mode to travel to work. The main alternative for car user is motorcycle, and vice versa, car for motorcycle user. However, considering sample travel with metro (MRT/BTS/ARL), metro user up to 50% change their commuting mode during the study period. Car and bus are the main alternatives for metro users.

325

r 1 1 <i>c</i>	C1	C	· ·	1 1	1.0		.1	1	4 1	•	1
lable 5.	Share	OI CO	mmuting	modal	shitt	on	the	sel	ected	main	modes
			0								

		Main Mode (unit: %)			
		Car	MC	Metro	
	Metro	2	5	-	
0	Aircon Bus	3	2	7	
ode	Non-Aircon Bus	1	0	10	
Ň	Office Bus	2	0	2	
ive	Van	2	3	2	
nat	Car	-	11	12	
ter	Taxi	2	2	2	
Al	MC	8	-	2	
irst	MC taxi	0	3	7	
H	SRT	4	2	5	
	No change	73	73	50	
	N=	95	62	42	

326

#### 327 (5) Commuting Mode Shift by Day of Week

In this analysis, in which day people shift the commuting mode to their first alternative mode will be analyzed. The result showed that, regardless of the mode of transportation, the sample tends to change their commuting mode to these first alternative modes on Thursday and Friday. One of the possible explanation is that people are getting tired during the end of the week but more evidence is needed to confirm our hypothesis.





Figure 15. First Alternative Mode Usage Distribution by Day of Week

## 335 (6) Commuting Travel Time

On average, people spend around one hour for their commuting to work with the main mode. However, when considering the commuting time on every alternative mode, it is found out that commuting with the alternative mode tends to be faster than the main mode. Faster commuting time found in alternative mode could be one of the reasons to explain the commuting mode shifting.

#### Average commuting travel time





342

Figure 16. Commuting Travel Time by Main Mode and Alternative Mode

345

This section is dedicated to the issues discovered during the survey period including both technical and survey problems. It is suggested that the following issues should be addressed before the future implementation of the application survey.

<sup>343</sup> 

<sup>344</sup> **4. SURVEY ISSUE** 

351

## 350 4.1 User-Related Issue

Although most of the samples use application perfectly – recording complete trip (pressing both departure and arrival button) and adding comments, some samples tend to forget about trip recording and require the reminding from the administrative team. There are several user related problems, such as

- 356
- sample forget to record a whole trip
- forget to change mode, or end the trip
- not confirm the trip correctness
- not indicate whether the trip has time limitation or not
- 361 turn off internet/GPS while recording
- change mode, or end the trip by mistake
- 363

It also requires a lot of effort to collect your own travel data for 10 days consecutively so some sample decides to quit before 10 days' study period. We suggest that better monitoring and better incentive to samples should be included to improve the quality of the data collection. In the long run, the improvement of the interface design is suggested to reduce the mistake from users.

Furthermore, the issue regarding privacy should be also highlighted. Every sample requires to turn on GPS during the trip recording so trip data, including commuting patterns, are all recorded. This means all of the personal travel data will be handled to survey administrator so we suggest that countermeasure to supervise the survey administrator should be conducted to ensure the privacy of samples and to prevent the exploitation of personal data.

## 375

# 376 4.2 Technical Issue

377

## 378 Signal

During the analysis, we found that several differences between actual departure time and arrival time record by the user, and departure time and arrival time record by GPS. This time difference could be more than 30 minutes in several cases. We also found several records where the location of the sample is missing. This usually occurred when recording in low/no signal area as such inside the building or in the subway. In the long run, we suggest that an additional algorithm to predict the route/mode should be implemented to fill the missing data.

385

# 386 Freezing

There are plenty of comments received from the samples on the connection when they start recording the trip; it takes some time to complete the process or the application even freezes. This causes the users to reinstall the application several times.

390

## 391 GPS

With GPS turned on, battery drains very fast. This cause a huge problem to the sample who travels in a long period of time. Currently, application records trip data every one second. We suggest that the frequency of 5-10 seconds should be enough for the analysis.

395

## 396 Sleep Mode

In this study, the device must not be in a sleep mode during the recording time, otherwise, the

data is not collected. Sometimes the device runs out of battery which can cause the disruption
 in recorded data / not-completed data.

# 400401 Compatibility

402 Currently, the application is only compatible with Android OS 5-7. iPhone users cannot 403 participate in this survey. We suggest that for the actual implementation, compatibility issue 404 should be carefully considered. Web-based access (through mobile phone or personal 405 computer) could be one of the options to make changes in the web diary.

406

## 407 Walking (mode of transport)

With the current application, every time the respondents start recording the trip, walking is recorded as the first selected mode of transport although it is not a part of their trip. So, they need to make an amendment in their web diary. We suggest that any starting mode should be available for selection.

412

# 413 **4.3 Survey Design Issue**414

## 415 **Time Constraint**

Regarding the application usage, samples need to select whether there is time constraint or not via web diary. This creates confusion in the trip recording. Also, sometimes the sample forgets to record it. We suggest that it would be better if the time constraint and late/early arrive

- information is asked right after the completion of the trip.
- 420

## 421 **Fare**

422 After completing the trip record, fare information will be asked. However, this input is rather 423 based on the sample's intuition. We suggest that in the long run, this input should be checked 424 with a fare database based on the travel time, transportation mode and travel distance.

425

## 426 Sample Distribution

Regarding the TOR, the samples are divided into different groups by age and living area; however, there is a group of elderly people (50s and 60s) who tend not to work further from their houses. As a consequence, the sample recruitment process struggles in this issue. Also, this survey targeting smartphone users only. Some attribute, such as the sample's income and education, could be biased from the whole sample size.

## 433 **Daily Information**

We also suggest that information which impact travel behavior such as weather and events should be recorded in the database. This could be done automatically without user input.

436

432

# 437 **4.4 Integration with HIS**

437 438

> 439For the actual implementation, how to reduce the survey cost should be further discussed. In 440 this survey, there are three cost component; application development cost, survey cost, and analysis cost. With the consideration of these cost components, the cost comparison with the 441 conventional survey approach (i.e., HIS) should be carefully considered. However, we want to 442 point out that the data collected from mobile application survey and HIS could be different. 443HIS collects the data from several samples only in one-day trip thus the data from HIS will be 444 the sample-based data. In other words, the data from HIS will provide a better variation on 445 sample's attribute. The analysis of trip structure based on age, gender, income will be more 446

reliable with the data from HIS. Mobile application survey, in contrary, collects the data from 447a limited sample size but in a longer period (10-days consecutively, for this trial). Therefore, 448 the data from the mobile application survey will be the trip based data. In other words, the 449 data from the mobile application survey will provide a greater day and time variation because 450more trip will be collected. Further discussion regarding the type of data should be also 451included to verify the needs for application survey. We suggest that the data from both surveys 452could be utilized together for better analysis performance. One of the examples of the 453methodology to integrate both survey data together is available in Hato and Kitamura (2008). 454

455

#### 456 **5. CONCLUSION**

457

The main purpose of this pilot survey is to give a test of mobile application survey in 458Bangkok. Based on the result, this study aims to provide a discussion for further actual 459implementation. With the target of actual implementation, first, we need to highlight the 460 structure of the model. The structure of the mobile application survey is rather different from 461 the typical household travel survey, as it is very easy to increase the size of travel data based 462on the same sample by extending the study period. However, comparing to the household 463 travel survey, it is more difficult to increase the number of the sample as the recruitment 464 process requires several conditions to be fulfilled. Several technical issues have been reported, 465466 yet, we believe that with a better design of application along with better monitoring, these 467 technical problems can be diminished.

The data from the application survey provides unique characteristics which enable us to 468 analyze travel pattern from several aspects. As shown in table 1, one of the advantages from 469 mobile application survey is the robustness in travel characteristics by the day of week. With 470this data, we can understand several unique travel characteristics in Bangkok. For example, 471unlike other cities, the trip rate on weekend is considerably high, especially on Saturday. This 472could be due to the fact that many workers in Bangkok have to work on Saturday. We also 473found that the peak hour in weekday is in the morning 7-9 am. While in the weekend, the 474peak hours are rather evenly distributed across morning, noon, and evening. Furthermore, the 475commuting trip pattern can be analyzed as shown in section 3. The unique characteristic from 476477mobile application survey enables us to investigate the modal shift pattern during each the day of week. For example, the survey reveals that the commuter tends to change their commuting 478mode on Thursday, Friday, and Saturday. Transport policy could be adjusted according to the 479day variation. One of our hypotheses to the modal shift on Thursday, Friday and Saturday is 480 that people become tired or bored during the end of the week. However, further investigation 481 is needed to explain the reason behind this change. 482

483 As discussed in Table 1, another important data from this survey is the GPS data. The GPS data provides the data of the exact location of in each second; this gives an opportunity 484for us to analyze the tempo-spatial data in further details. With application survey data, 485analysis such as bottleneck location as well as the route shift pattern during each day of week 486 can be determined. For demand forecast model, LOS of each mode in the same route or same 487OD can be referenced from GPS data. This will further enhance the accuracy of the modal 488489 split model estimation in demand forecast model. Unfortunately, due to the time constraint, we cannot analyze the GPS data for this study within time. 490

In terms of methodology, the method used in this study is merely one of the examples from many methods. For example, we ask the sample to answer the total fare during the course of the trip. However, this answer could be different from the actual total fare as the sample may use the commuting ticket or they may have forgotten the exact fare in each mode which they have paid. To solve this, we suggested in section 4 that by utilizing the GIS data and the mode data from the user record, the total fare can be identified with a fare database and a simple algorithm. Similarly, we also required the sample to identify their trip purpose. However, as applied in Chen et al. (2008), trip purpose can be identified from an algorithm-based on GIS data and mapping data. With the ability to collect the data and the benefit of robust travel data, mobile phone-based travel survey could be one of the promising choices for an actual implementation for transportation planning in the next upcoming years from now.

503 504

506

#### 505 **REFERENCES**

- Bohte, W., & Maat, K. (2009). Deriving and validating trip purposes and travel modes
  for multi-day GPS-based travel surveys: A large-scale application in the Netherlands.
  Transportation Research Part C: Emerging Technologies, 17(3), 285-297.
- Chen, C., Gong, H., Lawson, C., & Bialostozky, E. (2010). Evaluating the feasibility of a passive travel survey collection in a complex urban environment: Lessons learned from the New York City case study. *Transportation Research Part A: Policy and Practice*, 44(10), 830-840.
- Cottrill, C. D., Pereira, F. C., Zhao, F., Dias, I. F., Lim, H. B., Ben-Akiva, M. E., &
  Zegras, P. C. (2013). Future mobility survey: Experience in developing a
  smartphone-based travel survey in Singapore. *Transportation Research Record*, 2354(1), 59-67.
- Ishizaka, T., A. Fukuda. (2004). Utilizing probe car for travel survey in developing
  country: A case study in Bangkok. Proceedings for 59th Annual Conference of Japan
  Society of Civil Engineers, 505-506. (in Japanese)
- Hato, E., S. Itsubo, and T. Mitani. (2006). Development of MoALs (Mobile Activity
  Loggers Supported by GPS- Phones) for Travel Behavior Analysis. TRB 85th Annual
  Meeting Compendium of Papers (CD- ROM), Washington, D.C.
- Hato, E., & Kitamura, R. (2008). Data-oriented travel behavior analysis based on probe
   person systems. TRB conference proceedings, 187-196
- Shen, L., & Stopher, P. R. (2014). Review of GPS travel survey and GPS data-processing
   methods. *Transport Reviews*, 34(3), 316-334.
- 528 Stopher, P., FitzGerald, C., & Xu, M. (2007). Assessing the accuracy of the Sydney 529 Household Travel Survey with GPS. *Transportation*, *34*(6), 723-741.
- 530 Tipagornwong, C. (2003). The use of GPS equipped taxis as probe vehicles for travel
- 531time record in Bangkok (Master Thesis). Retrieved from Chulalongkorn University532Intellectual Repository. (in Thai)
- 533 Tongsinoot, L. (2017). Analysis of road traffic patterns using CDR and GPS (Master
- 534 Thesis). Retrieved from Chulalongkorn University Intellectual Repository. (in Thai)