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INTERNATIONAL CENTER FOR
URBAN SAFETY ENGINEERING

INSTITUTE OF INDUSTRIAL SCIENCE
THE UNIVERSITY OF TOKYO

WORKSHOP ON TRANSPORTATION RESEARCHES FOR URBAN SAFETY

December 11, 2008

Edited by

Shinji Tanaka
ICUS, IIS, The University of Tokyo, Japan

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Workshop on Transportation Researches for Urban Safety

11 December 2008
Bangkok, Thailand

Co-Organized by

International Center for Urban Safety Engineering (ICUS)
Institute of Industrial Science
The University of Tokyo, Japan

and
Regional Network Office for Urban Safety (RNUS)
School of Engineering and Technology
Asian Institute of Technology (AIT), Thailand

Edited by

Dr. Shinji Tanaka

WORKSHOP ON TRANSPORTATION RESEARCHES FOR URBAN SAFETY

ICUS Report No. 34, February 2009

PREFACE

There is a sharp increase of the number of vehicles in all Asian countries. This rapid motorization causes a lot of transportation problems such as traffic accident, traffic congestion and air pollution by emission gases. No one doubts that traffic accident has been an immediate and serious risk to our life in the urban safety. Environmental problems, especially CO2 emission are becoming the most important issues in our society. Traffic congestion affects both on traffic accident and emission. They are common issues in most of the large cities in Asia. To solve these problems must have a positive impact to enhance the urban safety and to achieve the sustainable urban environment.

Transportation researches have been widely conducted in various aspects, including above issues. And recently, ITS (Intelligent Transport Systems) researches and developments have become very active. They are expected to be powerful tools to solve these problems. Considering in Asia region, Japan is regarded as one of the leading country both in transportation problems and its solutions. And the other countries will probably follow it when the motorization proceeds further in the future. Therefore, it must be very meaningful and important to share the knowledge and experience among these countries.

Regional Network office for Urban Safety (RNUS) in Asian Institute of Technology (AIT) recognized that transportation problems are very serious issue to be solved for the sustainable urban environment although they are not natural disasters. Therefore, we planned to organize a workshop so that transportation researchers and engineers can get together, share issues and knowledge, and exchange their information and opinions. It would be a good opportunity both for practitioners to learn advanced technologies and for researchers to understand actual problems in Asian cities.

The objectives of this workshop are,

1. to share and exchange knowledge, information and opinions among transportation researchers and practitioners
2. to understand critical transportation problems in Asian cities
3. to find better solutions to improve the problems

The seminar was held on 11 December, 2008 at Rama Garden Hotel in Bangkok, Thailand. We welcomed 11 speakers who are all distinguished researchers in the various fields of transportation researches from Japan, Hong Kong and Thailand. Although Dr. Kazushi Sano could not join this workshop in the consequence of the troubles occurred at the International Airport in Bangkok just one week before, Dr. Pairoj Raothanachonkun kindly made a presentation on behalf of him. The topics of the presentation were very broad, such as urban planning, traffic safety analysis, travel information, traffic simulation, ITS and so on. The number of participants was 57, who were mainly from universities, government agencies and industries.

The workshop was completed successfully, with interesting and informative presentations, lively discussions and good mutual communication and understanding. We could also get a lot of positive evaluations through the questionnaire sheets answered by the participants.

Finally, we would like to express our sincere gratitude for those who kindly supported and contributed to the success of this workshop.

Shinji TANAKA

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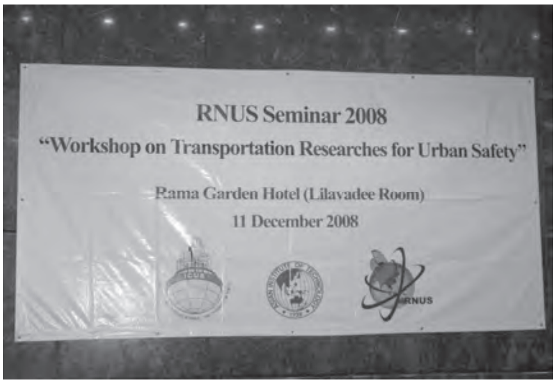


Welcome board

Registration

Opening ceremony (Dr. Tanaka)

Prof. Fumihiko Nakamura

Prof. Yasuhiko Kumagai

Dr. Toshi Yoshii

Prof. Masao Kuwahara

Dr. Pichai Taneerananon

Prof. Takashi Nakatsuji

Dr. Pairoj Raothanachonkun

Dr. Hidekatsu Hamaoka

Dr. Ryota Horiguchi

Dr. Sorawit Narupiti

Dr. Agachai Sumalee

Participant

After-Seminar Dinner


RNUS Seminar 2008
"Workshop on Transportation Researches for Urban Safety"

Group Photo

Urban Bus Planning and Management

Prof. Fumihiko Nakamura

URBAN BUS PLANNING AND MANAGEMENT

FUMIHIKO NAKAMURA
Yokohama National University
f-naka@ynu.ac.jp

Urban Bus Planning and Management

Prof. Fumihiko NAKAMURA
Yokohama National University

About the lecturer

- Fumihiko Nakamura, Dr. Eng.
- Born in Niigata in 1962.
- Graduate from Univ.of Tokyo in 1985
- 1989-1992: Research Associate at Univ. Of Tokyo
- **1992-1994: Assistant Prof.at AIT (Bangkok)**
  (Human Settlement Development (HSD) Department)
- 1995-2004 : Associate Prof.at Yokohama National University
- 2004- : Professor
- Majoring in Urban Transportation Planning and policies, urban planning, public transportation planning.
- http://www.cvg.ynu.ac.jp/G4/index_e.htm
- E-mail: f-naka@ynu.ac.jp

Contents

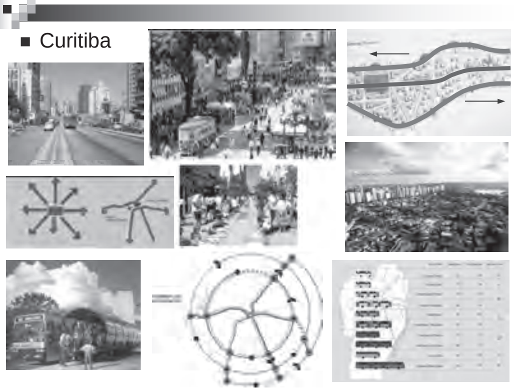
- Urban Buses in the world
- BRT strategies
- Planning and Management strategies
- Conclusion

Urban Buses in the World

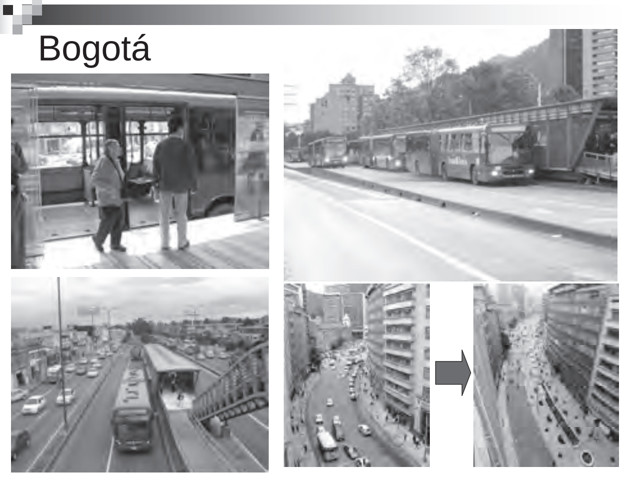
List of BRT and related practices shown below

City	Nation	Right-of-way	Network	Other Remarkds
Curitiba	Brazil	Busways	Hierarchical	Land use control
Bogota	Colombia	4-lane busways	Hierarchical	
Jakarta	Indonesia	Busways		
Seoul	Korea	Bus lanes	Hierarchical	Management Reform
Ottawa	Canada	Busways	Hierarchical	TOD
Adelaide	Australia	Guideways		
Leeds	UK	Short Guideways		
Nancy	France	Rail track		Urban Transport Strategies
Einthohen	Netherlands	Busways		Urban Transport Strategies, automated driving
Copenhagen	Denmark	Bus lanes	Hierarchical	Management Reform, Bus Strategies

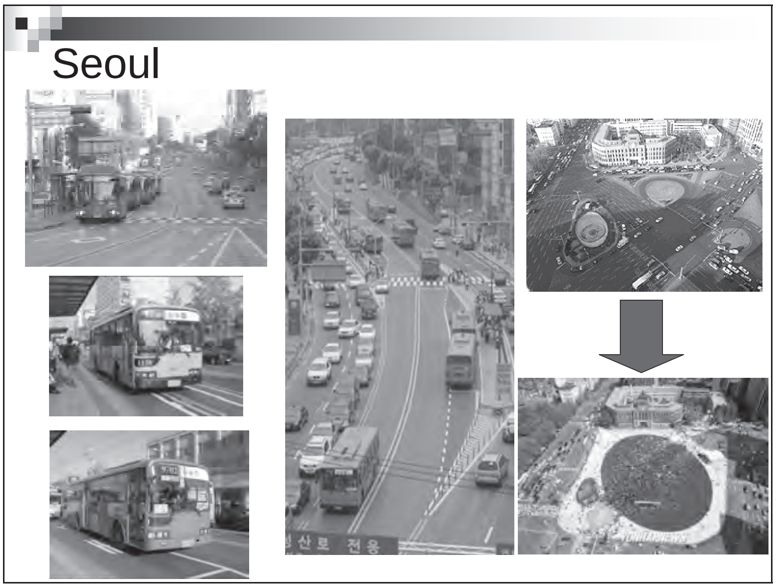
- Curitiba

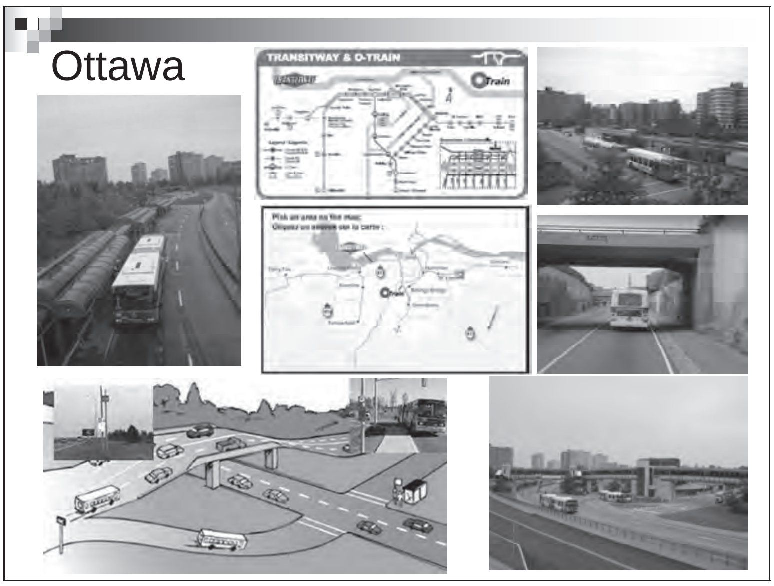


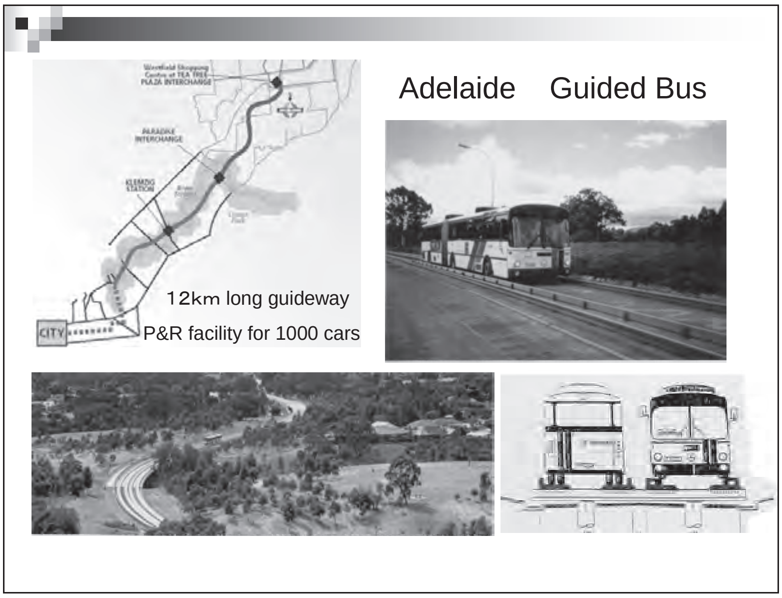
Bogotá

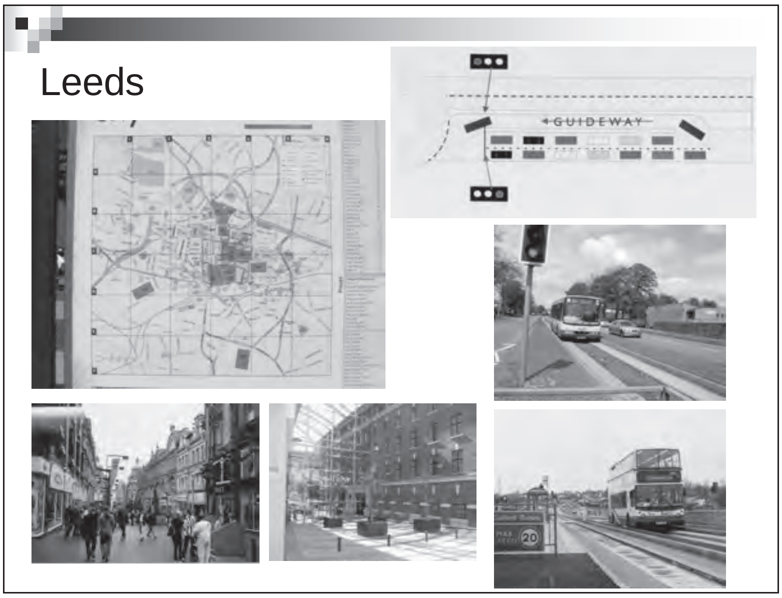


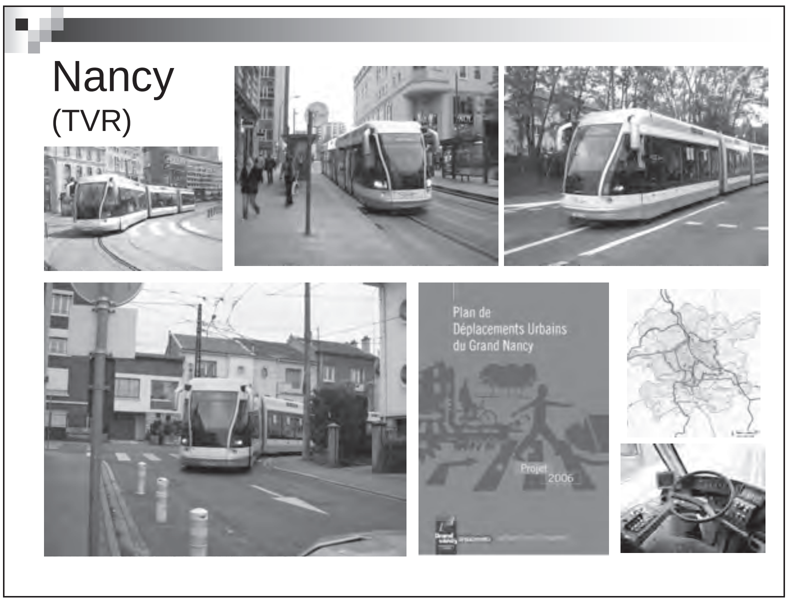

Jakarta (TransJakarta)


Seoul

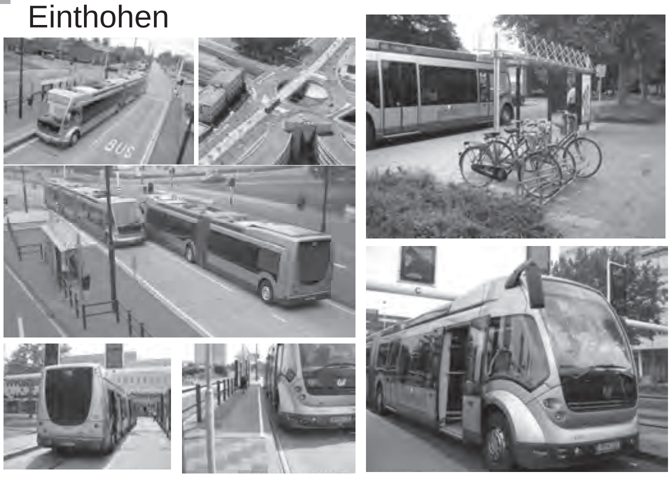

Ottawa
TRANSITWAY & O-TRAIN


Adelaide Guided Bus
12km long guideway
CITY
P&R facility for 1000 cars

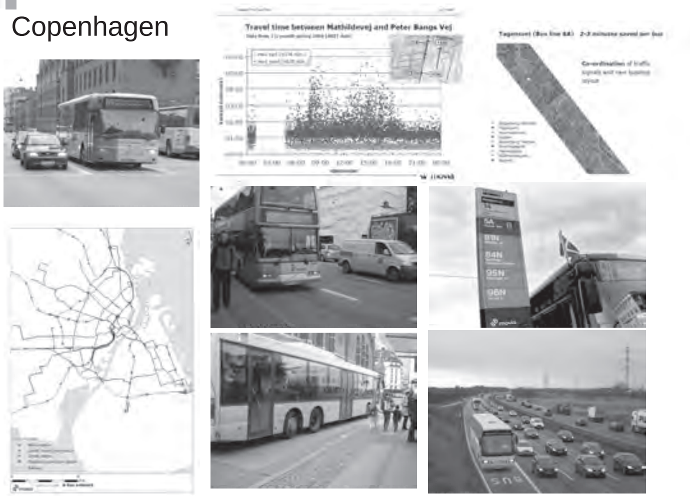

Leeds
GUIDEWAY
20


Nancy
(TVR)
Plan de
Déplacements Urbains
du Grand Nancy
Projet
2006

Einthohen



Copenhagen



BRT Strategies

BRT : Bus Rapid Transit

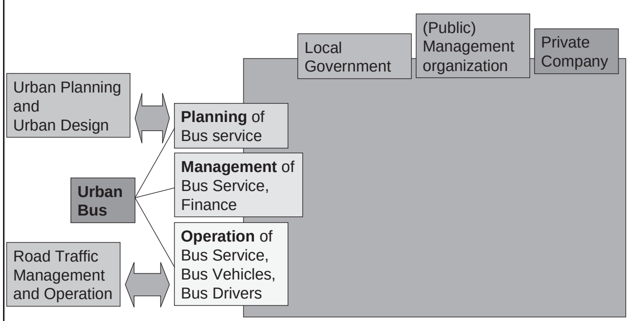
- Conceptually
  - Brand-New Transport System
  - Different image from conventional urban buses
  - Cheaper than but strong impact as LRTs
- Technically
  - High regularity with busways, bus lanes or/and bus priority signals
  - High capacity with advanced operation and facilities (bus stops, vehicles, payment etc.)

Learning from BRT Best Practices

- Busways, Bus Lanes, Bus priority signals
  - Maximizing the impact of the image to citizen
  - Minimizing the effect on other traffic (?)
- Vehicles
  - Articulated or bi-articulated bus or 15m-bus
- Stops and Payment
  - Exclusive facility, pre-payment or gate, IC card
- Management (the next chapter)
  - Involvement of public (road, traffic) sector to BRT
- Process
  - Re-arranging of existing bus network and management
  - Integration with comprehensive urban transportation strategy

Planning and Management Strategies

Concept of Management Strategies



Urban bus in Japan

	Local government	Operators
planning	Some proposal only	decide
Management	Do nothing	decide
Operation		do

Urban bus in many European cities

	Local government	Operators
Planning Management	Local government takes initiatives and take city-wide contract with an operator on network and service contents as well as amount of subsidies	
Operation		do

Urban bus in London

	Local government (London Bus in TfL)	Operators
planning	Decide everything	Can say opinion
Management	Select operators by tendering	Can apply at zone scale
Operation	Check by monitoring (with AVL and CS-survey)	do

Urban bus in other cities in UK

	Local government	Operators
Planning Management	Local government takes initiatives and take contract with operators (so-called **<u>Bus Quality Contract</u>** or **<u>Bus Quality Partnership</u>**) on network and service contents as well as amount of subsidies with some incentives to operators such as road and bus stop improvement, depo space provision etc.	
Operation		do

Urban Bus in Copenhagen

	Local government	Public Company (MOVIA)	Operator
planning		Decide everything	
management	Road and bus stop improvement when proposed by MOVIA	Select operators by tendering Order road improvement to local government	
operation		Monitor by AVL and CS	do

Urban Bus in Curitiba

	Local government with IPPUC	Public Authority (URBS)	Operator
planning	Decide concept	Decide everything	
management		Contract with operators. Fare revenue collection and distribution	
operation		Monitor by CS	do

Urban bus in Seoul

	Local government	Operators
planning	Decide everything incl. infrastructure such as busways, AVL, fare system	
Management	Assign routes to operators Fare revenue collection and distribution	
Operation	Check by monitoring (with AVL and surveys)	do

Other cases

- Ottawa, Brisbane
  - Public Operators run services
- Bogota and Jakarta
  - BRT is operated by a sort of consortium while other routes in conventional style
- Seoul
  - All private operators now under strong control by Seoul city govenment

Discussion

- Urban bus system
  - If it is business only, free market will be fine
  - If it is a part of transportation infrastructure, some extent of involvement by public sector should be essential. At least, BRT or similar main route extensive (and exclusive) service should be planned and managed by public.
- Role and Power of Local Government is strongly expected such as controlling roads, stops, terminals and traffic regulations and operations
- There might be some choices

Basic Strategies

- Identify the roles of public and private
- Identify the roles of operators
- Prepare urban transport strategies
- Identify the possibility of strong control land use (in many cases, unfortunately no).
  - If yes, Curitiba style will be recommended
  - If no, Seoul or Copenhagen styles will be referred.
- Road traffic management side should be involved both in planning and management stages.

Planning Strategies

- Governments should be involved
- Basic principles should be coordinated with other sectors such as urban planning, environmental policies, educational policies and social welfare policies, which might be related to budget acquisition.
- Network and Fare policies are most important, both of which might be as simple as possible.
- Coordination should be taken with Rail-based systems, suburban road networks, paratransit management and pedestrian circulation design.
- Clear and Clean image could be enhanced anyhow.

Management Strategies

- Public sector should be involved to manage especially financing issues by monitoring operation performance.
- Safety, compliance and efficiency should be balanced.
- Private operators should be able to get variety of incentives to do services.
- Seoul's experience is one of the management solutions to be applied into metropolitans in developing countries, as well as being referred to Copenhagen's case and Curitiba's case.

Conclusion

Urban Buses

- They have potentials as well as needs.
- They can and must change their existing slow, unreliable, bad, dangerous and dirty images.
- BRT is one of the opportunities to do this.
- BRT needs strong supports from infrastructure planning and traffic engineering
- BRT should be accompanied with city-wide re-arrangement of urban bus system.
- Management strategies might be renewed with involvement of public sector.

Grass-Roots ITS - Regional ITS of Kochi Prefecture in Japan -

Prof. Yasuhiko Kumagai

GRASS-ROOTS ITS – REGIONAL ITS OF KOCHI PREFECTURE IN JAPAN-

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Grass-Roots ITS
-Regional ITS of Kochi Prefecture in Japan-

Yasuhiko Kumagai Ph.D.
Professor
Kochi University of Technology, Japan

Kochi Prefecture

Distance from Tokyo : 1.5 hr flight
Osaka : 0.5 hr flight
Population: 796,000 (15 from Thailand)

KUT
(Kochi University of Technology)

- Established in 1997
- Contribute to local activations
- Most beautiful University in Japan (probably!)

My ITS Background

- National Projects in Japan (1973-1998)
  - CACS, DRM, ETC,VICS etc
- US ITS (1998-2003/3)
  - International Fellow
- Asian ITS (1997-2000)
  - Report "Introducing ITS in Asia" by ITSA
- GR ITS in Japan (2003/4-)
  - Kochi University of Technology

Contents

- Grass-roots ITS
- Systems in Kochi prefecture
- My ITS study in Asian countries

Macroscopic Groupings of ITS

- Grouped by Area
  - Nation wide ITS
  - Regional ITS
- Grouped by Functions
  - Basic ITS
  - Advanced ITS

Nation wide ITS

- ETC, VICS
- National Standard
- Very sophisticated on-board unit
- Large Market

Regional ITS

- Solutions for regional peculiar traffic problems
- Local specification
- Simple and easy functions by road unit
- Niche Market

What's Grass-roots ITS ?

- Regional ITS in our Kochi prefecture
- Deployed by Grass-roots movement
  - Solutions for today's problems, not for tomorrow
  - Needs oriented (Needs need Seeds !)
  - Cooperative movement by Public, Private and Academia

Regional disparities in Japan

Population rate

$$\frac{\text{Three Metropolitan Areas}}{\text{Whole Country}} = 0.49$$

Land rate

$$\frac{\text{Three Metropolitan Areas}}{\text{Whole Country}} = 0.10$$

Population desnsity(/Km^2)

$$\frac{\text{Kochi Prefecture}}{\text{Average of Whole Nation}} = \frac{115}{336}$$

Regional disparities in Kochi

- Aging society & Depopulation
  - ･Elderly rate 24.1% (ranked 3rd)
  - ･Population growth rate -0.15% (ranked 38th)
  - ･Death rate (10.3 /1000) (ranked 1st)
- Undeveloped social infrastructure
  - ･Poor public transportation such as trains & buses
  - ･Road reform rate 41.6% (ranked 44th)
- Severe natural disaster
  - ･83.3% covered by mountains and forest (ranked 1st)
  - ･Frequent typhoon and heavy rainfall

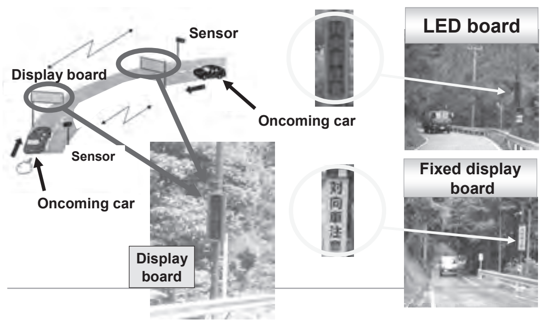
Road traffic problems in Kochi

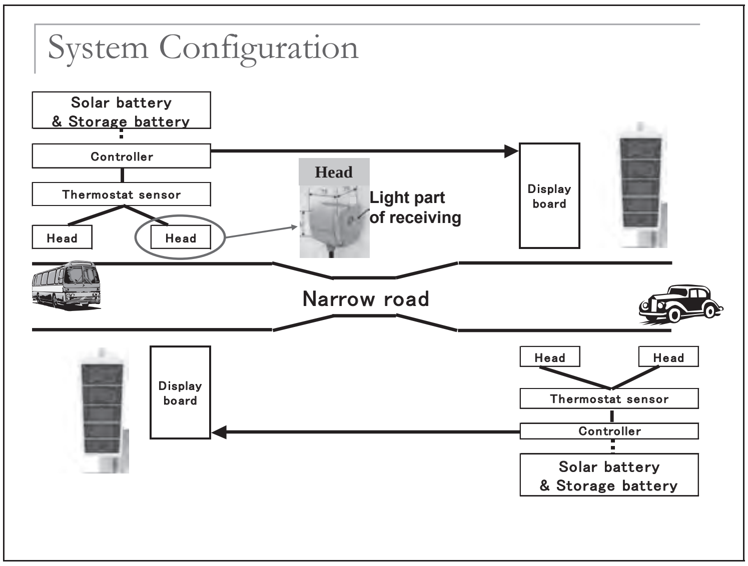
- High rate of aged persons by fatal accidents
  - 64% = 37/58 (aged/total) Ranked 2nd
- Uncomfortable traffic circumstances
  - Narrow road
  - Unsafely tram stop
  - Dangerous for pedestrian
- Frequent unexpected road blocked
  - Heavy congestion
  - Isolated village

Contents

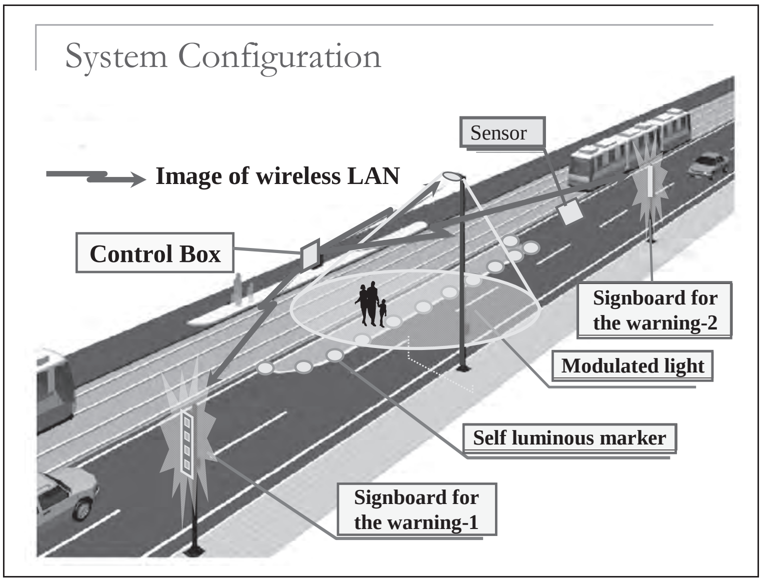
- Grass-roots ITS
- Systems in Kochi prefecture
- My ITS study in Asian countries

DRIVING SUPPORT SYSTEM FOR NARROW ROAD




System Configuration
Solar battery
& Storage battery
Controller
Thermostat sensor
Head
Head
Head
Light part
of receiving
Display
board
Narrow road
Display
board
Head
Head
Thermostat sensor
Controller
Solar battery
& Storage battery

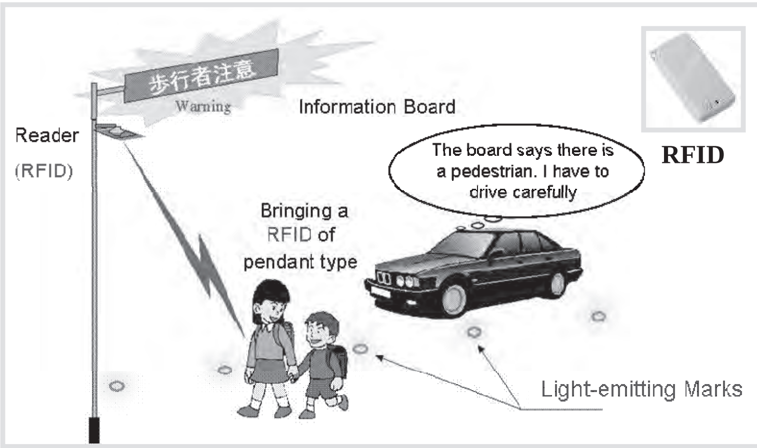

SAFETY SUPPORT SYSTEM AT
"STOPS WITH NO SAFETY BARRIERS"
Dangerous!


System Configuration
Sensor
Image of wireless LAN
Control Box
Signboard for
the warning-2
Modulated light
Self luminous marker
Signboard for
the warning-1

PEDESTRIAN SAFETY SUPPORT SYSTEM IN THE RURAL AREA

Development of the Pedestrian Information System to Improve the Safety in the Intermediate and Mountainous Area

System Configuration



Characteristics of Grass-Roots ITS

Those systems described above have the common characteristics as follows

(1) Cost of each system is comparably cheap

(2) The method for improving each problem is not the best and the best method is hard to realize due to high cost and long term construction.

Contents

- Grass-roots ITS
- Systems in Kochi prefecture
- My ITS study in Asian countries

My ITS study in Asian countries (1999-2003)

Bangladesh
Cambodia
China
HK
India
Indonesia
Korea
Laos
Malaysia
Myanmar
Nepal
Philippines
Singapore
Taiwan
Thailand
Vietnam

Traffic Status in Asia

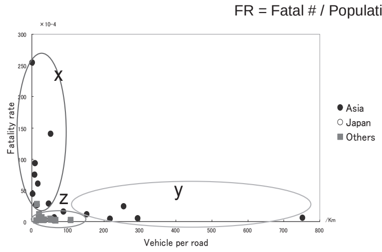
Generally speaking

- High Fatality Rate or High Vehicle Per Road
- Heavy congestion in the big cities
- Pollution (Air, Noise)
- Two or three wheels vehicles
- Un-inspected vehicle
- Low traffic morality

Vehicle per Road vs Fatality Rate

VPR = Vehicle # / Road Length

FR = Fatal # / Population



Lessons learned (1) from my past study

- A system that works well for AE may not always work so well for DC
- A method to match each condition is very important

Lessons learned (2)

- The status of ITS Infra. is important

ITS Infra. = Infrastructure
+
Supporting Conditions

ex. Maintenance and updating ability
Understanding of ITS
Rules for drivers and pedestrians

Lessons learned (3)

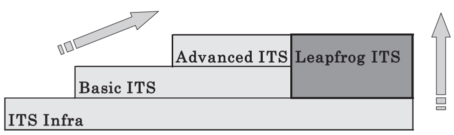
- ITS is classified two groups by functions,
  Basic ITS and Advanced ITS
- Basic ITS is more infrastructure and public sector base (ex TCS)
- Advanced ITS is public-private or private base (ex VICS) and use vehicle units in some case

Lessons learned (4)

To implement ITS, there are two Approaches,

Step by step approach and

Leapfrog Approach



Thank you for your attention

Kumagai.yasuhiko@kochi-tech.ac.jp

Symbolization of Intersections using Alphabet Signs

Dr. Toshio Yoshii

SYMBOLIZATION OF INTERSECTIONS USING ALPHABET SIGNS

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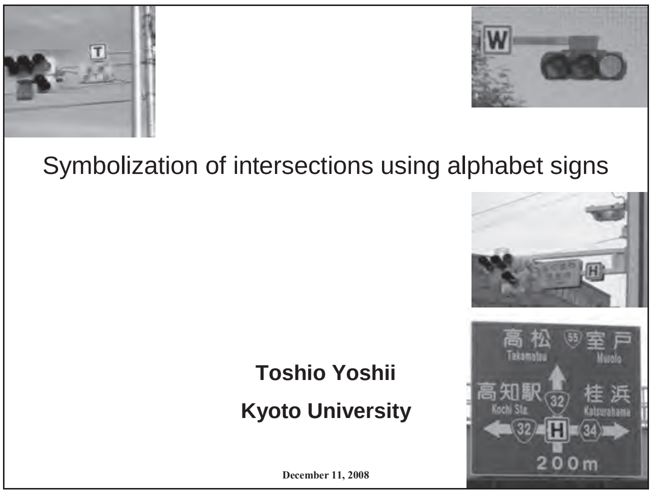
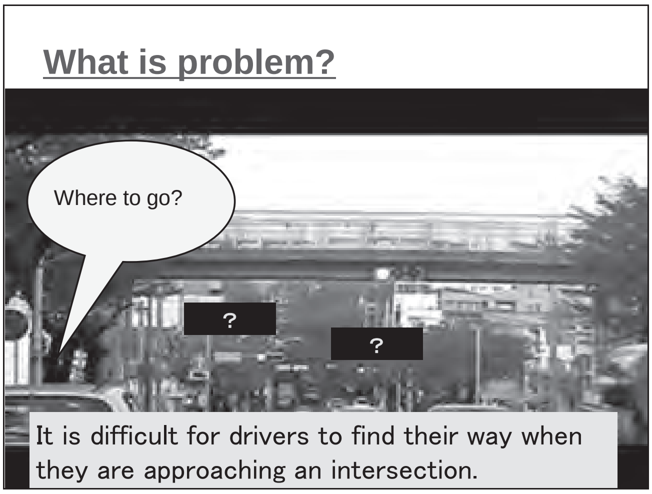
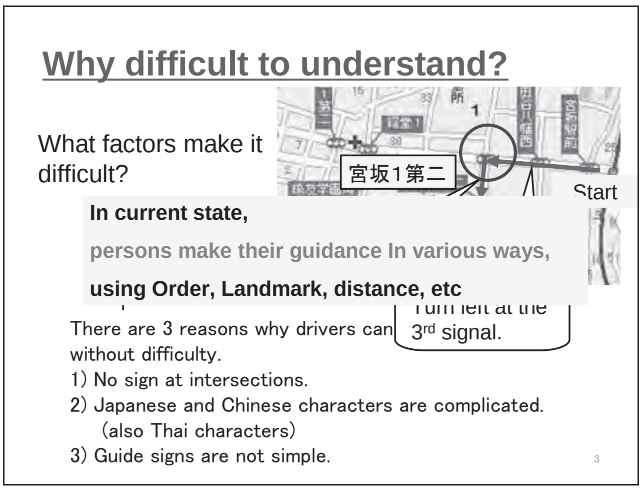






Simple and reasonable way

- Give a name to each intersection
- Use simple signs

Proposal of using symbolized guide signs

Proposed route instruction

1. Assign an alphabet at each intersection

Simple route guidance can be achieved by assigning simple name to each intersection.

5

Proposed route instruction

e.g.

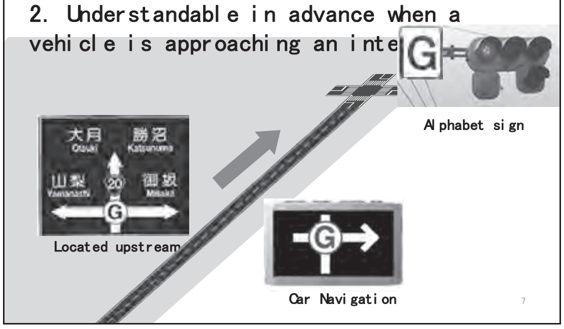
Turn left at intersection G

Turn right at intersection P

6

Proposed route instruction

2. Understandable in advance when a vehicle is approaching an inte



7

Understandable from long distance

Effect of the guide signs

・assign a name at each intersection

→ Simple guidance in common way

・understandable from long distance

→ Improvement on traffic safety

・alphabet sign use

→ everyone can understand

9

Verification

10

Verification results

・Color sign, symbolized sign have more visibility than character sign

note: Color sign tends to lead misunderstanding

・route guidance using symbolized signs provide the benefits

1) Safety driving without urgent deceleration

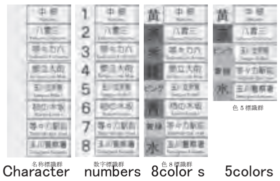
2) Less watching the picture on a navigation equipment

11

Color sign, symbolized sign have more visibility than character sign

12

Experiment

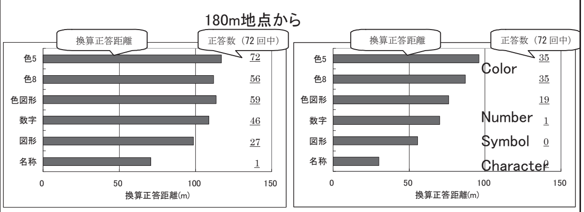


Character numbers 8color s 5colors

symbols colored symbols

13

Visible distance



daytime

night time

Color sign, symbolized sign have more visibility than character sign

More effect in the night time

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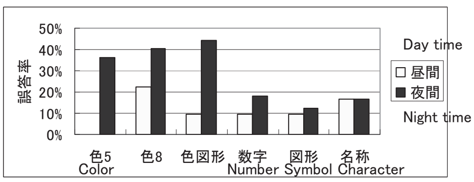
The ratio of misunderstanding



Color sign tends to lead misunderstanding

15

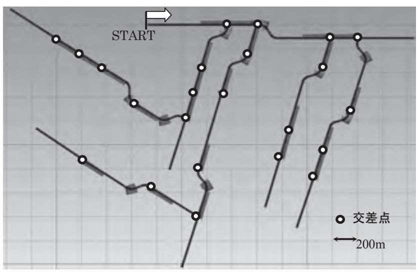
Effect to Driving behavior

16

Simulator experiment

17

Simulator experiment



Character

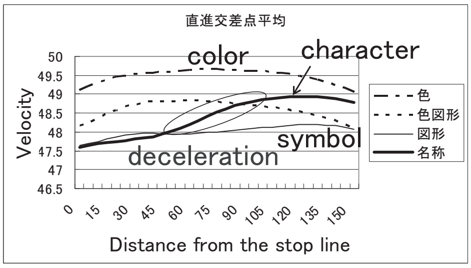
Color

Color & symbol

Symbol

18

Driving behavior



Deceleration appears at 100m upstream
in case with the character sign

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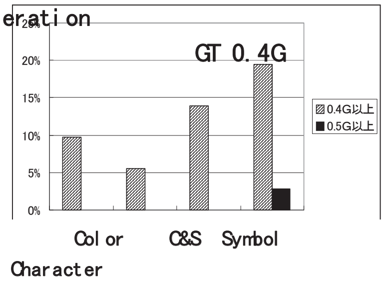
Driving behavior

The opportunity of urgent deceleration



Less urgent deceleration
Character is better on memorization

20

Field experiment

Date

before alphabet sign is set up
2006 June20, 21 5:00～8:00a.m.
after 2006 July 15, 16 5:00～8:00a.m.

Place

Furano, Hokkaido

- Instructing the route on the map
- Behaviors at 5 intersections are analyzed

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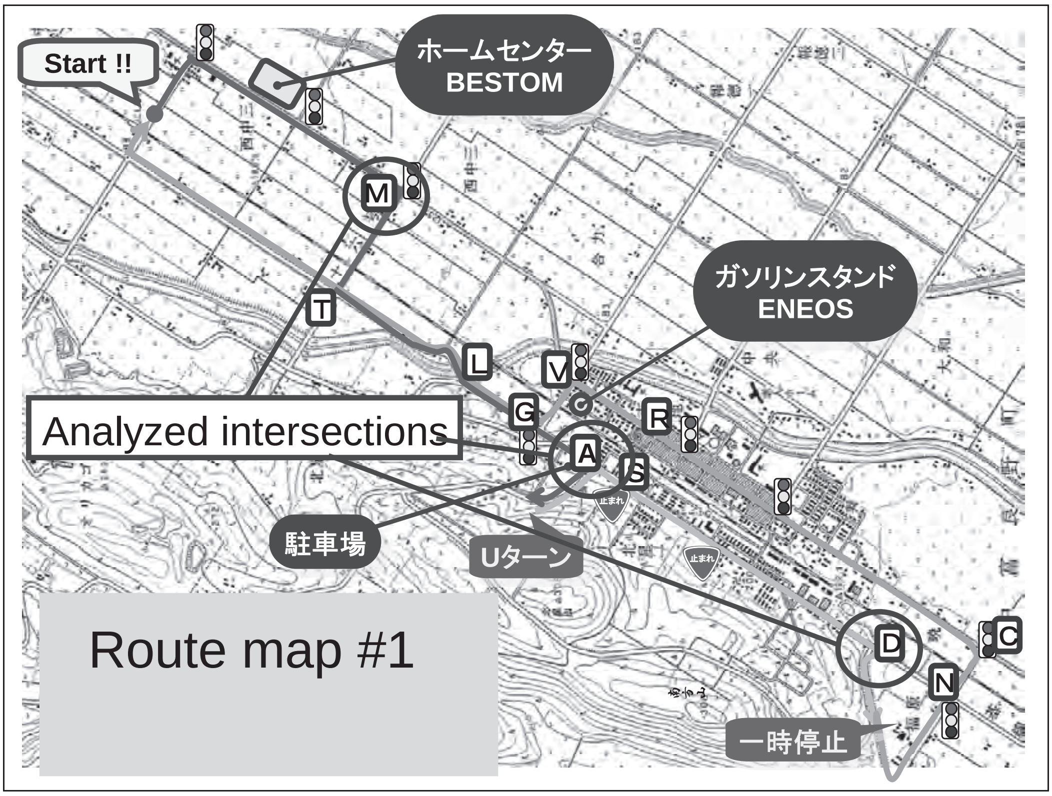
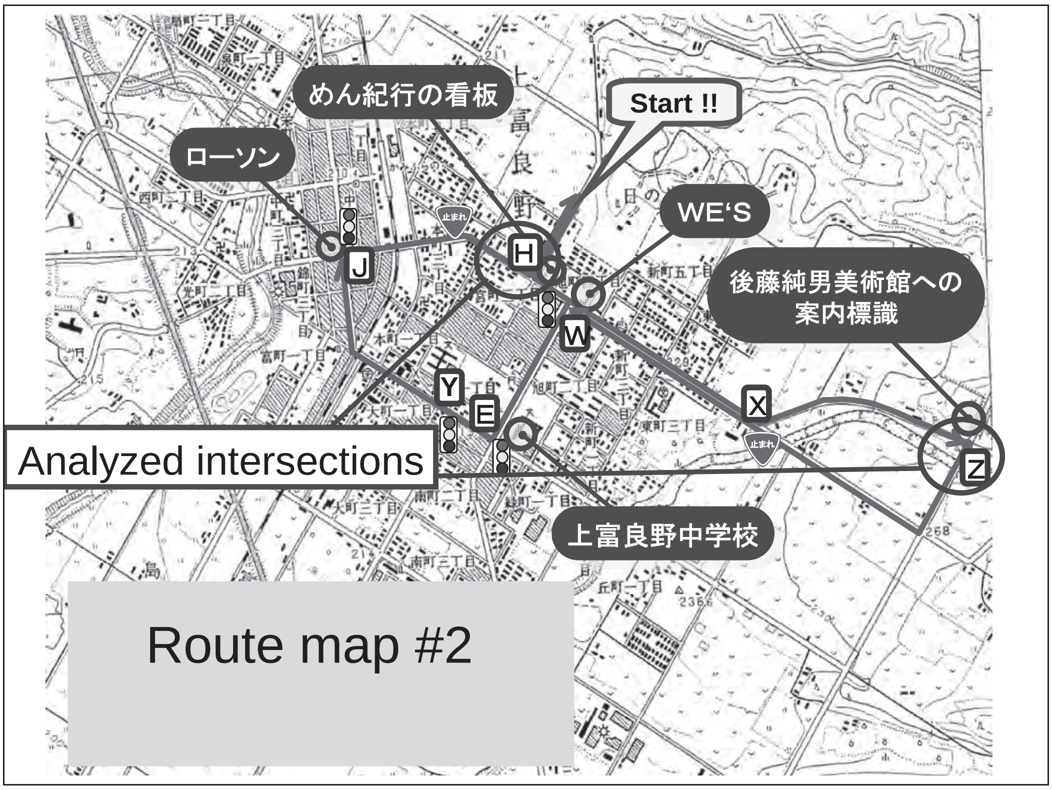

Start !!
ホームセンター
BESTOM
M
T
ガソリンスタンド
ENEOS
L
V
G
R
A
S
Analyzed intersections
駐車場
Uターン
Route map #1
D
C
N
一時停止


めん紀行の看板
Start !!
ローソン
WE'S
H
J
後藤純男美術館への
案内標識
W
Y
E
X
Analyzed intersections
Z
上富良野中学校
Route map #2

Experiment

＜Drivers＞

Drivers who are not familiar with the field road network.
20～50 years old

before 10persons
after 10persons

＜Instruction＞

・map
・instructions about the route

round 4 times

24

Evaluation

◆route guidance

1）. run off the route

◆uncertainness

2）.questionnaire after driving

◆driving behavior

Low speed → 3）.velocity at 100m upstream from intersections

Urgent deceleration → 4）.max. deceleration

Result 1）

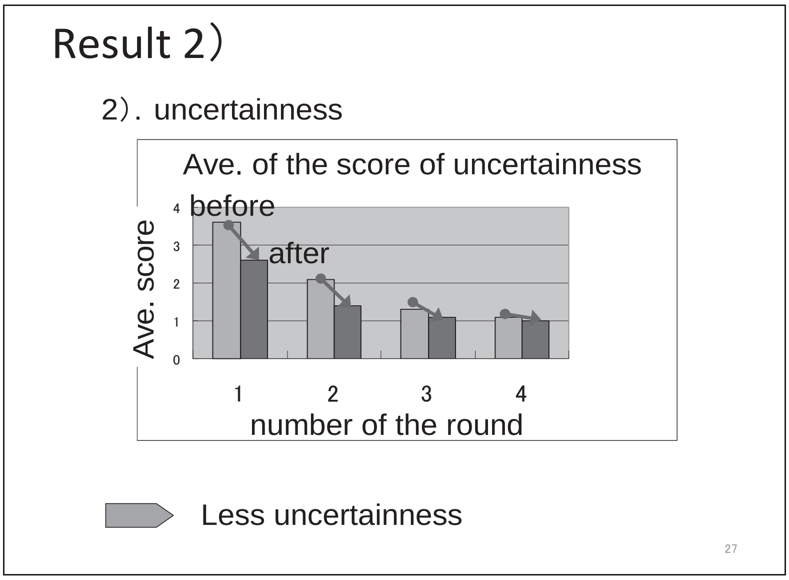
1）. Number of the times running off the route

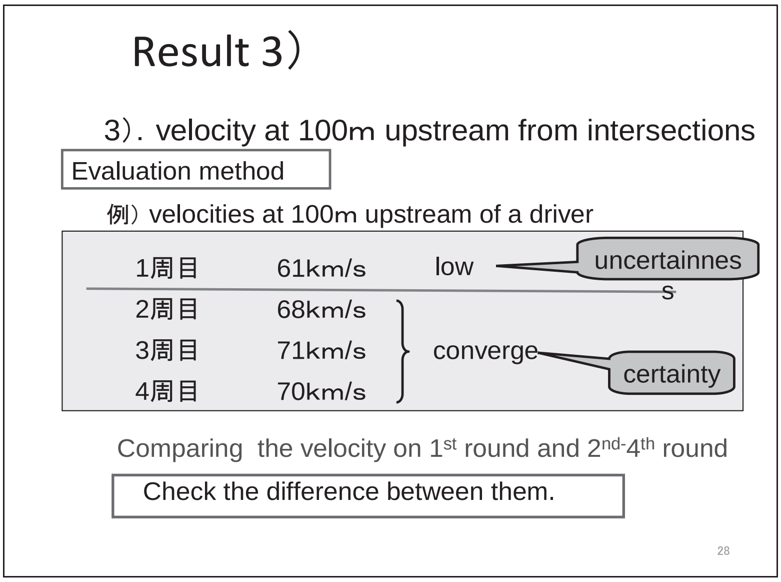
before 13回 → after 4回

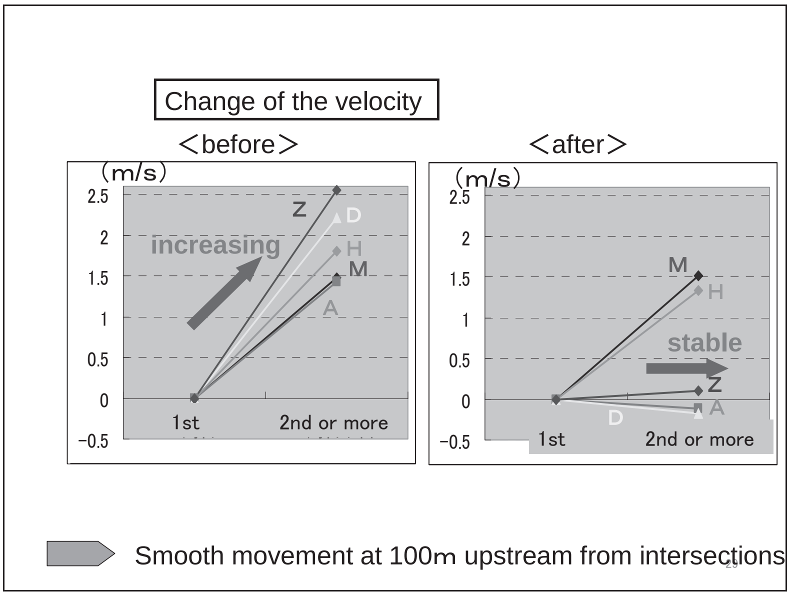
decreasing

Better guidance

26

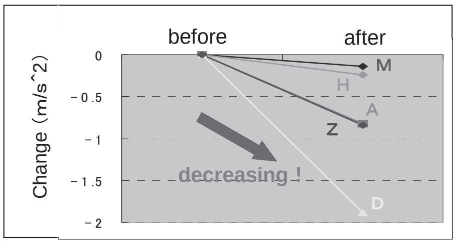

Result 2）
2）. uncertainness
Ave. of the score of uncertainness
before
after
Ave. score
0
1
2
3
4
1
2
3
4
number of the round
Less uncertainness
27


Result 3）
3）. velocity at 100m upstream from intersections
Evaluation method
例）velocities at 100m upstream of a driver
1周目 61km/s low
uncertainness
2周目 68km/s
3周目 71km/s
4周目 70km/s
converge
certainty
Comparing the velocity on 1st round and 2nd-4th round
Check the difference between them.
28


Change of the velocity
＜before＞
＜after＞
（m/s）
2.5
2
1.5
1
0.5
0
−0.5
increasing
Z
D
H
M
A
1st
2nd or more
stable
Smooth movement at 100m upstream from intersections

Result 4）

4）. Urgent deceleration



Less opportunity of urgent decelerations

30

Driving behavior using the route guidance using car navigation systems

31

Field experiment

Date ：2007 Jan.9, 10 daytime
Site：Kochi

Using the experimental vehicle with the car navigation using alphabet signs.

<observation>

◆ watching the picture on the navigation

32

◆ Observation method

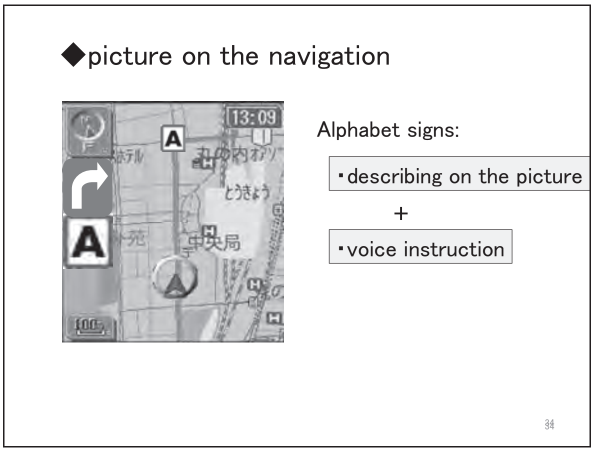
⇨ Observe driver' s eyes during the time from 300m upstream to the intersection

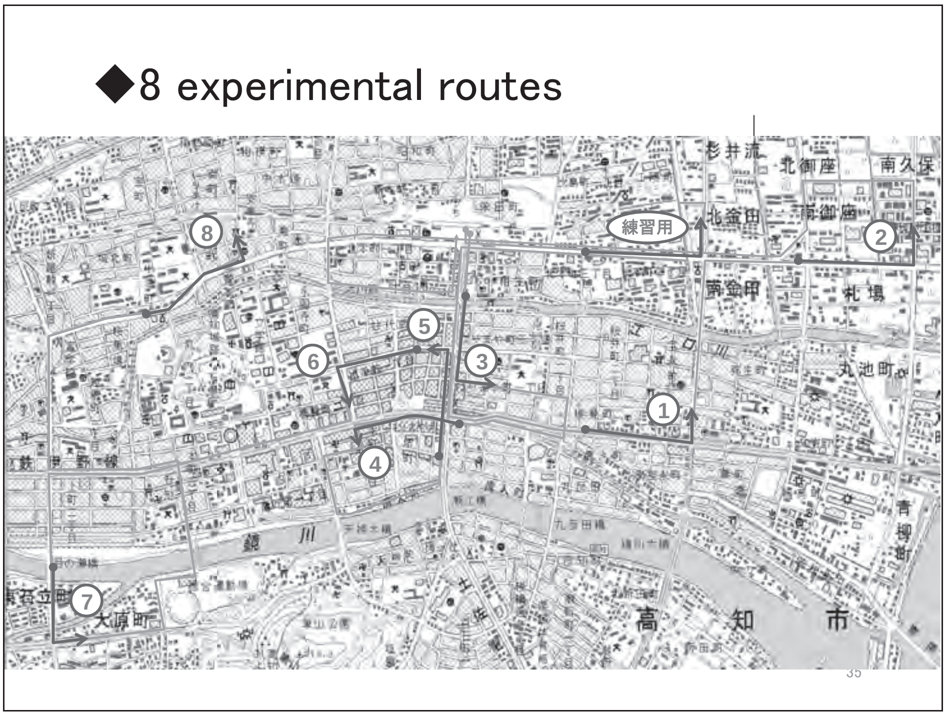
Video images

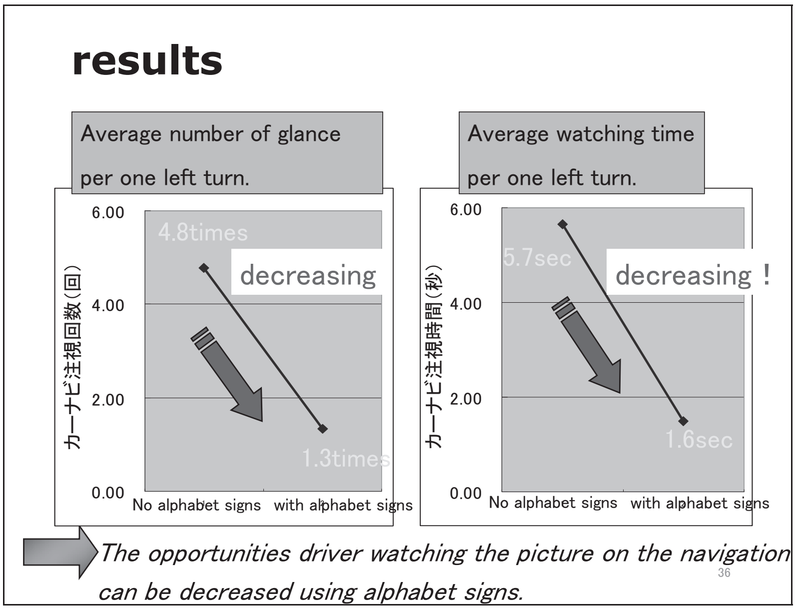
Watch in front

Glance at the navigation

33


◆picture on the navigation
Alphabet signs:
・describing on the picture
+
・voice instruction
13:09
34


◆8 experimental routes
練習用
高
知
市
35


results
Average number of glance per one left turn.
Average watching time per one left turn.
カーナビ注視回数(回)
カーナビ注視時間(秒)
6.00
4.00
2.00
0.00
4.8times
1.3times
5.7sec
1.6sec
decreasing
decreasing！
No alphabet signs
with alphabet signs
The opportunities driver watching the picture on the navigation can be decreased using alphabet signs.
36

Evaluating Social Problems using Transport Simulation

Prof. Masao Kuwahara

EVALUATING SOCIAL PROBLEMS USING TRANSPORT SIMULATION

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University of Tokyo
kuwahara@iis.u-tokyo.ac.jp

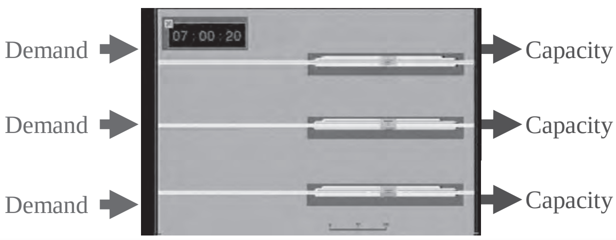
Evaluating Social Problems using Transport Simulation

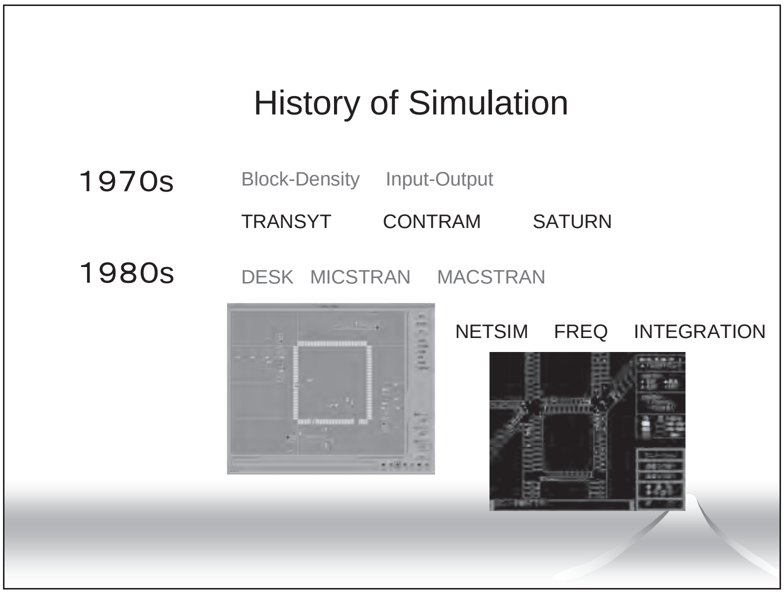
Institute of Industrial Science
University of Tokyo
Masao Kuwahara

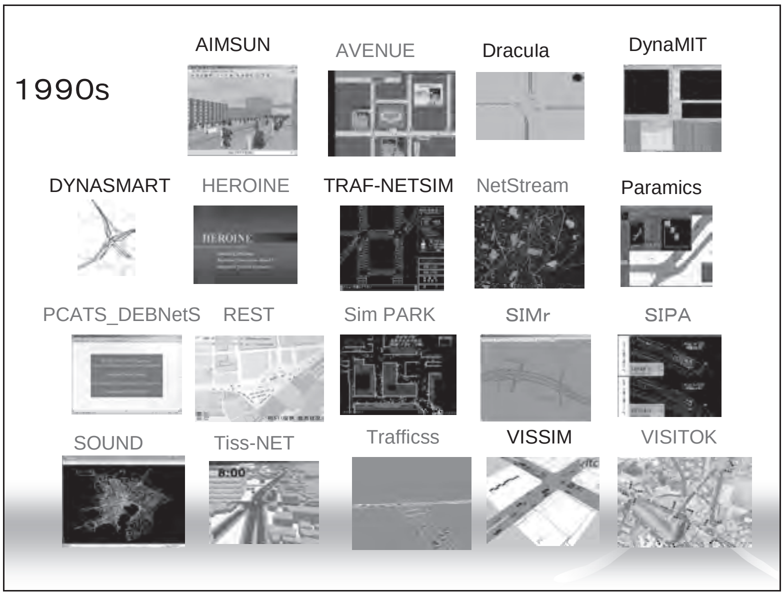
Time Loss =120 billion US$/Yr
Environmental Loss
Accident Loss=40 billion US$/Yr

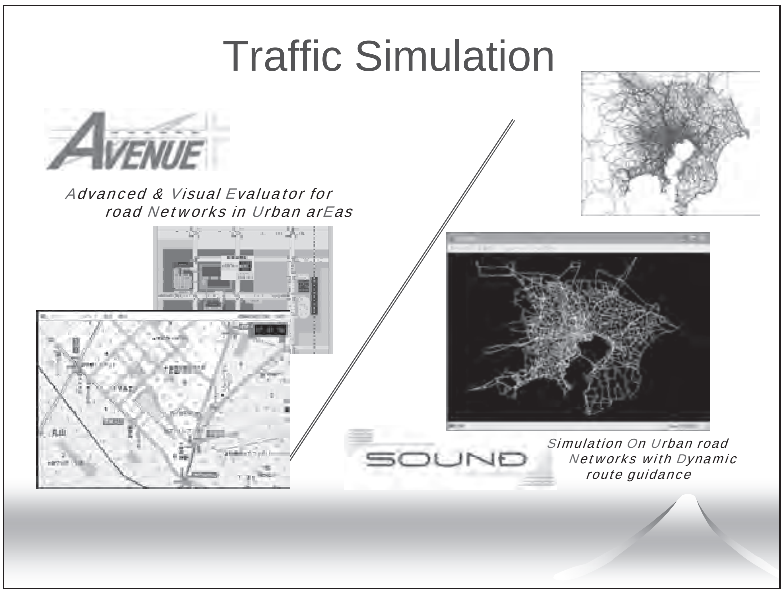
Traffic Congestion: Demand > Capacity

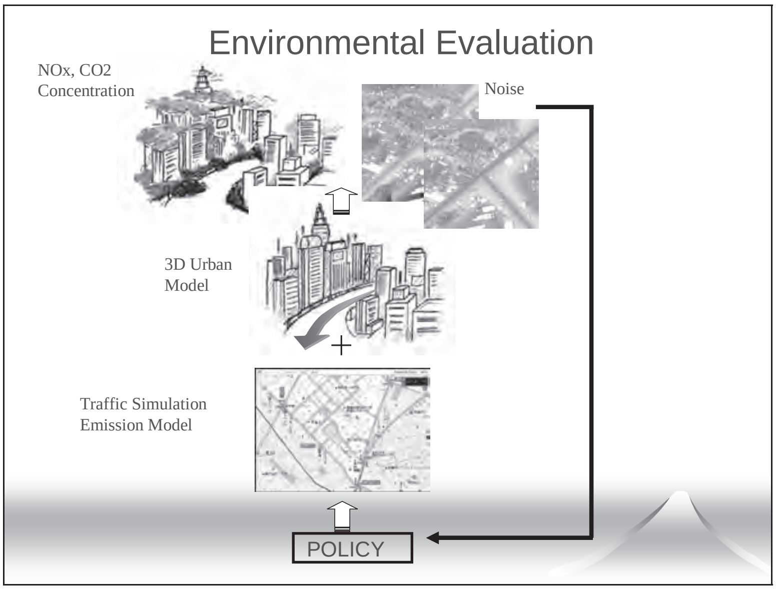
Demand – Capacity = Excess demand (surprisingly small)

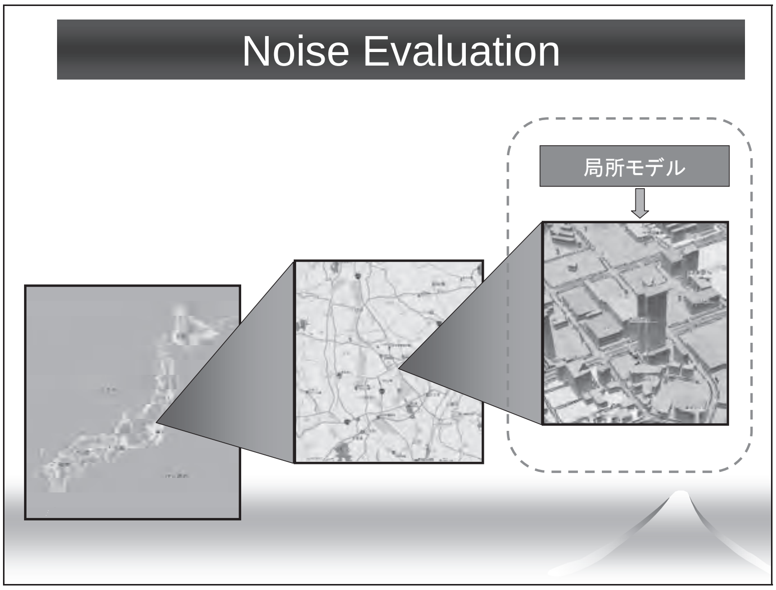


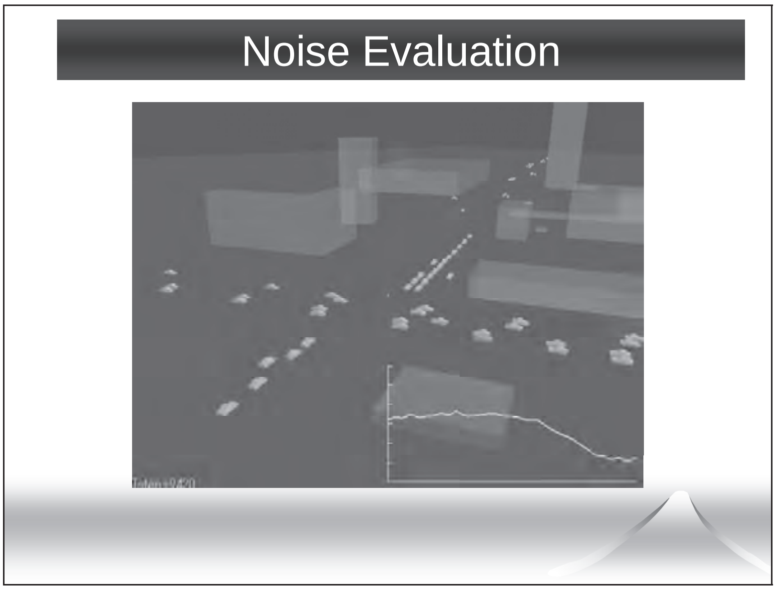

History of Simulation
1970s
Block-Density Input-Output
TRANSYT CONTRAM SATURN
1980s
DESK MICSTRAN MACSTRAN
NETSIM FREQ INTEGRATION


1990s
AIMSUN
AVENUE
Dracula
DynaMIT
DYNASMART
HEROINE
TRAF-NETSIM
NetStream
Paramics
PCATS_DEBNetS
REST
Sim PARK
SIMr
SIPA
SOUND
Tiss-NET
Trafficss
VISSIM
VISITOK

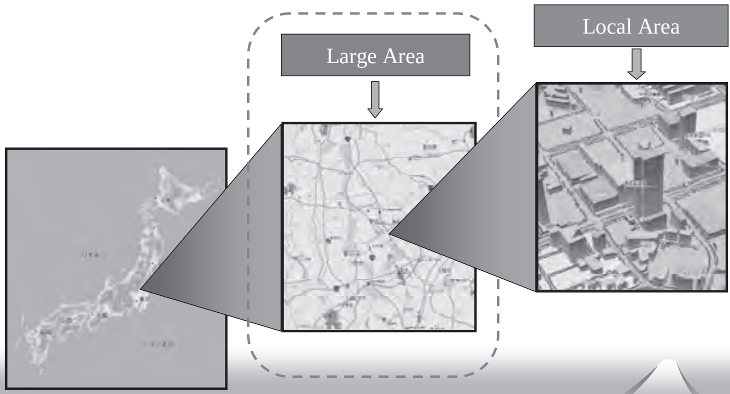

Traffic Simulation
AVENUE
Advanced & Visual Evaluator for
road Networks in Urban arEas
SOUND
Simulation On Urban road
Networks with Dynamic
route guidance


Environmental Evaluation
NOx, CO2
Concentration
Noise
3D Urban
Model
Traffic Simulation
Emission Model
POLICY


Noise Evaluation
局所モデル


Noise Evaluation

Noise Evaluation

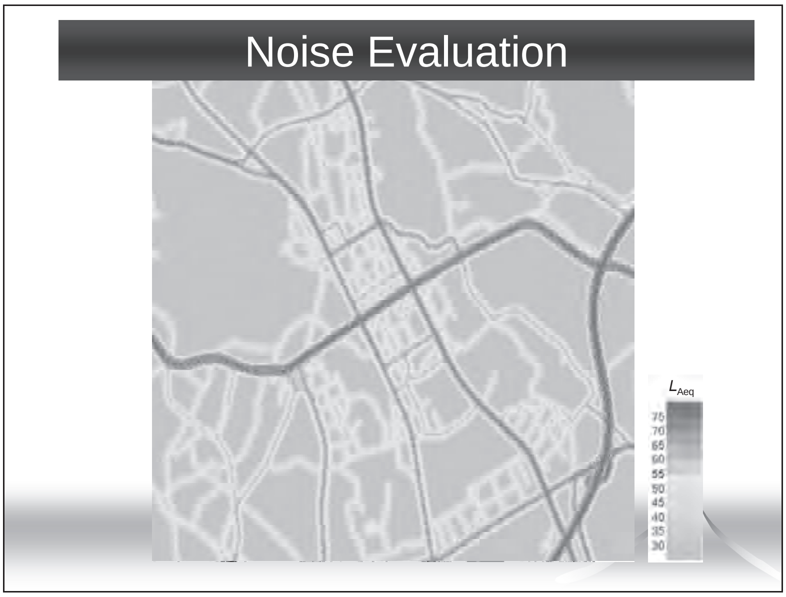


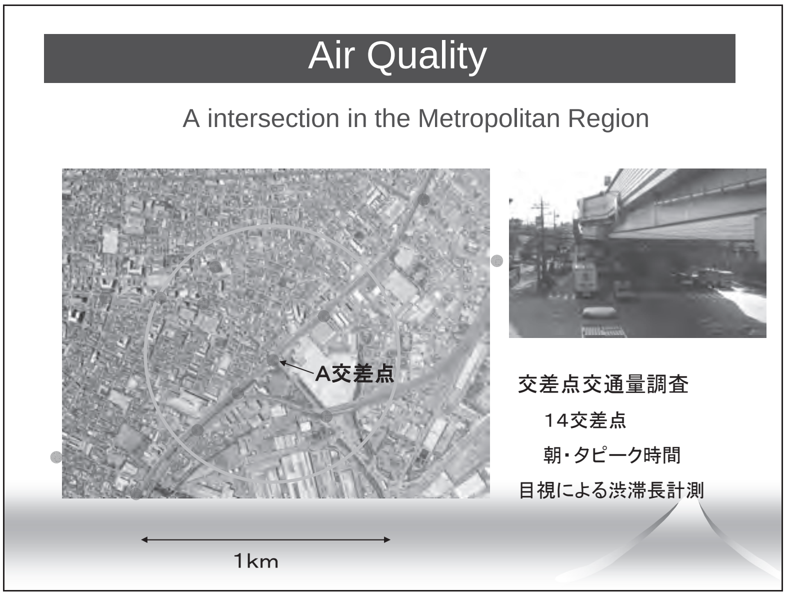
IIS＋JARI＋EPFL＋TMU

Noise Evaluation

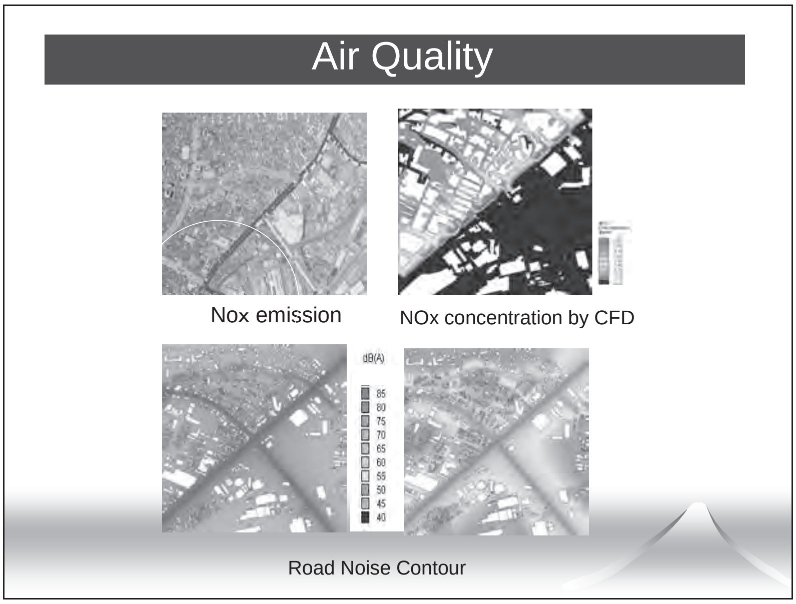
- # nodes:1,723
- # of links:4,832

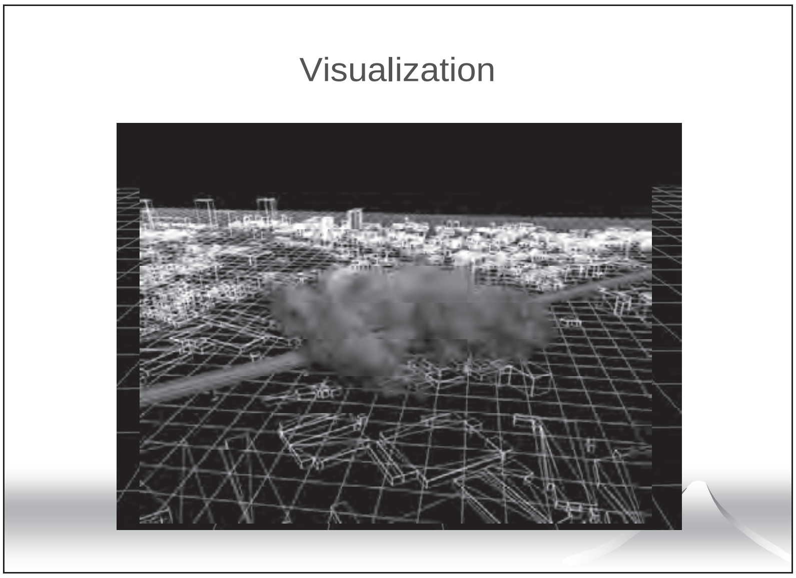
Noise Evaluation

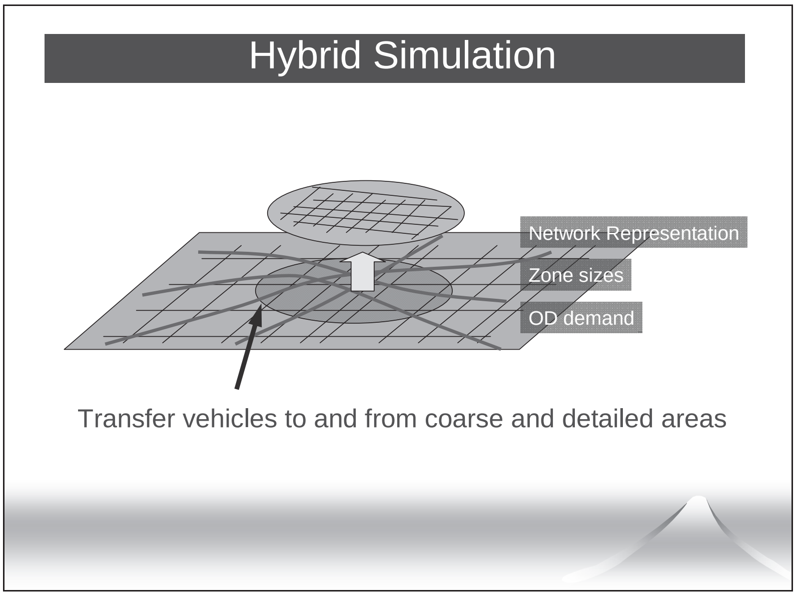

Noise Evaluation
LAeq
75
70
65
60
55
50
45
40
35
30

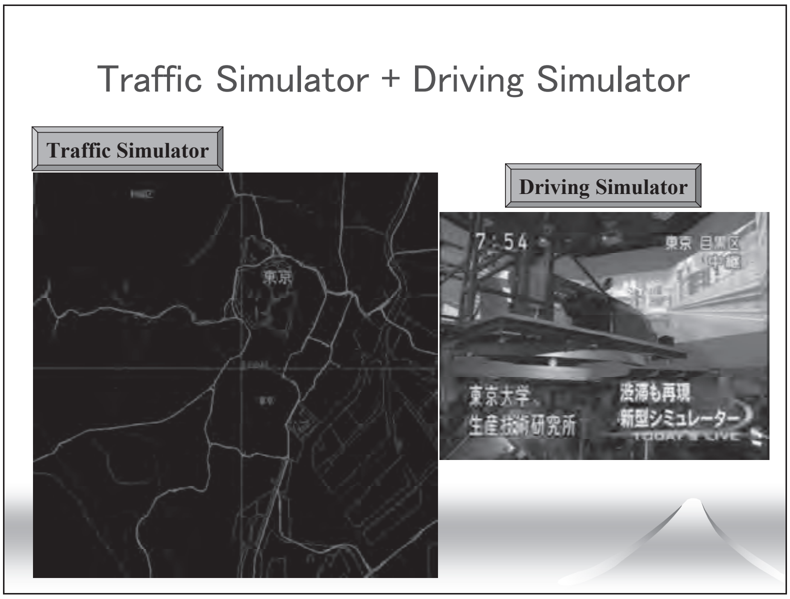

Air Quality
A intersection in the Metropolitan Region
A交差点
交差点交通量調査
14交差点
朝・タピーク時間
目視による渋滞長計測
1km

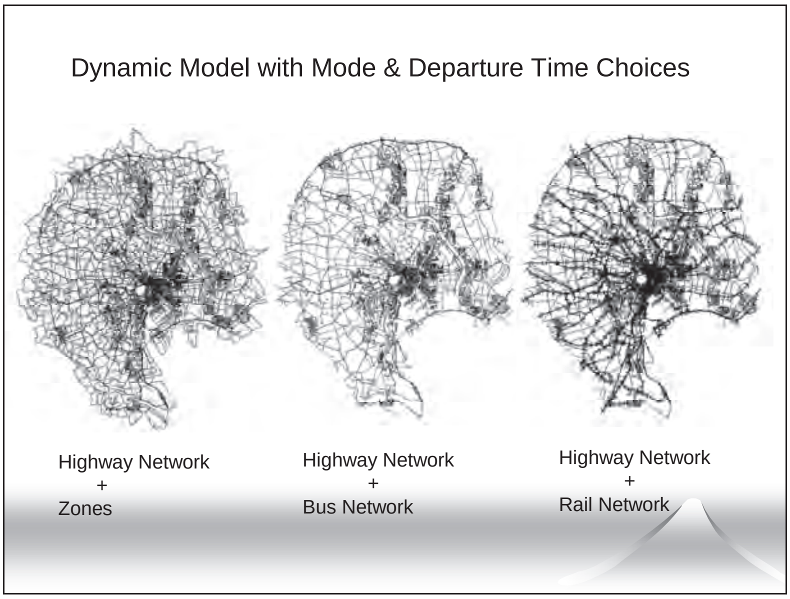

Air Quality
クリックにより動画

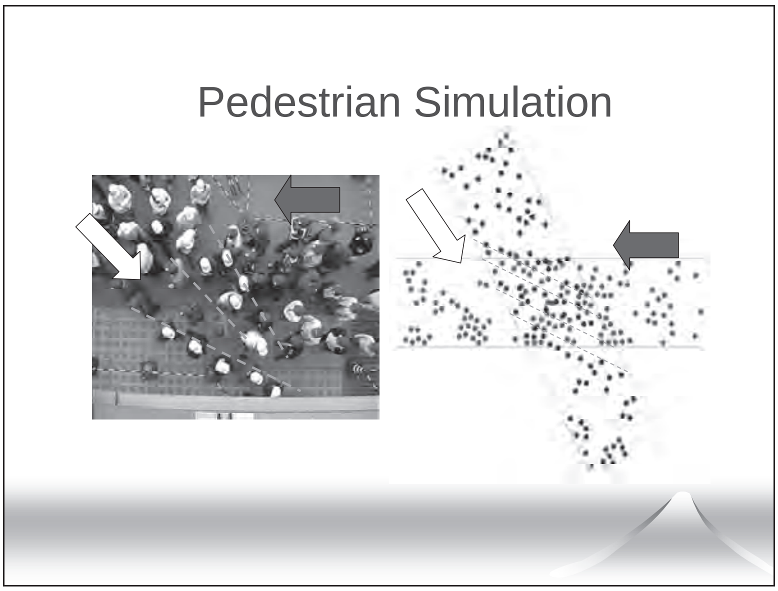

Air Quality
Nox emission
NOx concentration by CFD
dB(A)
85
80
75
70
65
60
55
50
45
40
Road Noise Contour


Visualization

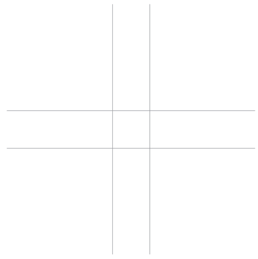

Hybrid Simulation
Network Representation
Zone sizes
OD demand
Transfer vehicles to and from coarse and detailed areas


Traffic Simulator + Driving Simulator
Traffic Simulator
Driving Simulator
東京
7:54
東京 目黒区
中継
東京大学
生産技術研究所
渋滞も再現
新型シミュレーター


Dynamic Model with Mode & Departure Time Choices
Highway Network
+
Zones
Highway Network
+
Bus Network
Highway Network
+
Rail Network


Pedestrian Simulation

Pedestrian Simulation



Necessity for Transport Data

Probe data
VICS
ETC

Detectors
Image data

Experiment
Vehicle data

OD census
PT survey

Network data

Accident data
Weather data

Traffic
regulation

Land use data

Transport data is the foundation for research and practice!

Importance of transport data storage and accessibility is commonly underestimated

Land Use Planning | Strategic Planning
Traffic Management | Transport Operation

Availability of Transport Data: provider

Data providers :

- Public sector : Transport authority, Police agency
- Private sector: Bus, taxi, freight companies

They often hesitate to disclose their data

- burdensome to provide data : efforts, time, cost
- concern undesirable use : mislead public
- data quality problem : errors, missing
- basically not interested in sharing data

Overcoming these problems may supply incentives
to data providers to more open, share and utilize their data.

Availability of Transport Data: user

Users:

- Public sector: Transport authority, Police agency
- Private sector: Consulting, Survey
- Academia: university, research institute

Where are the data?
How to get the data?
How to use the data?

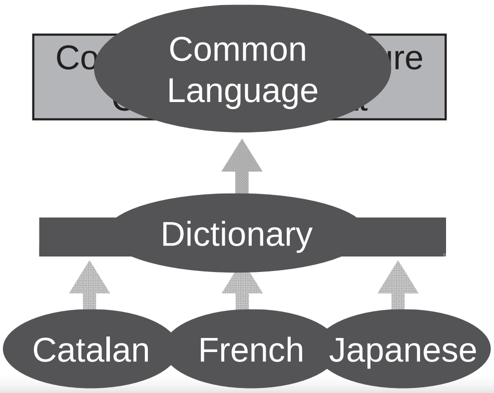
What we have to do now

1. Various data should be standardized so that they could be efficiently found and fused.
   Meta data information should be ideally located at one place.
   Translator of data format should be constructed.
2. Schemes that provides incentives to data providers to disclose the data is proposed.

Standardize Transport Data

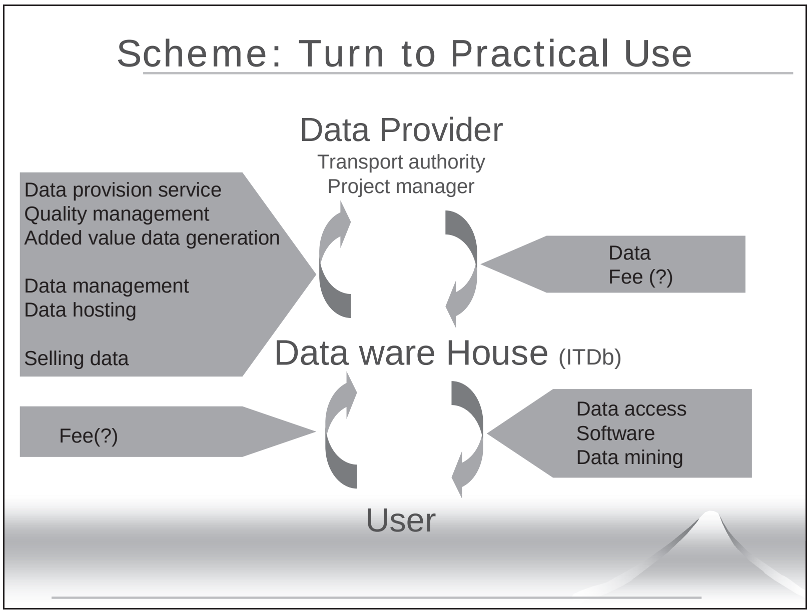
- Standards for transport data collection and its storage are still missing
  Standards exists mostly for information protocols between transport systems
- Variety of transport data make standardization difficult.

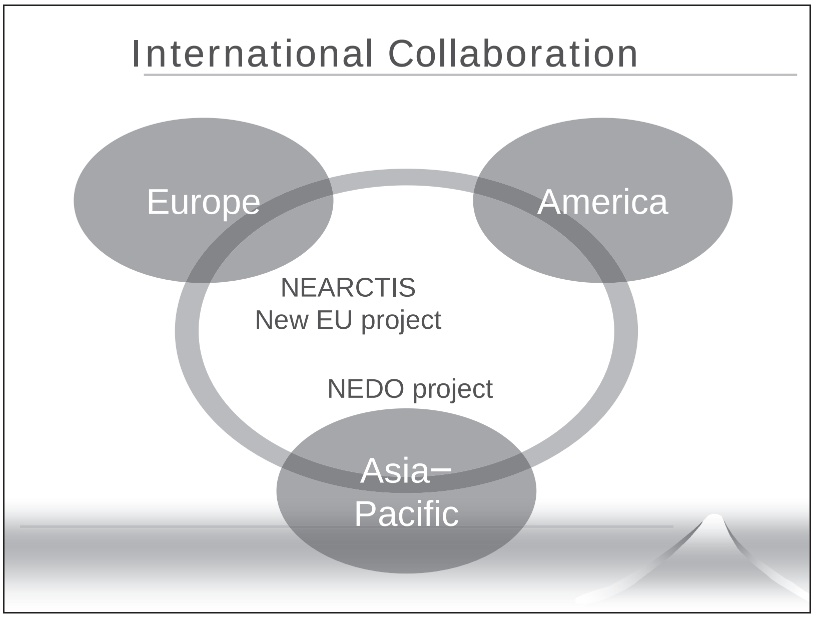
Translator into Common Format



International Traffic Database (ITDb)

International Traffic Database (ITDb)


Scheme: Turn to Practical Use
Data Provider
Transport authority
Project manager
Data provision service
Quality management
Added value data generation
Data management
Data hosting
Selling data
Data
Fee (?)
Data ware House (ITDb)
Fee(?)
Data access
Software
Data mining
User

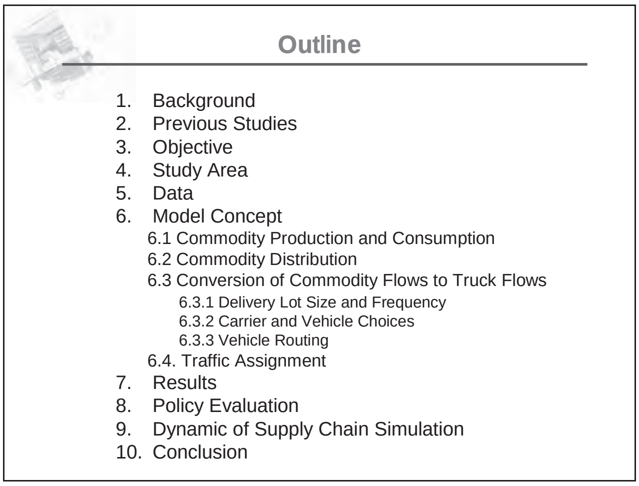

International Collaboration
Europe
America
NEARCTIS
New EU project
NEDO project
Asia–
Pacific

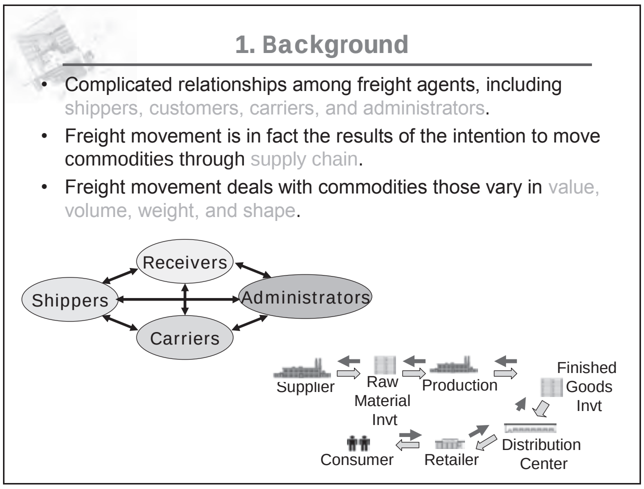
Micro-Simulation of Freight Agents in Supply Chain for Modeling Urban Freight Movement

Dr. Kazushi Sano

MICRO-SIMULATION OF REIGHT AGENTS IN SUPPLY CHAIN FOR MODELING URBAN FREIGHT MOVEMENT

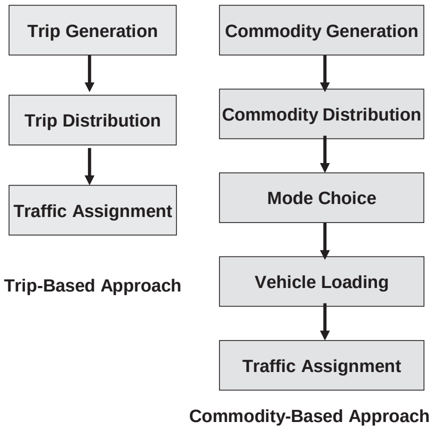
KAZUSHI SANO
Nagaoka University of Technology
sano@vos.nagaokaut.ac.jp





2. Previous Studies

- Most earliest model estimates truck trip as a percentage from the model for passenger trips
- Most models can be divided into two types: trip-based and commodity-based approaches (Holguin-Veras and Thorson, 2000)
- Commodity-based approach is widely accepted that it can better reflect the real mechanism of freight movement than trip-based approach



2. Previous Studies (Cont.)

- **Generation**
  - Regression model is generally used to explain the production activity
  - Ogden (1991) used typical regression for generate number of trips by vehicle type based on floor area.
- **Distribution**
  - Gravity model is commonly used in trip or commodity distribution
  - Sivakumar and Baht (2002) applied a fractional split distribution model in statewide freight movement instead of common gravity model.
    - Considering the demand is the key factor to determine the amount of consumption
- **Modal Split**
  - Most models focus on mode choice of the statewide freight demand
    - Choices including truck, rail, and ship.
  - Abelwahab and Sargious (1992) proposed a model that combines the choices of mode and shipment size together.

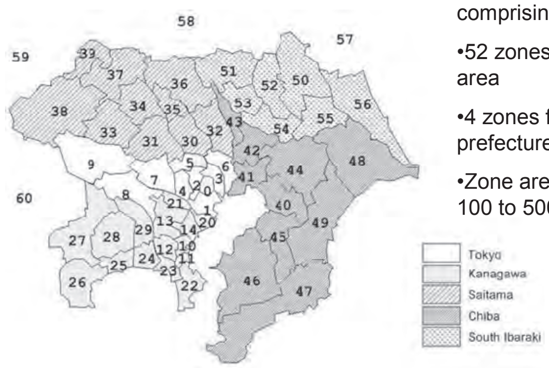
2. Previous Studies (Cont.)

- **Simulation Models**
  - Up to present, models for freight transportation rely the traditional four-step approach
  - Most models focus on statewide level of freight movement
    - Considering in zone level
  - Most existing models ignored the purpose of freight movement and the interaction among freight agents while modeling freight demand
  - GoodTrip model by Boerkamps and van Binsbergen (2000) considers urban freight movement at disaggregate level based on the logistical chain structure
    - Focusing at the share of each activity type level (consumer, supermarket, distribution center, etc.)
  - Current trend in demand modeling for both passenger and freight transportations is to model at the micro level since it results in a more realistic and policy-sensitive model.

3. Objective

- The purpose of this research therefore is **"to develop an integrated model to predict the urban freight transportation demand that reflects the mechanism of freight transportation in urban area".** The more specific objectives are:
  - To develop a mathematical model for predicting demand of urban freight transportation that is a microscopic model
    - Micro-simulating of movement of commodity lots through the behavior of each individual firm
    - Considering the behavior of each freight agent that influences on each decision
    - Incorporating the interactions with other freight agents
    - Considering supply chain structure
  - To apply and test the proposed model by analysis of a case study of urban freight transportation system in the Tokyo Metropolitan Area.
  - To test the model capability through the evaluation of the scenarios using the proposed model structure.

4. Study Area and Zoning



There are 56 zones comprising

•52 zones in the study area

•4 zones for the adjacent prefectures

•Zone area ranges from 100 to 500 km^2

5. Data

- Model Calibration
  - Tokyo Metropolitan Goods Movement Survey (TMGMS, 1982; 1994)
    - General data of the firms; number of employees, location, etc.
    - Goods movement; origin of shipment, destination of shipment, delivery frequency, etc.
    - Truck movement; vehicle type, departure time, etc.
- Model Input
  - Establishment and Enterprises Census (EEC, 1999)
    - General data of the firms in Japan; Location, no. of employees, industry type, etc.
- Model Validation
  - Road Traffic Census (RTC, 1999)
    - OD survey of truck movement; origin, destination, carrying weight, etc.

5. Data (Cont.)

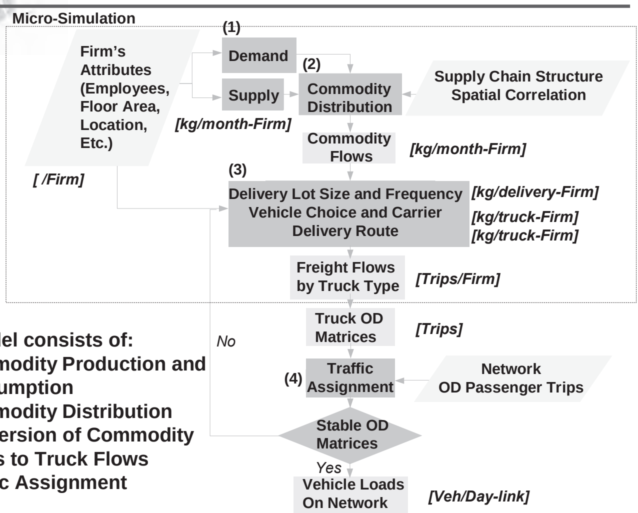
Industry Type

1	Agriculture, Forestry, and Fishery
2	Mining
3	Construction
4	Chemical Manufacturer
5	Metal Manufacture
6	Machinery Manufacture
7	Other Manufacture
8	Material Wholesaler
9	Product Wholesaler
10	Retailer
11	Warehouse
12	Electricity, Gas and Water Supplier
13	Service and Government Work

Commodity Type

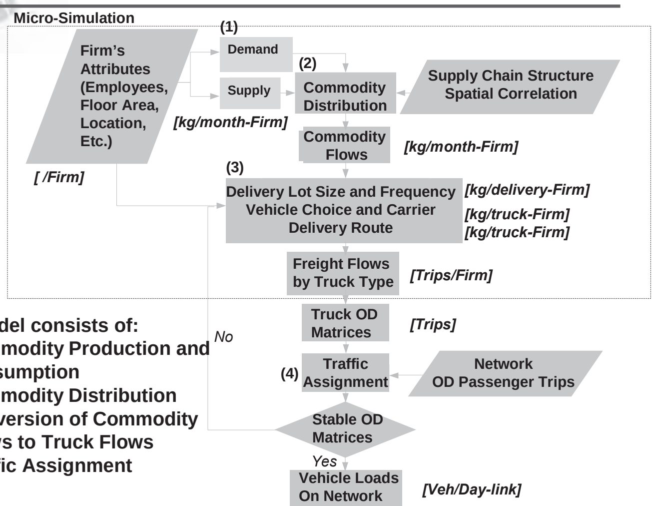
1	Agricultural Products
2	Forestry Products
3	Mineral Products
4	Metal and Machinery Products
5	Chemical Products
6	Light Industry Products
7	Other Products
8	Wastes and Scraps

6. Model Structure



The model consists of:
(1) Commodity Production and Consumption
(2) Commodity Distribution
(3) Conversion of Commodity Flows to Truck Flows
(4) Traffic Assignment

6. Model Structure



The model consists of:
(1) Commodity Production and Consumption
(2) Commodity Distribution
(3) Conversion of Commodity Flows to Truck Flows
(4) Traffic Assignment

6.1 Commodity Generation

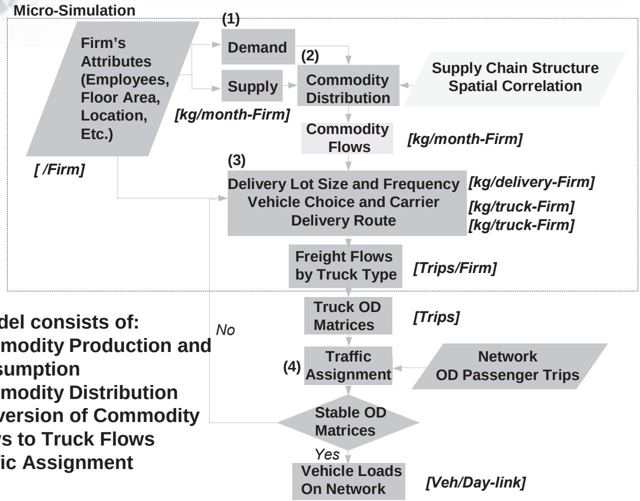
- The amounts of commodity production and consumption produced and consumed by each firm.
- Regression models are developed using firm size indicators such as number of employees and floor area.

$$G_i^k = f(x_1, x_2, x_3, ..., x_n)$$
$$A_j^k = f(y_1, y_2, y_3 ..., y_n)$$

G_i^k is the production amount of commodity *k* of firm *i*

A_j^k is the consumption amount of commodity *k* of firm *j*

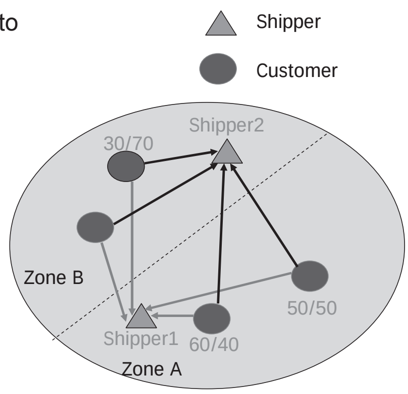
6. Model Structure



The model consists of:
(1) Commodity Production and Consumption
(2) Commodity Distribution
(3) Conversion of Commodity Flows to Truck Flows
(4) Traffic Assignment

6.2 Commodity Distribution

- Assuming a customer as a decision-maker who selects to purchase commodities from available shippers according to
  - the attractiveness of the supplier,
  - the characteristics of the customer,
  - the structure of the supply chain of commodity,
  - Spatial interactions.
- Developing using a discrete choice model



6.2 Commodity Distribution (Cont.)

- Commodity flows is the amount of commodity flowed from a shipper to a customer, defined as

$$Q_{ij}^{k} = P_j^k(i) \cdot A_j^k$$

Q_{ij}^{k} is the commodity flow of *k* between shipper *i* to customer *j*

$P_j^k(i)$ is the fraction commodity *k* purchased from shipper *i* by customer *j*

A_j^k is the total consumption amount of customer *j* for commodity *k*

- Summation of all commodity flows between zones will get:

$$Q_{IJ}^{k} = \sum_{i \in I} \sum_{j \in J} Q_{ij}^{k}$$

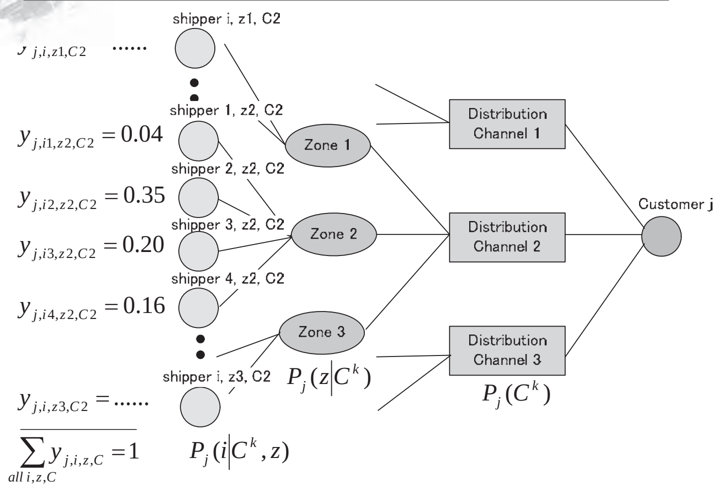
Q_{IJ}^{k} is the commodity flow of *k* between zone *I* and zone *J*

6.2 Commodity Distribution (Cont.)

- As a firm can purchase a commodity from many sources; we determines the fraction of commodity to be purchased from each source.
- The purchasing fraction, $P_j^k(i)$,is a multiplication of three parts:
  - – distribution channel choice, $P_j(C^k)$
  - – location choice, $P_j(z|C^k)$
  - – shipper choice, $P_j(i|C^k, z)$

$$P_j^k(i) = P_j(C^k) \cdot P_j(z|C^k) \cdot P_j(i|C^k, z), \quad i \in C^k, z$$

6.2 Commodity Distribution (Cont.)



6.2 Commodity Distribution (Cont.)

- Distribution channel choice, $P_j(C^k)$
  - The probability that each industry type is selected.
  - Directly calculate from survey data.

- Location choice, $P_j(z|C^k)$
  - Probability that zone ***z*** is selected.
  - Using a mixed logit model.
  - Considering spatial effects on the customer's preference.
  - Developing separately by industry type of customer, industry type of shipper, and commodity type.

6.2 Commodity Distribution (Cont.)

- Shipper choice, $P_j(i|C^k, z)$
  - Probability that shipper *i* is selected.
  - Derived from the amount of commodity production of each shipper.

$$P_j(i|C^k, z) = \frac{\exp(G_i^k)}{\sum_{i' \in C_j} \exp(G_{i'}^k)} \qquad \text{………………(1)}$$

$$P_j(i|C^k, z) = \frac{G_i^k}{\sum_{i' \in C_j} G_{i'}^k} \qquad \text{………………(2)}$$

G_i^k is the production amount of commodity *k* of firm *i*

6.2 Commodity Distribution (Cont.)

- Zonal Probability with Spatial Interaction, $P_j(z|C^k)$
  - Using mixed logit structure

$$\mathbf{U}_j = \mathbf{X}_j\boldsymbol{\beta} + \mathbf{F}_j\mathbf{T}\boldsymbol{\zeta}_j + \mathbf{v}_j$$

$\mathbf{X}_j\boldsymbol{\beta}$ is the deterministic part of the utility function

$\mathbf{F}_j\mathbf{T}\boldsymbol{\zeta}_j$ is the covariance structure among alternatives

$\mathbf{F}_j$ is the matrix of factor loading that is used to construct the pattern of correlation

$\mathbf{T}$ is the matrix of standard deviation with σ on the diagonal

$\boldsymbol{\zeta}_j$ is vector of random numbers with zero mean and unit variance

$\mathbf{v}_j$ is the vector of IID gumbel random variables

6.2 Commodity Distribution (Cont.)

- Incorporating spatial interaction among zone alternatives in the error term

Generalized Autoregressive: $\xi_j = \rho \mathbf{W} \xi_j + \mathbf{T}\zeta_j$

Thus, $\xi_j = (\mathbf{I} - \rho\mathbf{W})^{-1}\mathbf{T}\zeta_j$ or $\mathbf{F}_j = (\mathbf{I} - \rho\mathbf{W})^{-1}$

ξ_j is the disturbance term of mixed logit

ρ is a scalar unknown parameter

$\mathbf{I}$ is an identity matrix

$\mathbf{W}$ is weight matrix identifying the correlation among alternative zones

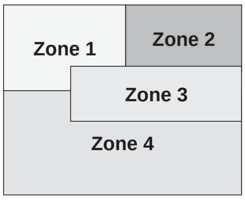
Thus, $\mathbf{U}_j = \mathbf{X}_j\boldsymbol{\beta} + (\mathbf{I} - \rho\mathbf{W})^{-1}\mathbf{T}\zeta_j + \mathbf{v}_j$

- After adding spatial effects

$$P_j(z|C^k) = P_{zj} = \int_\zeta \Lambda(z|\zeta)\, n(\zeta, I_Z)\, d\zeta = \int_\zeta \left(\frac{\exp(X_{zj}\boldsymbol{\beta} + F_{zj}\mathbf{T}\zeta_j)}{\sum_{z' \in Z} \exp(X_{z'j}\boldsymbol{\beta} + F_{z'j}\mathbf{T}\zeta_j)} \right) n(\zeta, I_Z)\, d\zeta$$

6.2 Commodity Distribution (Cont.)

- Weight matrix
  - Indicating the similarity between zones
  - Explaining the spatial interaction pattern of the model
  - Better specification of weight matrix will be selected for each case
- Adjacency weight matrix,



$$\mathbf{W} = \begin{bmatrix} 0 & 1/3 & 1/3 & 1/3 \\ 1/2 & 0 & 1/2 & 0 \\ 1/3 & 1/3 & 0 & 1/3 \\ 1/2 & 0 & 1/2 & 0 \end{bmatrix}, \quad w_{IJ} = \frac{c_{IJ}}{\sum_J c_{IJ}}$$

c_{IJ} is equals 1 if zone shares *I* a common boundary with zone *J* and 0 otherwise.

- Distance-based weight matrix,

$$w_{IJ} = \frac{1}{d_{IJ}^{\gamma}}$$

d_{IJ} is the distance between zones *I* and *J*

γ is a parameter to be estimated

6.2 Commodity Distribution (Cont.)

- Incorporating interaction among customers in deterministic part
  - Spatial dependences also include the correlations among customers since a consumer's preference is also influenced by the decision of other consumers.
  - The spatial interaction is incorporated into the deterministic part of the mixed logit
  - For each element of the deterministic part:

$$V_{zj} = X_{zj}\boldsymbol{\beta} + \phi_{zj} = \sum_{k=1}^{K} \beta_{zk} x_{zjk} + \lambda \sum_{s=1}^{S} y_{zs} \exp(-d_{js}^{\delta})$$

β_{zk} a parameter corresponding to the observed characteristic x_{zjk} of alternative zone *z* and customer *j*

d_{js} is the distance between customers *j* and *s*

y_{zs} is the consumption fraction of alternative zone *z* of customer *s*

S is the total number of customers

λ, δ are parameters to be estimated

6.2 Commodity Distribution (Cont.)

- Estimation Technique
  - The probability is approximated through the simulation of any given value of ζ_j^d

$$\hat{P}_j(z|\boldsymbol{\theta}) = \frac{1}{R}\sum_{r=1}^{R}\Lambda(z|\boldsymbol{\theta},\zeta_j^r)$$

$\boldsymbol{\theta}$ is the vector of joint parameters of all parameters to be estimated

ζ_j^r is r^{th} draw of j from the distribution of ζ, assumed follows $N(0,1)$

R is the total number of draws

  - Estimation using maximum likelihood, the simulated log-likelihood is

$$SLL = \sum_{j=1}^{N}\sum_{z=1}^{Z} y_{zj}\ln\hat{P}_j(z|\boldsymbol{\theta}), \qquad \sum_{z\in Z} y_{zj} = 1 \quad \text{and} \quad 0 \le y_{zj} \le 1$$

y_{zj} is the fraction of commodity consumed by customer *j* and supplied from zone *z*.

Z is the total number of zones $\quad$ N is the total number of customers

6.2 Commodity Distribution (Cont.)

- Empirical Analysis
  - Three Distribution channels are selected for analysis:
    - DC1: distribution channel for service and government work purchasing light industry products from retailers
    - DC2: distribution channel for retailers purchasing light industry products from wholesalers
    - DC3: distribution channel for other manufacturers purchasing light industry products from other manufacturers
  - Three modeling types are compared:
    - MNL: multinomial logit model
    - SML-A: spatial mixed logit model with spatial correlation among zone alternatives
    - SML-AD: spatial mixed logit model with both spatial correlation among zone alternatives and customers

6.2 Commodity Distribution (Cont.)

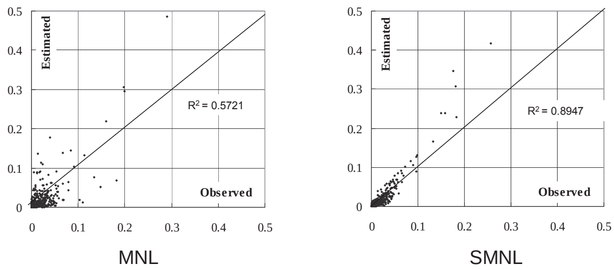
Variables		DC1			DC2			DC3		
		MNL	SML-A	SML-AD	MNL	SML-A	SML-AD	MNL	SML-A	SML-AD
Zonal Attractiveness Variables										
NC (in 1,000's.)	**paramete**	0.298[a]	0.3751[a]	0.1829[a]	-	-	0.0687	0.0383	0.0578	0.0629
	t-value	*(13.7)*	*(12.3)*	*(4.6)*	-	-	*(4.1)*	*(4.5)*	*(5.3)*	*(6.4)*
AREA (km)	**paramete**	0.0039	0.0045	0.0032	0.0028	0.0036	-	-	-	-
	t-value	*(13.3)*	*(13.0)*	*(7.4)*	*(10.7)*	*(8.6)*	-	-	-	-
GEN (in 1,000,000 kg)	**paramete**	-	-	-	0.0026	0.0037	-	0.0108	0.0153	0.0075
	t-value	-	-	-	*(15.2)*	*(10.3)*	-	*(26.9)*	*(15.4)*	*(6.0)*
POP (in 10,000 persons.)	**paramete**	-	-	-	0.0052	0.0071	-	0.003	0.0026	-
	t-value	-	-	-	*(5.3)*	*(4.8)*	-	*(2.5)*	*(2.6)*	-
EMP (in 10,000 persons.)	**paramete**	-	-	-	0.0073	0.0063	-	0.0588[b]	0.1609[b]	0.1569[b]
	t-value	-	-	-	*(5.0)*	*(2.5)*	-	*(1.4)*	*(5.1)*	*(3.4)*
Impedance Variables										
Distance (km)	**paramete**	-0.0623	-0.0736	-0.0631	-0.0429	-0.0582	-0.05	-0.0249	-0.0337	-0.03
	t-value	*(-16.1)*	*(-14.9)*	*(-10.9)*	*(-19.7)*	*(-13.7)*	*(-12.3)*	*(-16.7)*	*(-14.5)*	*(-15.4)*
Correlation Variables										
γ	**paramete**	-	-	-	-	2[c]	2[c]	-	2[d]	2[d]
ρ	**paramete**	-	1.0168	0.9983	-	-1.3978	-4.8709	-	-11.673	-11.6057
	t-value	-	*(69.0)*	*(64.0)*	-	*(-1.8)*	*(-1.5)*	-	*(-1.6)*	*(-1.6)*
σ	**paramete**	-	-0.1177	-0.1121	-	1.5061	-2.3196	-	2.8734	2.5064
	t-value	-	*(-2.0)*	*(-2.2)*	-	*(3.9)*	*(-4.4)*	-	*(4.0)*	*(3.8)*
δ	**paramete**	-	-	0.4437	-	-	1.2169	-	-	1.5341
	t-value	-	-	*(19.5)*	-	-	*(15.9)*	-	-	*(8.2)*
λ	**paramete**	-	-	1.4823	-	-	1.5861	-	-	1.3001
	t-value	-	-	*(11.2)*	-	-	*(6.1)*	-	-	*(3.9)*
Number of observations		389	389	389	500	500	500	667	667	667
Log-likelihood at zero		-1537	-1537	-1537	-1841.3	-1841.3	-1841.3	-2635.5	-2635.5	-2635.5
Log-likelihood at convergence		-807.9	-773.9	-459	-1333.1	-1269	-1073.3	-2118.5	-2024.9	-1918.7
Adjusted likelihood ratio		0.474	0.496	0.701	0.276	0.311	0.4	0.196	0.232	0.272
AIC test		4.174	4.01	2.401	5.348	5.1	4.636	6.37	6.096	5.78

Note: **a)** NC 's unit is 1000's/km. **b)** EMP 's unit is 10,000 persons/km^2

c), d) The parameter is constrained to 2 for identification purposes

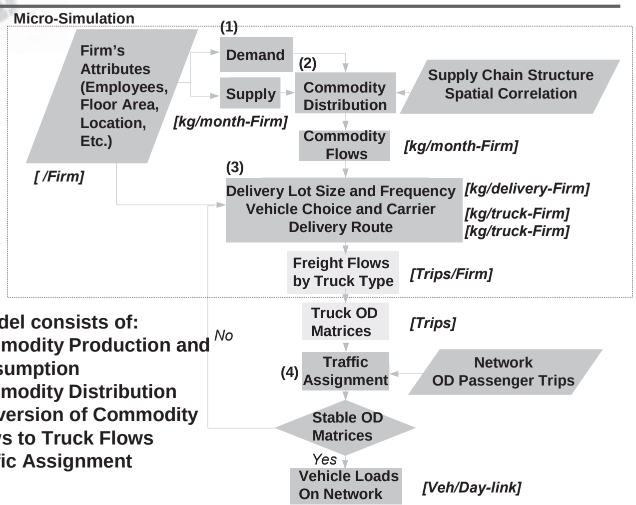
6.2 Commodity Distribution (Cont.)

- Result after applying spatial interaction among customers to all industry types and commodity types



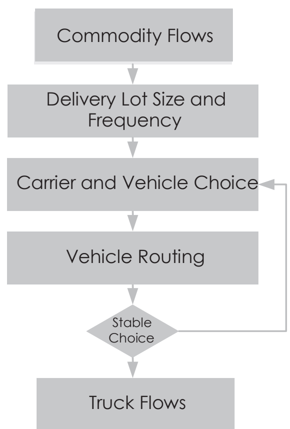
Observed and Estimated Fraction of Commodity Flows for All Commodity Types Comparing between MNL and SMNL Model

6. Model Structure



The model consists of:
(1) Commodity Production and Consumption
(2) Commodity Distribution
(3) Conversion of Commodity Flows to Truck Flows
(4) Traffic Assignment

6.3 Conversion of Commodity Flow to Truck Flow



6.3.1 Delivery Lot Size and Frequency

- Minimizing of delivery costs
- Developing differently by commodity type and by industry type of shipper

$$Q_{ij}^{k} = L_{ij}^{k} \cdot F_{ij}^{k}$$

$$L_{ij}^{k} = a + bD_{ij} \quad ....(1)$$

$$L_{ij}^{k} = a + b\ln(D_{ij}) \quad ....(2)$$

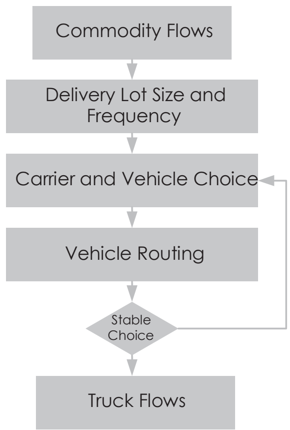
L_{ij}^{k} Lot size that shipper i delivers commodity k to customer j

F_{ij}^{k} Frequency that shipper i delivers commodity k to customer j

Q_{ij}^{k} Monthly amount of commodity k that shipper i delivers to customer j

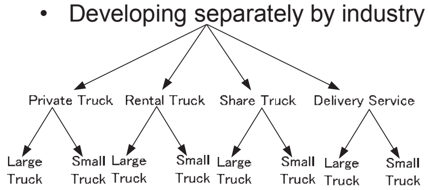
D_{ij} Distance between shipper i and customer j

6.3 Conversion of Commodity Flow to Truck Flow

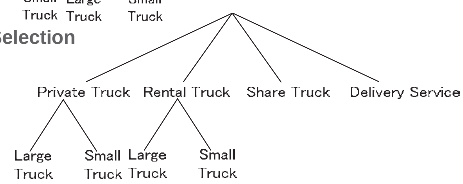


6.3.2 Carrier and Vehicle Choice

- Consisting of two levels: carrier and vehicle size choices
- Deciding based on maximization of the utility including cost, travel time, number of employees
- Developing separately by industry type of shipper



Flow Chart of Choice Selection

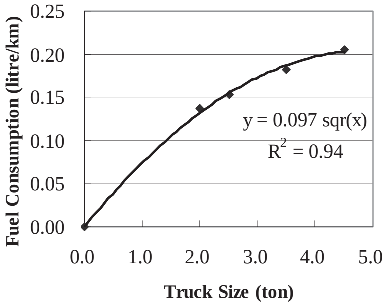


Nested Logit Model Structure of Carrier and Vehicle Choice Model

6.3.2 Carrier and Vehicle Choice (Cont.)

- Private Truck: consist of truck running cost, truck depreciation and insurance cost, and driver cost.
  - Running Cost

$$RC_{i,r} = \varphi \cdot \sqrt{WT_{\max}} \cdot D_{i,r} \cdot NT_{i,r}$$



$WT_{\max}$ maximum carrying weight of the truck of each choice

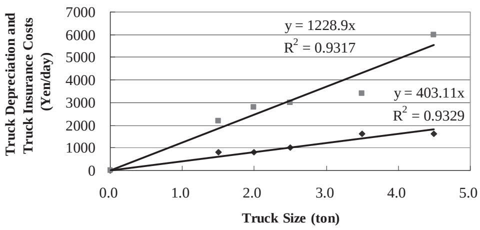
$D_{i,r}$ total distance of truck route r of shipper i

$NT_{i,r}$ required number of trucks for delivery of truck route r of shipper i.

$$NT_{i,r} = roundup(\frac{WT_{i,r}}{WT_{\max}})$$

6.3.2 Carrier and Vehicle Choice (Cont.)

- Private Truck
  - Truck Depreciation and Insurance Cost



$$DIC_{i,r} = [\beta + \omega WT_{\max}]NT_{ir} \frac{WT_{i,r}}{\sum_{all\,r} WT_{i,r}}$$

$WT_{i,r}$ carrying weight of truck route r of shipper i

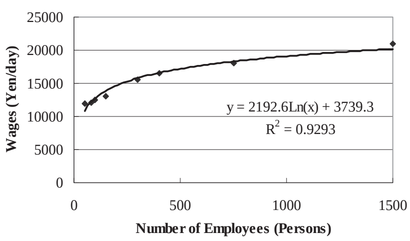
$WT_{\max}$ maximum carrying weight of the truck of each choice

$D_{i,r}$ total distance of truck route r of shipper i

$NT_{i,r}$ required number of trucks for delivery of truck route r of shipper i.

6.3.2 Carrier and Vehicle Choice (Cont.)

- Private Truck
  - Driver Cost



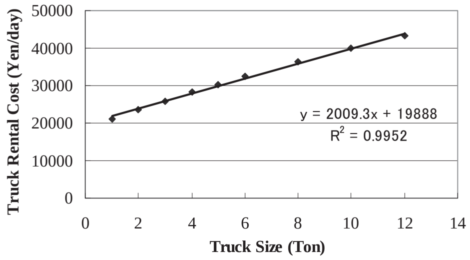
$$DC_{i,r} = [\mu + \tau \ln(Emp_i)] \frac{WT_{i,r}}{\sum_{all\,r} WT_{i,r}}$$

$WT_{i,r}$ carrying weight of truck route r of shipper i

Emp_i Number of Employees of Shipper i

6.3.2 Carrier and Vehicle Choice (Cont.)

- Rental Truck



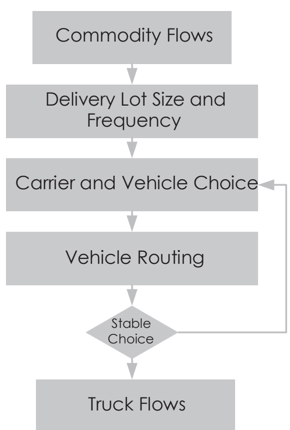
$$RTC_{i,r} = \varpi + \pi WT_{\max}$$

$WT_{\max}$ maximum carrying weight of the truck of each choice

6.3.2 Carrier and Vehicle Choice (Cont.)

- Share Truck
  - Share truck generally has the cheapest cost but firm has limitation of the information and has the preferences on the share truck
  - Other parameters (such as travel time and lot size) are used to represent the utility function of this choice
- Delivery Service Truck
  - Cost for delivery service truck is calculated from the fare table which is proportional to the total travel distance and weight of the shipment.

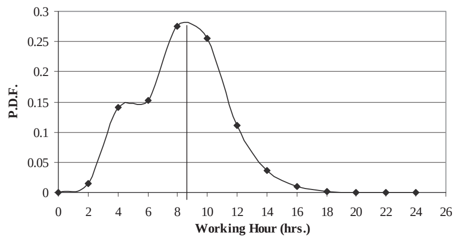
6.3 Conversion of Commodity Flow to Truck Flow



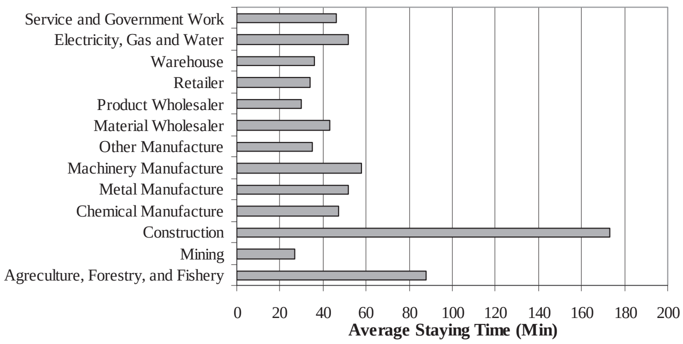
6.3.3 Vehicle Routing

- Provide an order of visiting customers
- Minimization of total travel time for delivery which is constrained by
  - Maximum working hours of driver
  - Maximum carrying weight of truck

P.D.F. of driver's working hours

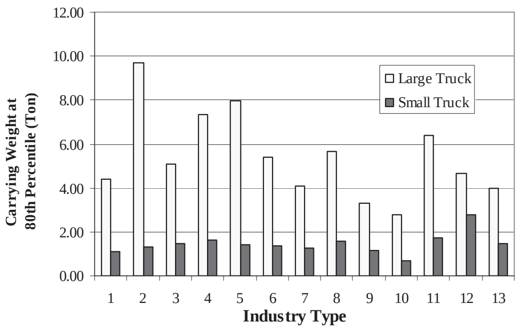


6.3.3 Vehicle Routing (Cont.)



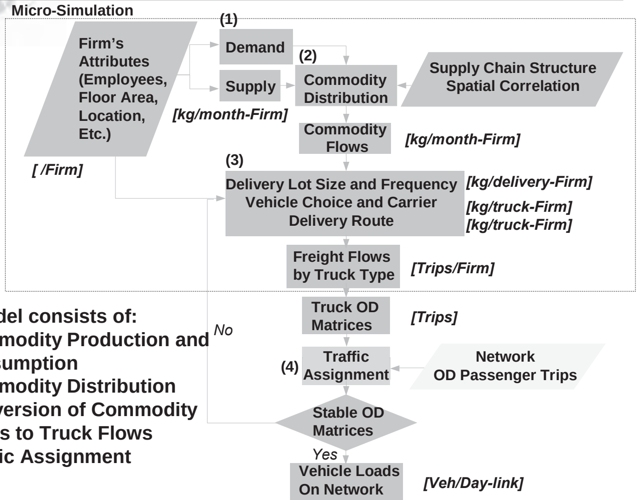
Average Staying time at customer's location

6.3.3 Vehicle Routing (Cont.)



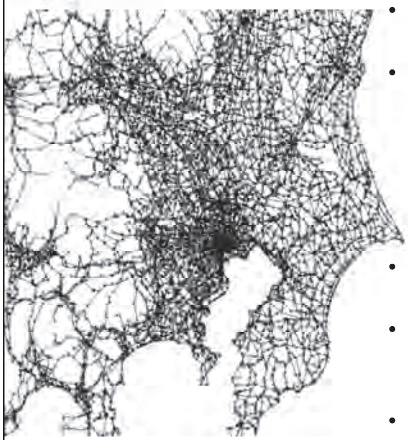
Carrying weight of trucks by industry type

6. Model Structure



The model consists of:
(1) Commodity Production and Consumption
(2) Commodity Distribution
(3) Conversion of Commodity Flows to Truck Flows
(4) Traffic Assignment

6.4 Traffic Assignment

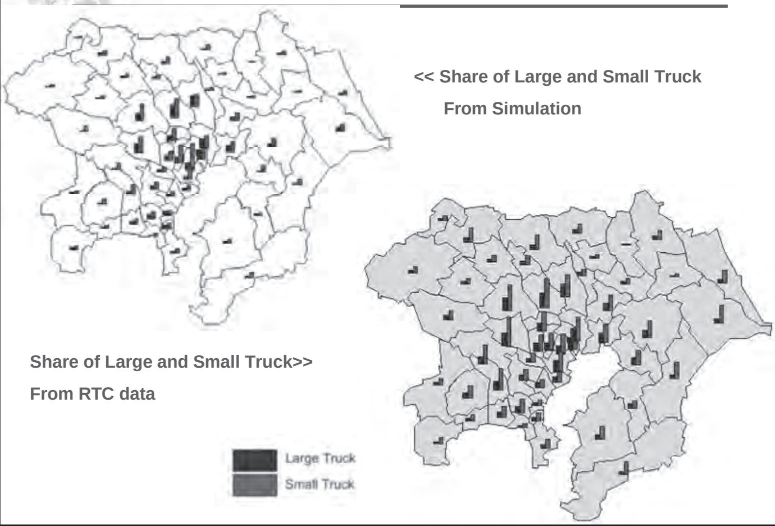


- Using equilibrium traffic assignment
- Convert truck to passenger car unit
  - PCU is assumed as follows:
    - Small truck: 1.5 PCU
    - Large truck: 2.0 PCU
- Road Network consists of 32,273 links and 24,220 nodes
- 56 zones are divided into 1,140 sub-zones for traffic assignment
- Using software package (JICA STRADA) for calculation

7. Results

- Calibration
  - Commodity Generation Model
    - Average value of R for all industry types and commodity types is about 0.4
  - Commodity Distribution Model
    - Average value of ρ^2 for all industry types and commodity types is about 0.4
  - Delivery Frequency and Lot size
    - Average value of R for all industry types and commodity types is about 0.5
  - Carrier and Vehicle Choice
    - Average value of Hit-ratio for all industry types is about 70 percent
- Validation
  - Applying to 87,446 virtual firms generated using Monte-Carlo simulation
  - Corresponding to 5 percent of total number of firms in the EEC data

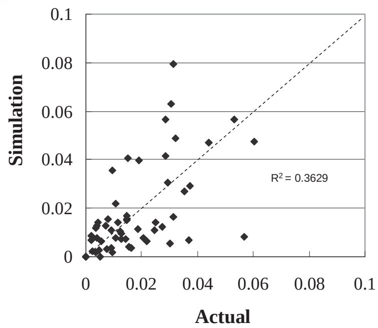
7. Results



<< Share of Large and Small Truck From Simulation

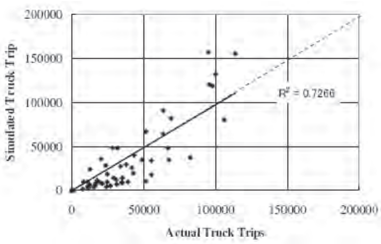
Share of Large and Small Truck>> From RTC data

7. Results (Cont.)

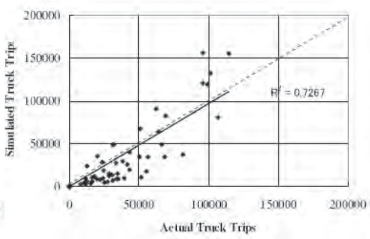


Commodity OD Pattern Comparing between TMGMS data and Simulation using SMNL model

7. Results (Cont.)

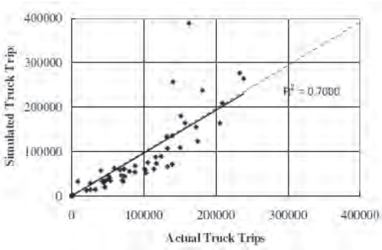


Freight Movement Pattern of Large Trucks using Exponential Equation for Shipper Choice

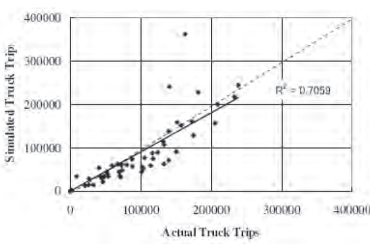


Freight Movement Pattern of Large Trucks using Fraction Equation for Shipper Choice

7. Results (Cont.)



Freight Movement Pattern of Small Trucks using Exponential Equation for Shipper Choice



Freight Movement Pattern of Small Trucks using Fraction Equation for Shipper Choice

7. Results (Cont.)

Comparing Number of Truck Trips per Day from Simulation and RTC data

1000 Trips per Day	Large Truck	Small Truck
Simulation	2,258	4,651
RTC	2,120	5,135

Comparing VKT per Day from Simulation and RTC data

1000 VKT per Day	Large Truck	Small Truck
Simulation	217,090	169,906
RTC	174,875	122,517

8. Policy Evaluation

- Two policies are assumed implementing in TMA
  - Construction of new ring roads (Tokyo-Gaikan Expressway)
  - Change in fuel price
- Evaluating in terms of
  - Travel condition
    - Average travel speed
  - Environmental condition
    - CO_2 Emission
    - NO_X Emission

CO_2 Emission Rate

Fuel Type	Emission Rate
Gasoline	2.322 Kg/L
Kerosene	2.489 Kg/L
Diesel	2.619 Kg/L
LPG	3.000 Kg/L

Source: Policy on Countermeasure against World Global Warming, 2002

NO_X Emission Rate

Travel Speed (kph)	Emission Rate (g/km)	
	Small Truck	Large Truck
15	1.21	3.38
25	1.00	2.83
35	0.98	2.77
45	0.98	2.78
55	0.96	2.75
70	0.92	2.65
90	1.37	2.94
100	2.19	3.54

Source: Traffic Engineering Handbook (JSTE, 1984)

8. Policy Evaluation (Cont.)

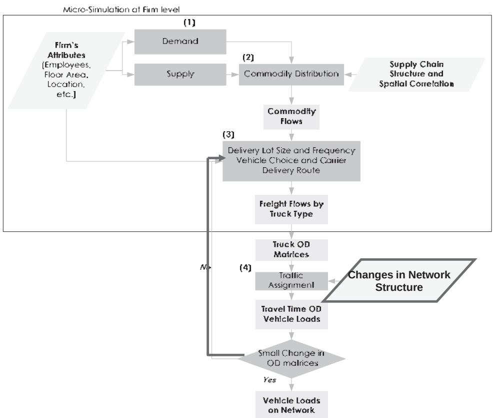
- Construction of new ring roads (Tokyo-Gaikan Expressway)

- Two-lane divided national highway
- 2,100 veh/hr/lane

8. Policy Evaluation (Cont.)

Construction of new ring roads (Tokyo-Gaikan Expressway)

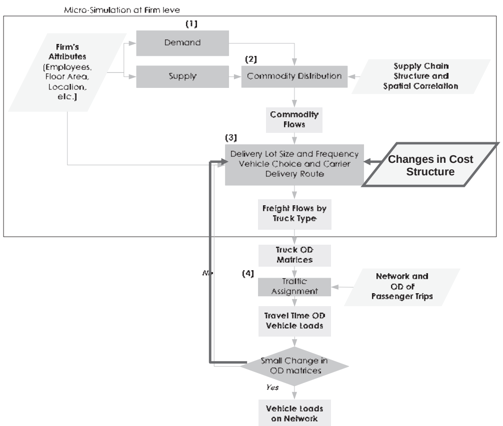
– Procedure
  - Change network structure by adding new links
  - Result in change in travel time OD and vehicle loads
  - Recalculate vehicle choice and carrier and delivery route models from the resulted travel time OD



8. Policy Evaluation (Cont.)

Increasing of fuel price by 10 percent

– Procedure
  - Change fuel cost in the cost structure of vehicle choice and carrier model
  - Recalculate vehicle choice and carrier and delivery route models from the resulted travel time OD



8. Policy Evaluation (Cont.)

- Comparing between two policies

	Unit	Base Case	New Ring	%Diff	Fuel Price Increases	%Diff
Average Travel Speed						
Inside Ring Road	kph	26.5	29.1	9.6	28.3	6.6
All Area	kph	25.7	27.7	7.7	27.7	8.0
VKT						
Inside Ring Road	1000VKT/day	119,763	119,916	0.1	95,995	-19.8
All Area	1000VKT/day	386,098	389,061	0.8	310,919	-19.5
CO_2						
Inside Ring Road	1000Kg/day	65,474	65,537	0.1	60,129	-8.2
All Area	1000Kg/day	208,800	210,165	0.7	191,617	-8.2
NO_X						
Inside Ring Road	1000Kg/day	218,769	218,930	0.1	220,008	0.6
All Area	1000Kg/day	691,977	695,901	0.6	694,290	0.3

9. Conclusion

- A comprehensive approach to modeling freight transportation in a way that systematically reflects the individual behavior of freight decision makers.
- The model takes into account the fundamentals of freight movement, which is the outcomes of commodity flows through supply chain.
- Since the model considers the individual behavior of freight agent, the model can be applied to both static and dynamic of freight transportation system.
- Interactions among freight agents, as well as the spatial interactions are incorporated.
- Since the proposed model is a discrete type that considers the individual behavior, resulting in a more policy-sensitive model.
- For dynamic model, since the model is a dynamic system, it can result not only the mean value but also the variation in freight demand.

Thank You for Your Attention

Urban Road Safety Challenge

Dr. Pichai Taneerananon

URBAN ROAD SAFETY CHALLENGE

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Regional Network Office for Urban Safety , AIT

Urban Road Safety Challenge

Workshop on Transportation Researches for Urban Safety

11 December 2008

Pichai Taneerananon

Prince of Songkla University

Overview

- Introduction
- The Problem
- The Cause
- The Challenge
- The Strategy
- Conclusion

Urban Living

- 2008, more than 50 % of world population now live in urban areas

UNFPA

"No one doubts that traffic accident has been an immediate and serious risk to our lives in the urban setting"

Source :
Regional Network Office for Urban Safety (RNUS) Asian Institute of Technology (AIT)

The Rarity of a Human Life

- "Monks, suppose that this great earth were totally covered with water, and a man were to toss a yoke with a single hole there.
- A wind from the east would push it west, a wind from the west would push it east.
- A wind from the north would push it south, a wind from the south would push it north.
- And suppose a blind sea-turtle were there.
- It would come to the surface once every one hundred years.

- Now what do you think: would that blind sea-turtle, coming to the surface once every one hundred years, stick his neck into the yoke with a single hole?"
- "It would be a sheer coincidence, lord, that the blind sea-turtle, coming to the surface once every one hundred years, would stick his neck into the yoke with a single hole."
- "**It's likewise a sheer coincidence that one obtains the human state**.

Overview

- Introduction
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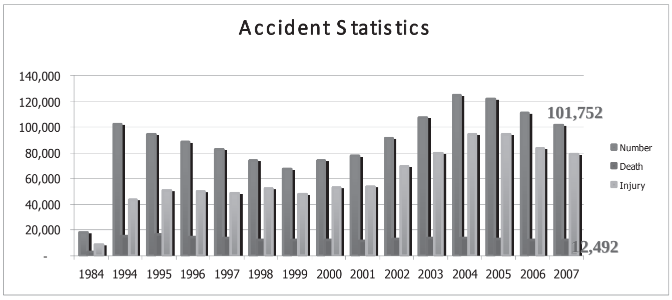
Estimated annual deaths in ASEAN + four

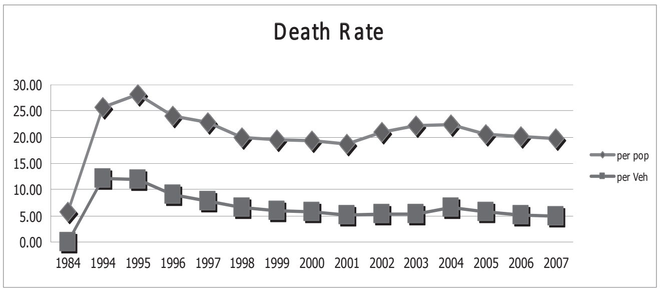
Country	Year	Death (police-reported)
Brunei Darussalam	2005	38
Cambodia	2005	904
China	2005	98,738
Indonesia(estimated)	2003	30,484
Japan	2007	5,744
Lao People's Democratic Republic	2003	426
Malaysia	2005	6,200
Myanmar	2003	1,308
Philippines (estimated)	2003	9,000
Republic of Korea	2004	6,563
Singapore	2005	173
Taiwan	2005	2,894
Thailand	2007	12,492
Viet Nam	2005	11,000
Total		185,964

Number of road crashes injuries and fatalities during 1994-2007



Source: Royal Thai Police, Department of Provincial Administration and Department of Land Transport, and Office of Transport and Traffic Policy and Planning

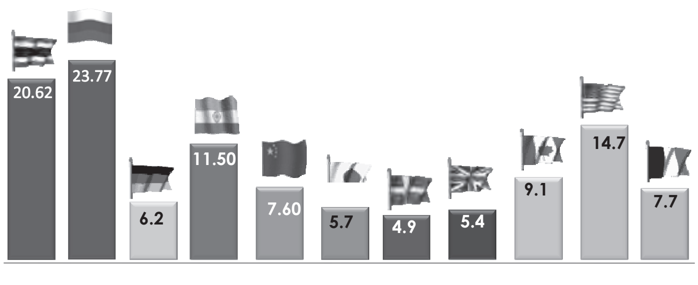
Trend in the number of accident fatalities per 100,000 population and per 10,000 vehicle during 1994-2007



Source: Department of Highways 2007

Road Traffic Fatality Rate 2005

Fatalities per 100,000 population



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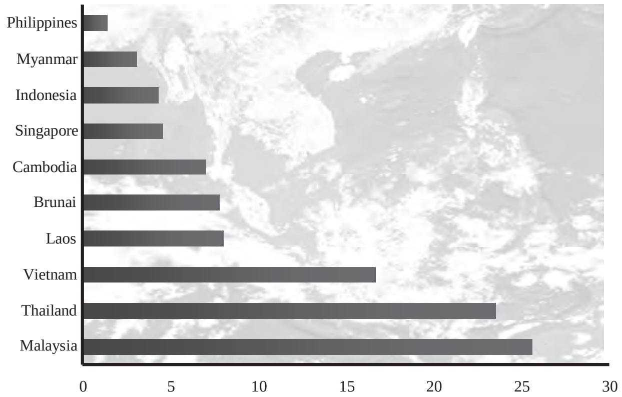
ASEAN Road Fatality Rate
(Fatality per 100,000 population)



Source: ADB (2005)

14

The Cost

Total cost to the nation (2007 value)

232,855 million Baht

2.81% GDP

Source: Department of Highways 2007

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Average Value of Costs according to Crash Severity for Thailand in 2007

Crash Severity	Average value of Costs (baht)
A Fatality	5,315,556
A Disability	6,167,061
A Serious Injury	147,023
A Slight Injury	34,761
A Property Damage Only Crash	45,898

Average Value of Costs according to Crash Severity for Bangkok 2007

Crash Severity	Average value of Costs (baht)
A Fatality	11,078,982
A Disability	12,435,767
A Serious Injury	301,746
A Slight Injury	154,850
A Property Damage Only Crash	146,773

Overview

- Introduction
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Thai MC Research Findings

- Rider error was the most frequent primary contributing factor in the majority of both single and multiple vehicle accidents
- Alcohol involved accidents preceded 30% of all accidents reported here.
- ~ 40% of the accidents involved improper traffic strategy such as unsafe speed, unsafe position, or following another vehicle too closely.
- ~ half of the accident-involved riders were unlicensed and none had any formal training in motorcycle riding techniques and collision avoidance strategies
- Most were self-taught or learned from friends and family. This lack of training, licensing and knowledge frequently appeared as rider errors in many accidents.

Source : Motorcycle Accident Causation and Identification of countermeasures in Thailand Vira Kasantikul, MD 2001

A small error can be fatal

True Comrades, Hanoi

Source: VN Students at AIT

The Need to improve MC safety

Source: VN Students at AIT

Everyone for themselves, Protect yourself !

Source: VN Students at AIT

Real people, Hanoi

Source: VN Students at AIT

The Inevitable, Vietnam

Real Deaths Vietnam

- 12,857 died from road crashes in 2007
- ~ 60 % or 7,714 from MC related

Source: National Traffic Safety Committee, VN

Real Deaths Thailand

- 12,492 died from road crashes in 2007
- ~ 70 % or 8,744 from MC related

Source: Police, Ministry of Public Health etc.

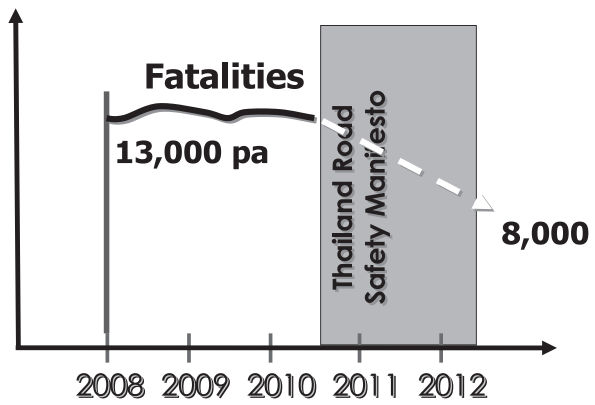
Overview

- Introduction
- The Problem
- The Cause
- **The Challenge**
- The Strategy
- Conclusion

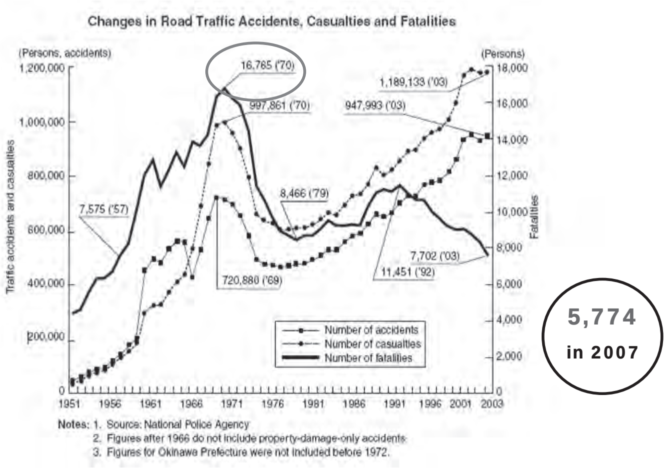
The Challenge

Save 5,000 lives

2008-2012



Japan Experience



Overview

- Introduction
- The Problem
- The Cause
- The Challenge
- **The Strategy**
- Conclusion

The Strategy

- 1st line defence : the Rider
- 2nd line defence : the Motorcycle Lane
- 3rd line defence : the Motorcycle and Helmet

第六十四章

其安易持，其未兆易謀。
其脆易泮，其微易散。為
之於未有，治之於未亂。
合抱之木，生於毫末；九
層之台，起於累土；千里
之行，始於足下。為者敗
之，執者失之。是以聖人
無為故無敗，無執故無失
。民之從事，常於幾成而
敗之。慎終如始，則無敗
事。是以聖人欲不欲，不
貴難得之貨；學不學，復
眾人之所過。以輔萬物之
自然，而不敢為。

Tao Te Jing Chapter 64 by Gia-Fu Feng and Jane English

Peace is easily maintained;
Trouble is easily overcome before it starts.
The brittle is easily shattered;
The small is easily scattered.
Deal with it before it happens.
Set things in order before there is confusion.
A tree as great as a man's embrace springs from a small shoot;
A terrace nine stories high begins with a pile of earth
The journey of a thousand miles start with the first step……………
.

Lao Tzu
Circa 2600 bc

The Principle

- Prevention is better than cure

Japan Strategy

- Road Environment Enhancements
- Implementation of the Road Traffic Safety Initiative
- Promotion of Safe Driving
- Improvement of Vehicle Safety
- Enhancement of Rescue Systems
- Improvement of Liability Security and Victim Support

1st line defence

- Sustained Education
- Vigorous Skill training
- Tougher Licensing

【People-Related Countermeasures 】 TOYOTA

-To continually maintain a frame of mind that transcends the concept of perpetrator/victim and enables people to avoid involvement in accidents PREVENTION

(Protection of yourself by your own actions)

-To strengthen awareness of good traffic manners beyond skin-deep

(Creation of a pleasant society full of consideration for others)

【Characteristics (The Toyota Style)】 TOYOTA

Point	The Toyota style	Conventional model
Pursuit of effect on awareness	Experience, images	Theory, words
	Satisfaction, emotion	Interest, comprehension
	Driving of actual vehicles	Posters, leaflets, slogans
	Creation of inner awareness	Top-down explanation/ persuasion
	Seriousness	Attraction oriented
	One-on-one individual communication	Communication through the mass media and advertisements
Corporate citizenship	Going out to actual sites	Inviting people to you
	Active personal involvement	Donation/support
	Collaboration with local needs/regions	Action based solely on personal judgment of what is correct
Educational viewpoint	Manners	Rules
	Establishment of comfortable society	Thinking that simply preventing accidents is enough

【 Toyota's Traffic Safety Education Activities】 TOYOTA

Toyota Traffic Safety Campaign

Toyota Child Safety Communication

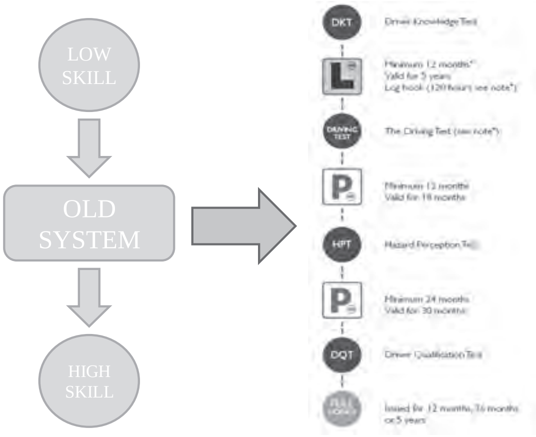
Toyota Safety School
(Traffic Safety Classes for Young Children)

UK Learner plate

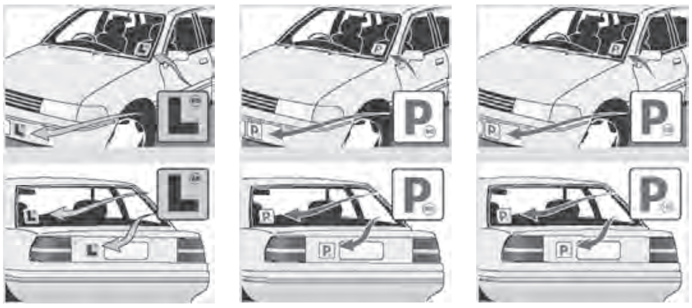
Australian L permit

Red Provisional License P Plate

License System

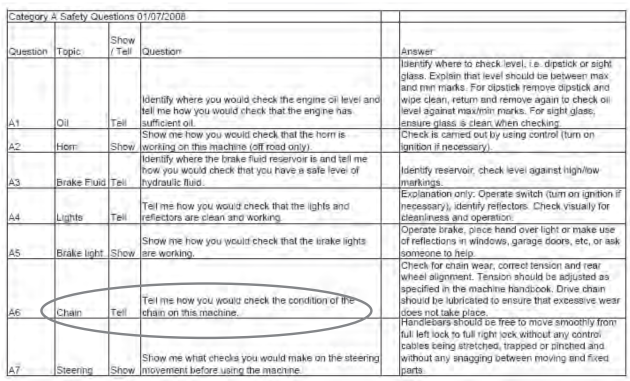


Licensing System



Max: 80 km/h 90 km/h 100 km/h

Some typical mc safety Qs in UK !



Category A Safety Questions 01/07/2008					
Question	Topic	Show / Tell	Question		Answer
A1	Oil	Tell	Identify where you would check the engine oil level and tell me how you would check that the engine has sufficient oil.		Identify where to check level, i.e. dipstick or sight glass. Explain that level should be between max and min marks. For dipstick remove dipstick and wipe clean, return and remove again to check oil level against max/min marks. For sight glass, ensure glass is clean when checking.
A2	Horn	Show	Show me how you would check that the horn is working on this machine (off road only).		Check is carried out by using control (turn on ignition if necessary).
A3	Brake Fluid	Tell	Identify where the brake fluid reservoir is and tell me how you would check that you have a safe level of hydraulic fluid.		Identify reservoir, check level against high/low markings.
A4	Lights	Tell	Tell me how you would check that the lights and reflectors are clean and working.		Explanation only: Operate switch (turn on ignition if necessary), identify reflectors. Check visually for cleanliness and operation.
A5	Brake light	Show	Show me how you would check that the brake lights are working.		Operate brake, place hand over light or make use of reflections in windows, garage doors, etc, or ask someone to help.
A6	Chain	Tell	Tell me how you would check the condition of the chain on this machine.		Check for chain wear, correct tension and rear wheel alignment. Tension should be adjusted as specified in the machine handbook. Drive chain should be lubricated to ensure that excessive wear does not take place.
A7	Steering	Show	Show me what checks you would make on the steering movement before using the machine.		Handlebars should be free to move smoothly from full left lock to full right lock without any control cables being stretched, trapped or pinched and without any snagging between moving and fixed parts.

Reference: About Driving School in Japan TOYOTA

1) 1,400 schools in Japan
2) 1.3 million graduates in 2006 (regular car license)
3) The rate of license acquisition by age (regular car license)

   teen:48.8% , twentieth:33.1% , thirtieth:10%
4) Standard term for acquisition : 30days
5) Total cost for training : \350,000
6) The rate of graduates / license acquisition : 95%

The Strategy

- 1st line defence : the Rider
- 2nd line defence : the Motorcycle Lane
- 3rd line defence : the Motorcycle and Helmet

BKK , An Equity and Safety issue

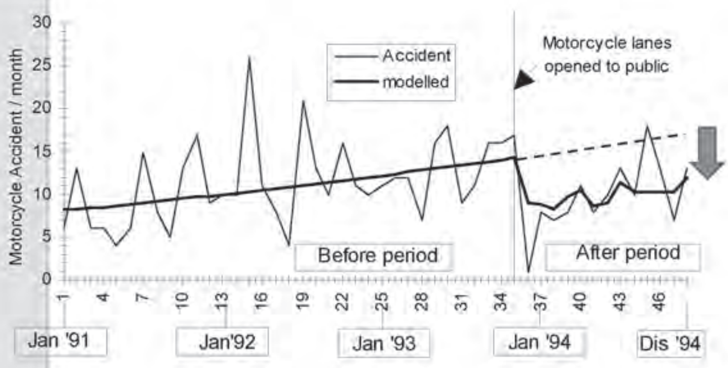
Enough pavement for MC lane

The Need is obvious Hanoi

Source: VN Students at AIT

The obvious majority, Cambodia

A small error can be fatal



- 39% less Accidents
- 83% less Fatality
- Benefit:Cost = 5

Source: Radin Umar MIROS

The Strategy

- 1st line defence : the Rider
- 2nd line defence : the Motorcycle Lane
- 3rd line defence : the Motorcycle and Helmet

WMD ?

Or Efficient Transport ? Cambodia

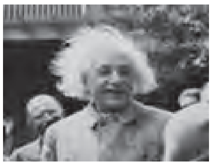
Source: Cambodia Students at AIT

Look like Thailand, But Indonesia ? Hanoi ?

Source: VN Students at AIT

Conclusions

- Life is the ultimate precious thing
- Asian Governments and Corporations can do a lot more to save the lives of their urban citizens
- Focus placed on most vulnerable mass, the Motorcyclist and pax
- Tougher Licensing should follow Sustained Education, Training
- Motorcycle lane as a Safety and Equity issue
- Can the MC be made safer, not faster !



We have to do the best we can.
This is our sacred human responsibility.

Albert Einstein

State-of-Art of Traffic Accident Reconstruction Technology

Prof. Takashi Nakatsuji

STATE-OF-ART OF TRAFFIC ACCIDENT RECONSTRUCTION TECHNOLOGY

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State-of-the-art Technology in Vehicle Dynamics

-Estimation of Vehicle Dynamics Parameters Using Unscented Kalman Filter-

Takashi NAKATSUJI

Hokkaido University

1

Backgrounds

Parameters in Vehicle Dynamics

- **Vehicle Geometry:**
  - ✓Length, Width, Weight, Moment Inertia,...
  - ✓Vehicle Database: SPEC, DASD, ADAD, Vyskocil,...
- **Tire Geometry:**
  - ✓Width, Weight, Moment Inertia,...
  - ✓Contact Length &Width, Contact Pressure Distribution
  - ✓Elastic Constants
- **Model Parameters Model:**
  - ✓Tire model, Steering Model, Driver Model, Aero Dynamics
  - ✓Crash Model, Collision Model,...
- **Interaction between Vehicle/Tire and Environment**
  - ✓**Friction Coefficient**

2

Backgrounds

Drive Recorder

- CCD Camera
  - ✓Video Image & Sound
- Vehicle Motion
  - ✓Speed, Acceleration

CAN (Controller Area Network) Sensor

- Vehicle Motion
  - ✓Speed, Acceleration
  - ✓Lateral, Longitudinal, Angular Motion Data
  - ✓Steering, Braking, Accelerating,...
  - ✓Engine Rotation, Fuel Consumption,...
- GPS
  - ✓Position

3

Outlines

Estimation of the Friction Coefficient on Winter Road Surface using Unscented Kalman Filter

1. Fundamentals of Vehicles Dynamics
   - Non-Linear Equation in Tire Model
   - Differential Equation
2. Unscented Kalman Filter (UKF)
   - Conventional Kalman Filter
   - What is new in Unscented Kalman Filter
3. Application of UKF to Vehicle Dynamics
4. Potentials for Traffic Accident Analyses

4

Part 1
Unscented Kalman Filter
for Vehicle Dynamics

Friction Coefficient on Winter Road Surface

Conventionally

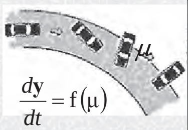
Skid Tester

- **Expensive**
- **Calibration**
- **Maintenance**
- **.....**

New Technology

Probe car equipped with CAN sensor

ITS Technology



$$\frac{d\mathbf{y}}{dt} = f(\mu)$$

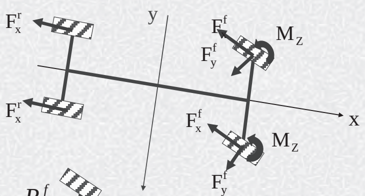
$$\mu = f^{-1}\left(\frac{d\mathbf{y}}{dt}\right)$$

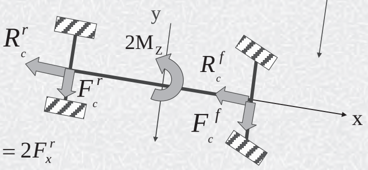
$\frac{d\mathbf{y}}{dt}$ → f^{-1} → μ

Vehicle Dynamics

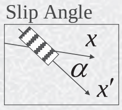
Equation of Motion

3 DOF Model
Longitudinal: x
Lateral: y
Rotational: θ





Slip Angle



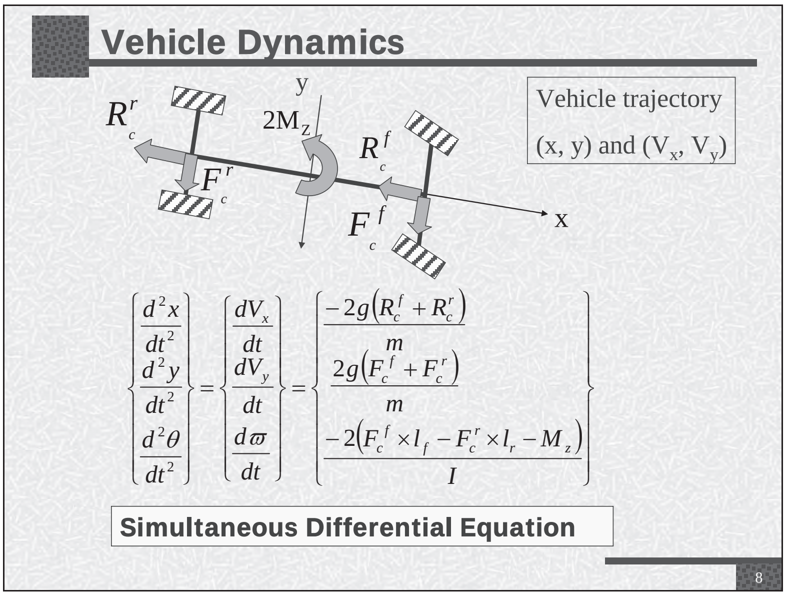
$$R_c^r = 2F_x^r$$

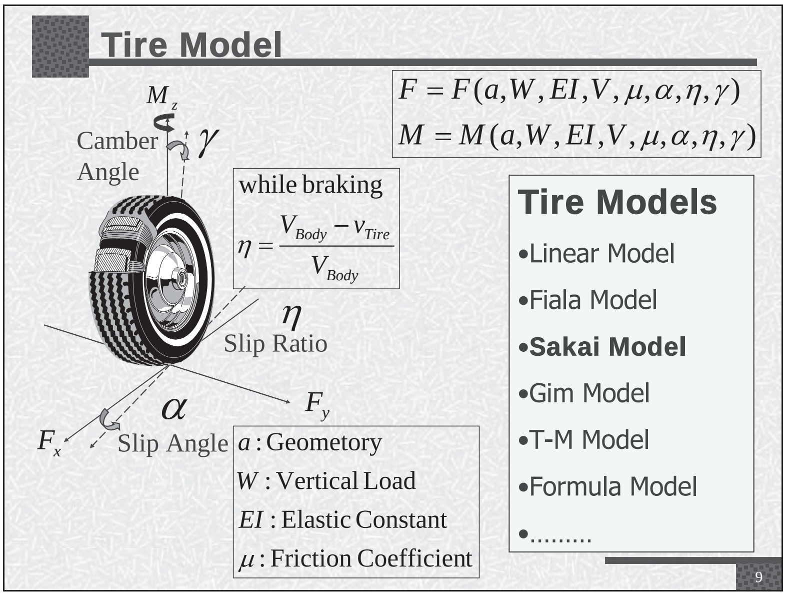
$$F_c^r = 0$$

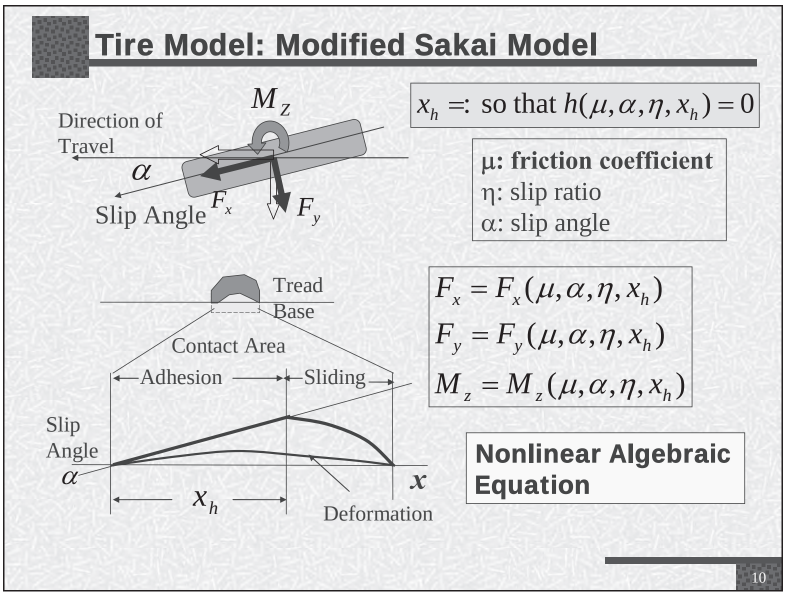
$$R_c^f = F_y^f \sin\alpha + F_x^f \cos\alpha$$

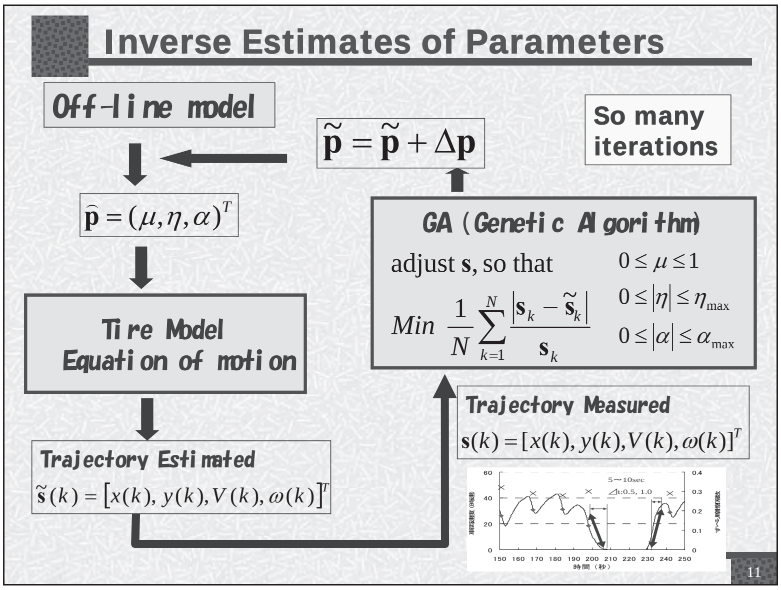
$$F_c^f = F_y^f \cos\alpha - F_x^f \sin\alpha$$

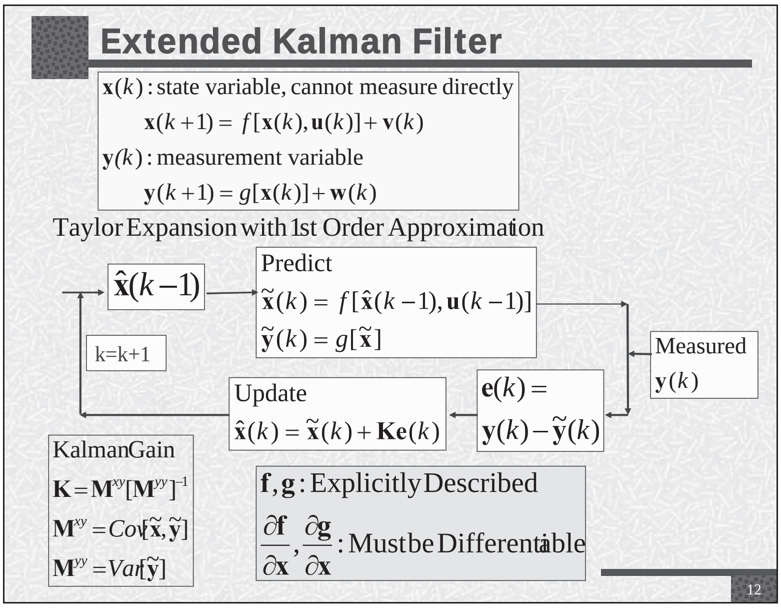
7

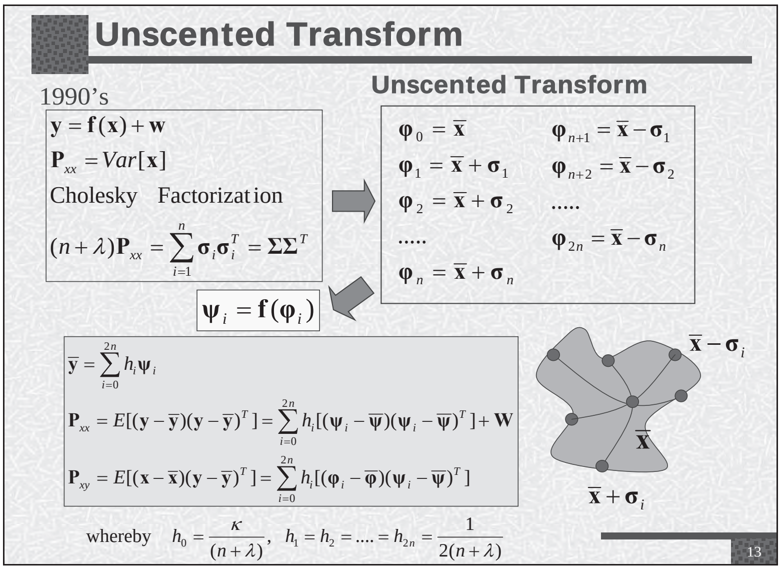

Vehicle Dynamics
Vehicle trajectory (x, y) and (V_x, V_y)
R_c^r
F_c^r
2M_Z
R_c^f
F_c^f
y
x
$$\begin{Bmatrix} \frac{d^2x}{dt^2} \\ \frac{d^2y}{dt^2} \\ \frac{d^2\theta}{dt^2} \end{Bmatrix} = \begin{Bmatrix} \frac{dV_x}{dt} \\ \frac{dV_y}{dt} \\ \frac{d\varpi}{dt} \end{Bmatrix} = \begin{Bmatrix} \frac{-2g\left(R_c^f + R_c^r\right)}{m} \\ \frac{2g\left(F_c^f + F_c^r\right)}{m} \\ \frac{-2\left(F_c^f \times l_f - F_c^r \times l_r - M_z\right)}{I} \end{Bmatrix}$$
Simultaneous Differential Equation
8

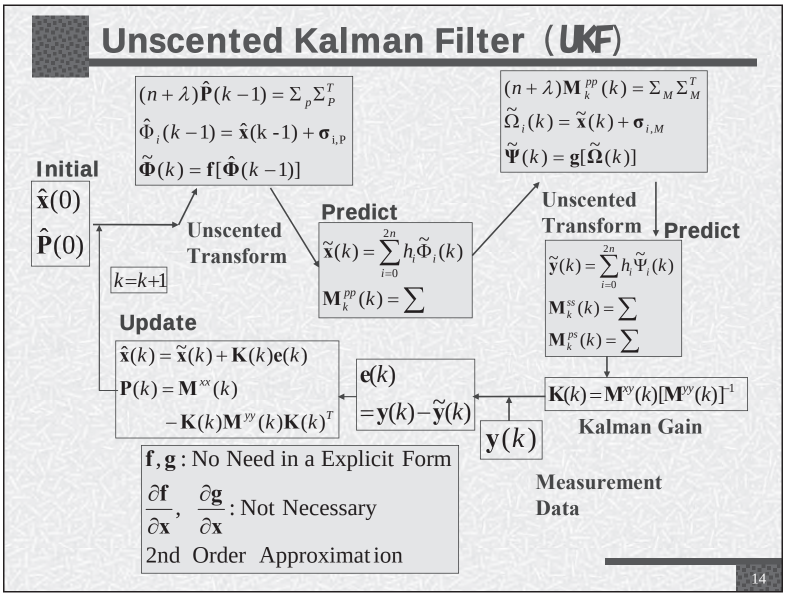

Tire Model
$F = F(a, W, EI, V, \mu, \alpha, \eta, \gamma)$
$M = M(a, W, EI, V, \mu, \alpha, \eta, \gamma)$
M_z
Camber Angle
γ
while braking
$\eta = \frac{V_{Body} - v_{Tire}}{V_{Body}}$
η
Slip Ratio
α
F_y
F_x
Slip Angle
a : Geometory
W : Vertical Load
EI : Elastic Constant
μ : Friction Coefficient
Tire Models
•Linear Model
•Fiala Model
•Sakai Model
•Gim Model
•T-M Model
•Formula Model
•.........
9

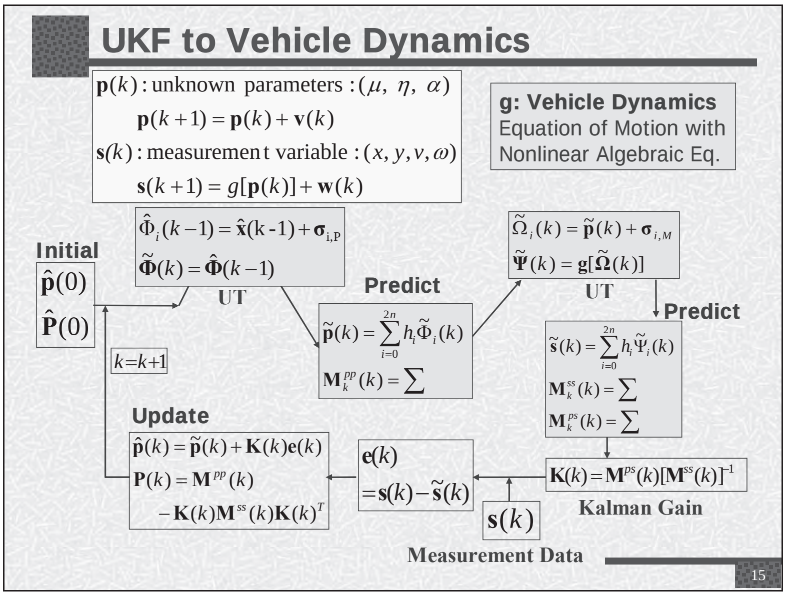

Tire Model: Modified Sakai Model
x_h =: so that $h(\mu, \alpha, \eta, x_h) = 0$
Direction of Travel
M_Z
α
Slip Angle
F_x
F_y
μ: friction coefficient
η: slip ratio
α: slip angle
Tread
Base
Contact Area
Adhesion
Sliding
Slip Angle
α
x
x_h
Deformation
$F_x = F_x(\mu, \alpha, \eta, x_h)$
$F_y = F_y(\mu, \alpha, \eta, x_h)$
$M_z = M_z(\mu, \alpha, \eta, x_h)$
Nonlinear Algebraic Equation
10

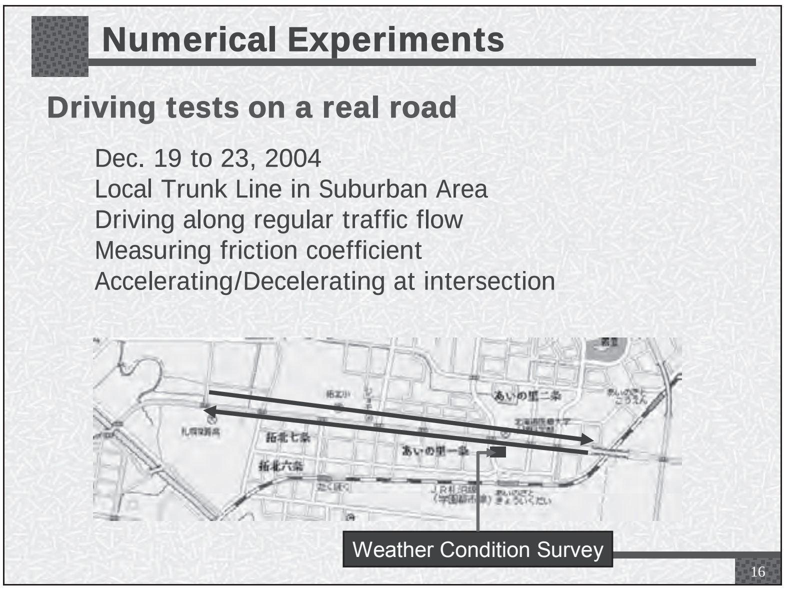

Inverse Estimates of Parameters
Off-line model
$\tilde{\mathbf{p}} = \tilde{\mathbf{p}} + \Delta\mathbf{p}$
So many iterations
$\hat{\mathbf{p}} = (\mu, \eta, \alpha)^T$
GA (Genetic Algorithm)
adjust s, so that
$Min \ \frac{1}{N}\sum_{k=1}^{N} \frac{|\mathbf{s}_k - \tilde{\mathbf{s}}_k|}{\mathbf{s}_k}$
$0 \le \mu \le 1$
$0 \le |\eta| \le \eta_{max}$
$0 \le |\alpha| \le \alpha_{max}$
Tire Model
Equation of motion
Trajectory Measured
$\mathbf{s}(k) = [x(k), y(k), V(k), \omega(k)]^T$
Trajectory Estimated
$\tilde{\mathbf{s}}(k) = [x(k), y(k), V(k), \omega(k)]^T$
11


Extended Kalman Filter
$\mathbf{x}(k)$: state variable, cannot measure directly
$\mathbf{x}(k+1) = f[\mathbf{x}(k), \mathbf{u}(k)] + \mathbf{v}(k)$
$\mathbf{y}(k)$: measurement variable
$\mathbf{y}(k+1) = g[\mathbf{x}(k)] + \mathbf{w}(k)$
Taylor Expansion with 1st Order Approximation
$\hat{\mathbf{x}}(k-1)$
Predict
$\tilde{\mathbf{x}}(k) = f[\hat{\mathbf{x}}(k-1), \mathbf{u}(k-1)]$
$\tilde{\mathbf{y}}(k) = g[\tilde{\mathbf{x}}]$
k=k+1
Measured
$\mathbf{y}(k)$
Update
$\hat{\mathbf{x}}(k) = \tilde{\mathbf{x}}(k) + \mathbf{K}\mathbf{e}(k)$
$\mathbf{e}(k) = \mathbf{y}(k) - \tilde{\mathbf{y}}(k)$
Kalman Gain
$\mathbf{K} = \mathbf{M}^{xy}[\mathbf{M}^{yy}]^{-1}$
$\mathbf{M}^{xy} = Cov[\tilde{\mathbf{x}}, \tilde{\mathbf{y}}]$
$\mathbf{M}^{yy} = Var[\tilde{\mathbf{y}}]$
$\mathbf{f}, \mathbf{g}$: Explicitly Described
$\frac{\partial \mathbf{f}}{\partial \mathbf{x}}, \frac{\partial \mathbf{g}}{\partial \mathbf{x}}$: Must be Differentiable
12


Unscented Transform
1990's
$\mathbf{y} = \mathbf{f}(\mathbf{x}) + \mathbf{w}$
$\mathbf{P}_{xx} = Var[\mathbf{x}]$
Cholesky Factorization
$(n+\lambda)\mathbf{P}_{xx} = \sum_{i=1}^{n} \boldsymbol{\sigma}_i \boldsymbol{\sigma}_i^T = \boldsymbol{\Sigma}\boldsymbol{\Sigma}^T$
Unscented Transform
$\boldsymbol{\varphi}_0 = \bar{\mathbf{x}}$
$\boldsymbol{\varphi}_1 = \bar{\mathbf{x}} + \boldsymbol{\sigma}_1$
$\boldsymbol{\varphi}_2 = \bar{\mathbf{x}} + \boldsymbol{\sigma}_2$
.....
$\boldsymbol{\varphi}_n = \bar{\mathbf{x}} + \boldsymbol{\sigma}_n$
$\boldsymbol{\varphi}_{n+1} = \bar{\mathbf{x}} - \boldsymbol{\sigma}_1$
$\boldsymbol{\varphi}_{n+2} = \bar{\mathbf{x}} - \boldsymbol{\sigma}_2$
.....
$\boldsymbol{\varphi}_{2n} = \bar{\mathbf{x}} - \boldsymbol{\sigma}_n$
$\boldsymbol{\psi}_i = \mathbf{f}(\boldsymbol{\varphi}_i)$
$\bar{\mathbf{y}} = \sum_{i=0}^{2n} h_i \boldsymbol{\psi}_i$
$\mathbf{P}_{xx} = E[(\mathbf{y}-\bar{\mathbf{y}})(\mathbf{y}-\bar{\mathbf{y}})^T] = \sum_{i=0}^{2n} h_i[(\boldsymbol{\psi}_i - \bar{\boldsymbol{\psi}})(\boldsymbol{\psi}_i - \bar{\boldsymbol{\psi}})^T] + \mathbf{W}$
$\mathbf{P}_{xy} = E[(\mathbf{x}-\bar{\mathbf{x}})(\mathbf{y}-\bar{\mathbf{y}})^T] = \sum_{i=0}^{2n} h_i[(\boldsymbol{\varphi}_i - \bar{\boldsymbol{\varphi}})(\boldsymbol{\psi}_i - \bar{\boldsymbol{\psi}})^T]$
whereby $h_0 = \frac{\kappa}{(n+\lambda)}, \ h_1 = h_2 = ... = h_{2n} = \frac{1}{2(n+\lambda)}$
$\bar{\mathbf{x}} - \boldsymbol{\sigma}_i$
$\bar{\mathbf{x}}$
$\bar{\mathbf{x}} + \boldsymbol{\sigma}_i$
13


Unscented Kalman Filter (UKF)
$(n+\lambda)\hat{\mathbf{P}}(k-1) = \Sigma_P \Sigma_P^T$
$\hat{\Phi}_i(k-1) = \hat{\mathbf{x}}(k-1) + \boldsymbol{\sigma}_{i,P}$
$\tilde{\boldsymbol{\Phi}}(k) = \mathbf{f}[\hat{\boldsymbol{\Phi}}(k-1)]$
$(n+\lambda)\mathbf{M}_k^{pp}(k) = \Sigma_M \Sigma_M^T$
$\tilde{\Omega}_i(k) = \tilde{\mathbf{x}}(k) + \boldsymbol{\sigma}_{i,M}$
$\tilde{\boldsymbol{\Psi}}(k) = \mathbf{g}[\tilde{\boldsymbol{\Omega}}(k)]$
Initial
$\hat{\mathbf{x}}(0)$
$\hat{\mathbf{P}}(0)$
Unscented Transform
Predict
$\tilde{\mathbf{x}}(k) = \sum_{i=0}^{2n} h_i \tilde{\Phi}_i(k)$
$\mathbf{M}_k^{pp}(k) = \sum$
Unscented Transform
Predict
$\tilde{\mathbf{y}}(k) = \sum_{i=0}^{2n} h_i \tilde{\Psi}_i(k)$
$\mathbf{M}_k^{ss}(k) = \sum$
$\mathbf{M}_k^{ps}(k) = \sum$
$k=k+1$
Update
$\hat{\mathbf{x}}(k) = \tilde{\mathbf{x}}(k) + \mathbf{K}(k)\mathbf{e}(k)$
$\mathbf{P}(k) = \mathbf{M}^{xx}(k) - \mathbf{K}(k)\mathbf{M}^{yy}(k)\mathbf{K}(k)^T$
$\mathbf{e}(k) = \mathbf{y}(k) - \tilde{\mathbf{y}}(k)$
$\mathbf{K}(k) = \mathbf{M}^{xy}(k)[\mathbf{M}^{yy}(k)]^{-1}$
Kalman Gain
$\mathbf{y}(k)$
$\mathbf{f}, \mathbf{g}$: No Need in a Explicit Form
$\frac{\partial \mathbf{f}}{\partial \mathbf{x}}, \frac{\partial \mathbf{g}}{\partial \mathbf{x}}$: Not Necessary
2nd Order Approximation
Measurement Data
14


UKF to Vehicle Dynamics
$\mathbf{p}(k)$: unknown parameters : (μ, η, α)
$\mathbf{p}(k+1) = \mathbf{p}(k) + \mathbf{v}(k)$
$\mathbf{s}(k)$: measurement variable : (x, y, v, ω)
$\mathbf{s}(k+1) = g[\mathbf{p}(k)] + \mathbf{w}(k)$
g: Vehicle Dynamics
Equation of Motion with Nonlinear Algebraic Eq.
Initial
$\hat{\mathbf{p}}(0)$
$\hat{\mathbf{P}}(0)$
$\hat{\Phi}_i(k-1) = \hat{\mathbf{x}}(k-1) + \boldsymbol{\sigma}_{i,P}$
$\tilde{\boldsymbol{\Phi}}(k) = \hat{\boldsymbol{\Phi}}(k-1)$
UT
Predict
$\tilde{\mathbf{p}}(k) = \sum_{i=0}^{2n} h_i \tilde{\Phi}_i(k)$
$\mathbf{M}_k^{pp}(k) = \sum$
$\tilde{\Omega}_i(k) = \tilde{\mathbf{p}}(k) + \boldsymbol{\sigma}_{i,M}$
$\tilde{\boldsymbol{\Psi}}(k) = \mathbf{g}[\tilde{\boldsymbol{\Omega}}(k)]$
UT
Predict
$\tilde{\mathbf{s}}(k) = \sum_{i=0}^{2n} h_i \tilde{\Psi}_i(k)$
$\mathbf{M}_k^{ss}(k) = \sum$
$\mathbf{M}_k^{ps}(k) = \sum$
$k=k+1$
Update
$\hat{\mathbf{p}}(k) = \tilde{\mathbf{p}}(k) + \mathbf{K}(k)\mathbf{e}(k)$
$\mathbf{P}(k) = \mathbf{M}^{pp}(k) - \mathbf{K}(k)\mathbf{M}^{ss}(k)\mathbf{K}(k)^T$
$\mathbf{e}(k) = \mathbf{s}(k) - \tilde{\mathbf{s}}(k)$
$\mathbf{K}(k) = \mathbf{M}^{ps}(k)[\mathbf{M}^{ss}(k)]^{-1}$
Kalman Gain
$\mathbf{s}(k)$
Measurement Data
15


Numerical Experiments
Driving tests on a real road
Dec. 19 to 23, 2004
Local Trunk Line in Suburban Area
Driving along regular traffic flow
Measuring friction coefficient
Accelerating/Decelerating at intersection
Weather Condition Survey
16

Driving Experiments

Probe car

GPS

Moti on Sensor

Sensor	Components	Sampling Rate
Acceleration	ax: longitudial ay:lateral az:vertical	0.1sec
Angular speed	Rolling Pitching Yaw rate	
Wheel pulse	Front wheel Rear wheel	
GPS	Longitude Latitude GPS speed	1sec

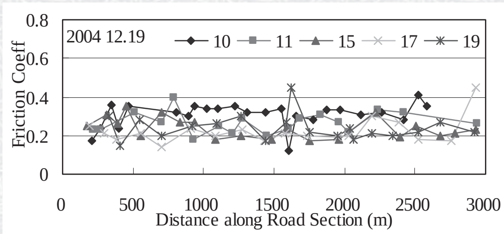
Skid tester

Direction	Date	Driving Conditions	
		Accelated	Decelerated
East-West	12/19	69	89
	12/20	19	35
	12/22	122	112
	12/23	104	94
West-East	12/19	56	82
	12/20	21	38
	12/22	90	122
	12/23	84	99
		565	671

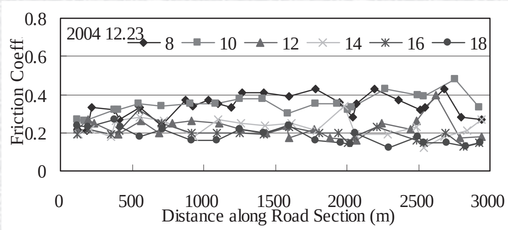
17

Road Surface Conditions

Dec. 19



Dec. 23



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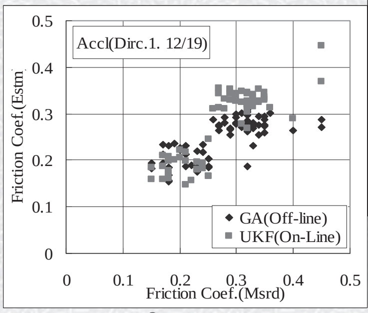
Comparison between UFK and GA

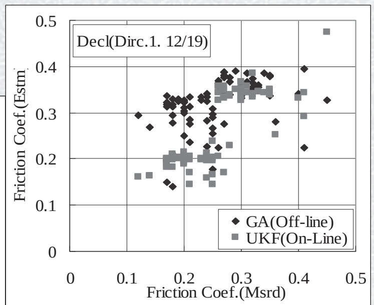
Dec. 19, East->west bound

69 datasets in accelerating



UKF R^2=0.73
GA R^2=0.71

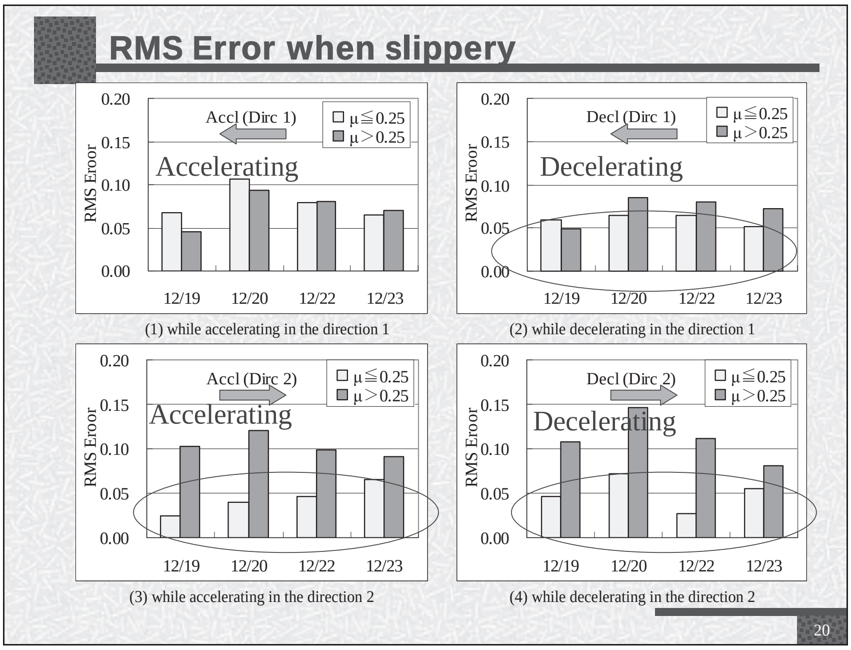
89 datasets in decelerating

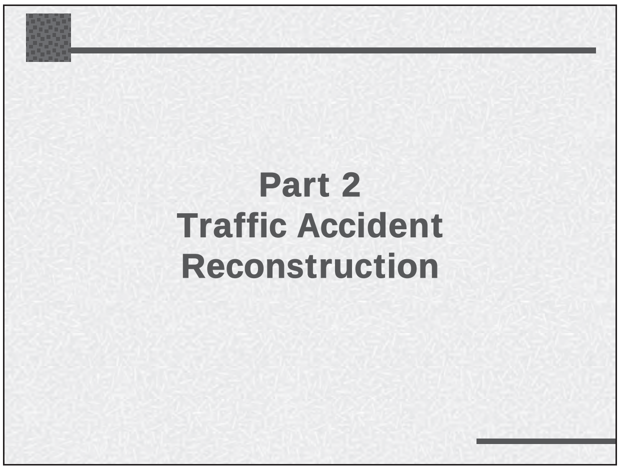


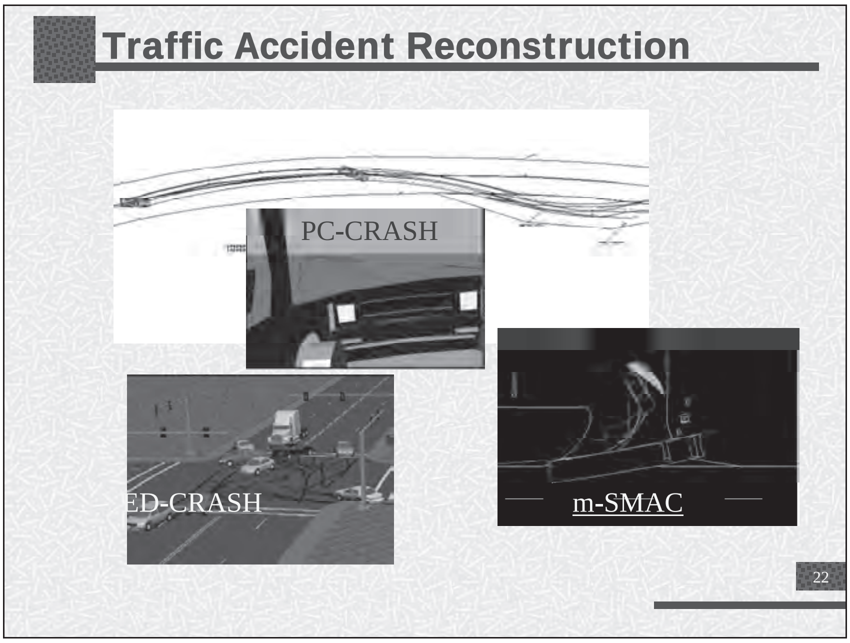
UKF R^2=0.62
GA R^2=0.17

Catch overall trend, but not yet for each dataset

19


RMS Error when slippery
RMS Eroor
0.20
0.15
0.10
0.05
0.00
Accl (Dirc 1)
μ≦0.25
μ＞0.25
Accelerating
12/19
12/20
12/22
12/23
(1) while accelerating in the direction 1
Decl (Dirc 1)
Decelerating
(2) while decelerating in the direction 1
Accl (Dirc 2)
Accelerating
(3) while accelerating in the direction 2
Decl (Dirc 2)
Decelerating
(4) while decelerating in the direction 2
20


Part 2
Traffic Accident
Reconstruction


Traffic Accident Reconstruction
PC-CRASH
ED-CRASH
m-SMAC
22

History

NHTSA (National Highway Traffic Safety Administration)

- 1960's Synthetic Approach for Traffic Accident Analysis
- 1970's **SMAC** and **CRASH3** (Damaged-Based Model)
- 1980's Open Source Code of **SMAC** and **CRASH3**
  EDSMAC (Damaged-Based Model)
- 1990's **m-SMAC, WinSMAC** (Damaged-Based Model)
  PC-CRASH (Momentum-Based Model)
  Animation, Graphic User Interface

JARI (Japan Automobile Research Institute)

- 1990's Ishikawa's Model
- 1990's CARS

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Traffic Accident Analysis

- **Pre-Impact Phase**
  Trajectory Model: Skid Mark, Initial Position, Speed,
- **Contact Phase**
  Collision Model
  ① Damage-Based
  ② Momentum-Based
- **Post-Impact Phase**
  Trajectory Model: Skid Mark, Rest Position & Direction

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Model Elements

- **Trajectory Model**
- **Collision Model**
- **Tire Model**
- **Steering Model**
- **Driver Model**
- **.....**

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Trajectory Model

- Kinematics Model

Resultant Acceleration

$$a = g \frac{\sum \mu_i F_{zi} B_i}{\sum F_{zi}}$$

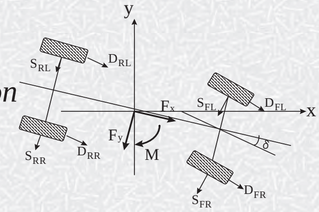
F_{zi} : Normal Load for each Wheel
μ_i : friction coefficientfor
B_i : Braking Factor

- **Kinetics Model**

Newton's Equation of Motion

$\cdot (x, y, z)\ \ (\varphi, \varphi, \theta)$

· Tire Forces



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Collision Model

- **Momentum-Based Model**

Conservation of Momentum

$$M_1 V_{10} + M_2 V_{20} = M_1 V_1 + M_2 V_2$$

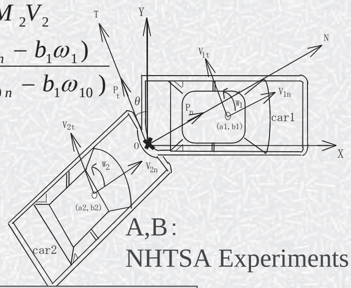
$$e_n = -\frac{(v_{2n} - b_2\omega_2) - (v_{1n} - b_1\omega_1)}{(v_{20n} - b_2\omega_{20}) - (v_{10n} - b_1\omega_{10})}$$

- **Damage-Based Model**

$\varDelta V = Ax + B$

$\varDelta V$: Speed Change

x : Permanent Damage



A,B :
NHTSA Experiments

①Period of Deformation
- Initial Impact to Maximum Deformation

②**Period of Restitution**
- Maximum to Permanent Deformation

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Reconstruction Tools

1. **Damaged-Based Model**
   - **m-SMAC / m-EDIT**
   - Win-SMAC
   - ED-SMAC
2. **Momentum Based Model**
   - **PC-CRASH**
   - Win-CRASH
   - ED-CRASH
   - CARS

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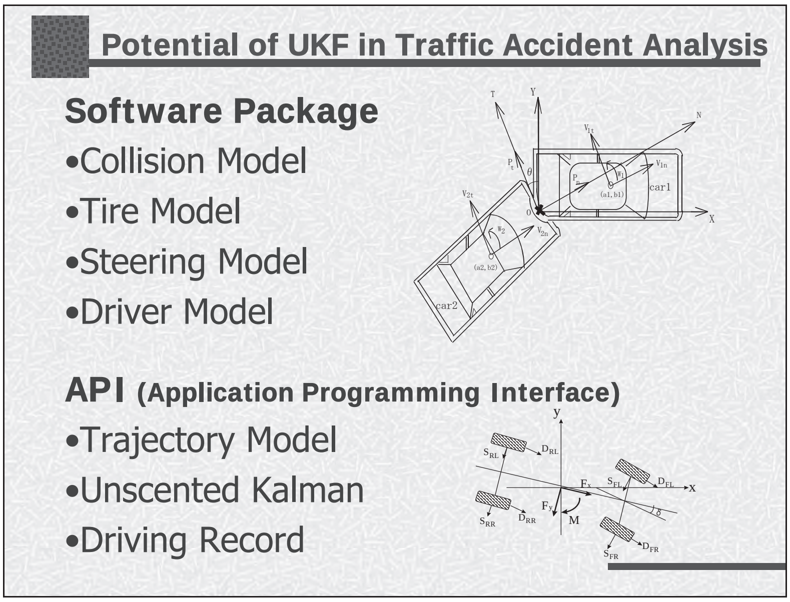
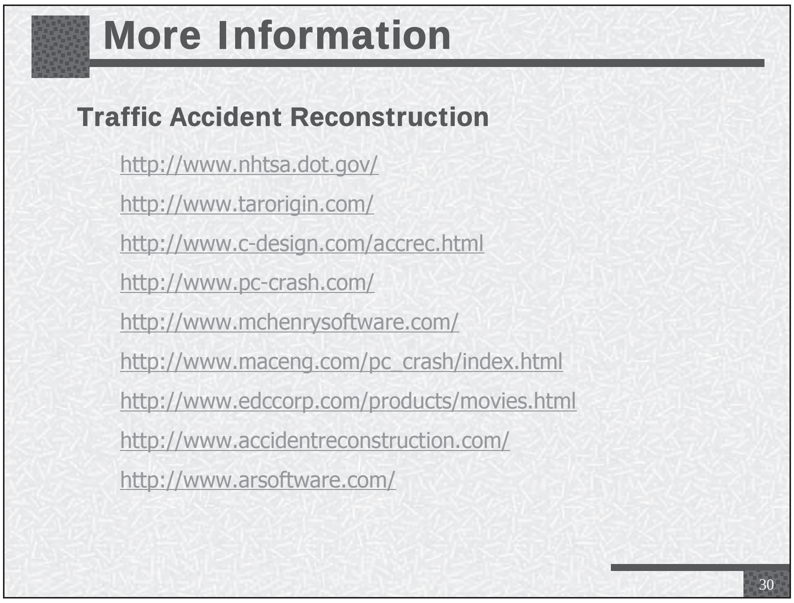

Potential of UKF in Traffic Accident Analysis
Software Package
•Collision Model
•Tire Model
•Steering Model
•Driver Model
API (Application Programming Interface)
•Trajectory Model
•Unscented Kalman
•Driving Record
car1
car2


More Information
Traffic Accident Reconstruction
http://www.nhtsa.dot.gov/
http://www.tarorigin.com/
http://www.c-design.com/accrec.html
http://www.pc-crash.com/
http://www.mchenrysoftware.com/
http://www.maceng.com/pc_crash/index.html
http://www.edccorp.com/products/movies.html
http://www.accidentreconstruction.com/
http://www.arsoftware.com/
30


Fin
Thank you!!
31

A Safety Analysis Based on Driver Decisions when Acquiring Signal Change Information

Dr. Hidekatsu Hamaoka

A SAFETY ANALYSIS BASED ON DRIVER DECISIONS WHEN ACQUIRING SIGNAL CHANGE INFORMATION

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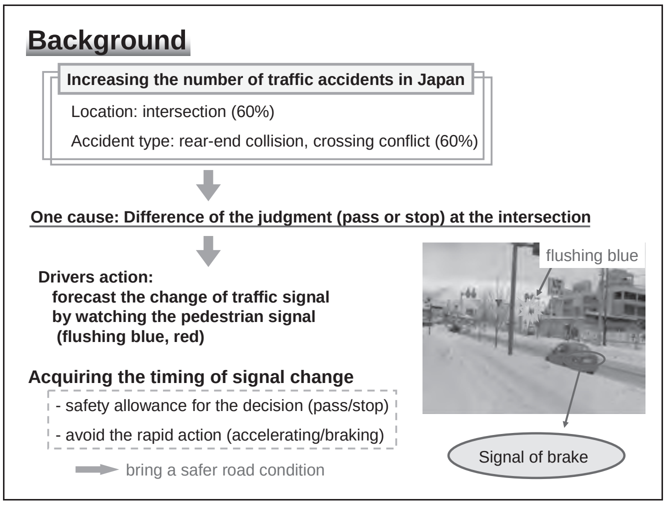
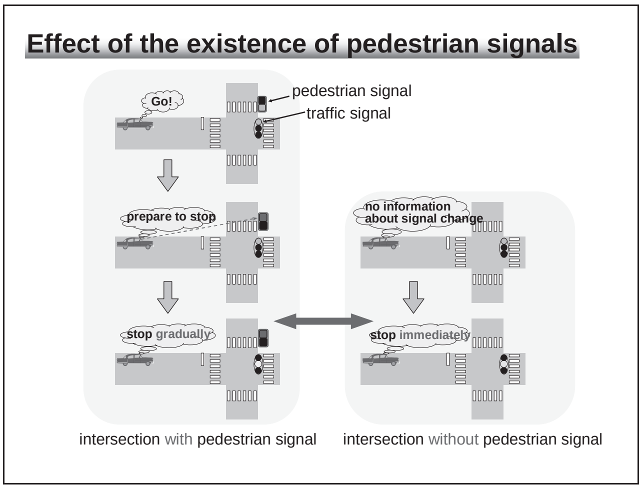
A Safety Analysis Based on Driver Decisions when Acquiring Signal Change Information

Workshop on Transportation Researches for Urban Safety

11 December 2008

HAMAOKA, Hidekatsu
Dept. of Civil and Environmental Engineering
Akita University, Japan





Objective

Evaluate the safety at the intersection by acquiring the signal change information

Vehicle movement at the real intersection

Compare the characteristics of the vehicle movement at the signal change to yellow

Driver decision in the laboratory experiment

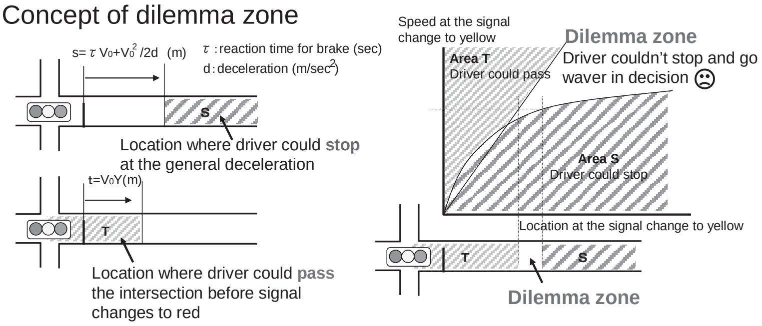
Driver decision when acquiring the signal change information

Compare the required behavior to avoid the hazardous situation

Safety at the signal change

Dilemma zone: hazardous area in the distance-speed diagram

Concept of dilemma zone



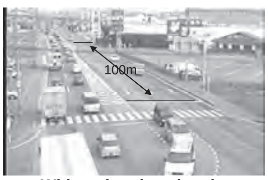
Forecasting the signal change

Avoidance to enter the dilemma zone
>> freedom from the waver in decision
allowance of time brings allowance for decision

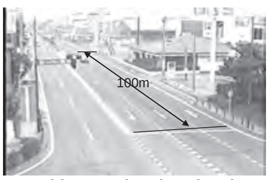
Outline of the survey

- record the vehicle movement at the intersection both with and without pedestrian signal
- select the vehicle that exists within the 100m toward the traffic signal

pedestrian signal	with pedestrian signal	without pedestrian signal
date	2005.6.22 / 7:00-9:00	2005.6.23 / 7:00-9:00 2005.6.27 / 17:00-19:00
weather / road condition	fine / dry	fine / dry
vehicle: pass / stop (total)	62 / 24 (86)	84 / 44 (128)
number of cycle	43	89

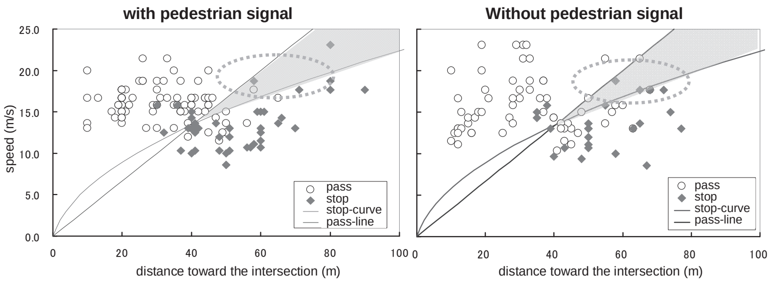


With pedestrian signal



Without pedestrian signal

Percentage to enter the dilemma zone



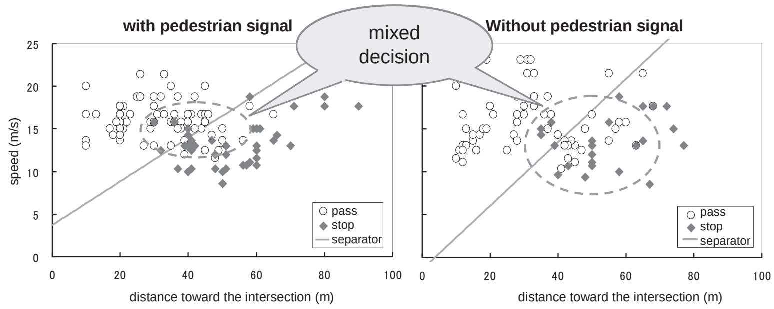
Percentage to enter the dilemma zone

num. of vehicle that enter the dilemma zone / num. of cycle	with ped-signal	<	without ped-signal
	0.03		0.11

pedestrian signal

higher percentage to escape the dilemma zone!!

Result of discriminant analysis



	with ped-signal	without ped-signal
Distance (D)	-0.1391	-0.1065
Speed (S)	0.5428	0.2875
Constant	-2.0123	0.3944
Hit-ratio	84.4%	75.6%
Slope (D/S)	0.37	0.25

Hit-ratio

with > without

smaller risk for traffic accident (with pedestrian signal)

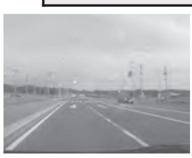
Laboratory Experiment of driver decision

【Purpose of experiment】
- compare the driver decision for each signal control
- subjects decide stop/pass in the dilemma zone

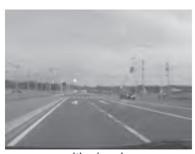
【Outline of experiment】

Date	2006.12.14～2006.12.21
	40 persons (30 males, 10 females), aged 20-24
s	without signal with signal countdown × 40km/h～80km/h (5 patterns) = Total: 15 pattern
Acquired data	・proceed/stop decision ・ease of decision ・decision time

Inform the time to change the traffic signal



without signal

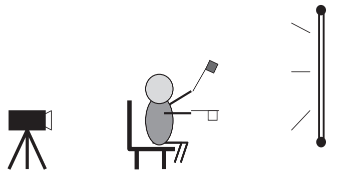


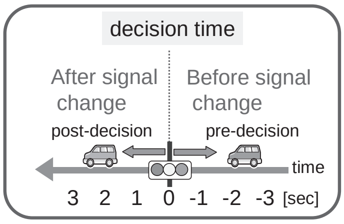
with signal

countdown

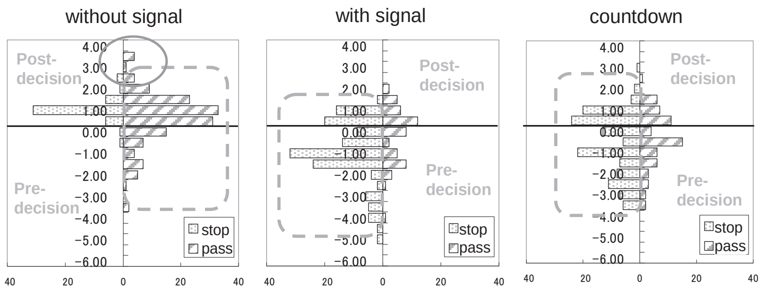
Method of experiment

- subjects hold two flags (red, white)
- subjects watch the screen that shows the passing scene at the intersection
- subjects raise the flag when he decide to stop (red) or pass (white)





Distribution of decision time



without signal: - many passes
- existence of late decision

with signal: } - many stops
countdown: } - earlier decision

Characteristics of subjects with late decision

Existence of subjects with late decision

Waver of decision brings severe situation in the dilemma zone

Characteristics of subjects with late decision

➡ **low-frequency driver!!**

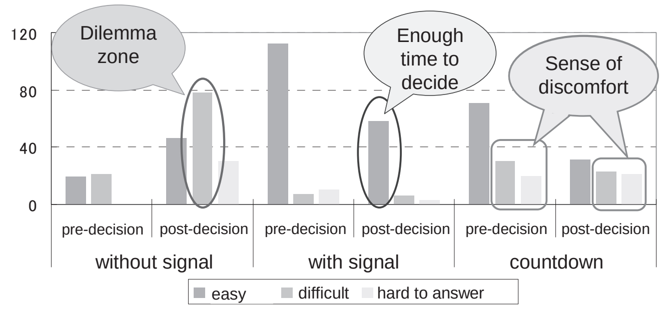
Ratio of low-frequency driver in the subjects with late decision

	None		Pedestrian signal		Countdown	
Decision time	Proceed	Stop	Proceed	Stop	Proceed	Stop
1s or more	16%	43%	43%	50%	33%	40%
2s or more	60%	50%	None		100%	100%
3s or more	75%					

○decision in the dilemma zone needs to have "experience of driving"
○subjects with late decision would decrease by confirming the pedestrian signal

➡ pedestrian signal have effect to make early decision for the "low-frequency driver"

Evaluation of the decision for each signal control

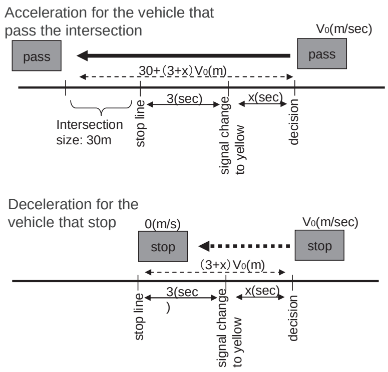


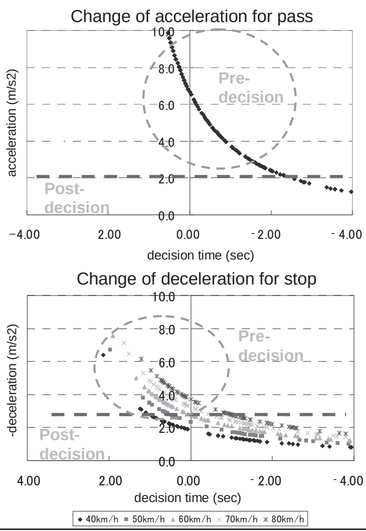
For the case of Post-decision

without signal: many sample of "**difficult**"
due to the dilemma zone
with signal: many sample of "**easy**"
enough time to decide
countdown: some sample of "**hard to answer**"
sense of discomfort by the video image

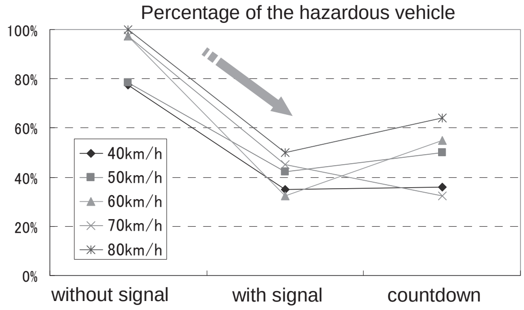
Evaluation of the driver decision by behavior

Calculate the required behavior by the decision time and the result of decision



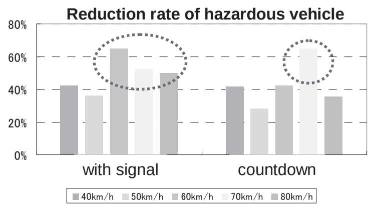


Evaluation of the driver decision by behavior



Information of signal change

decrease the number of hazardous vehicle



Reduction rate of hazardous vehicle compared to the "without signal"

➡ Higher rate for high-speed

Effective for the high-speed vehicle

Conclusion

Vehicle movement at the real intersection

Intersection with pedestrian signal

- smaller percentage to enter the dilemma zone
- easy-to-decide condition for stop/pass

Laboratory experiment of driver decision

Acquiring the signal information

- effect to make earlier decision for low-frequency driver
- user feel easy to decide because of having enough time to decide

→ Effect to avoid the hazardous situation by acquiring the signal information

Space Syntax Approach to Estimate the Risk of Traffic Accidents

Dr. Ryota Horiguchi

SPACE SYNTAX APPROACH TO ESTIMATE THE RISK OF TRAFFIC ACCIDENTS

RYOTA HORIGUCHI
i-Transport Lab. Co., Ltd.
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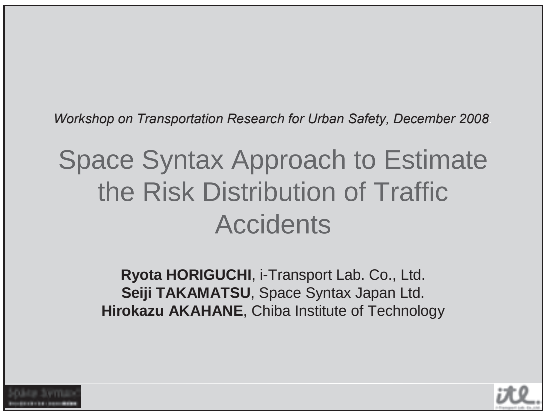
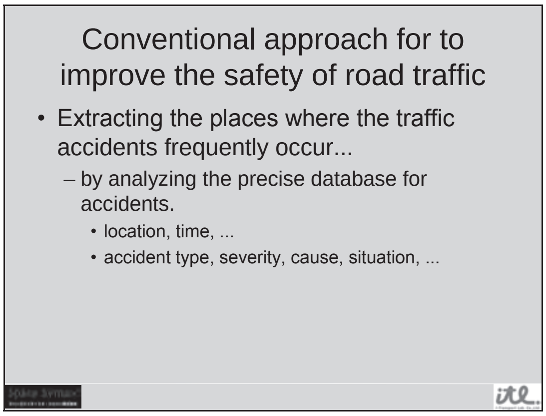
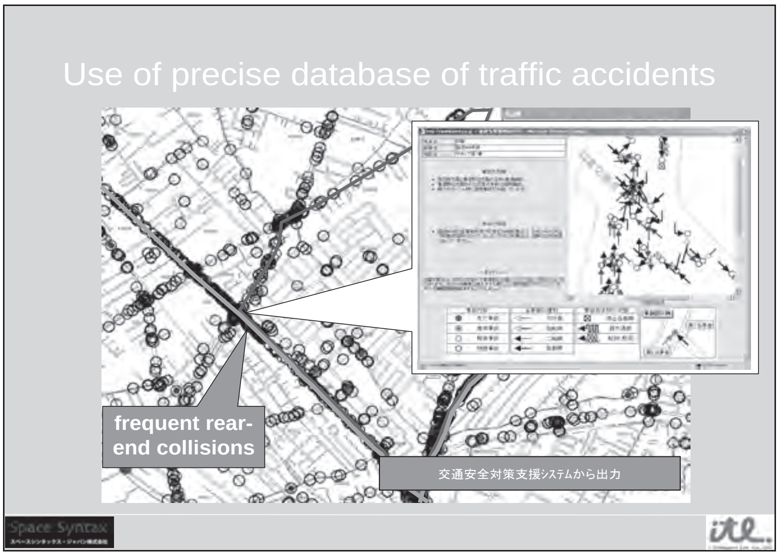
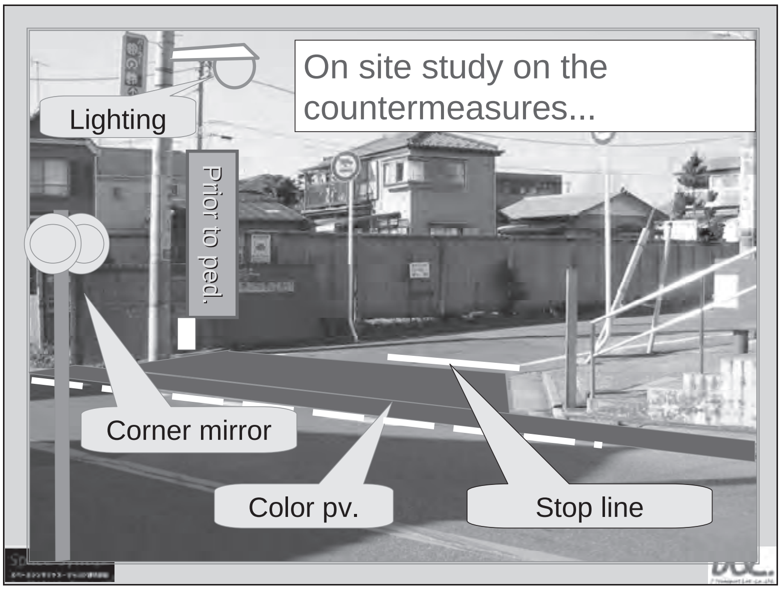








Problems

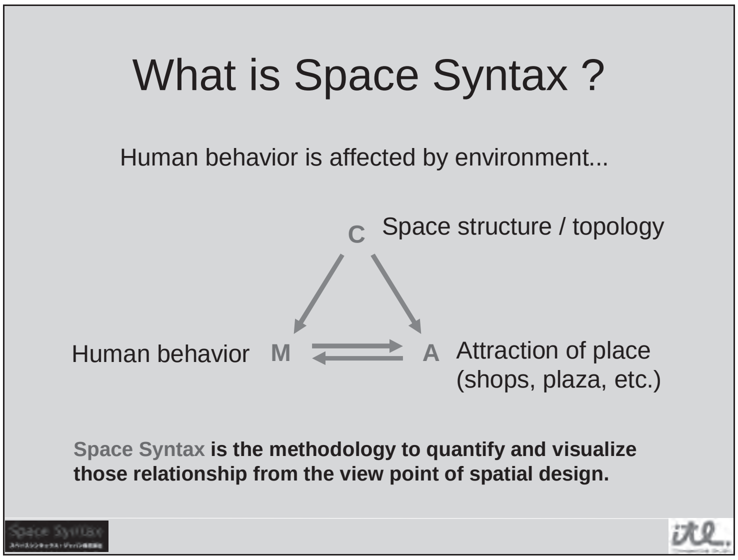
- Low accessibility of traffic accident data.
- Labor intensive work to build the database of traffic accident onto digital map.
  – inconsistency of location reference.

↓

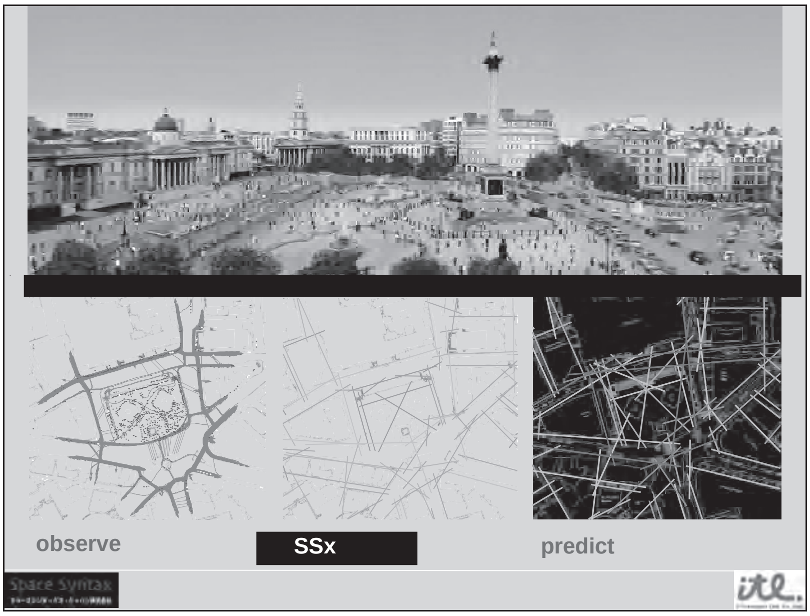
- Necessity for ‘less-laborious’ methodology to roughly estimate the dangerousness of each place.

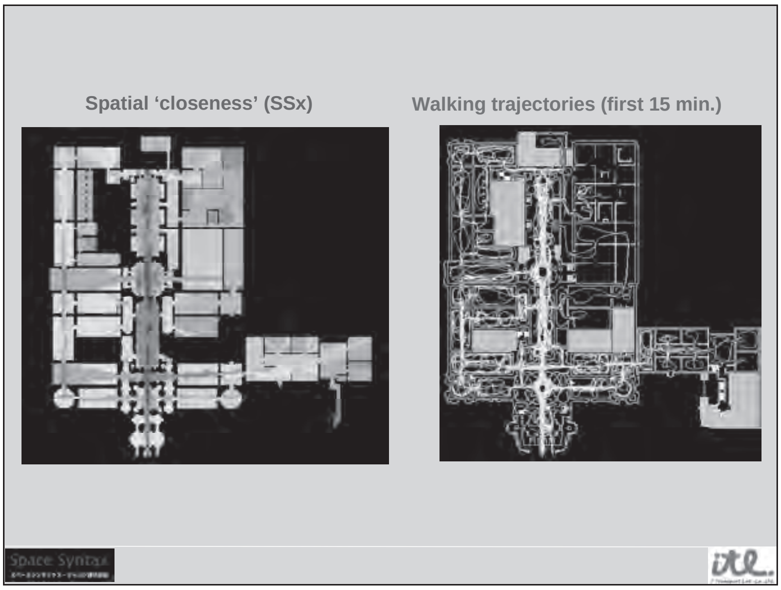
Objectives

- Estimate the risk of accidents possibly occurring on surface streets, in order to...
  – give the priority to the intersections for the improvement of geometry, installation of safe facilities, introduction of ITS for safety, etc.
  – only by using the accessible data which can be purchase in the market.
- with the estimation model using ‘Space Syntax’ indices developed for urban design.

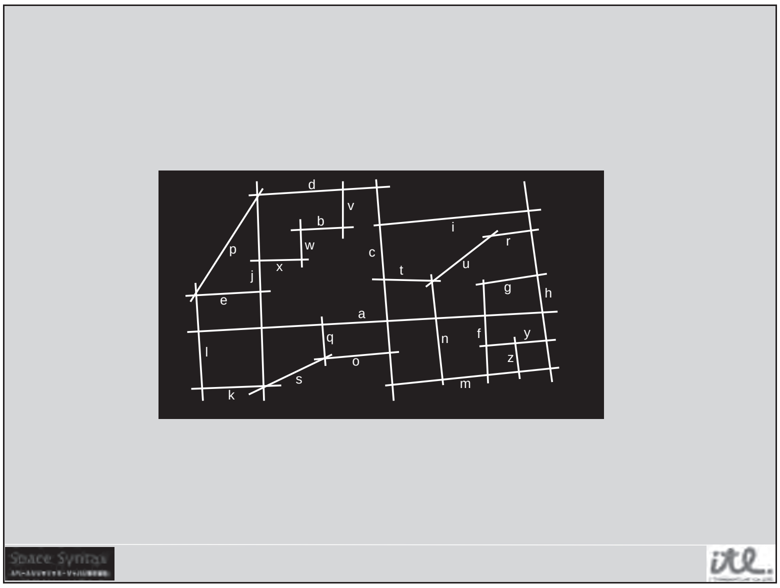

What is Space Syntax ?
Human behavior is affected by environment...
C
Space structure / topology
Human behavior
M
A
Attraction of place
(shops, plaza, etc.)
Space Syntax is the methodology to quantify and visualize those relationship from the view point of spatial design.
Space Syntax

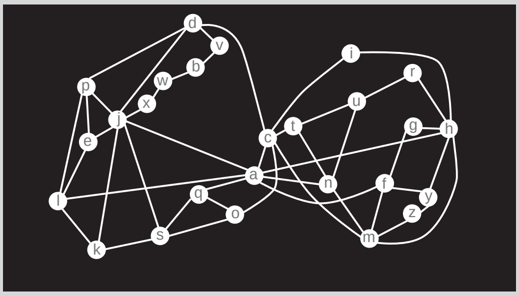

Easiness of access (SSx)
Ped. traffic (obs)
Space Syntax


observe
SSx
predict
Space Syntax

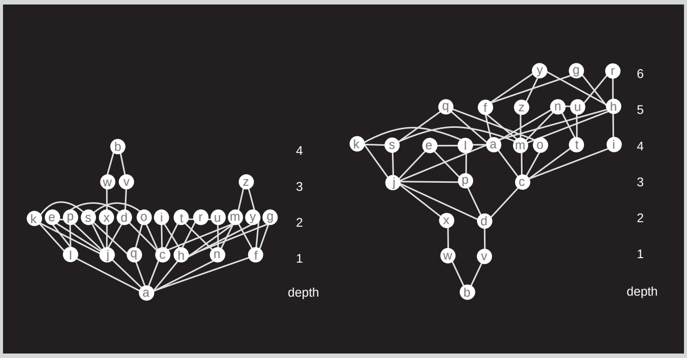

Spatial 'closeness' (SSx)
Walking trajectories (first 15 min.)
Space Syntax


Space Syntax


d
v
b
w
p
x
j
c
i
r
t
u
e
g
h
a
q
n
f
y
l
o
z
s
m
k
Space Syntax



Ex) SSx Depth

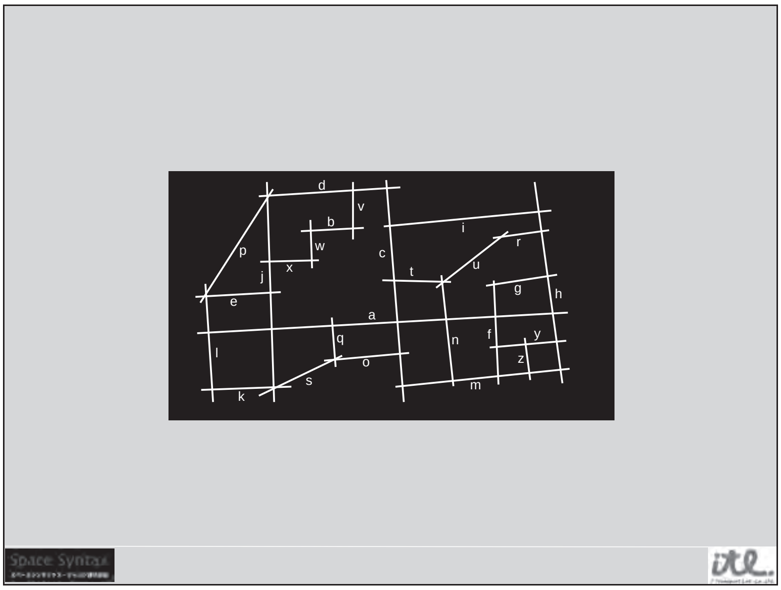


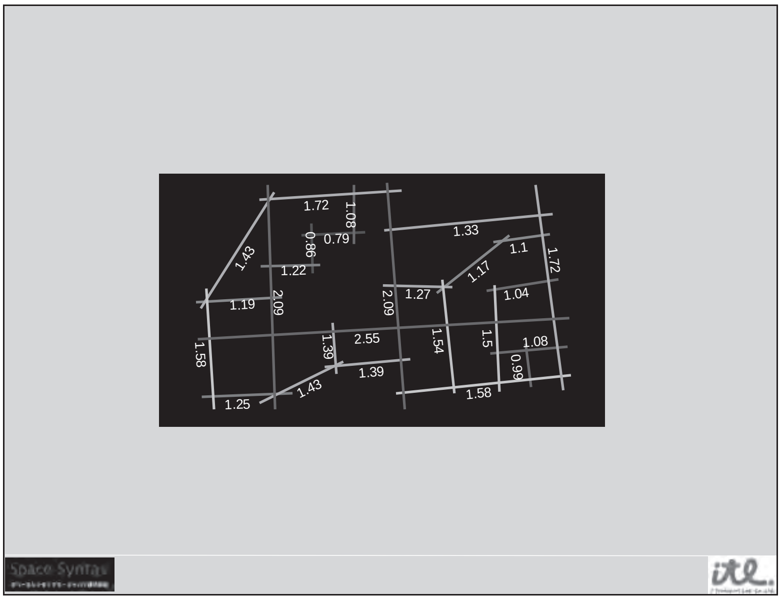
Ex) SSx Integration

$$\frac{\left[k \left\{ \log_2 \left(\frac{(k+2)}{3} - 1 \right) + 1 \right\} \right]}{\{ (MD-1)(k-1) \}}$$

k ･･･ number of segments

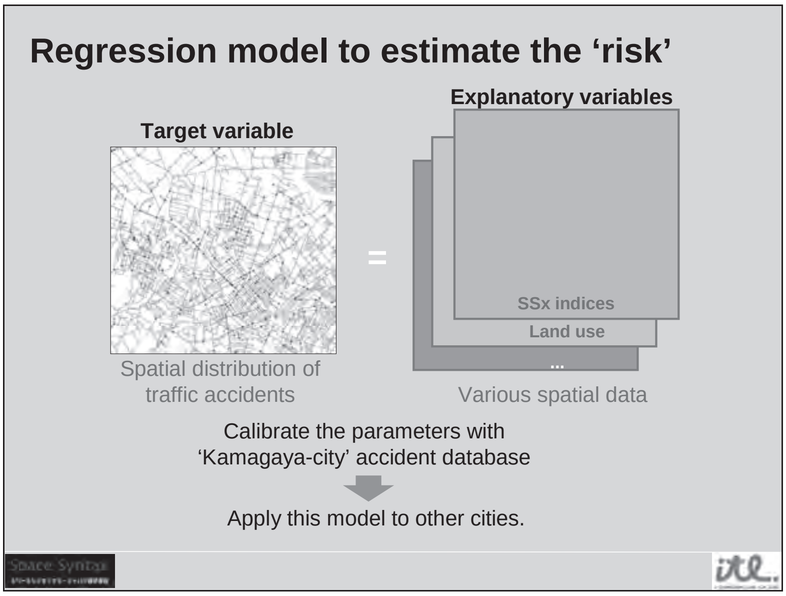
MD ･･･ Mean Depth

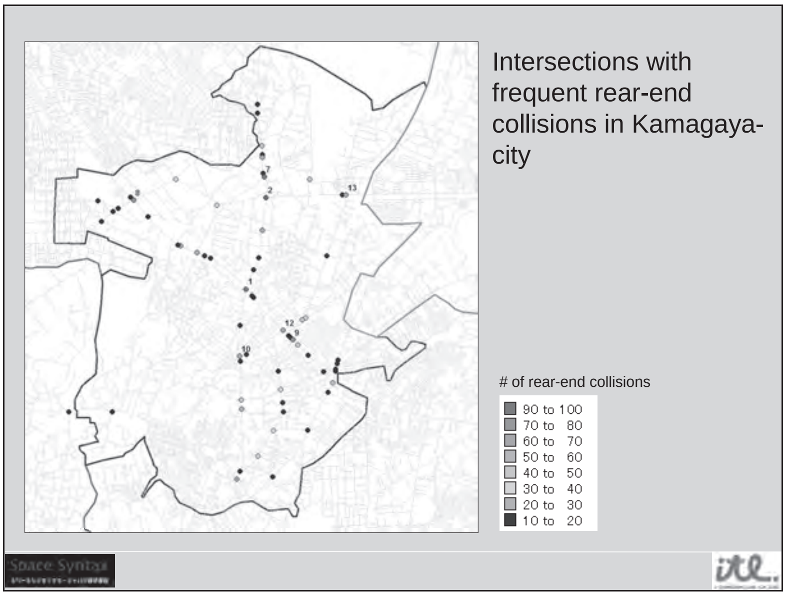

d
v
b
w
p
x
c
i
r
j
t
u
g
h
e
a
l
q
n
f
y
o
z
s
m
k
Space Syntax


1.72
1.08
0.86
0.79
1.33
1.43
1.1
1.72
1.22
1.17
1.19
2.09
2.09
1.27
1.04
1.58
1.39
2.55
1.54
1.5
1.08
0.99
1.39
1.43
1.58
1.25
Space Syntax


LONDON : Global (Rad=N) Integration
Space Syntax

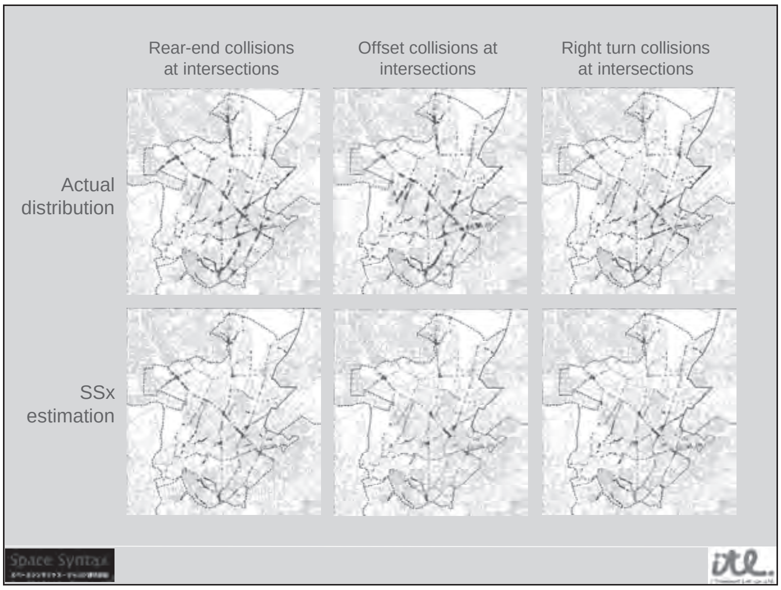

LONDON : Local (Rad=3) Integration

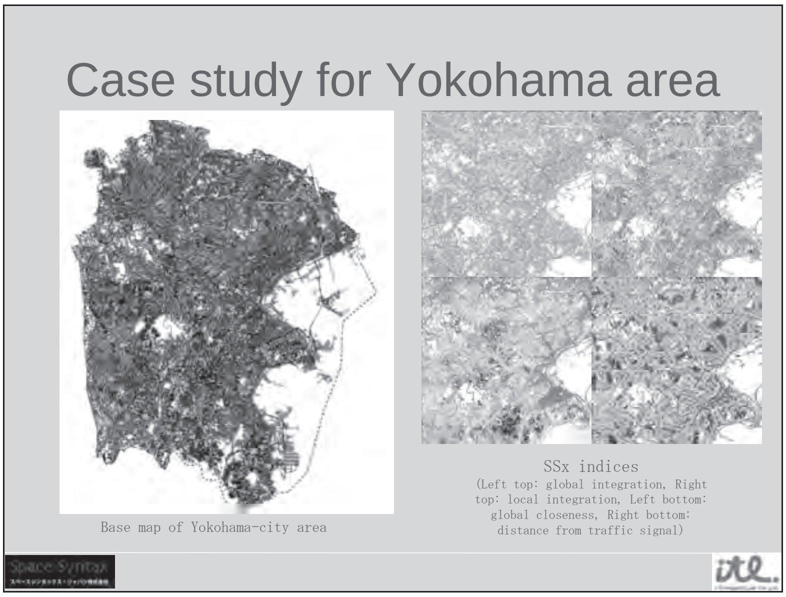

Regression model to estimate the 'risk'
Explanatory variables
Target variable
=
SSx indices
Land use
...
Spatial distribution of traffic accidents
Various spatial data
Calibrate the parameters with 'Kamagaya-city' accident database
Apply this model to other cities.

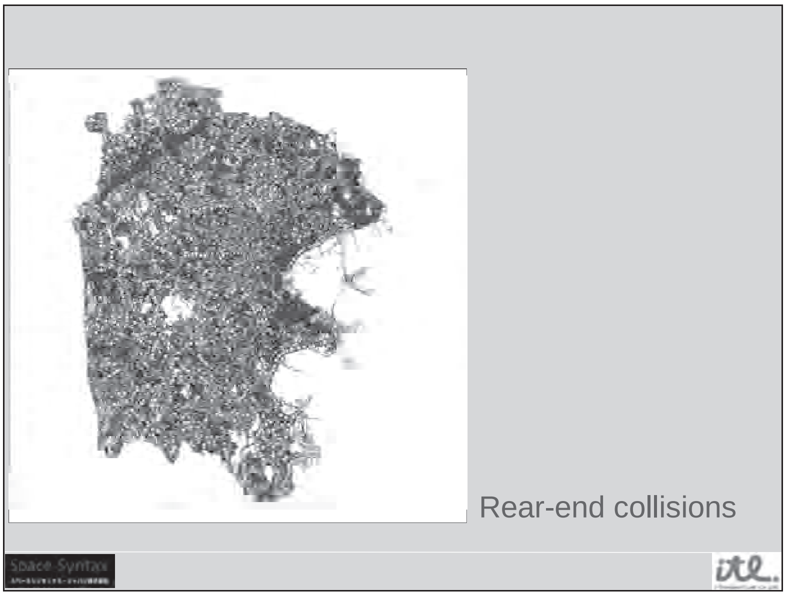

Intersections with frequent rear-end collisions in Kamagaya-city
# of rear-end collisions
90 to 100
70 to 80
60 to 70
50 to 60
40 to 50
30 to 40
20 to 30
10 to 20

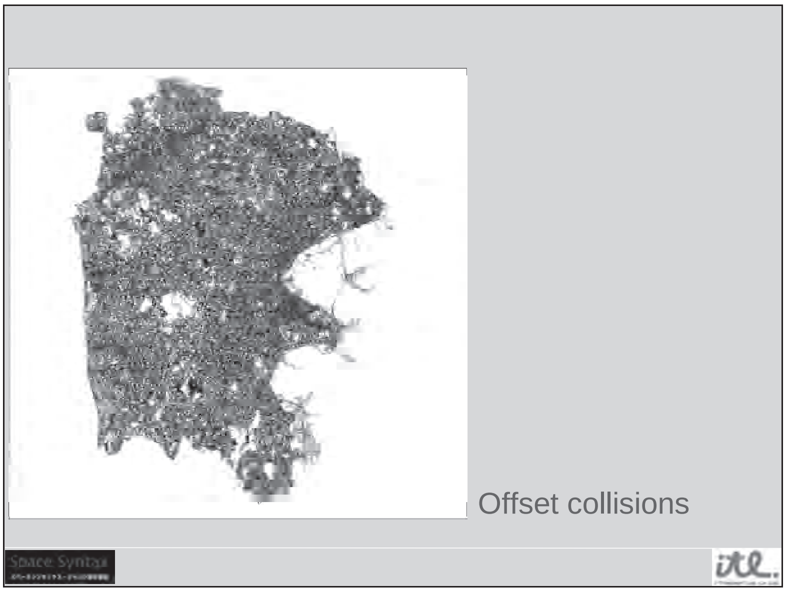

SSx: Global integration
with radius 5,000 meters

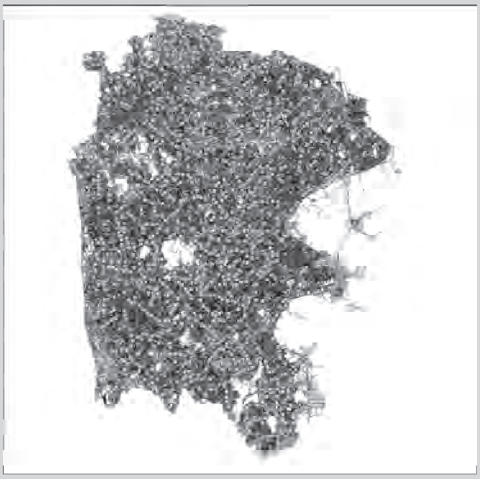

SSx: Global 'closeness'
with radius 5,000 meters


Rear-end collisions at intersections
Offset collisions at intersections
Right turn collisions at intersections
Actual distribution
SSx estimation

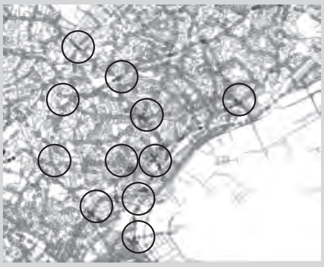

Case study for Yokohama area
Base map of Yokohama-city area
SSx indices
(Left top: global integration, Right top: local integration, Left bottom: global closeness, Right bottom: distance from traffic signal)


Rear-end collisions


Offset collisions



Right-turn collisions



Estimated risk distribution with SSx.

Points of frequent occurrence of traffic accident <www.kotsu-anzen.jp>

Conclusion

- Have developed the model estimating the spatial distribution of the risk for traffic accidents with Space Syntax indices.
  – no accident database.
  – no traffic count data.
  – only with the commercial products for spatial data, such as road network, land use, etc.

Many thanks!

i-Transport Lab. Co., Ltd.

www.i-transportlab.jp

AVENUE

an Advanced & Visual Evaluator
for road Networks in Urban arEas

Space Syntax Laboratory, UCL, London

www.spacesyntax.org

Space Syntax Limited, London

www.spacesyntax.com

Space Syntax Japan Ltd.

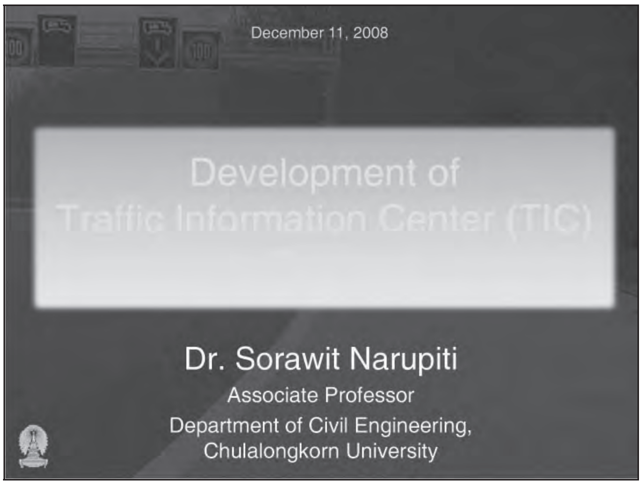
www.spacesyntax-japan.com

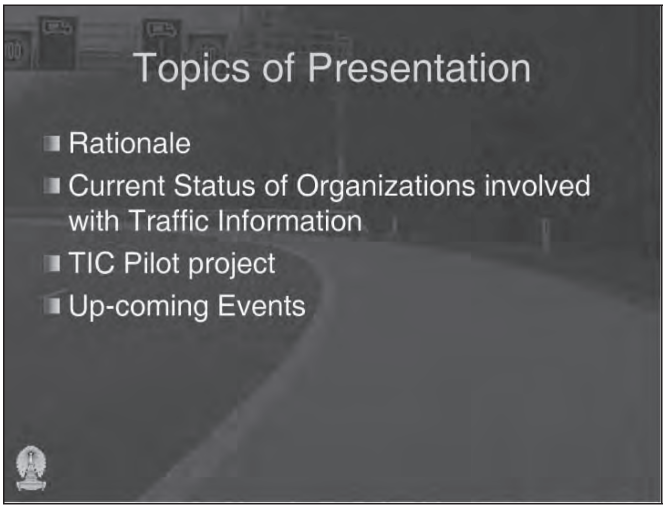
Development of Traffic Information Center in Bangkok

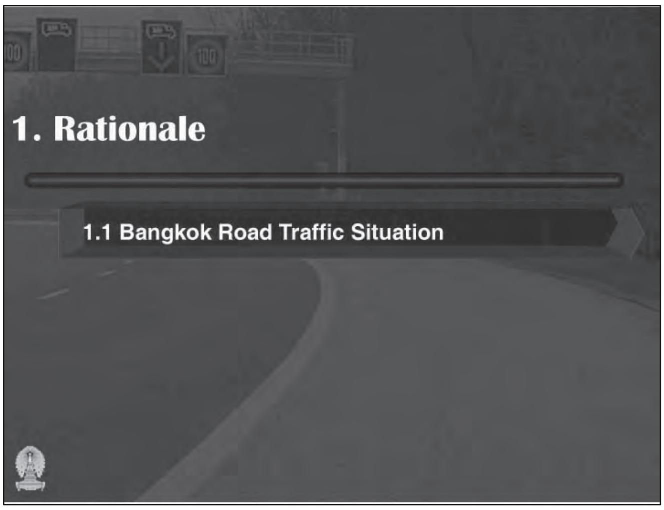
Dr. Sorawit Narupiti

DEVELOPMENT OF TRAFFIC INFORMATION CENTER IN BANGKOK

SORAWITH NARUPITI
Chulalongkorn University
kong@chula.ac.th







Traffic Congestion Problem in Bangkok

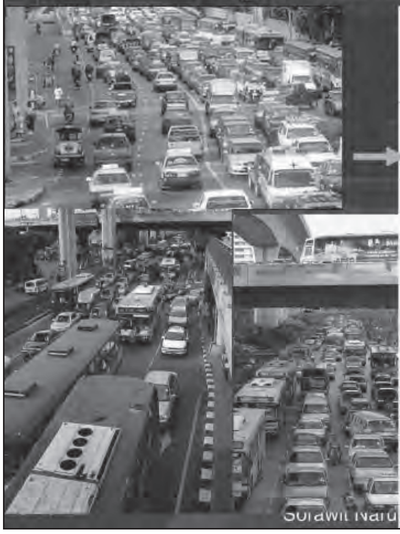


Table 1. Average Speeds of Travel in Selected APEC Cities, 1990

Average Speeds of Travel by Mode (km/h)

	Car	Train	Bus
Singapore	32.5	40.0	19.2
Hong Kong, China	23.7	40.2	18.4
Tokyo	24.4	39.6	12.0
Wealthy Asian Cities	27.5	39.9	16.5
Kuala Lumpur	29.4	...	16.3
Bangkok	13.1	34.0	9.0
Metro Manila	23.5	37.5	15.4
Jakarta	23.6	35.6	14.6
Developing Asian Cities	22.9	35.7	13.8
Portland	49.7	31.5	26.0
San Francisco	44.3	43.3	20.1
Los Angeles	45.0	...	19.9
San Diego	35.7	35.0	26.7
Houston	61.2	...	23.6
New York	38.3	39.0	18.8
US Cities	51.1	37.2	22.0
Vancouver	38.0	41.7	20.1
Toronto	35.0	30.9	20.3
Ottawa	40.0	...	24.0
Canadian Cities	39.8	33.3	21.1
Sydney	37.0	42.0	19.0
Melbourne	45.1	28.6	21.0
Brisbane	50.1	44.0	28.7
Adelaide	46.4	26.3	22.1
Perth	45.0	34.0	24.6
Australian Cities	43.5	35.0	25.0

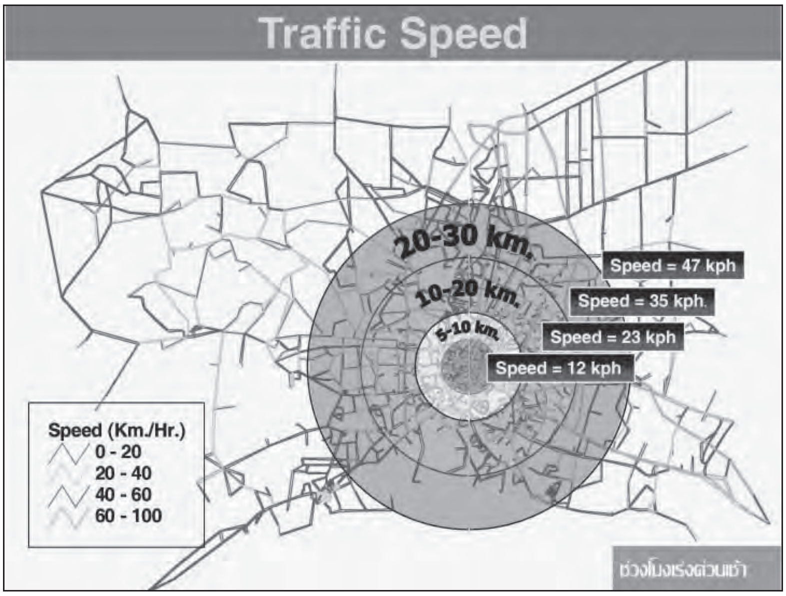
Source: Newman and Kenworthy, 1999, pp. 82-83.

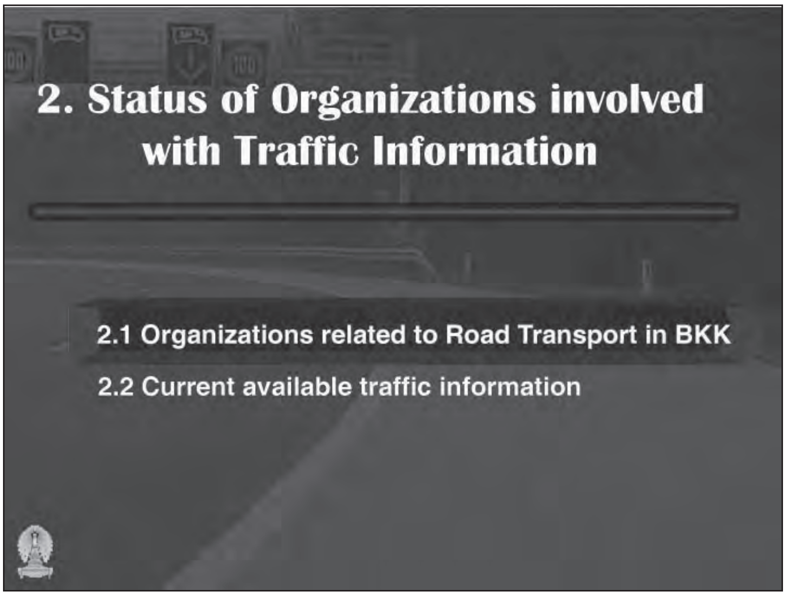
Traffic Condition in Bangkok....

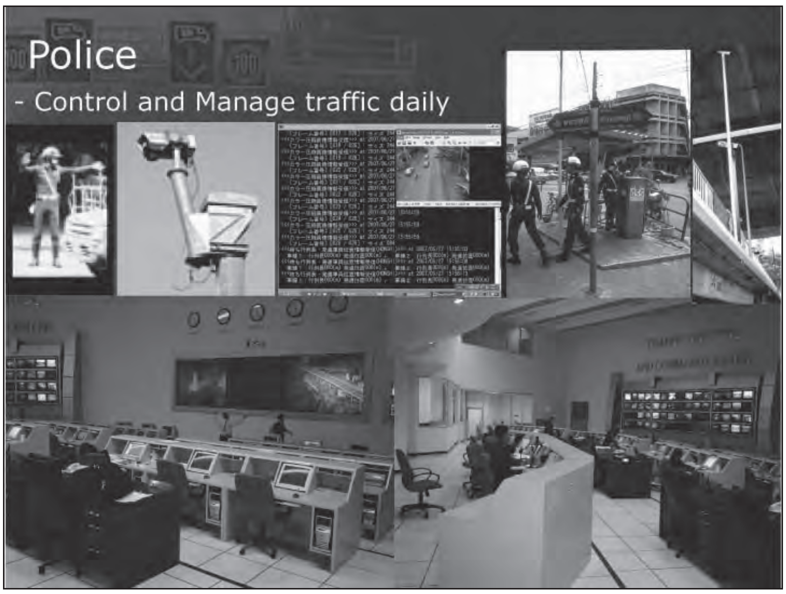
- Traffic Speed is low
- Unpredictable travel time
  - Reliability of travel time

How to get Better Travel Decision to get through traffic jam?

  - Accidents
  - VIP pass
  - Road Closure
- Events
  - Many major events affect traffic flow

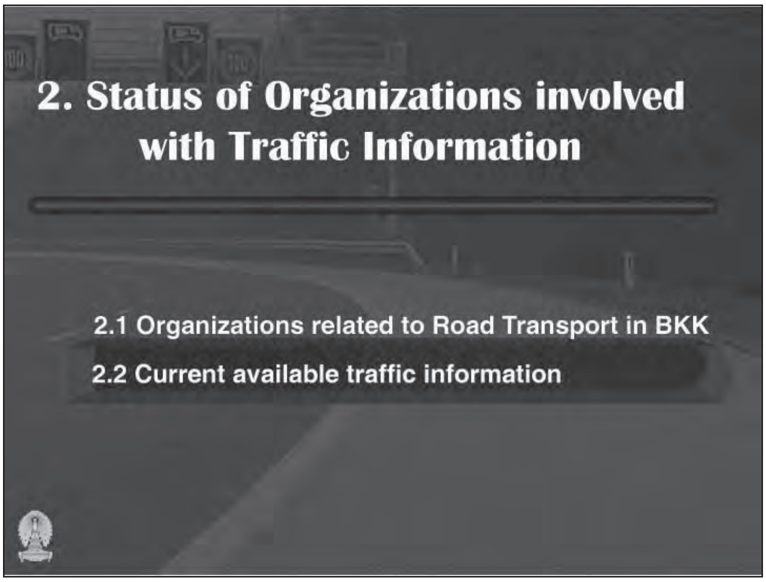

Traffic Speed
20-30 km.
10-20 km.
5-10 km.
Speed = 47 kph
Speed = 35 kph
Speed = 23 kph
Speed = 12 kph
Speed (Km./Hr.)
0 - 20
20 - 40
40 - 60
60 - 100
ช่วงโมงเร่งด่วนเช้า

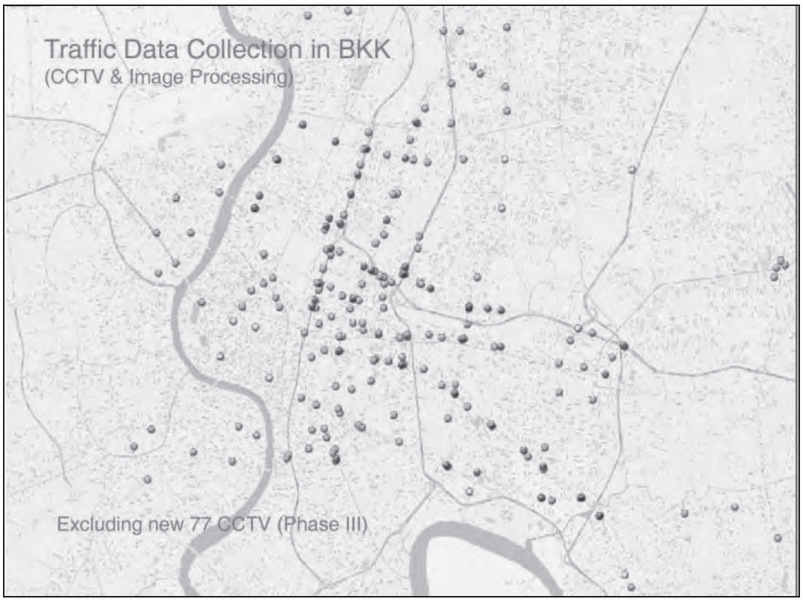

2. Status of Organizations involved with Traffic Information
2.1 Organizations related to Road Transport in BKK
2.2 Current available traffic information

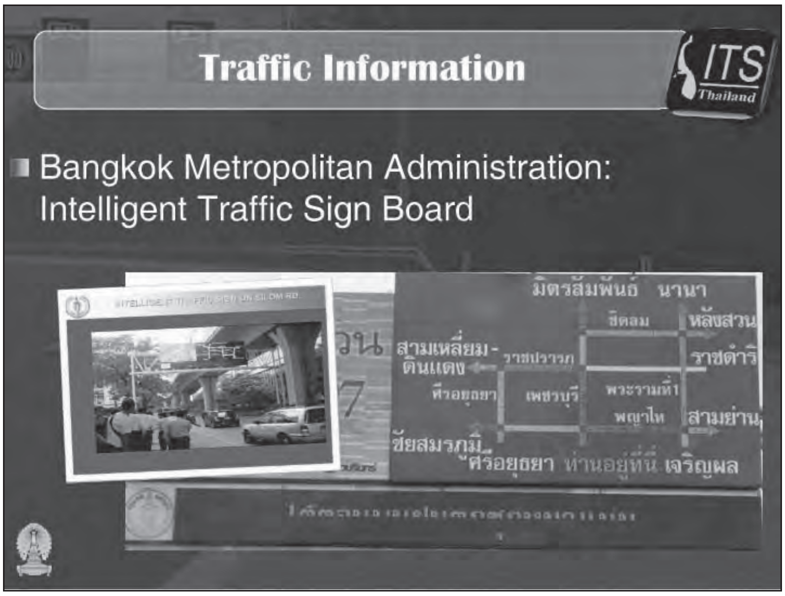

Police
- Control and Manage traffic daily

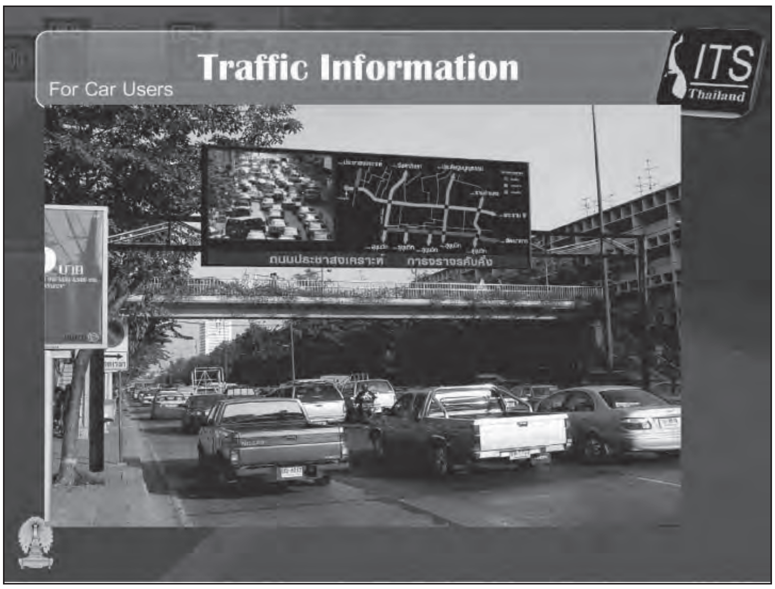

City of Bangkok
- Physical improvement and Signal operation

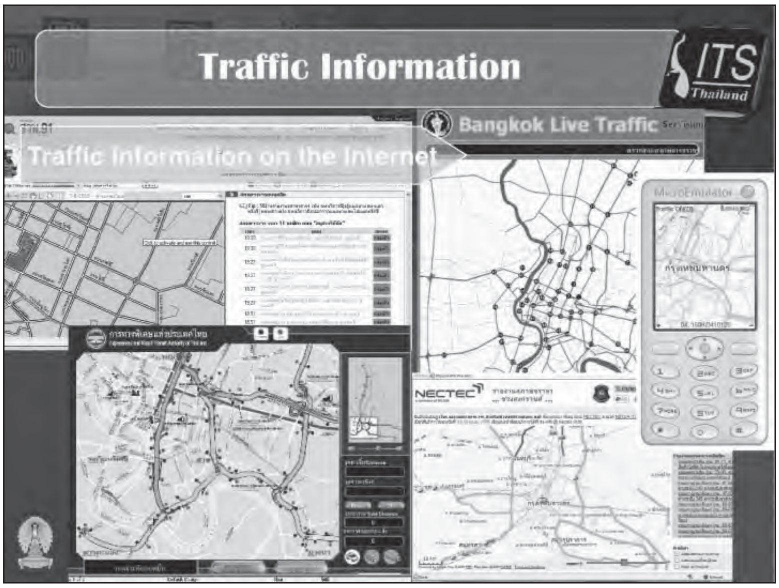

Ministry of Transport
-Some operating agencies; expressway authority
-Oversee and plan traffic condition


2. Status of Organizations involved with Traffic Information
2.1 Organizations related to Road Transport in BKK
2.2 Current available traffic information


Traffic Data Collection in BKK
(CCTV & Image Processing)
Excluding new 77 CCTV (Phase III)

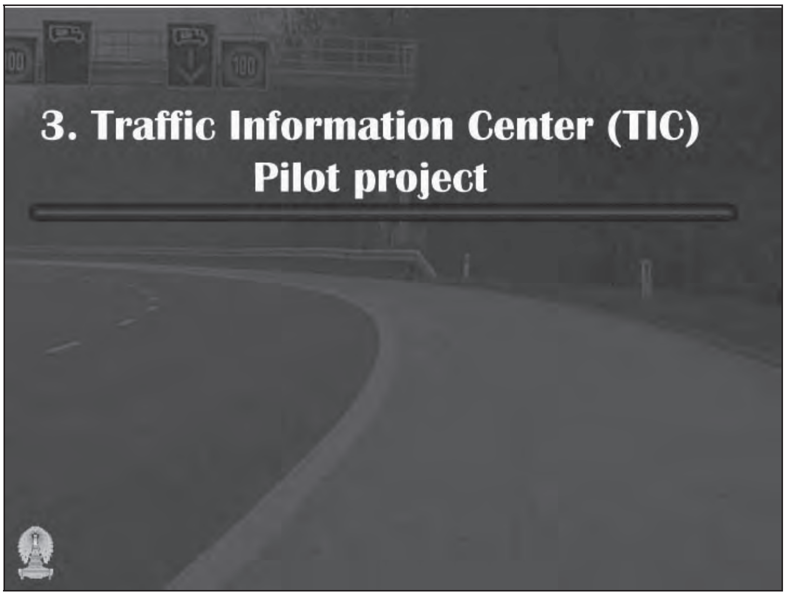

Traffic Information
ITS Thailand
Bangkok Metropolitan Administration: Intelligent Traffic Sign Board
มิตรสัมพันธ์ นานา
ชิดลม หลังสวน
สามเหลี่ยม-ดินแดง ราชปรารภ ราชดำริ
ศรีอยุธยา เพชรบุรี พระรามที่1
พญาไท สามย่าน
ชัยสมรภูมิ ศรีอยุธยา ห้างอยู่ที่นี่ เจริญผล

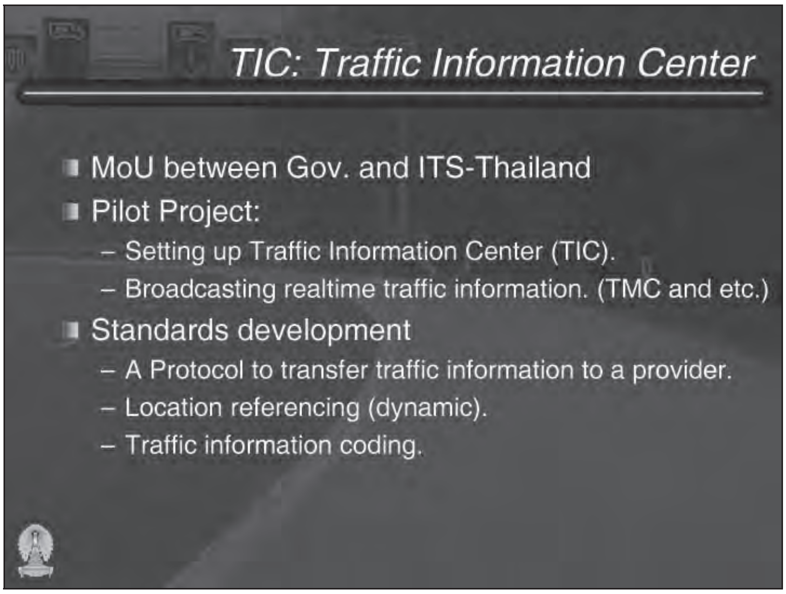

Traffic Information
For Car Users
ITS Thailand
ถนนประชาสงเคราะห์ การจราจรคับคั่ง

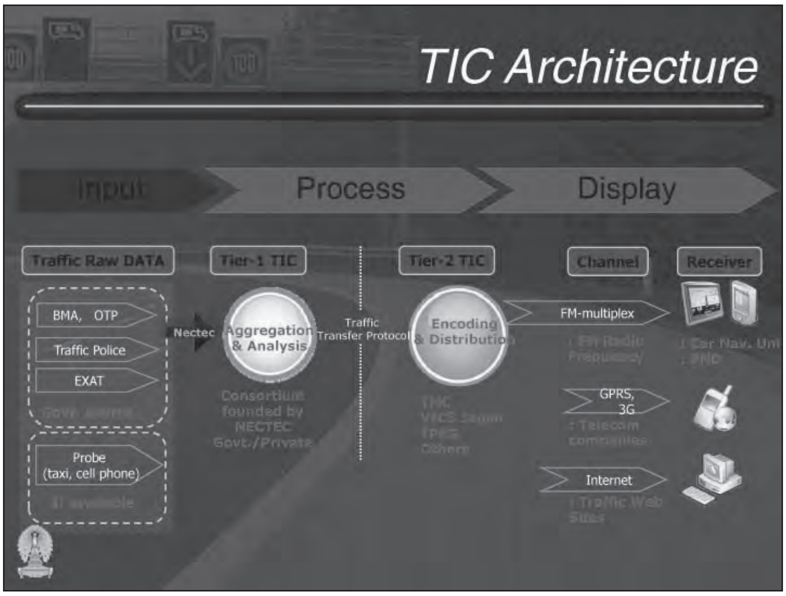

Traffic Information
ITS Thailand
Bangkok Live Traffic
Traffic Information on the Internet
MicroEmulator
NECTEC

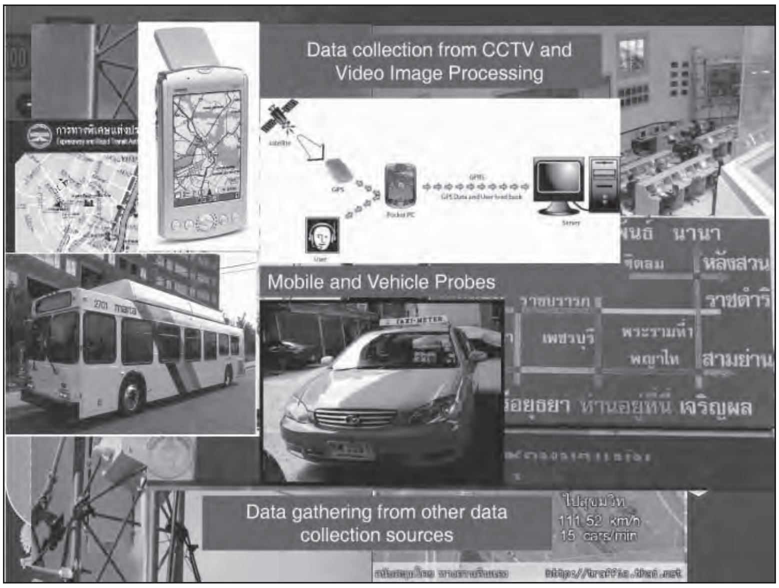

NECTEC: www.traffic.thai.net
NECTEC
รายงานสภาพจราจร
... ช่วงสงกรานต์ ...
กรุงเทพมหานคร
สมุทรปราการ
10 km

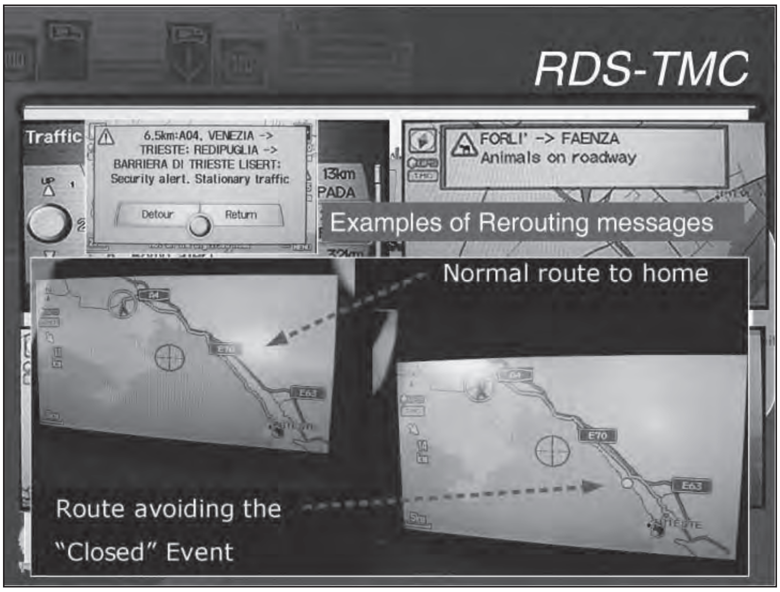

Expressway Traffic Information
ITS Thailand
การทางพิเศษแห่งประเทศไทย
Expressway and Rapid Transit Authority of Thailand

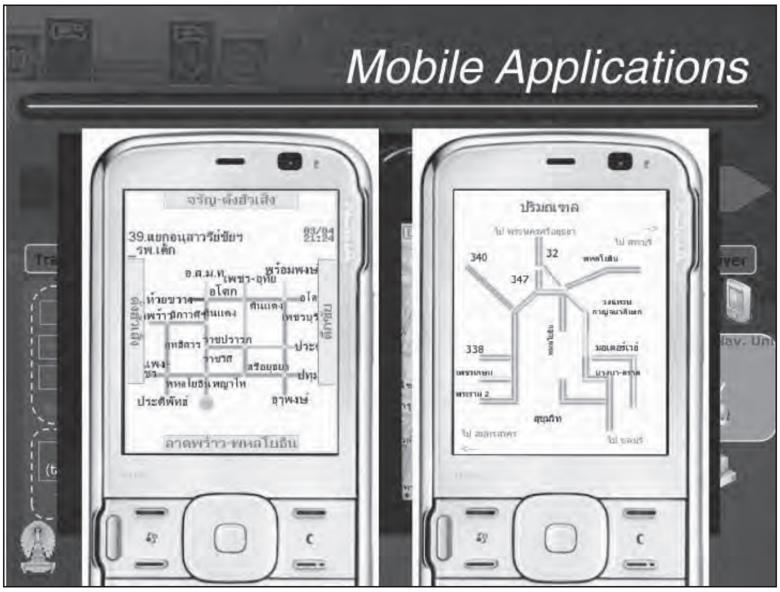

3. Traffic Information Center (TIC)
Pilot project

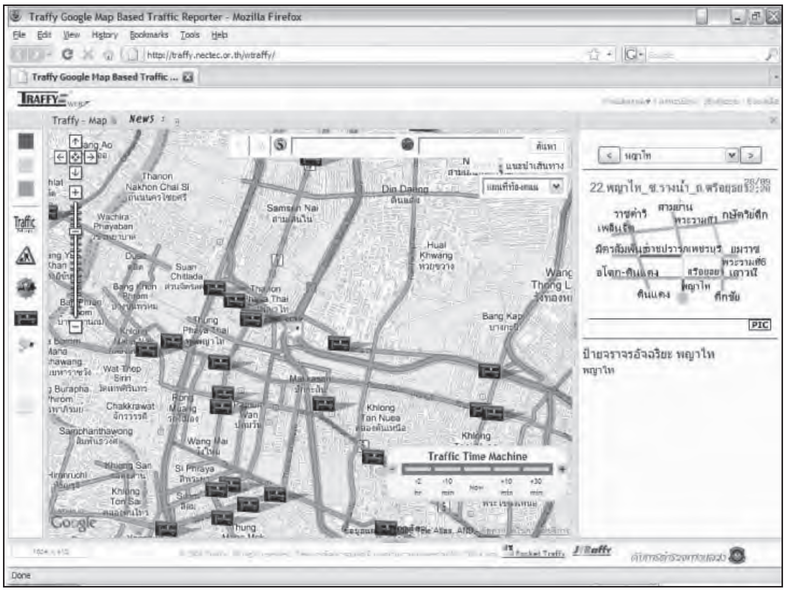

TIC: Traffic Information Center
MoU between Gov. and ITS-Thailand
Pilot Project:
– Setting up Traffic Information Center (TIC).
– Broadcasting realtime traffic information. (TMC and etc.)
Standards development
– A Protocol to transfer traffic information to a provider.
– Location referencing (dynamic).
– Traffic information coding.


TIC Architecture
Input
Process
Display
Traffic Raw DATA
Tier-1 TIC
Tier-2 TIC
Channel
Receiver
BMA, OTP
Traffic Police
EXAT
Probe
(taxi, cell phone)
Nectec
Aggregation & Analysis
Consortium founded by NECTEC Govt./Private
Traffic Transfer Protocol
Encoding & Distribution
FM-multiplex
GPRS, 3G
: Telecom companies
Internet


Data collection from CCTV and
Video Image Processing
Mobile and Vehicle Probes
Data gathering from other data
collection sources
111.52 km/h
15 cars/min

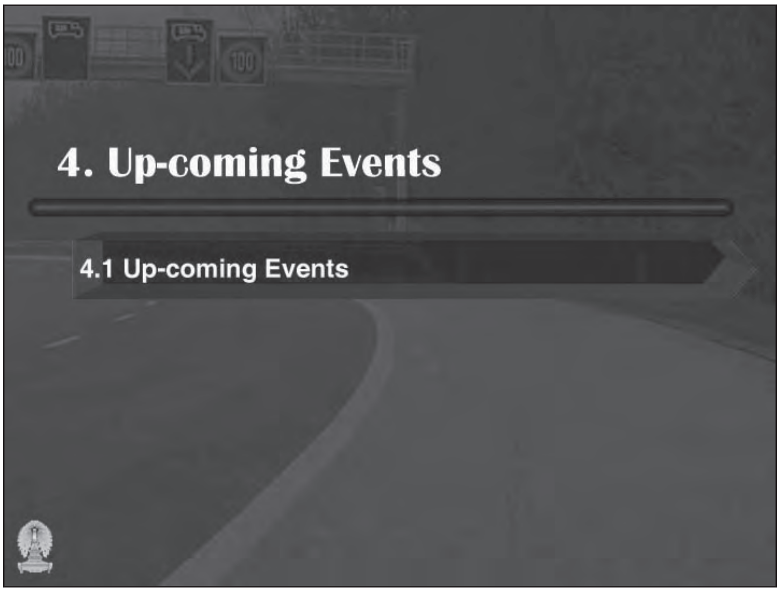

RDS-TMC
Traffic
6.5km:A04. VENEZIA ->
TRIESTE: REDIPUGLIA ->
BARRIERA DI TRIESTE LISERT:
Security alert. Stationary traffic
Detour
Return
FORLI' -> FAENZA
Animals on roadway
Examples of Rerouting messages
Normal route to home
Route avoiding the
"Closed" Event


Mobile Applications


Traffy Google Map Based Traffic Reporter - Mozilla Firefox
Traffic Time Machine


What will be implemented soon?
Traveler Information : Enhanced Driver's information and go multimodal


What will be implemented soon?
Popular and add more feature (parking)
Traffic Management


4. Up-coming Events
4.1 Up-coming Events


Bangkok 2009
10th AP ITS Forum
Welcome to Bangkok
ITS Thailand
TAIA
NECTEC


SMART MOVE - ITS 2009
8-10 July 2009 | Queen Sirikit Convention Center
Venue Queen Sirikit National Convention Center
Conference Expected 500 delegates
Exhibition Expected 50 companies over 3,100 sqm gross area
http://its-ap2009.in.th


24
SMART MOVE - ITS 2009
10th ITS Asia Pacific
8-10 July 2009 | Queen Sirikit Convention Center
http://its-ap2009.in.th


24
SMART MOVE - ITS 2009
10th ITS Asia Pacific
8-10 July 2009 | Queen Sirikit Convention Center
See You In THAILAND
http://its-ap2009.in.th

Incident Detection Based on Short-Term Travel Time Forecasting

Dr. Agachai Sumalee

INCIDENT DETECTION BASED ON SHORT-TERM TRAVEL TIME FORECASTING

DR. AGACHAI SUMALEE
Hong Kong Polytechnic University
http://www.cse.polyu.edu.hk/~ceasumal/
ceasumal@polyu.edu.hk

ABSTRACT

Prediction of short-term future traffic condition is an important element for route guidance and incident management systems. In this presentation, a solution algorithm is proposed for short-term travel time forecasting in congested urban roads of Hong Kong. The travel times at the next 5-minute interval are predicted by using the historical travel time estimates together with their updated temporal variance-covariance relationships. The territory-wide historical travel time database is generated by the real-time travel information system (RTIS) using the automatic vehicle identification data available in Hong Kong. Based on the travel time forecasts and the RTIS travel time estimates, traffic incident can be detected by comparing their differences on the road section before and after the incident. Case studies are presented to evaluate the performance of the proposed algorithms for short-term travel time prediction and incident detection, respectively.

Incident Detection based on Short-term Travel Time Forecasting

1

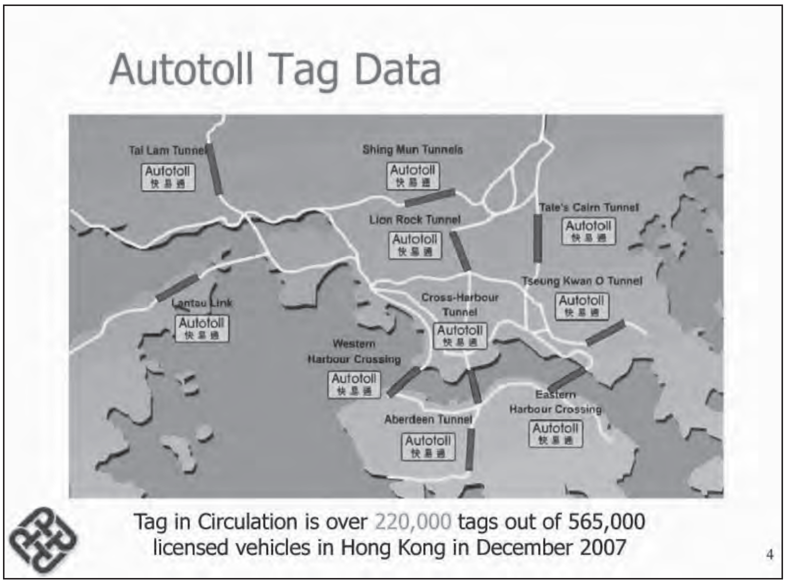
Outline

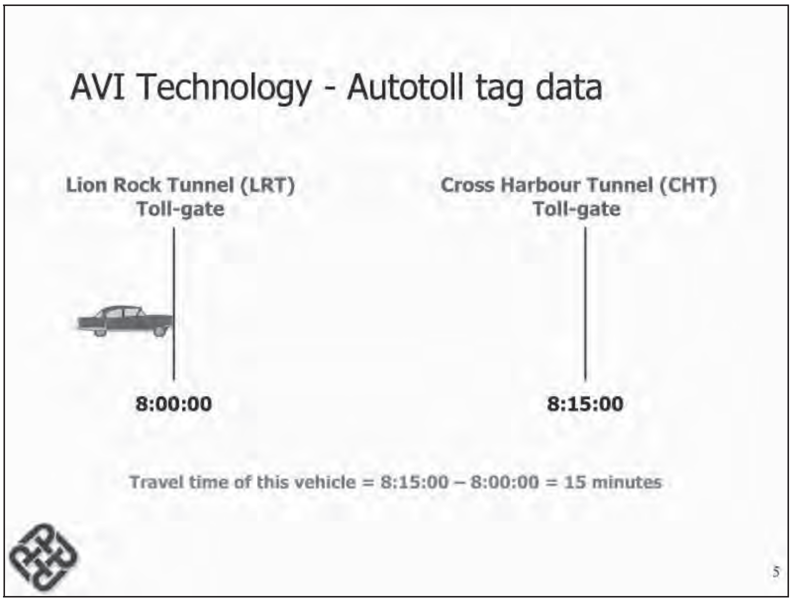
1. Background of RTIS system;
2. Objectives;
3. Proposed algorithms for short-term travel time prediction and incident detection
4. Case studies; and
5. Conclusions and further study.
6. Current development for Bangkok system

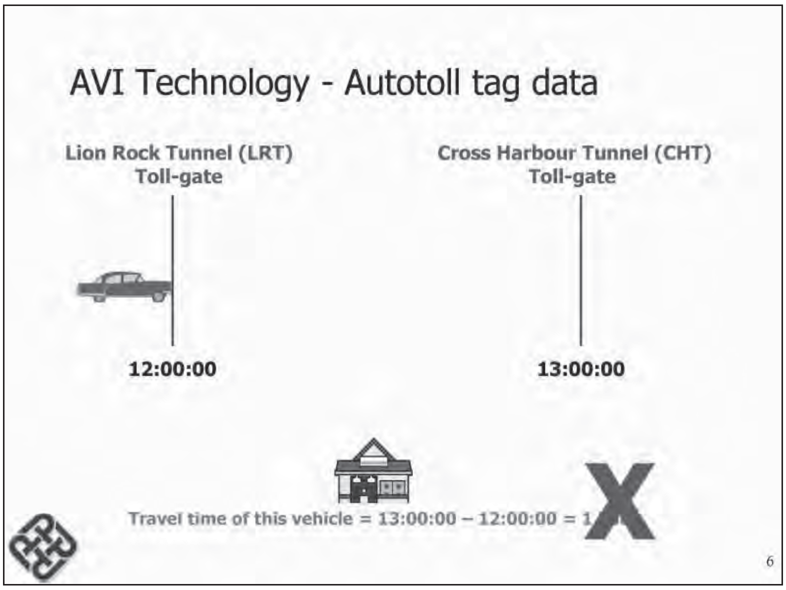
2

Automatic Vehicle Identification (AVI) Technology

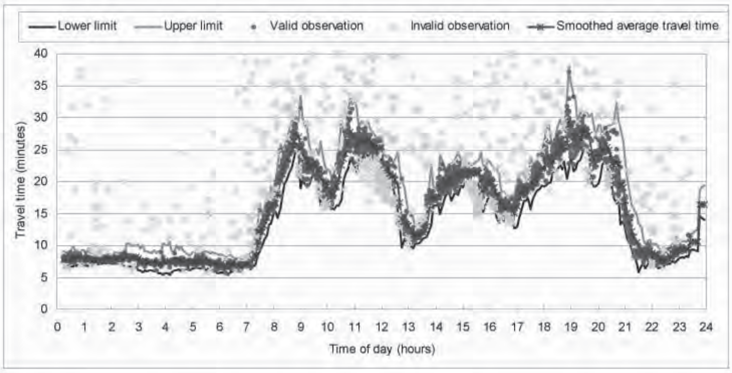
3


Autotoll Tag Data
Tai Lam Tunnel
Shing Mun Tunnels
Lion Rock Tunnel
Tate's Cairn Tunnel
Tseung Kwan O Tunnel
Cross-Harbour Tunnel
Lantau Link
Western Harbour Crossing
Eastern Harbour Crossing
Aberdeen Tunnel
Autotoll 快易通
Tag in Circulation is over 220,000 tags out of 565,000 licensed vehicles in Hong Kong in December 2007
4


AVI Technology - Autotoll tag data
Lion Rock Tunnel (LRT) Toll-gate
Cross Harbour Tunnel (CHT) Toll-gate
8:00:00
8:15:00
Travel time of this vehicle = 8:15:00 – 8:00:00 = 15 minutes
5

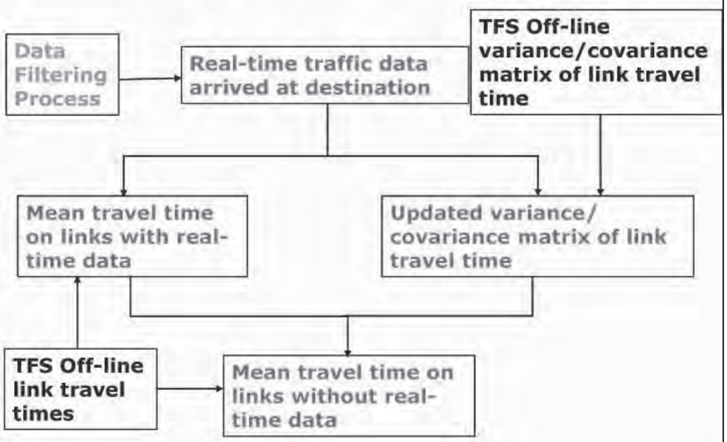

AVI Technology - Autotoll tag data
Lion Rock Tunnel (LRT) Toll-gate
Cross Harbour Tunnel (CHT) Toll-gate
12:00:00
13:00:00
Travel time of this vehicle = 13:00:00 – 12:00:00 = 1
X
6

Data Filtering Method for Generating Valid Time Windows



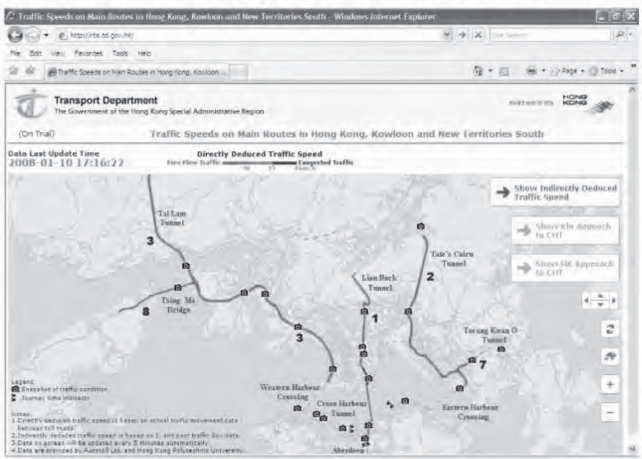
7

Methodology for Current Travel Time Estimation



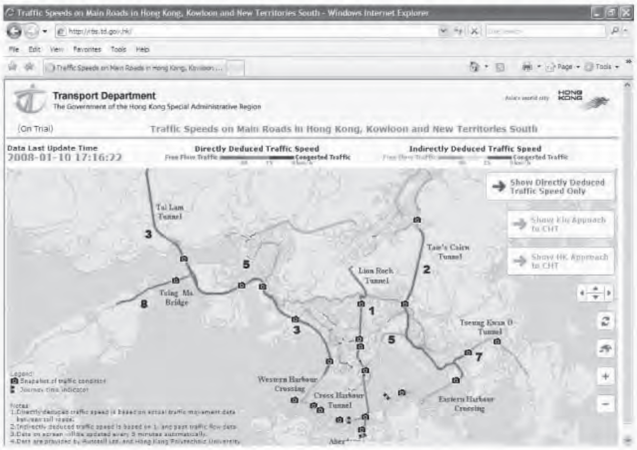
8

RTIS Speed Map (Directly Deduced)



9

RTIS Speed Map (Indirectly Deduced)



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RTIS Validation Results on December 2007 (19 weekdays)

	Accuracy of Speed Estimates falling within the specified speed interval
Cross Harbour Tunnel (Kowloon)	**97%**
Eastern Harbour Crossing (Kowloon)	**100%**
Western Harbour Crossing (Kowloon)	**100%**
Aberdeen Tunnel (Wan Chai)	**97%**
Tate's Cairn Tunnel (Shatin & Kowloon)	**100%**
Tseung Kwan O Tunnel (Sau Mau Ping)	**100%**
Kwun Tong Bypass	**100%**
Ting Kau Bridge	**100%**
Cheung Tsing Bridge	**100%**

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RTIS Validation Results on December 2007 (19 weekdays)

	Accuracy of Speed Estimates falling within the specified speed interval
Waterloo Road	**100%**
Princess Margaret Road	**100%**
Kai Tak Tunnel (Kowloon City Side)	100%
Chatham Road	100%
Salisbury Road near Nathan Road	98%
Kowloon Park Drive	100%
Island Eastern Corridor	100%
Connaught Road Central	99%
Harcourt Road	97%

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2. Objectives of this study

- To develop an algorithm capable of predicting travel times on the route with real-time auto-toll tag data **in the next 5-min interval**
- To devise an algorithm for **detecting traffic incidents** at current 5-min interval

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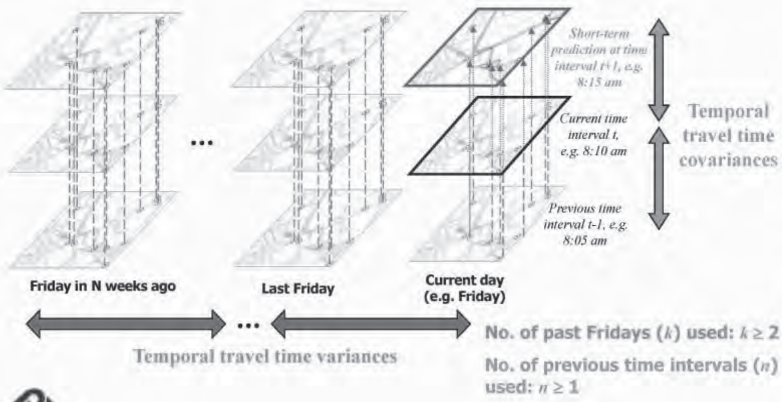
3. Proposed Algorithm



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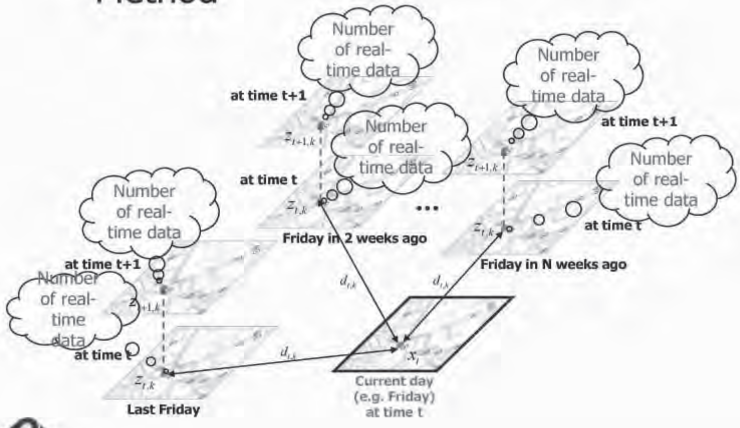
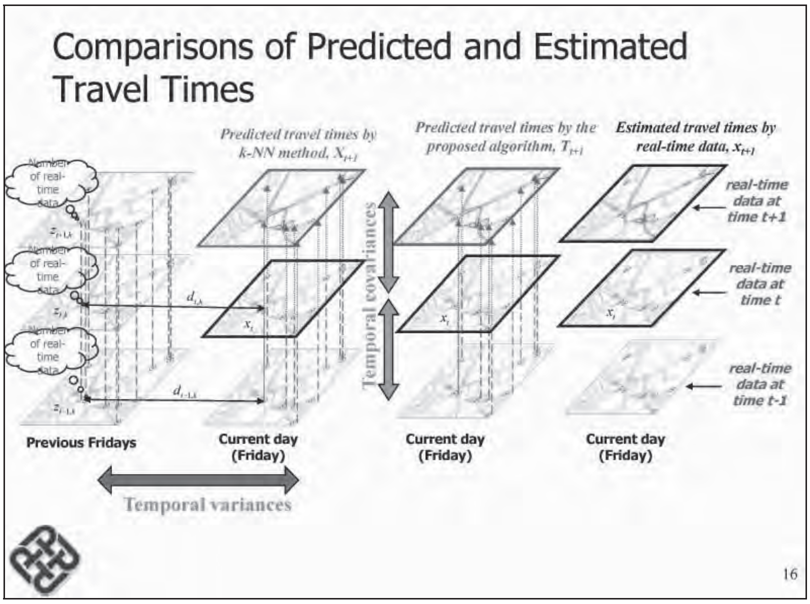
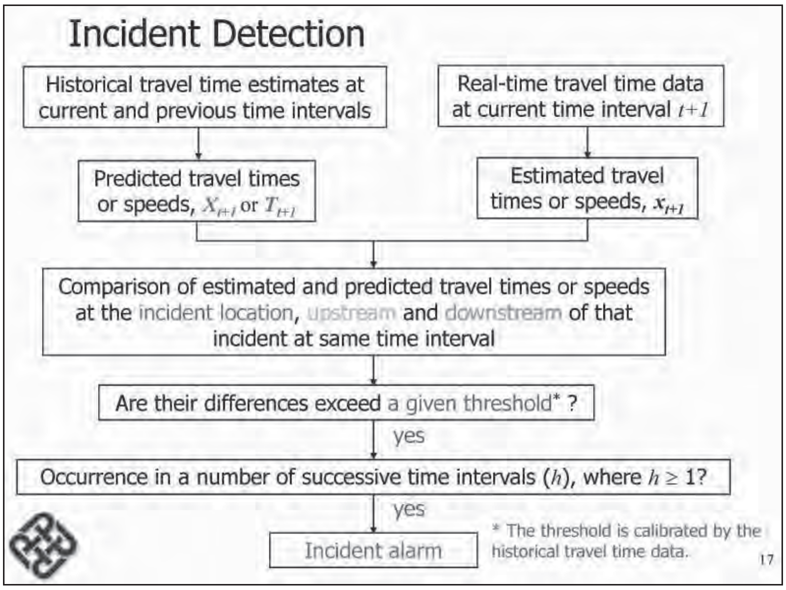
K-Nearest Neighbourhood (k-NN) Method



15


Comparisons of Predicted and Estimated Travel Times
Predicted travel times by k-NN method, X_{t+1}
Predicted travel times by the proposed algorithm, T_{t+1}
Estimated travel times by real-time data, x_{t+1}
Number of real-time data
$z_{t+1,k}$
$z_{t,k}$
$z_{t-1,k}$
$d_{t,k}$
$d_{t-1,k}$
x_t
Temporal covariances
real-time data at time t+1
real-time data at time t
real-time data at time t-1
Previous Fridays
Current day (Friday)
Current day (Friday)
Current day (Friday)
Temporal variances
16


Incident Detection
Historical travel time estimates at current and previous time intervals
Real-time travel time data at current time interval $t+1$
Predicted travel times or speeds, X_{t+1} or T_{t+1}
Estimated travel times or speeds, x_{t+1}
Comparison of estimated and predicted travel times or speeds at the incident location, upstream and downstream of that incident at same time interval
Are their differences exceed a given threshold* ?
yes
Occurrence in a number of successive time intervals (h), where $h \geq 1$?
yes
Incident alarm
* The threshold is calibrated by the historical travel time data.
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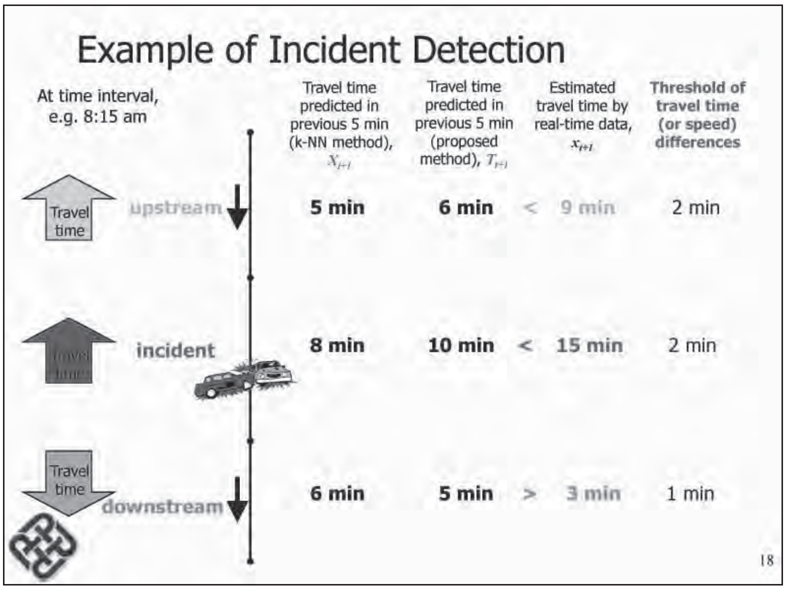
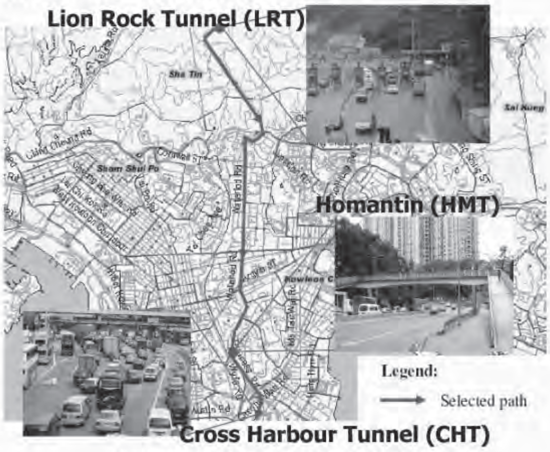

Example of Incident Detection
At time interval, e.g. 8:15 am
Travel time predicted in previous 5 min (k-NN method), X_{t+1}
Travel time predicted in previous 5 min (proposed method), T_{t+1}
Estimated travel time by real-time data, x_{t+1}
Threshold of travel time (or speed) differences
Travel time
upstream
5 min
6 min
<
9 min
2 min
Travel time
incident
8 min
10 min
<
15 min
2 min
Travel time
downstream
6 min
5 min
>
3 min
1 min
18

4. Case Study for Short-term Travel Time Prediction



Distance = 6.23 km,
Average free-flow travel speed = 60 km/hour

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Number of Vehicles Travelled on the Selected Path from LRT to CHT on 26 May 2006 (Friday)

	Valid Observations		
	Autotoll tag records	Manual license plate matching survey	Total
AM Peak (08:00-10:00)	285	303	588
Inter Peak (14:00-16:00)	217	250	467
PM Peak (17:30-19:30)	259	608	867
Total	761	1,161	1,922

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Validation Results for Short-term Travel Time Prediction

Comparison of the Performance of the Three Prediction Methods in the Six-hour Survey Period

Model	R^2	Mean Absolute Error (MAE) (min)	Mean Absolute Percentage Error (MAPE) (%)
Proposed algorithm	0.82	1.03	4.62
2-nearest neighbourhood	0.35	1.57	6.82
Historical average	Approaches 0.00	3.28	14.27

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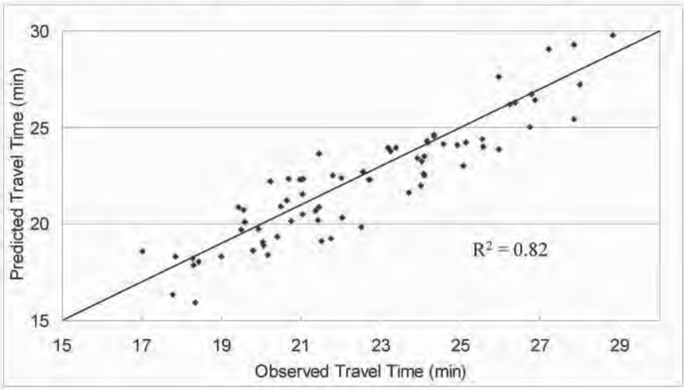
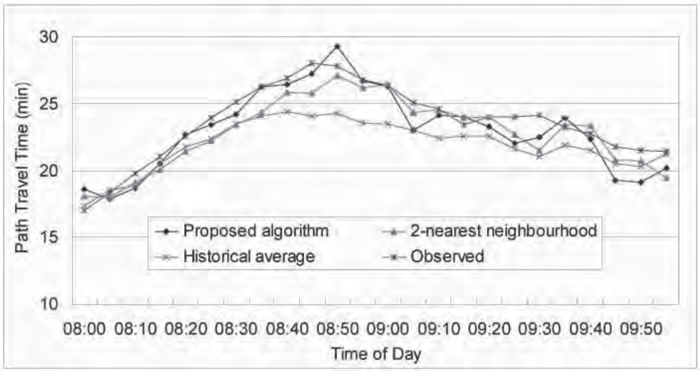
Predictability of the Proposed Algorithm



22

Predicted Travel Times on the Selected Path from LRT to CHT during AM Peak Period (08:00-10:00)



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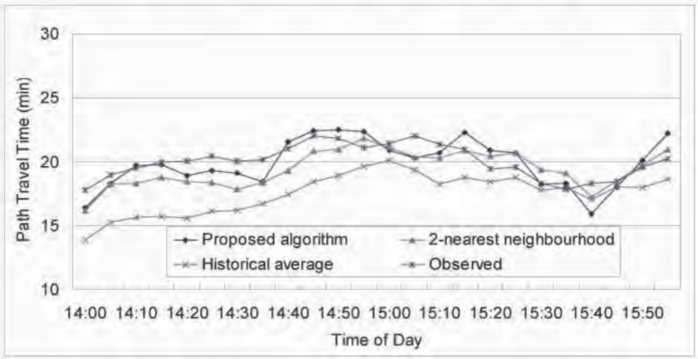
Predicted Travel Times on the Selected Path from LRT to CHT during Inter-peak Period (14:00-16:00)



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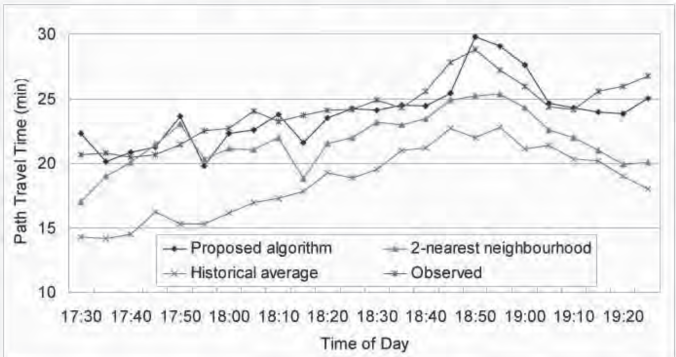
Predicted Travel Times on the Selected Path from LRT to CHT during PM Peak Period (17:30-19:30)



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4. Case Study for Incident Detection

- Based on the road accident records in 2006 collected from Transport Department, an incident has occurred on
  - 26 May 2006 at 13:41
  - Waterloo Road in North bound direction
  - Involved 2 vehicles with 1 person injured

- However, no observed data has been collected on the path from Cross Harbour Tunnel to Lion Rock Tunnel on 26 May 2006 for validation of the travel time prediction.

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HMT-LRT (Incident location)

Time Interval	Predicted Travel Speed (T_{t+1}) (km/h)	Estimated Travel Speed (x_{t+1}) (km/h)	Travel Speed Difference ($T_{t+1} - x_{t+1}$) (km/h)	Threshold of Travel Speed Differences (km/h)
13:35-13:39	39.2	38.8	0.4	8
13:40-13:44 (Incident occurred)	**43.0**	**34.9**	**8.1**	8 Alarm
13:45-13:49	36.7	28.2	**8.5**	8 Alarm
13:50-13:54	31.8	28.5	3.3	8
13:55-13:59	33.0	31.5	1.5	8

Further comparisons on the predicted and estimated travel times and their standard errors at the incident location, upstream and downstream of that incident should be conducted, particularly when real-time data are available on the road segments of the path.

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CHT-HMT (Upstream of the incident)

Time Interval	Predicted Travel Speed (T_{t+1}) (km/h)	Estimated Travel Speed (x_{t+1}) (km/h)	Travel Speed Difference ($T_{t+1}-x_{t+1}$) (km/h)	Threshold of Travel Speed Differences (km/h)
13:35-13:39	44.2	44.1	0.1	8
13:40-13:44	**48.6**	**39.6**	**9.0**	8 Alarm
13:45-13:49	41.4	31.3	**10.1**	8 Alarm
13:50-13:54	35.8	30.6	5.2	8
13:55-13:59	37.3	32.7	4.6	8

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5. Conclusions

- Short-term travel time prediction algorithm has been proposed for incident detection.
- The results show that the proposed algorithm could predict satisfactorily the travel times on the selected path for the study periods with the minimum mean absolute errors and mean absolute percentage errors.
- The results of the case study for incident detection illustrated the potential and capability of the proposed method to detect incidents accurately.

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6. Current development for BKK

- Joint research and development with BAL-LABS, Burapha University
- Follow up from the previous project funded by NECTEC
- A new project also funded by NECTEC to develop the prototype for RTIS system on a specific route in BKK
- Also kindly supported by BMTA and TOT
- Using RFID system for bus management (in contrast to the RFID system of Auto-toll in HKG)

BAL Labs NECTEC a member of NSTDA

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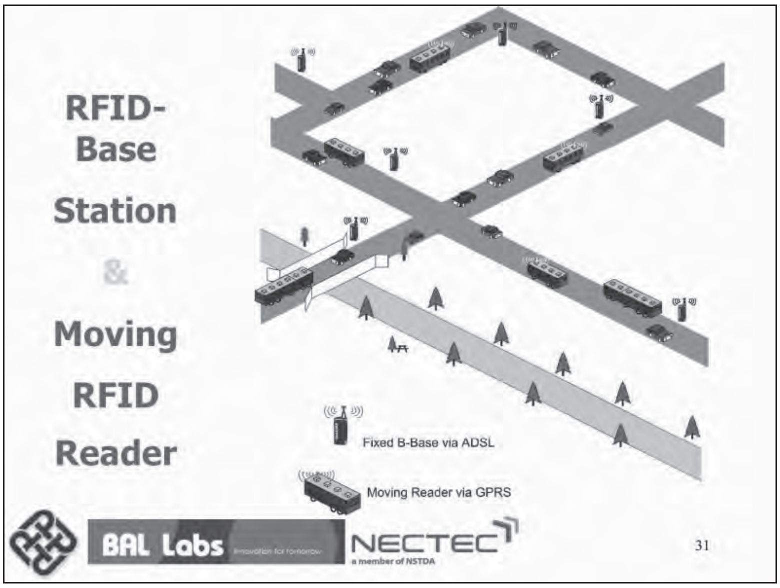
RFID-
Base
Station
&
Moving
RFID
Reader
Fixed B-Base via ADSL
Moving Reader via GPRS
BAL Labs
NECTEC
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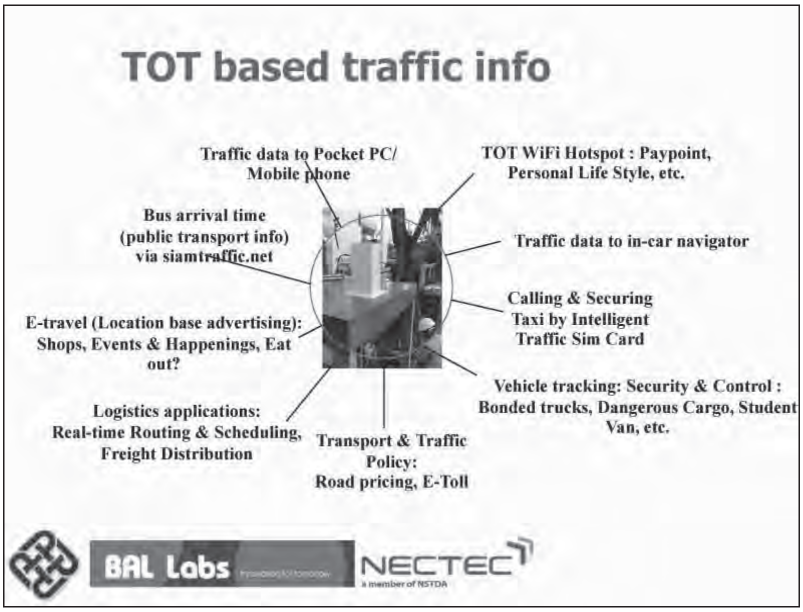
B-MOV
BAL Labs
NECTEC
a member of NSTDA
32


TOT based traffic info
Traffic data to Pocket PC/ Mobile phone
TOT WiFi Hotspot : Paypoint, Personal Life Style, etc.
Bus arrival time (public transport info) via siamtraffic.net
Traffic data to in-car navigator
Calling & Securing Taxi by Intelligent Traffic Sim Card
E-travel (Location base advertising): Shops, Events & Happenings, Eat out?
Vehicle tracking: Security & Control : Bonded trucks, Dangerous Cargo, Student Van, etc.
Logistics applications: Real-time Routing & Scheduling, Freight Distribution
Transport & Traffic Policy: Road pricing, E-Toll
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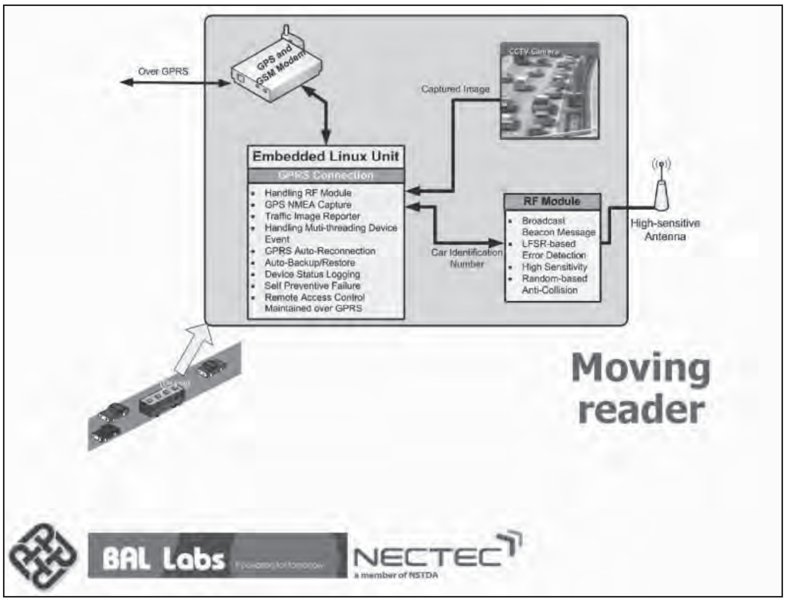
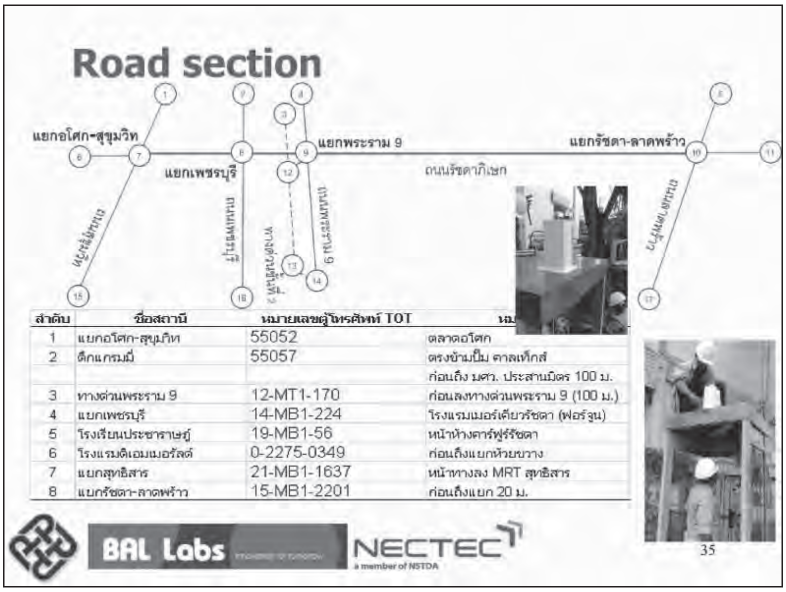
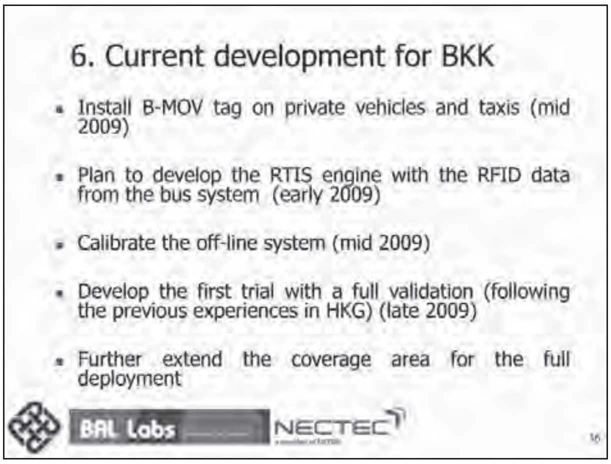
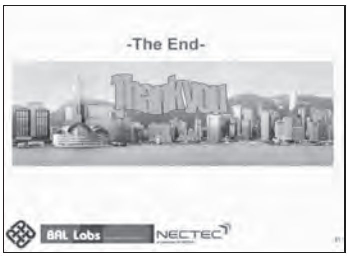




ลำดับ	ชื่อสถานี	หมายเลขตู้โทรศัพท์ TOT	หม
1	แยกอโศก-สุขุมวิท	55052	ตลาดอโศก
2	ตึกแกรมมี่	55057	ตรงข้ามปั๊ม คาลเท็กส์
			ก่อนถึง มศว. ประสานมิตร 100 ม.
3	ทางด่วนพระราม 9	12-MT1-170	ก่อนลงทางด่วนพระราม 9 (100 ม.)
4	แยกเพชรบุรี	14-MB1-224	โรงแรมเมอร์เคียวรัชดา (ฟอร์จูน)
5	โรงเรียนประชาราษฎ์	19-MB1-56	หน้าห้างคาร์ฟูร์รัชดา
6	โรงแรมดิเอมเมอรัลด์	0-2275-0349	ก่อนถึงแยกห้วยขวาง
7	แยกสุทธิสาร	21-MB1-1637	หน้าทางลง MRT สุทธิสาร
8	แยกรัชดา-ลาดพร้าว	15-MB1-2201	ก่อนถึงแยก 20 ม.





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