Importance of Solid Demand Forecast in the Railway Master Plan Based on Experiences in BMR

Prof. Atsushi Fukuda
Nihon University, JAPAN
First Master Plan for Urban Transportation
Network data to estimate travel time by commuting was developed based on network data which was developed PCI (1982) and other information from 1973 to 1978. Travel speed on each link was prepared by adjusting the data from Bangkok Transportation System (German Advisory Team, 1975) by the results of hearing, etc. This network consists of 500 nodes and 250 links. Shortest route was estimated by Dijkestra Method.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Time Value</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>13.12</td>
<td>2.22</td>
</tr>
<tr>
<td>Bus</td>
<td>3.51</td>
<td>1.6(&lt;10Km), 2.8</td>
</tr>
<tr>
<td>MC</td>
<td>4.37</td>
<td>0.59</td>
</tr>
</tbody>
</table>

34 years ago
We finally evaluated an impact of the outer ling road on population.
Mass Rapid Transit Systems Master Plan (MTMP)

Following JICA Study (1991)
Comprehensive Urban Transportation Study in BKK

- 1975  WG Study
- 1991  JICA Study

<OTP>
- 1995- Urban Transport Database Management (UTDM)
- 1997- TDMC I-TDMC III
- 2005- TDMC IV-VI, eBUM
JBIC Study for evaluation of environmental improvement effect of ODA loan in Thailand (2006)

Japan Transportation Cooperation Agency (JTCA), Japan Weather Association (JWA) and Nihon U. with OTP

- Estimation of impacts of Blue Line Extension on environment (Road side emissions and CO2)
- Employ OD Table and network data from TDMC III

- Analyze travel behavior of people who live in Thonburi side (West Bank) by conduction SP survey (around 568 samples).
- Apply MNL model which was estimated based on SP survey data.
- Assigned traffic by highway and transit assignment models of JICA STRADA

- Estimate road side emissions and CO2 by applying emission factors which was developed by JTCA, PCD & OTP (MLIT Study)
- Estimate distribution road side emissions by using JEA model.
Process of Demand Forecasting

1. **Zoning of Study Area**
2. **Trip Generation**
3. **Trip Distribution**
4. **Modal Split**
5. **Traffic Assignment**
6. **Total Traffic Volume (Daily Traffic Volume)**

**Traffic Demand Estimation using JICA STRADA ver.3**

- 16 OD matrices split to Private modes and Public modes by applying mode choice parameters from TDMC III
- Estimate Trip converting from existing modes to MRT & BRT by applying parameters developed from results of questionnaire survey
- Network in year 2006 (Existing condition), Network in year 2011 (without Subway Extension Line), Network year 2011 (with Subway Extension Line)
- Highway Assignment: (OD matrices: Car, Bike, Truck, and Special Bus)
- Transit Assignment: (OD matrices: Up-market and Standard)
- Truck and Special bus OD matrices available from TDMC III

**Model Verification:** Traffic count at intersections

**Peak hour ratio (data from TDMC III)**

Data from TDMC III

Data from many sources
OD Matrix; Traffic Demand on TDMC III

- **0 Veh:** HBW, HBE, HBO, NHB
- **1 MC:** HBW, HBE, HBO, NHB
- **1 Car:** HBW, HBE, HBO, NHB
- **2 Veh:** HBW, HBE, HBO, NHB

Assigned to road network:

- **Private:** Track
- **Private:** Passenger car
- **Private:** Motor cycle
- **Private:** Special Bus

Assigned to Public transport network:

- **Public Up Market:** BTS, MRT and Air Bus
- **Public Standard Market:** Non Air Bus

**Impedance Matrix:**

- 8 Matrixes

**Modal choice model:**

- HBW: home based work
- HBE: home based Edu.
- HBO: home based others
- NHB: non home based
The Example of Stated Preference Survey

- Private Car
  - (Total Time: 49min. Total Cost: 108B.)
- Private Motorcycle
  - (Total Time: 49min. Total Cost: 23B.)
- Taxi
  - (Total Time: 77min. Total Cost: 81B.)
- Bus
  - (Total Time: 78min. Total Cost: 28B. Transfer Frequency: 3)
- Ferry
  - (Total Time: 64min. Total Cost: 30B. Transfer Frequency: 5)
- Para-transit
  - (Total Time: 59min. Total Cost: 30B. Transfer Frequency: 6)
- Subway
  - (Total Time: 31min. Total Cost: 37B. Transfer Frequency: 2)
Result of Traffic Assignment on Road Network

### Congestion Ratio

- 1.0
- 1.2
- 1.5

### Result of Traffic Assignment on Road Network

<table>
<thead>
<tr>
<th></th>
<th>2006</th>
<th>2011 (Subway Excluded)</th>
<th>2011 (Subway Included)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total PCU kilometers</td>
<td>240,404,345</td>
<td>250,038,375</td>
<td>249,774,202</td>
</tr>
<tr>
<td>Total PCU hours</td>
<td>16,296,587</td>
<td>16,223,473</td>
<td>16,180,440</td>
</tr>
<tr>
<td>Average speed (km/h)</td>
<td>14.8</td>
<td>15.4</td>
<td>15.4</td>
</tr>
</tbody>
</table>
Result of Estimation of Ridership on Blue Line
CO2 Emission reduction by Blue Line Extension

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Emission reductions</th>
<th>Proportion of emission reduction to total emission</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Air pollutants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO</td>
<td>637t/yr</td>
<td>0.17%</td>
</tr>
<tr>
<td>NOx</td>
<td>70t/yr</td>
<td>0.25%</td>
</tr>
<tr>
<td>PM</td>
<td>365 kg/yr</td>
<td>0.0083%</td>
</tr>
<tr>
<td><strong>Greenhouse gas</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CO₂</td>
<td>14,965t/yr</td>
<td>0.075%</td>
</tr>
</tbody>
</table>
This study was the part II of JBIC Study funded by OTP. Targeted network was similar with M-MAP.

-> Different Orange line route, No Green line Extension, No Gray line, etc.
Study was conducted by Khon Kaen U., Nihon U., JWA, etc.
By Using eBUM - extended Bangkok Urban Model (Qube)

Demand Forecasting

625 zones
Modal Split and Traffic Assignment

Total Person Matrices by Purpose/Vehicle Groups (16 Matrices)

Main Mode Split

Split by modal split model

Public Matrices
- Other Matrix
- Work/School Bus

Split by survey proportion

Sub-mode Split by Vehicle Availability Class
- Up market Matrix
- Standard Matrix

Split by modal split model

Private Matrices
- Taxi Matrix
- Other Matrix

Split by survey proportion

Car Matrix

Split by survey proportion

MC Matrix

Highway Assignment
## Model Results

<table>
<thead>
<tr>
<th>Mass Transit Line/Public Transport Mode</th>
<th>Passenger (1,000-Trip/Day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2005</td>
</tr>
<tr>
<td>Red Line</td>
<td>-</td>
</tr>
<tr>
<td>Green Line (BTS)</td>
<td>360</td>
</tr>
<tr>
<td>Blue Line (MRTA)</td>
<td>163</td>
</tr>
<tr>
<td>Orange Line</td>
<td>-</td>
</tr>
<tr>
<td>Yellow Line</td>
<td>-</td>
</tr>
<tr>
<td>Purple Line</td>
<td>-</td>
</tr>
<tr>
<td>Pink Line</td>
<td>-</td>
</tr>
<tr>
<td>Brown Line</td>
<td></td>
</tr>
<tr>
<td>SRT</td>
<td>98</td>
</tr>
<tr>
<td>Bus</td>
<td>2,949</td>
</tr>
</tbody>
</table>
New Mechanism Feasibility Study for Development of Mass Rapid Transit (MRT) Network in Bangkok, Thailand

By JWA, Nihon U., ALMEC VPI and Climate Consulting with OTP

(1) Transportation Demand Forecasting Approach
(2) Simplified ACM0016 approach
3 lines, 45.7km
15 lines, 509km
Modification of OTP Database of Bangkok

Four-Step Transport Demand Forecasting Model & Traffic Simulation

Basic Year 2010
Without MRTs
Calibration and Validation

Future Scenarios
2020
With/Without MRTs
2030
With/Without MRTs

Estimation of roadside emission reduction by links

Estimation of CO₂ emission reduction

eBUM
EMME/2,3
VISUM & VISSIM

JEA
Modal Choice Model

Employ the modal choice model which included captive group for passenger vehicles to represent actual travel behavior.

Utility Function of Private Transport:

\[
U_{d}^{PrT} = -ASC_d - (\gamma_{travel} \times u_{d}^{PrT}) - FC_d
\]

Here,
- \(ASC_d\): alternative specific constant for OD pair \(d\),
- \(\gamma_{travel}\): value of travel time (1.27 baht/min),
- \(u_{d}^{PrT}\): private transport travel time between OD pair \(d\) (min),
- \(FC_d\): fuel cost for OD pair \(d\) (3 baht/km)

Utility Function of Public Transport:

\[
U_{d}^{PuT} = -\left(\gamma_{travel} \times u_{d}^{PuT}\right) - F_d - (\gamma_{wait} \times W_d)
\]

Here,
- \(\gamma_{travel}\): value of travel time (1.27 baht/min),
- \(u_{d}^{PuT}\): public transport travel time between OD pair \(d\) (min),
- \(\gamma_{wait}\): value of waiting time (1.46 baht/min),
- \(W_d\): total waiting time spend in taking public transport to travel between OD pair \(d\)
## Results; Traffic Volume and CO₂ Emission

<table>
<thead>
<tr>
<th>CO₂ Emission (tCO₂/yr)</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without Project</td>
<td>13,317,246</td>
<td>18,251,177</td>
<td>25,279,356</td>
</tr>
<tr>
<td>With Project</td>
<td>12,736,649</td>
<td>17,453,825</td>
<td>17,453,825</td>
</tr>
<tr>
<td>Reduction</td>
<td>5,514,528</td>
<td>7,825,531</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- 30.2 %</td>
<td>- 31.0 %</td>
<td></td>
</tr>
</tbody>
</table>
## Results; Roadside Emission

<table>
<thead>
<tr>
<th>NOx</th>
<th>CO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual mean concentration in 2010</strong></td>
<td><strong>Annual mean concentration in 2010</strong></td>
</tr>
<tr>
<td>105,193 (t/year)</td>
<td>298,730 (t/year)</td>
</tr>
<tr>
<td><strong>Reduction effects of development of MRT network in 2030</strong></td>
<td><strong>Reduction effects of development of MRT network in 2030</strong></td>
</tr>
<tr>
<td>32,161 (t/year)</td>
<td>129,179 (t/year)</td>
</tr>
</tbody>
</table>
## Results; Roadside Emission

<table>
<thead>
<tr>
<th></th>
<th>PM</th>
<th>THC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual mean concentration in 2010</td>
<td><strong>787 (t/year)</strong></td>
<td><strong>87,824 (t/year)</strong></td>
</tr>
<tr>
<td>Reduction effects of development of MRT network in 2030</td>
<td><strong>76 (t/year)</strong></td>
<td><strong>56,463 (t/year)</strong></td>
</tr>
</tbody>
</table>
Issues regarding demand forecasting

<Related to Transportation Demand Analysis (eBUM2)>

• Basically result of eBUM2 has be applied.

• Increase sample size of home interview survey to develop or renew proper OD Tables;
  • Around 5 million households in BMR > Sample size; 200,000 (4%), 100,000(2%), ?
  • Feasibility to estimate of trips by applying the gravity type mode with parameters which were obtained with OD pares which isn’t zero only

• Development of the zoning system which will be able to represented service level of urban railway system and access mode to the railway stations
  • Appropriate configuration of each zone which includes only one railway station
Issues regarding demand forecasting

<Related to Travel Behavior Analysis>

• Consideration of service level of urban railway system
  • How to set fare level, frequency, transition time, accessibility, etc.

• Consideration of multi-modal behavior
  • Many commuters and students have to take more than 3 modes to travel in BKK.
  • Service level of feeder access affects to modal choice behavior significantly.
  • Policy for P&R, K&R, Feeder bus service, etc. should be examined.

• Consideration of automobile captive group
  • Should this behavior be explained by income level or not?

• Coordination between transport and urban plan (land use plan)
  • How to consider this relationship on demand forecasting?
Issues regarding demand forecasting

*Setting of necessary parameters*

- Time Value
- Parameters for BPR function

\[ t_a(x_a) = t_{a0}\left\{1 + \alpha \left(\frac{x_a}{C_a}\right)^\beta\right\} \]

<table>
<thead>
<tr>
<th></th>
<th>Japan (Mizokami)</th>
<th>Thailand (Sittha)</th>
<th>HCM</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
<td>0.96</td>
<td>0.73</td>
<td>0.15</td>
</tr>
<tr>
<td>(\beta)</td>
<td>1.2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

etc.
Issues regarding master plan (M-MAP2) development

• Coordination with Urban Plan
• Identify the character and role of each railway route
• Set up the order to develop each of rail system which can respond to Urban Plan
• Estimate Impacts of rail network development with different scenario

• Find out the system to develop a rail system on already developed area
東京首都圏のNT；30-50Km
M-Map: The Mass Rapid Transit Master Plan in Bangkok Metropolitan Region

15 lines, 509km

LRT 18.3Km

BRT 16Km

2029

10Km

20Km

Map; The Mass Rapid Transit Master Plan in Bangkok Metropolitan Region
DPT (2009) "Bangkok and its Vicinity Regional Plan 2057"
Urban Sprawl is progressing in BMR

http://www.newgeography.com/content/003367-the-evolving-urban-form-bangkok
Land Development along ARL
Low Accessibility
Access Modes
Land Development along Purple Line
Land Subdivision Development along PL
Thank you for your attention
Development of OD Table (Matrix)

Summarize the result of person trip survey in Origin Destination Matrix.
Assuming present trip pattern from PT survey can represent actual trip pattern, we expand present trip pattern and develop present OD table.
Applying Gravity Type Model

If there are so many zero on a present pattern, it is impossible to estimate a present OD table by expanding a present pattern. Thus, any gravity type mode such as below is applied only for intra-zonal trip which isn’t zero. Then, estimate a present OD table. But, it is impossible to confirm reliability of estimated OD table.

\[ t_{ij} = A_i B_j O_i D_j \exp(-\beta c_{ij}) \]

\[ \sum_j t_{ij} = O_i, \quad \sum_i t_{ij} = D_j \]