WLTP-DHC-05-07

# In-use Vehicle Data Collection in Korea for WLTP/DHC

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Transportation Pollution Research Center
National Institute of Environmental Research
Ministry of Environment, Republic of Korea

# Contents

# Introduction

## ❖ Schedule

| Task | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul | Aug. |
|---|---|---|---|---|---|---|---|---|
| 1. Budget allocation | | | | | | | | |
| 2. Engineering service contract | | | | | | | | |
| 3. Driving test Design | | | | | | | | |
| 4. Data collection | | | | | | | | |
| 5. Data check/Analysis | | | | | | | | |
| 6. Pattern Extraction | | | | | | | | |

◆ **Budget: $100,000**

## ❖ To Obtain Representative Driving Pattern Data

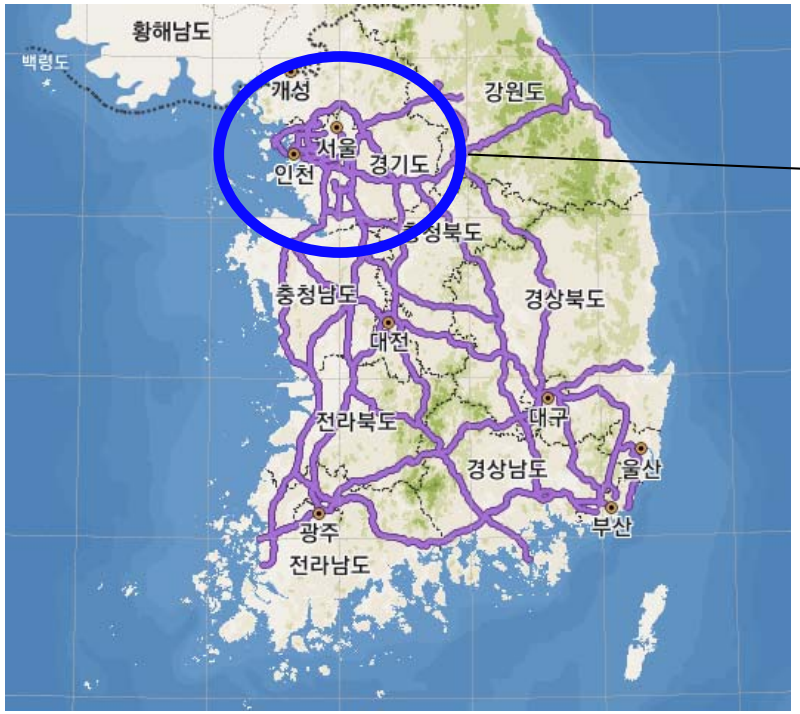
- ✓ Routes: chosen using Korean Household Travel Survey data (HTS)
- ✓ Driving test: done in Seoul Metropolitan Area where more than 45% of Korean vehicles are registered
- ✓ Test vehicles: selected considering the number of registration
- ✓ Test drivers: selected by age / gender

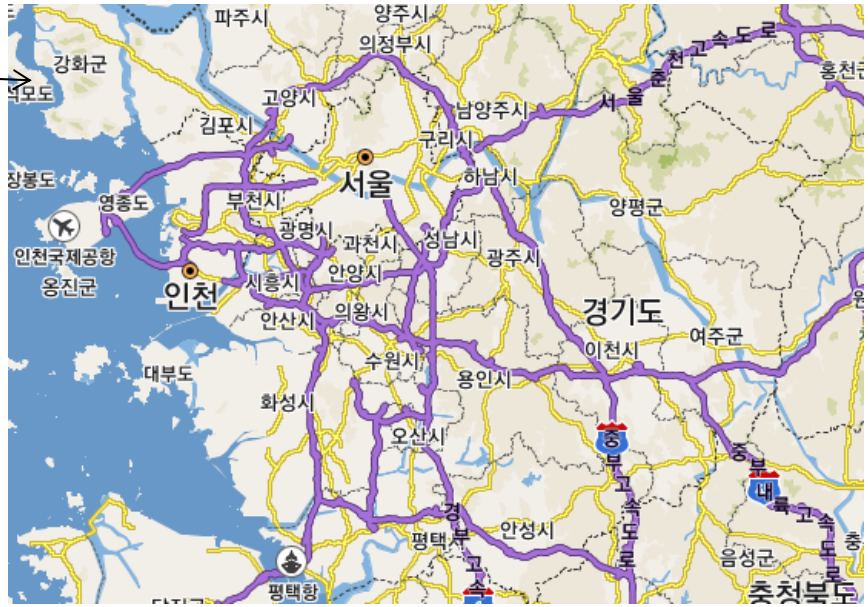
# Test Design

## ❖ Data collection methods based on WLTP proposal

| Items | Reference |
|---|---|
| Region | Seoul Metropolitan Area |
| Vehicle selection | WLTP-DHC-02-04, 4.3.1<br>WLTP-DHC-02-06, 3.2 |
| Driving behavior | WLTP-DHC-02-06, 3.3.1 |
| Driver selection | WLTP-DHC-02-06, 3.3.2 |
| Road type | WLTP-DHC-02-06, 3.3.3 |
| Season/weather condition | WLTP-DHC-02-06, 3.3.4 |
| Time of data collection | WLTP-DHC-02-06, 3.3.4<br>WLTP-DHC-02-06, 3.3.5 |
| Amount of data to be collected | WLTP-DHC-02-06, 3.4 |
| Data to be collected | WLTP-DHC-02-06, 3.5<br>WLTP-DHC-02-14, 2.3 |

# Test Design–Region




- ❖ Seoul Metropolitan area – Seoul, Incheon, Gyeonggi province
  - ✓ population:  about 25million (about 50% of the total South Korea's)
  - ✓ vehicle registration: over 45% of the total South Korea's

# Test Design–Test vehicles and drivers

## ❖ Vehicles registration number

| Rank | PC (1 to 2 L) | | PC (2 to 4 L) | | SUV (1 to 2 L) | | SUV (2 to 4 L) | | Van | | LD Commercial | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Avante** | 1263 | **Grandeur** | 592 | **Santafe** | 414 | **Carnival** | 359 | **Starex** | 218 | **Porter** | 828 |
| 2 | **Sonata** | 1165 | Equus | 130 | Sportage | 235 | Musso | 279 | Grace | 65 | Bongo | 555 |
| 3 | Matiz | 584 | Chairman | 111 | Tussan | 210 | Sorento | 273 | Istana | 52 | Libero | 50 |
| 4 | SM5 | 481 | SM7 | 96 | Trajet | 138 | Korando | 218 | Damas | 39 | Ceres | 39 |
| 5 | Morning | 261 | Opirus | 88 | Action | 81 | Galloper | 190 | Pregio | 27 | SV110 | 5 |

Note: 97% of passenger vehicles are automatic transmission

## ❖ Drivers age and gender distribution by HTS

| Age and gender of drivers | | PC | LD commercial | Total |
|---|---|---|---|---|
| 20s | Male | 1.4% | 1.2% | 1.4% |
| | Female | 0.7% | 0.3% | 0.7% |
| **30s to 40s** | **Male** | **45.4%** | **47.1%** | **45.4%** |
| | Female | 16.7% | 9.0% | 16.3% |
| 50s or above | Male | 29.6% | 40.3% | 30.0% |
| | Female | 6.2% | 2.1% | 6.0% |

# Test Design–Test vehicles and drivers

❖ Test vehicles and drivers: 8 vehicles with male drivers in 30~40s

| Vehicle Category | Vehicle | Transmission | Fuel | Year of first registration | Mileage (km) | Age / Driving Exp. |
|---|---|---|---|---|---|---|
| PC (1 to 2 L) | Avante HD | A/T | gasoline | 2008 | 37,771 | 32 / 3 years |
| | Sonana YF | A/T | gasoline | 2010 | 8 ,745 | 33 / 13 years |
| PC (2 to 4 L) | Grandeur TG | A/T | gasoline | 2006 | 19,915 | 30 / 6 years |
| SUV (1 to 2 L) | Santafe CM | A/T | diesel | 2007 | 19,306 | 32 / 8 years |
| SUV (2 to 4 L) | Grand Carnival | A/T | diesel | 2010 | 7,416 | 33 / 13 years |
| Van | Grand Starex | A/T | diesel | 2008 | 33,905 | 30 / 10 years |
| LD Comercial | Porter | A/T | diesel | 2008 | 40 ,370 | 36 / 9 years |
| | Porter | M/T | diesel | 2008 | 104,717 | 49 / 20 years |

❖ Drivers were instructed to follow the traffic flow and paid fuel cost

# Test Design–Road type

- Using the concept of administrative boundaries
  - ✓ Urban
    - trip generated between districts where the population is over 50,000
    - speed limit is from 40 to 80km/h
  - ✓ Rural:
    - trip generated between other districts
    - speed limit is from 50 to 80km/h
  - ✓ Motorway
    - constructed and controlled for the faster traffic
    - speed limit is 100 to 120km/h

# Test Design-Road type

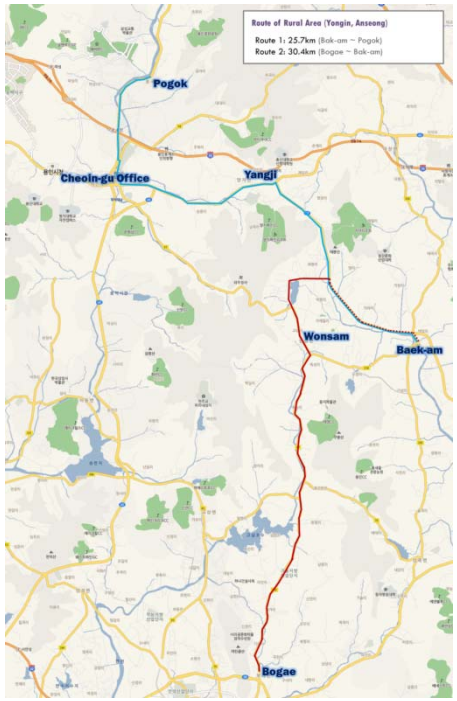
Urban

Rural

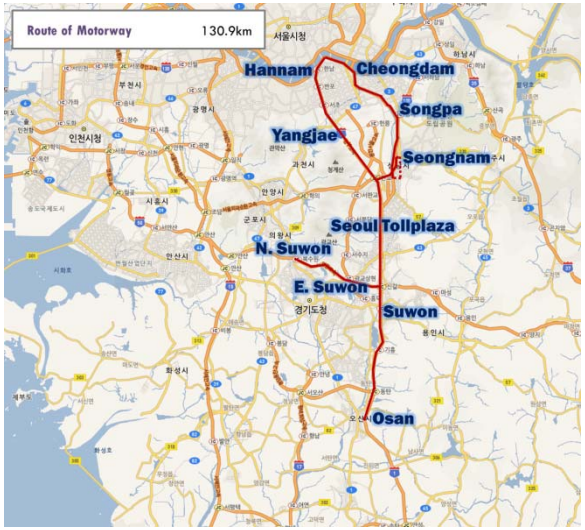
Motor way

# Test Design–Test routes


Route of urban area




Route of rural area




Route of motorway

- Routes of urban and rural area: 2 pairs of about 25km trip, considering HTS origin and destination data
- Route of motorway: chosen considering traffic volume and route characteristics (about 130km)

# Test Design–Time of data collection

- Data collected from May to June
  - ✓ Late spring / early summer
  - ✓ Similar seasonal and weather conditions
- Test Time of Day (period): based on HTS
  - ✓ Peak hour: 7 to 9 AM, 6 to 8 PM in weekday
    9 to 12 AM, 5 to 8 PM in weekend
- Target distance: 36,000km

| | Urban Area | Rural Area | Motorway |
|---|---|---|---|
| Weekday Peak | 4000km (500km/veh) | 4000km (500km/veh) | 4000km (500km/veh) |
| Weekend Peak | - | - | 4000km (500km/veh) |
| Weekday Off-peak | 8000km (1000km/veh) | 8000km (1000km/veh) | 4000km (500km/veh) |
| Sub-Total | 12 000km (1500km/veh) | 12 000km (1500km/veh) | 12 000km (1500km/veh) |
| Total | **36 000km (4500km/veh)** | | |

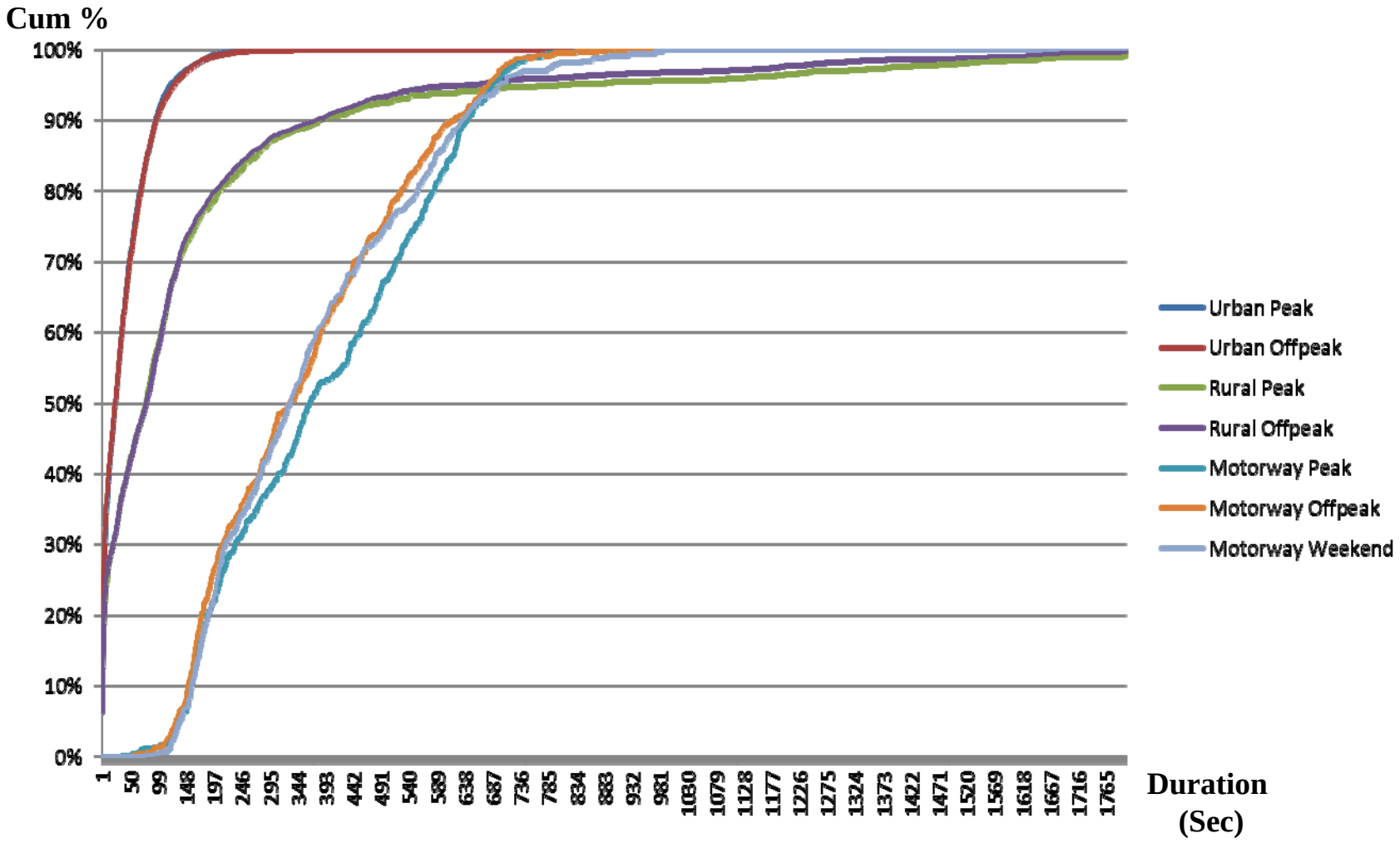
# Test Result–The amount of collected data

## ❖ Summary of data collection

| | | driving distance [km] | Number of short trips | Average duration of short trips (s) | Average speed of short trips (km/h) | Number of idling | Average duration of idling (s) |
|---|---|---|---|---|---|---|---|
| Urban | peak | 3886.8 | 12503 | 39.4 | 17 | 12511 | 27.3 |
| | off-peak | 7862.4 | 24389 | 39.9 | 16.8 | 24397 | 26.4 |
| Rural | peak | 3861.7 | 1510 | 194.8 | 34.1 | 1518 | 25.2 |
| | off-peak | 7921.6 | 3592 | 160.2 | 32.4 | 3600 | 25.1 |
| Motorway | peak | 3776.8 | 505 | 388.6 | 58.8 | | |
| | off peak | 4090.6 | 653 | 355.8 | 55 | | |
| | Weekend | 4009.6 | 567 | 367.3 | 59.7 | | |
| total | | 35409.5 | 43719 | | | | |

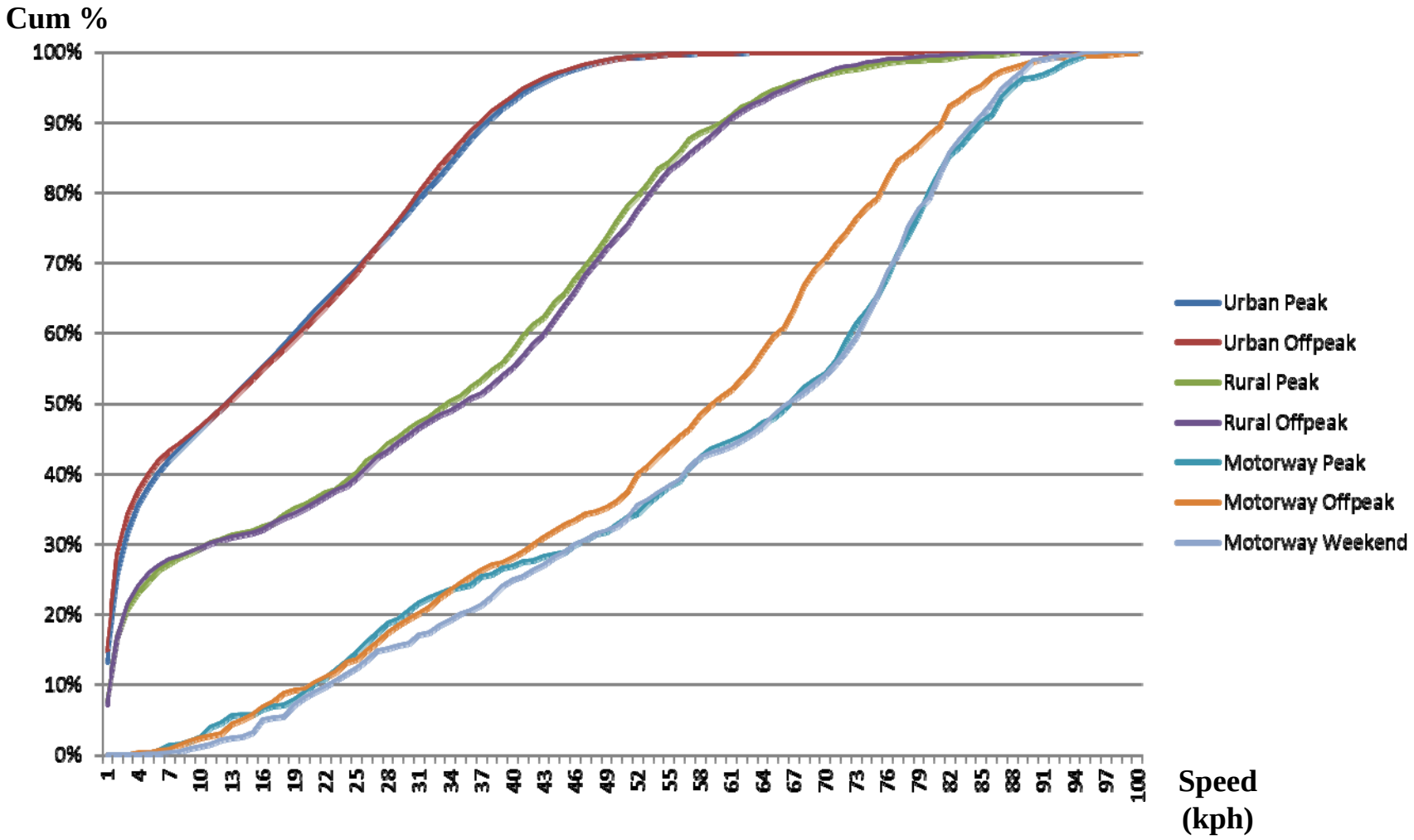
# Test Result–Short trip duration

❖ Distribution of short trip duration



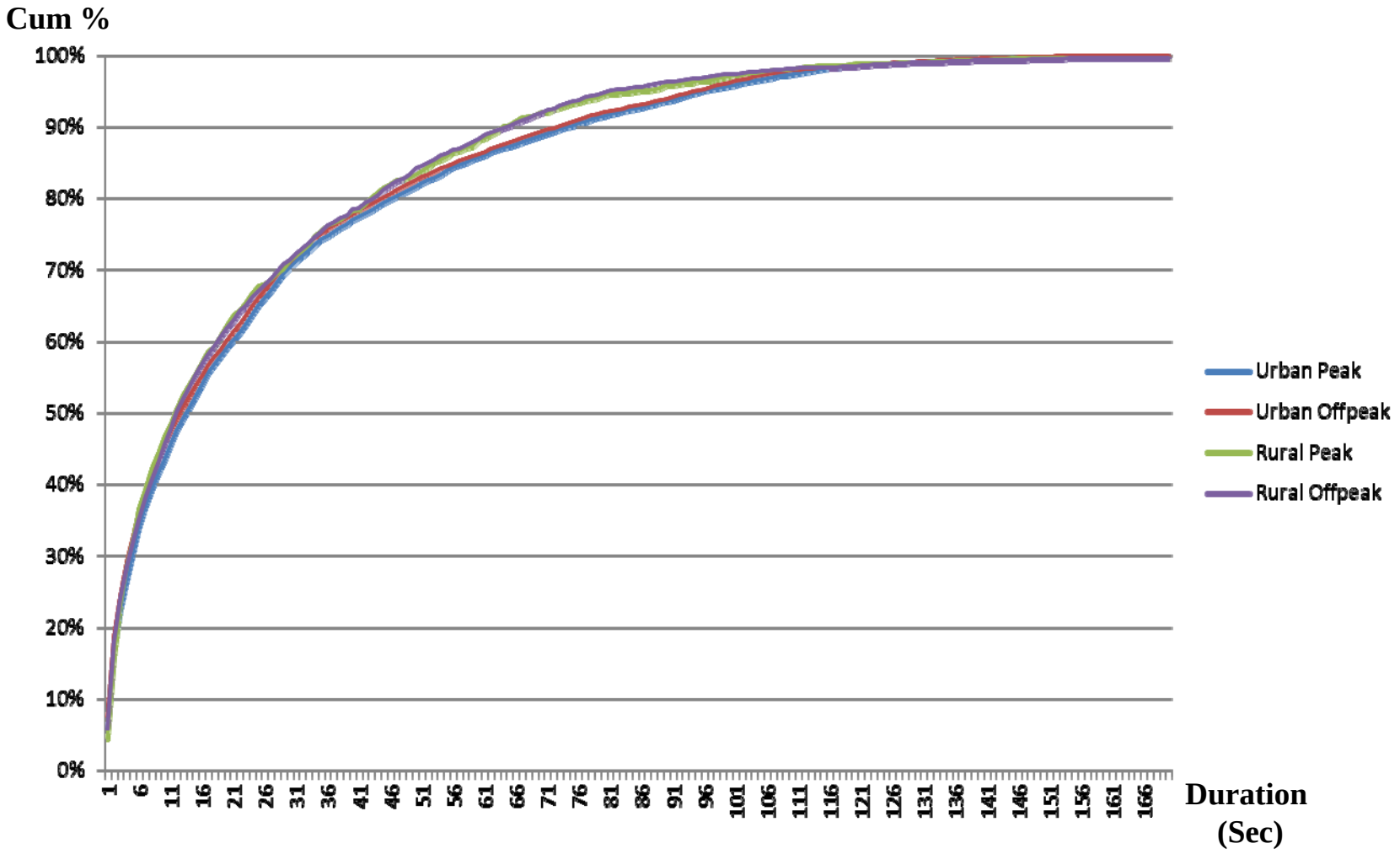
# Test Result–Short trip average speed

❖ Distribution of short trip average speed



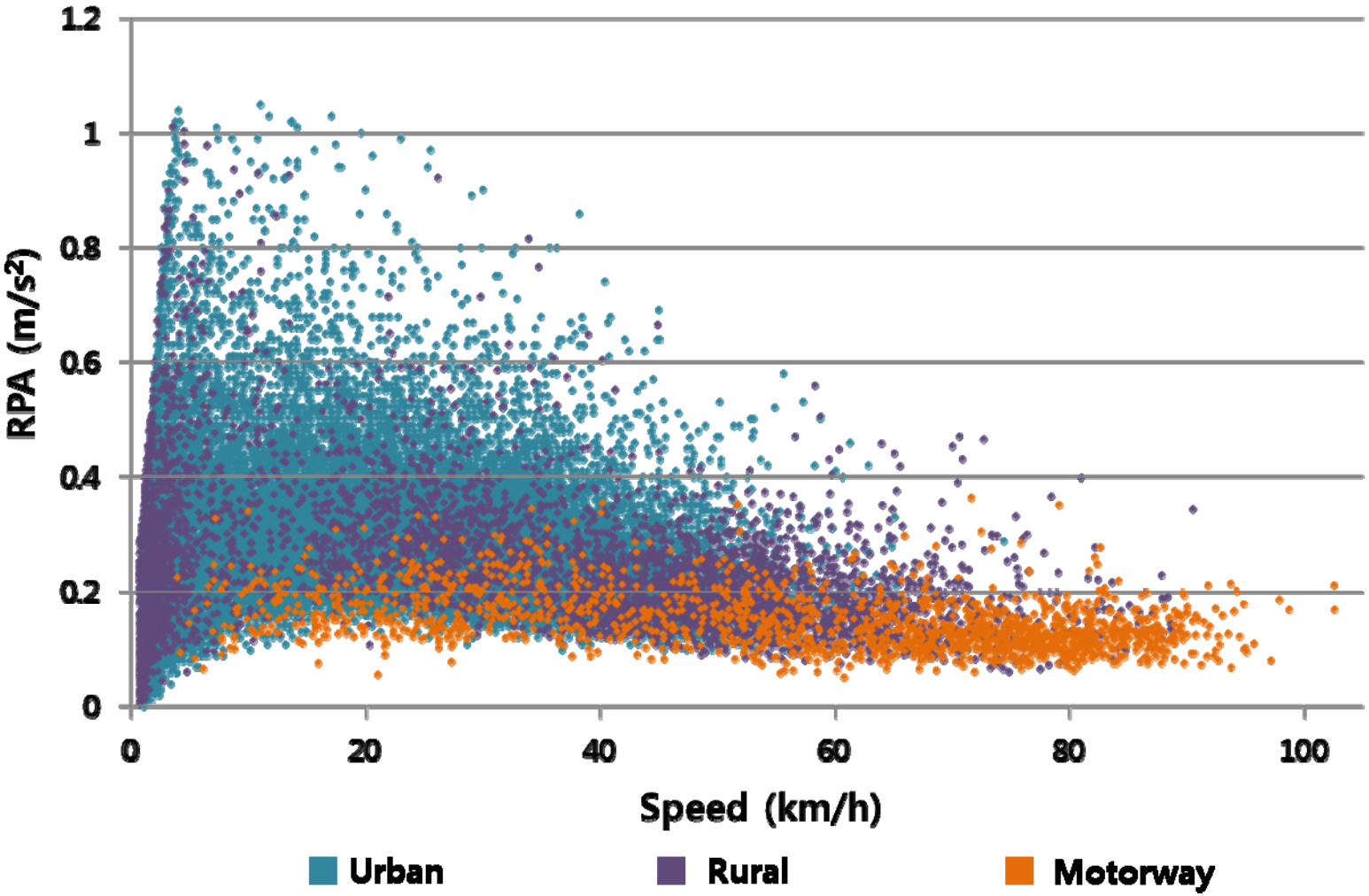
# Test Result–Idling duration

❖ Distribution of idling duration



# Test Result–Speed–Acceleration

- Speed–RPA distribution



# Initial Analysis

- Conducted initial analysis following the first proposal of DHC with the collected data in Korea
- Determine the number of idle and short trip in each phase,

  then make short trip combinations

| | no. of short trip durations | no. of combinations |
|---|---|---|
| Urban | 8 | $1.53 \times 10^{16}$ |
| Rural | 3 | 1280 |
| Motorway | 2 | 117 |

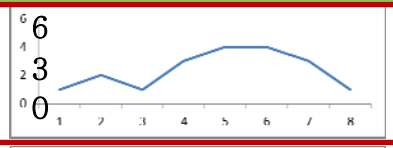
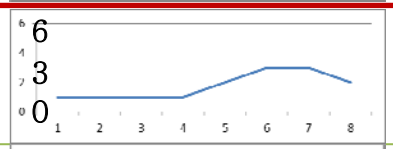
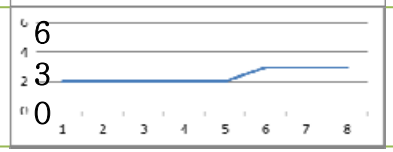
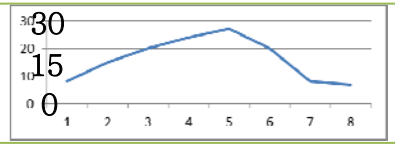
- Short trip selection based on Chi-square fit test
  - ✓ Use modified method for Urban phase due to too many combinations which require too much time for calculation

# Initial Analysis

## ❖ Modified method for urban phase

- ✓ Chi-square test in each short trip duration separately
- ✓ Select a short trip of the lowest chi-square value as the representative short trip of the short trip duration
- ✓ Combine the representative short trips for the urban phase

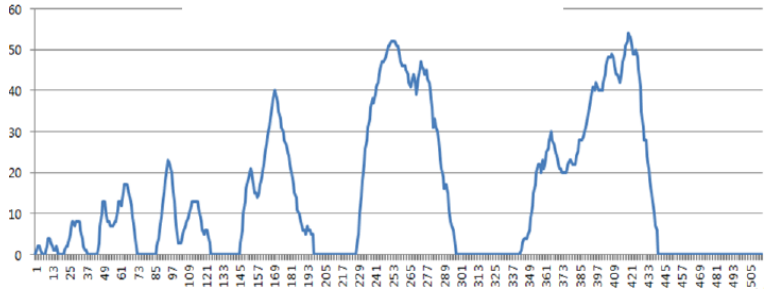
## ➢ Example of modified method

| Rank | Short Trip ID | $\chi^2$ value | Short Trip Pattern |
|---|---|---|---|
| 1 | 8sec. (8th) | $3.009\times10^{-4}$ |  |
| 2 | 8sec. (256th) | $3.029\times10^{-4}$ |  |
| 3 | 8sec. (243th) | $3.030\times10^{-4}$ |  |
| … | … | … | … |
| 388 | 8sec. (303th) | $34.167\times10^{-4}$ |  |

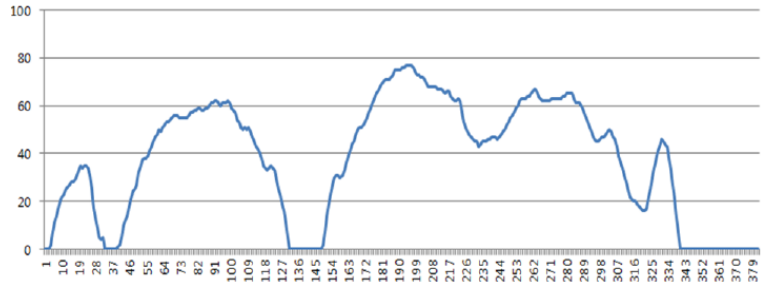
Representative Short Trip for 8-second duration

# Initial Analysis

❖ Urban (514s)



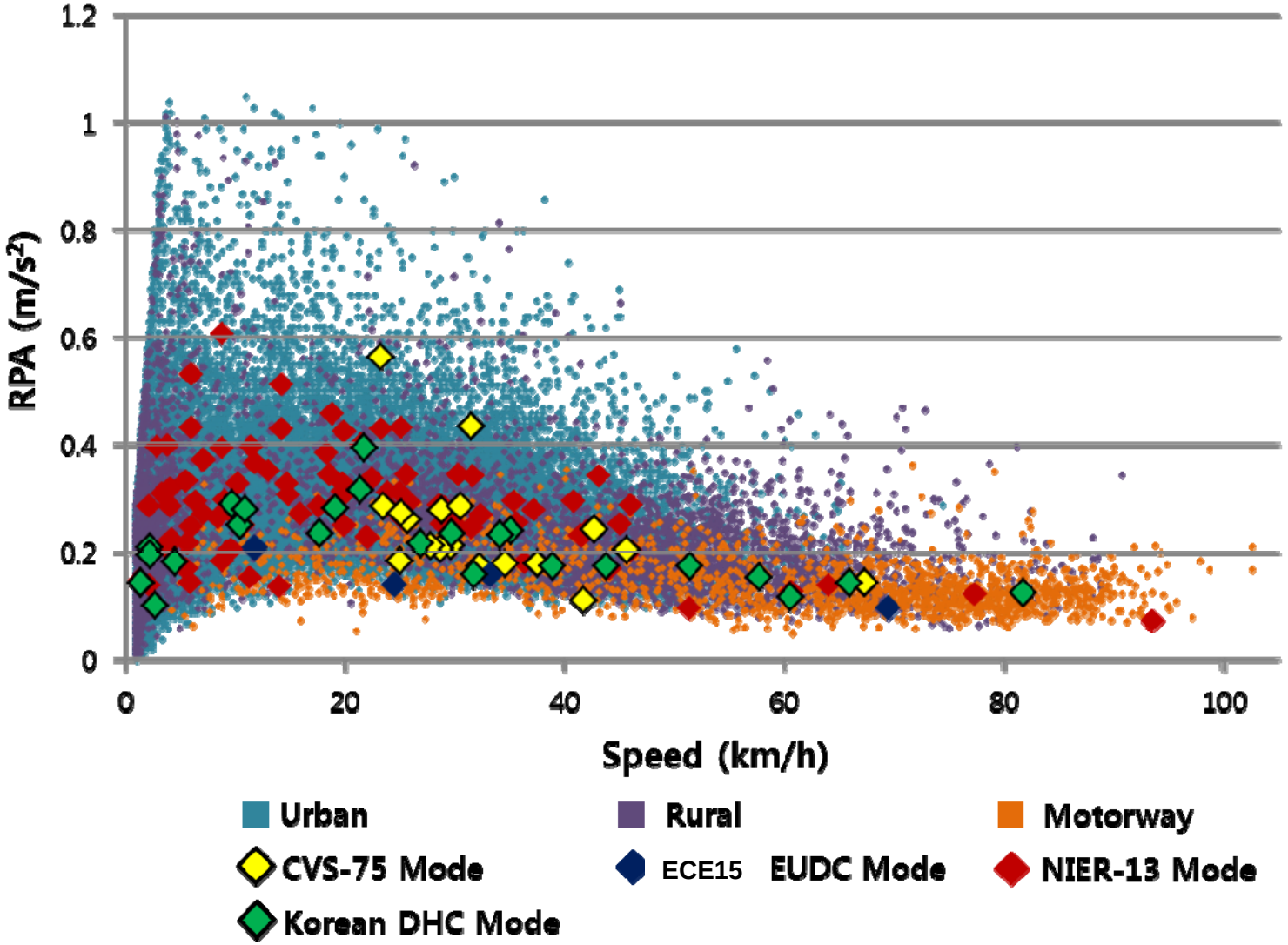

❖ Rural (383s)




❖ Motorway (747s)

# Initial Analysis

❖ Speed-RPA distribution



# Summary

- With the help from some traffic census information, Korea could submit quite representative driving pattern data
- Analysis methodology may need to be modified for Urban (or low speed) phase due to enormous number of short trip combinations
- With preliminary analysis Korea expect that harmonized driving cycle could reflect Korean real driving pattern better than the present test cycles (FTP-75, ECE15-EUDC) for Korean emission certification

# Thank you!!