2006

PIARC

Freeway Integrated Incident Management System

Doohee Nam, Ph.D.

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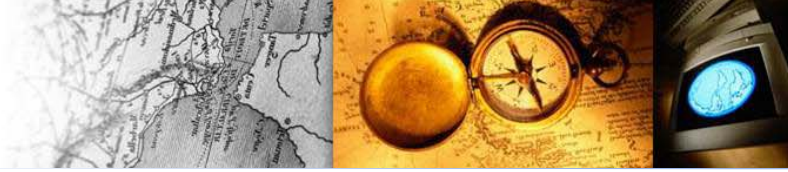
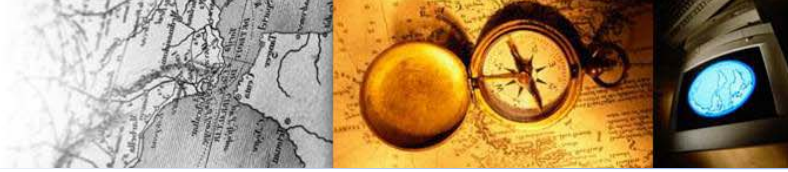


1. Backgrounds
2. Traffic Characteristics
3. Incident Detection(ID)
4. Estimation of Incident Probability(EIP)
5. Integrated Incident Management (IIM)

Backgrounds



- **Intelligent Transportation Systems Master Plan**
  - Preliminary ITS Plan(1994)
  - Transportation Efficiency Act(1999)
  - ITS Master Plan(1999, currently under revision)

- **Intelligent Transportation Systems Research and Development Program**
  - Develop Key System Elements for ITS
  - System Integration
  - Efficiency and Productivity

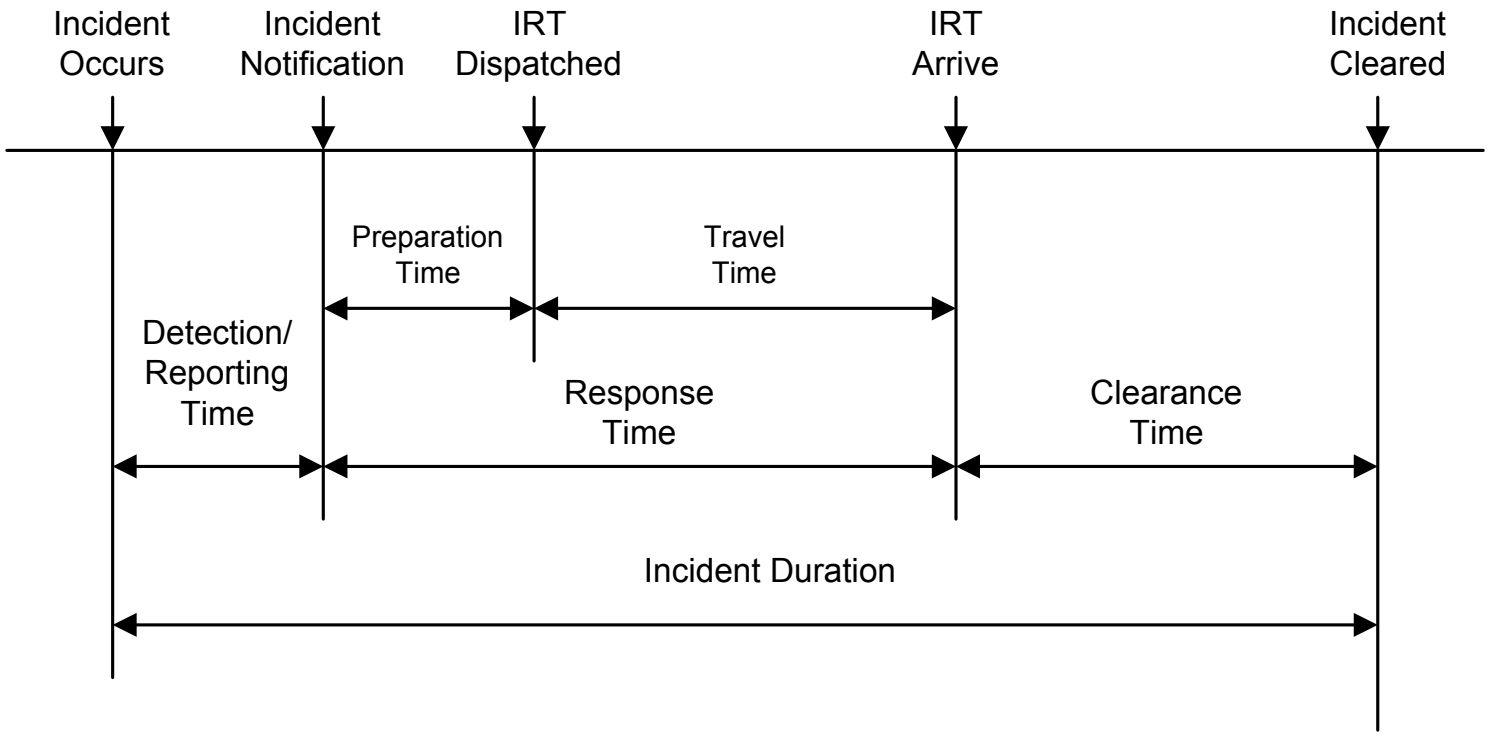
- **ITS Model Deployment Program**
  - Kwachon(1996) : ITS World Congress Demonstration Site
  - Model Deployment Initiative: Daejeon, Jeonju, Cheju (2002)

Integrated Incident Management Research

	Research Scope
Existing Research Review	- Review of Previous Research and Development
Analysis of Traffic Characteristics	- Study Area - Traffic Characteristics under Incident - Simulation Analysis
Evaluation of Incident Detection Algorithms	- Develop Testing Scenarios - Categorize Incident Type and Traffic Situation - Develop Evaluation Software - AIP, DELOS, DES, McMaster
Development of Estimation of Incident Probability and Response Scheme	- Estimation of Incident Probability (EIP) - Modeling for Incident Duration - Integrated Incident Management Program Modules

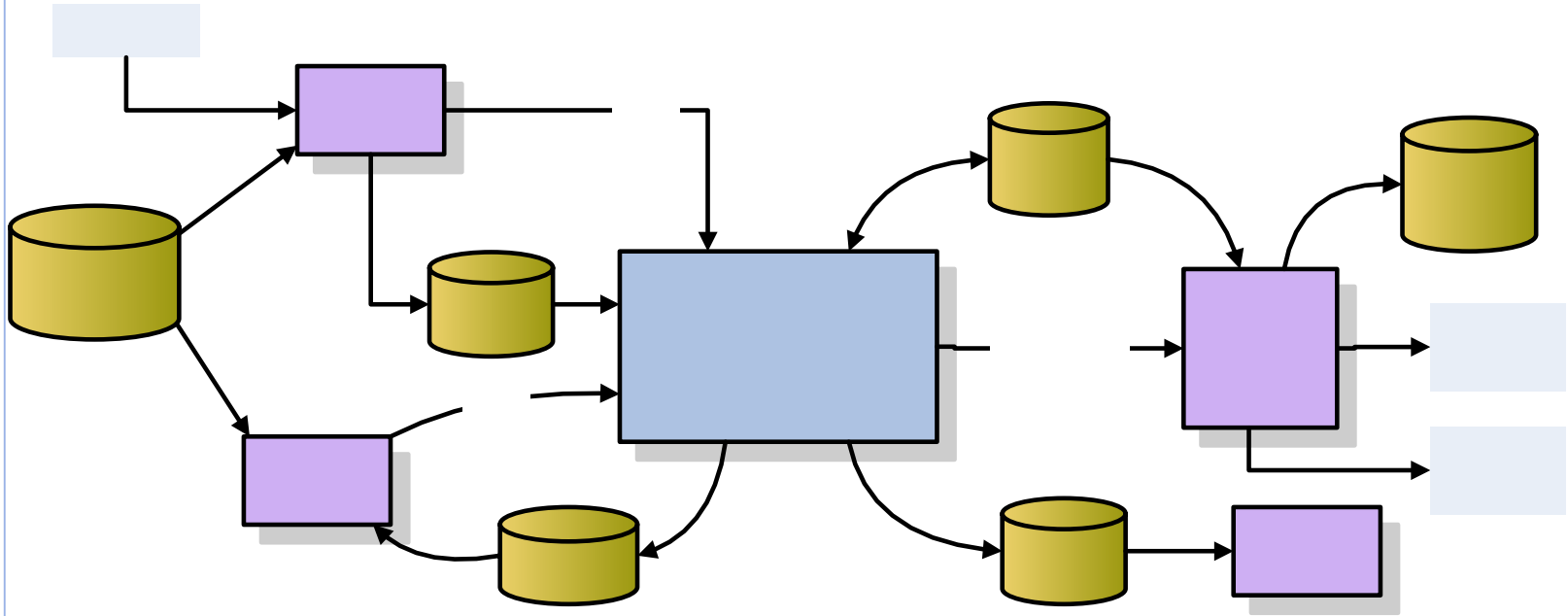
Incident Components

- **Incident Detection(ID) :** automatic/manual detection
- **Incident Verification(IV):** Severity, Duration, Impact
- **Incident Response(IR):** IRT, Information Dissemination
- **Incident Clearance(IC):** Technology and Methods

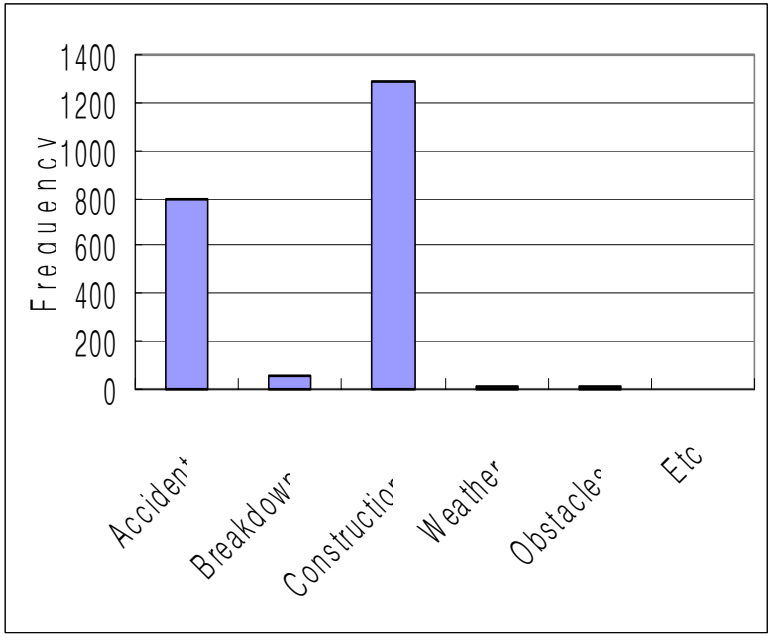


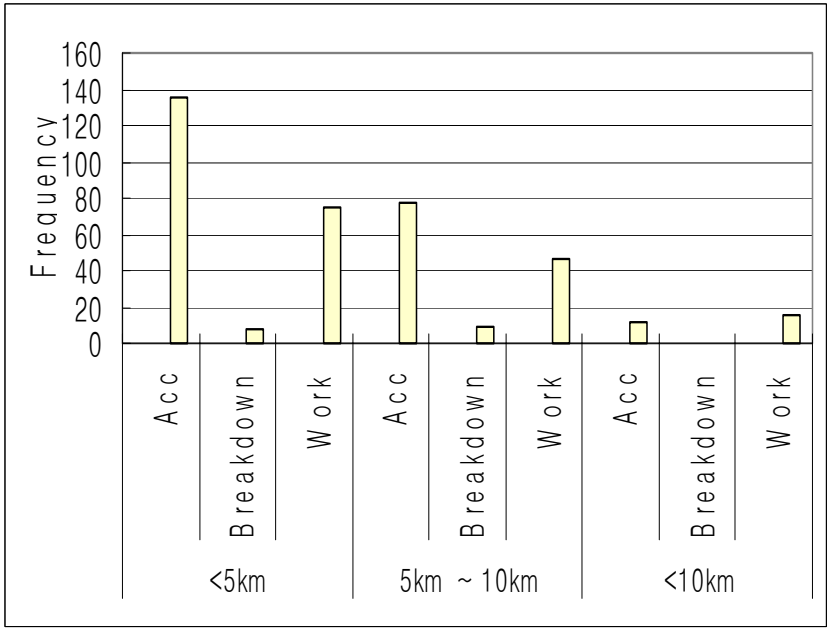
Integrated Incident Management

- ID, IR, IC
- Estimation of Incident Probability
- Incident Information Management(IIM): DB and ADUS



Freeway Incidents (May 2003)



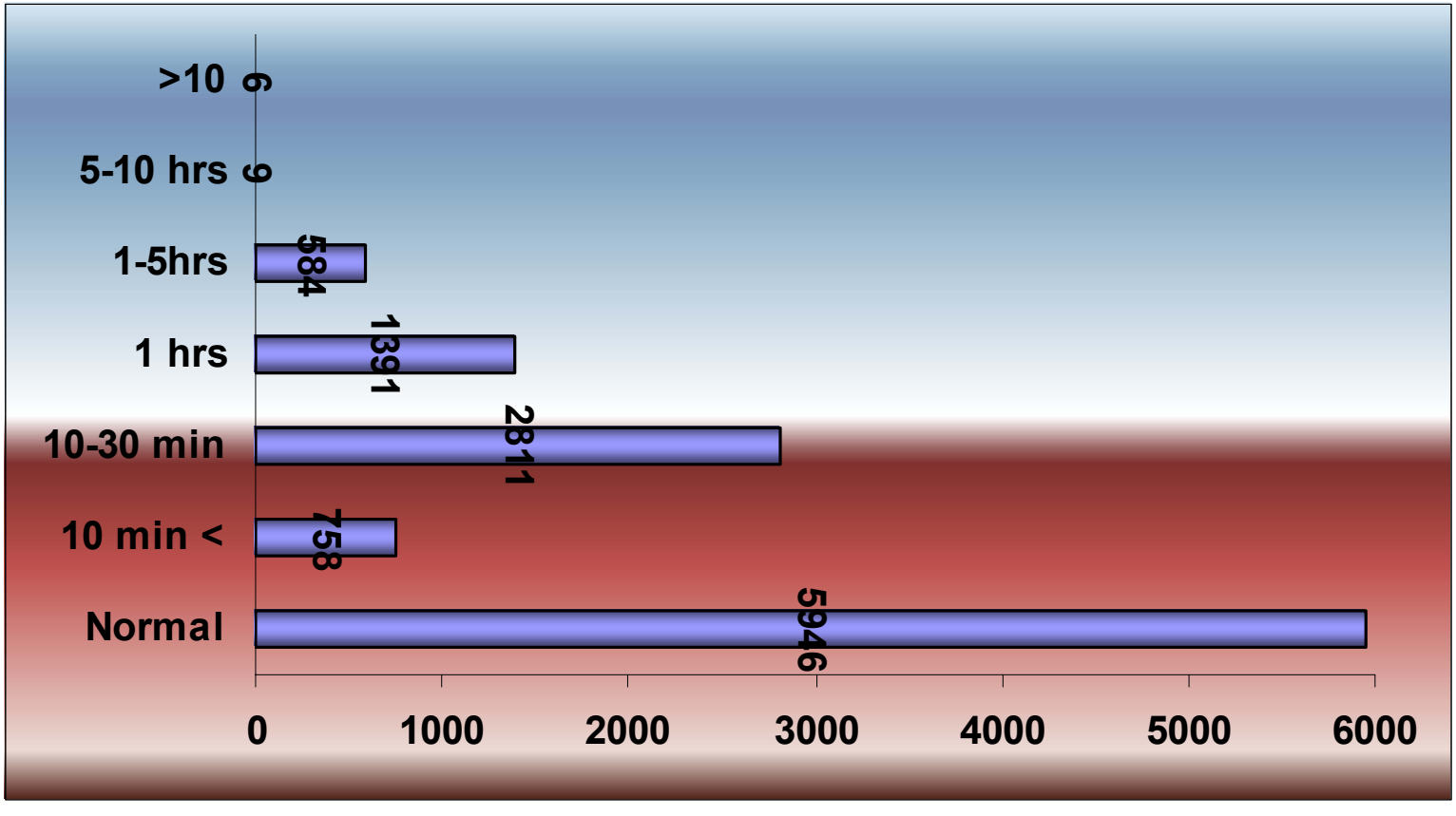


- **Frequent Construction Work**
- **Accidents are major cause for 5km more Delay**

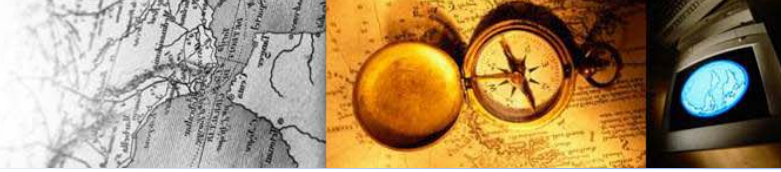
Traffic Impact

Year 2000 – Year 2002

Incident Duration



Data Collection



1. Detector Type

- Space continuity: good detector data for analysis area
- Time Continuity: Time-Series Data

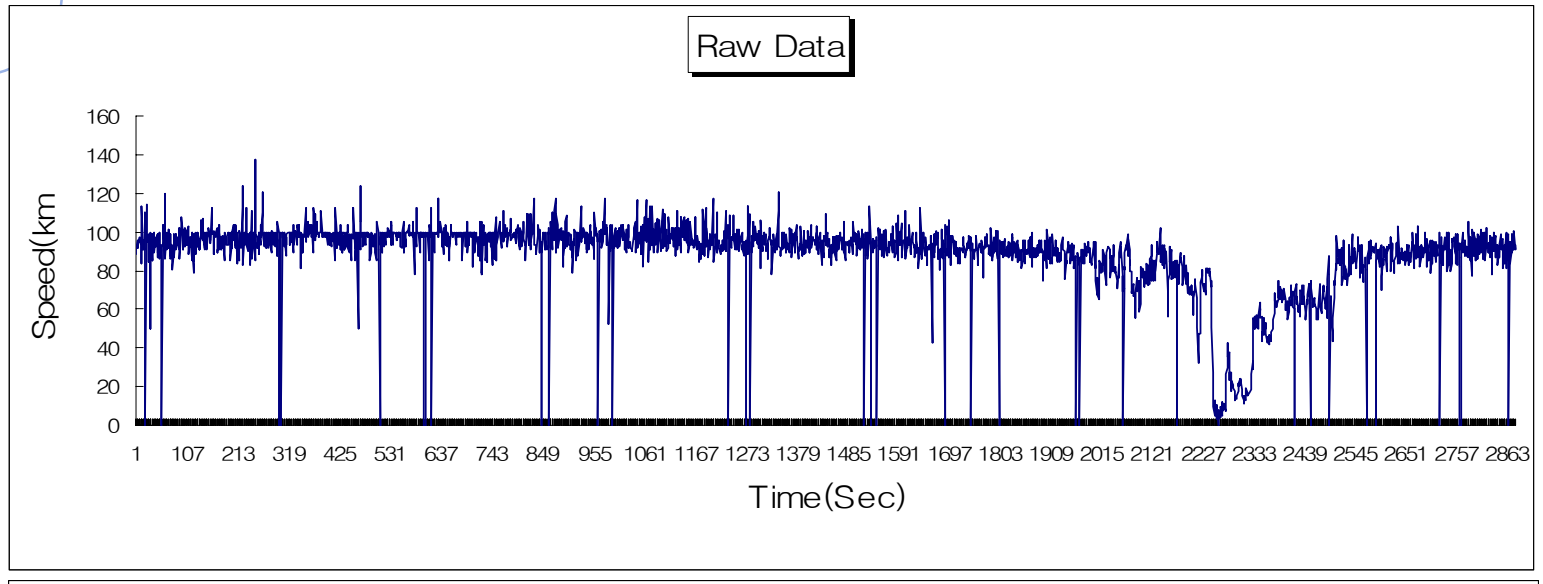
2. Traffic Environments

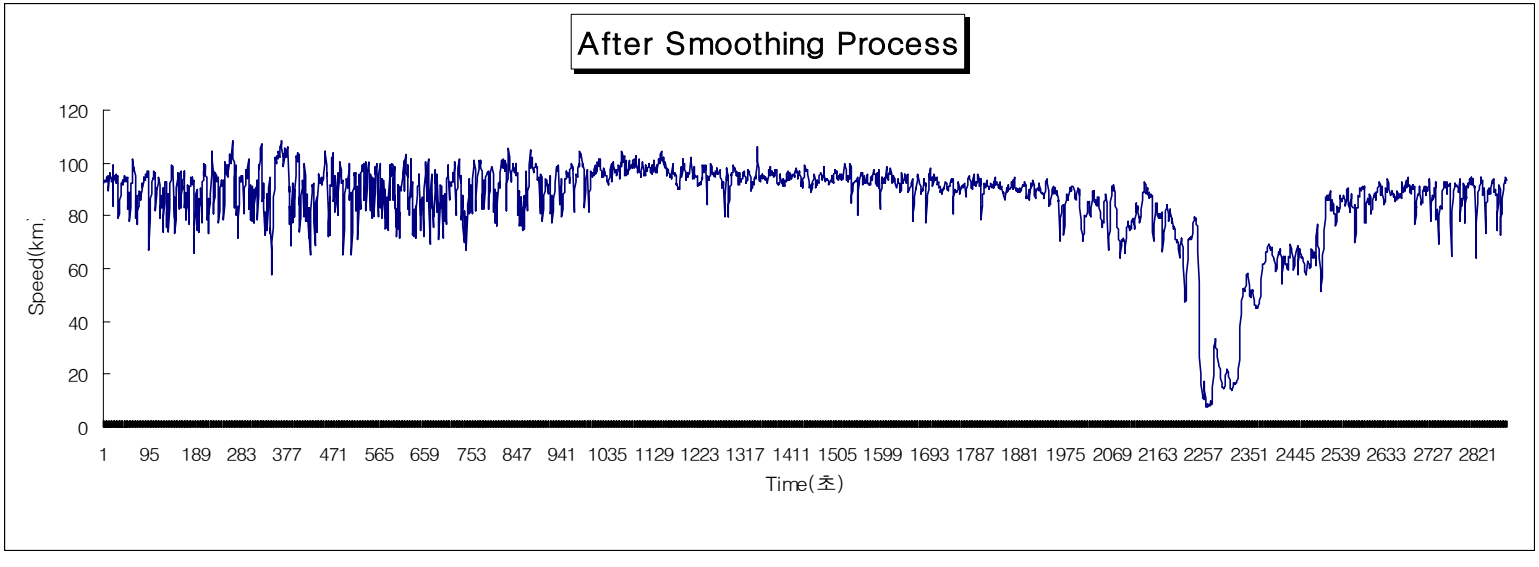
- IC/JC Type
- Traffic Volume
- Environmental and Geometric Elements

3. Type of Incident

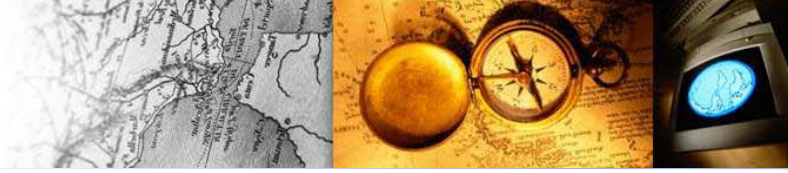
- Degree of Congestion
- Continuous Data for Entire Incident Duration
- Isolate the Incident

Smoothing with Moving Average Method



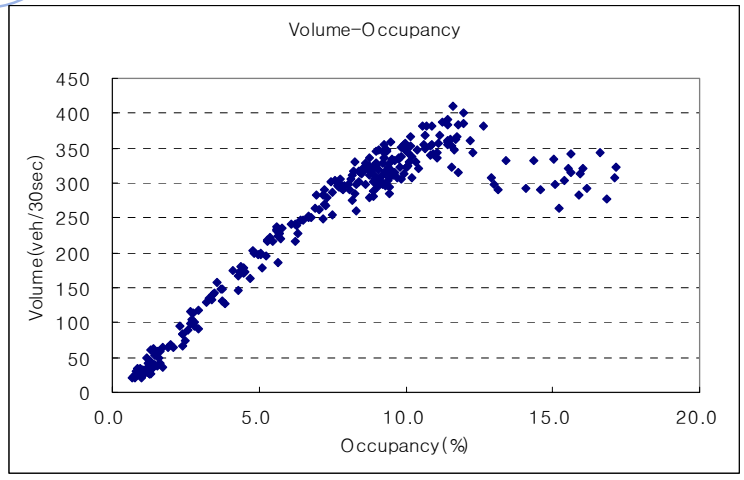


Traffic Characteristics



- Normal Flow Vs. Incident Flow
- Lane Grouping (All lane Flow Vs. Individual lane flow)
- Traffic Flow Analysis before/after Incidents
  - Time-series Analysis
  - Reference Points Analysis
- Traffic Flow Analysis with Detection Type
  - loop, Video Imaging, magnetic
- Traffic Flow Analysis with Different Aggregation Interval
  - 30sec, 2min, 5min

Normal Flow Vs. Incident Flow

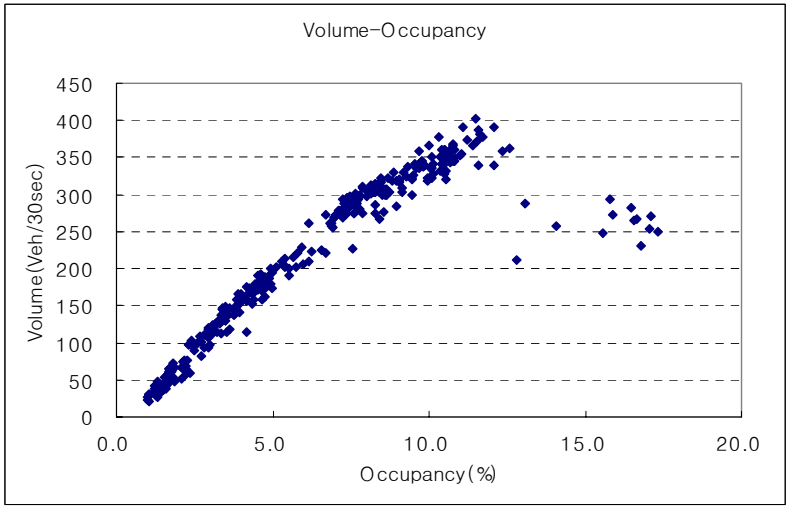


❑ Normal Flow

- Breakdown at capacity
- Transition Stage

❑ Incident Flow

- Non-linear at Capacity
- Traffic Break down from the Incidents



Lane Grouping

❑ Speed Variation

- Individual Lane Analysis

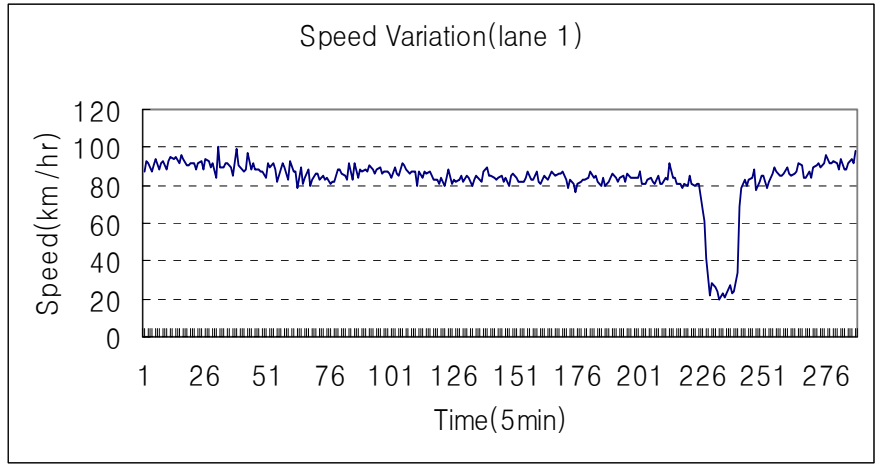
  Abrupt Speed Change (80km/h to 20km/hr)

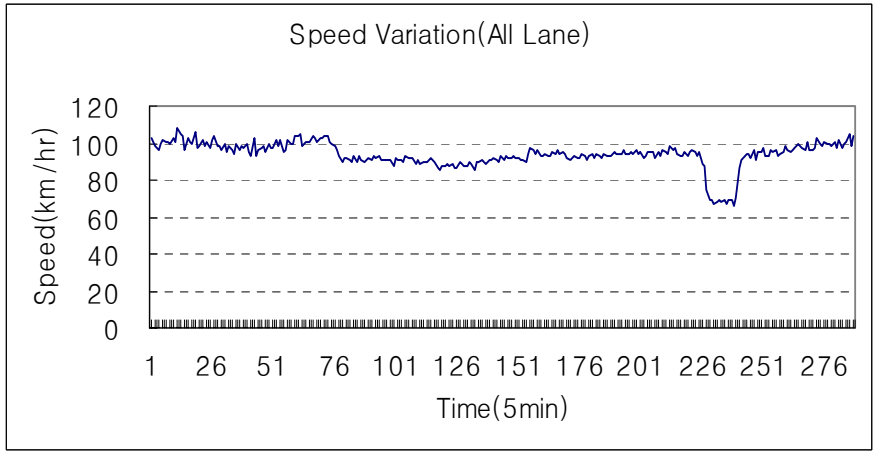
- Combined Lane Analysis

  Maintain higher speed (60km/hr)

  Average effect

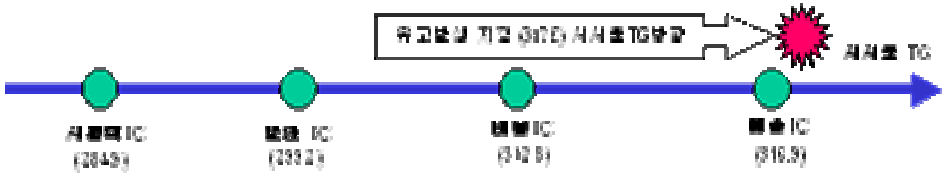
➡ Using Individual Lane Data for Automatic Incident Detection

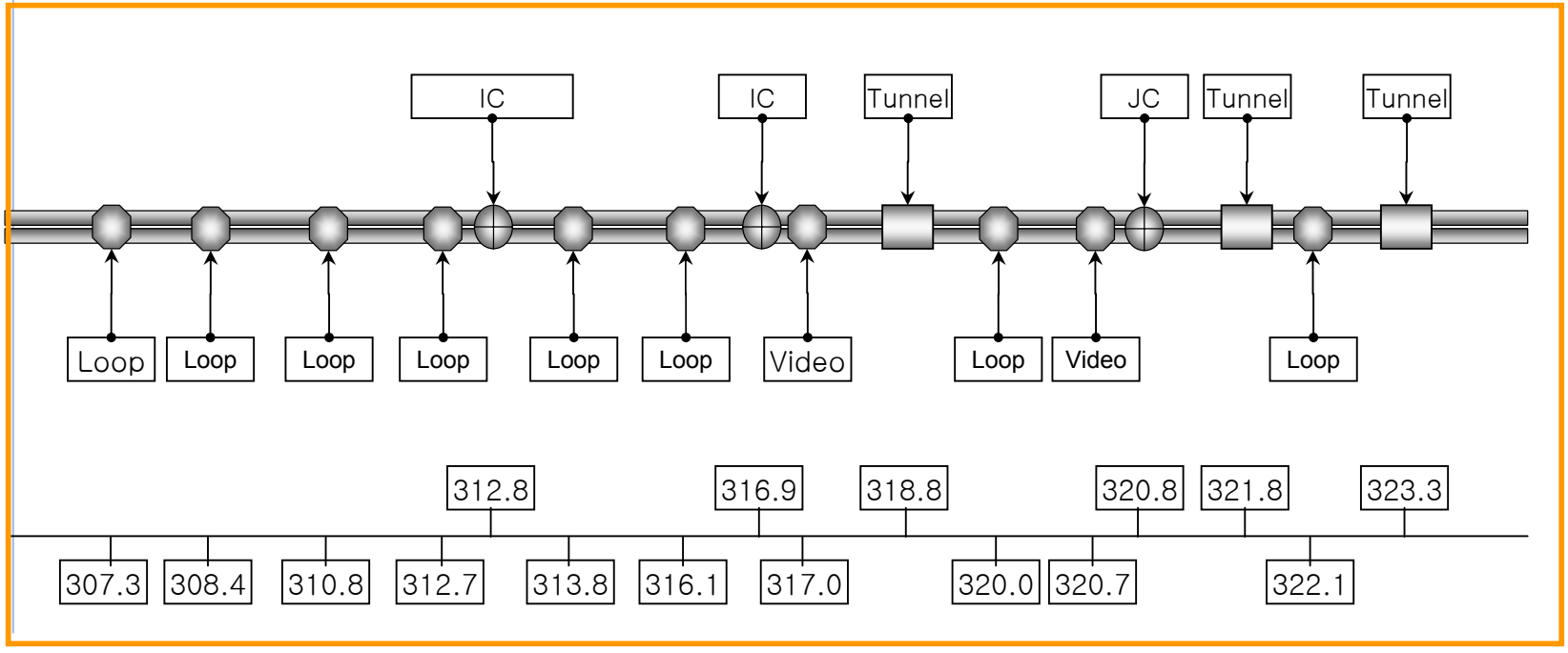




Space-series Traffic Analysis

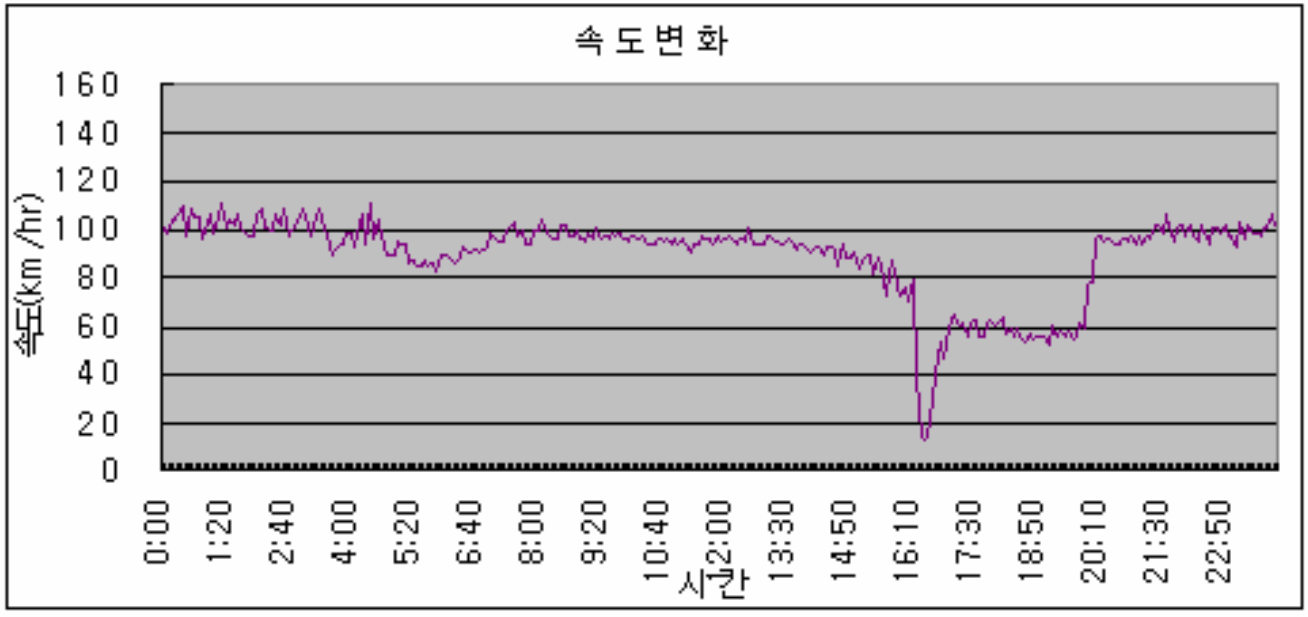
Incident Location(317.0km)



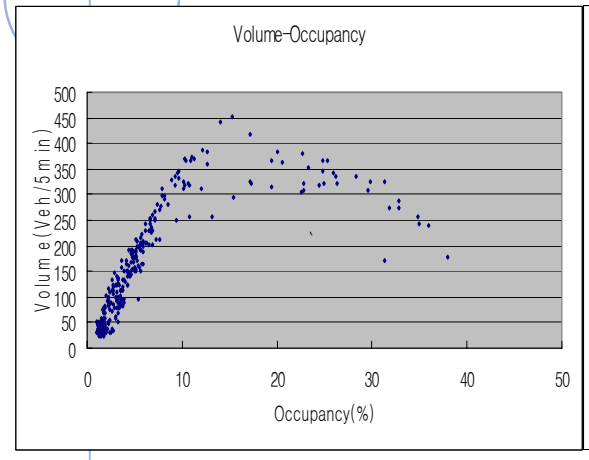


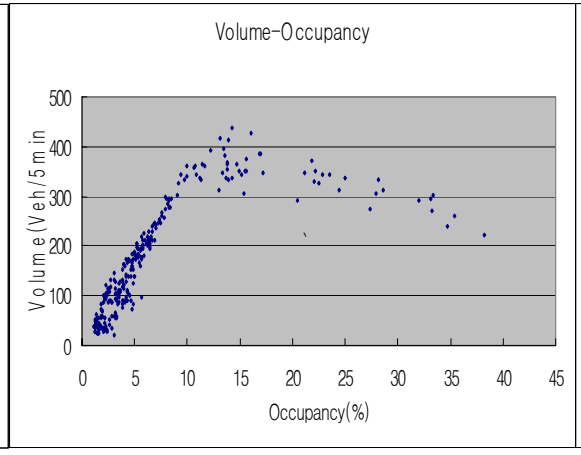
Time-Speed Diagram

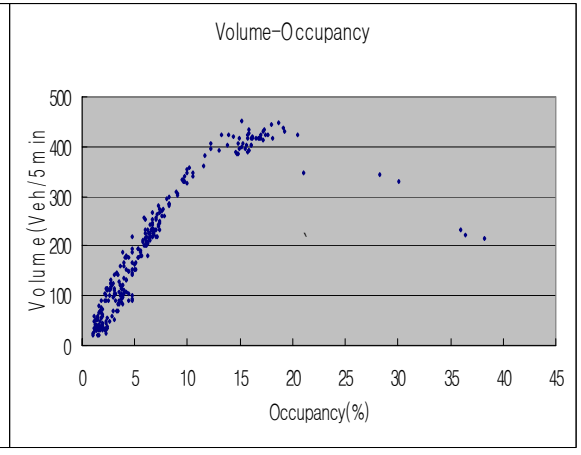
- Incident starts at 16:15
- Incident Duration: 35min (16:50]
- Queue Dissipation : 3hrs 15min (20:05)



Traffic Characteristics by Location

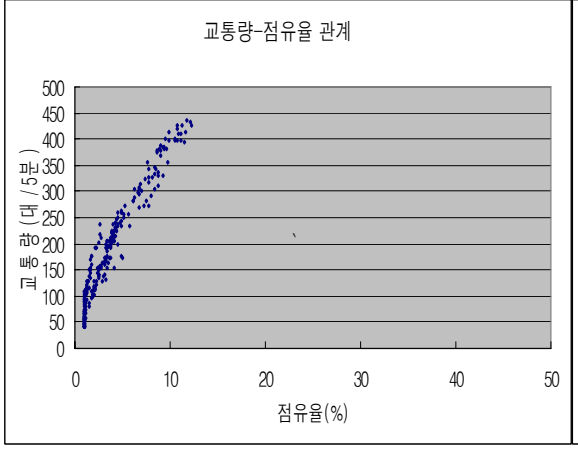


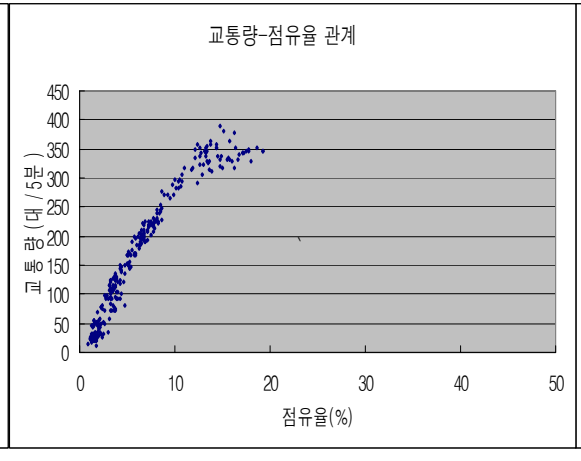


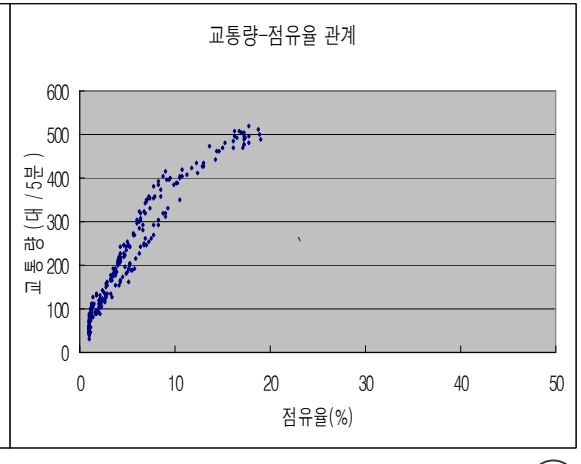


307.3km 308.4km 316.1km

320.7km 320.0km 317.0km







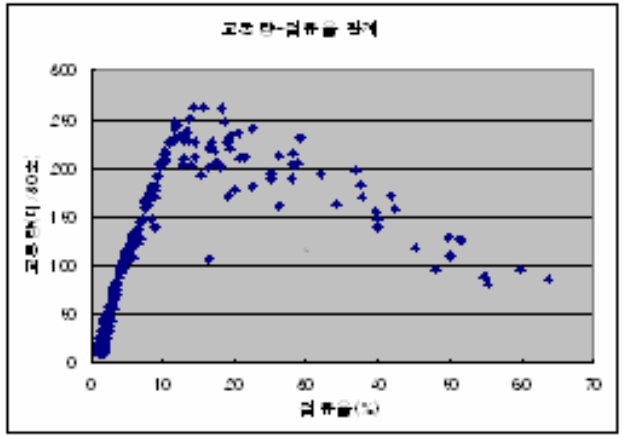
Traffic Characteristics by Detector type

- Different Volume-Occupancy Shape

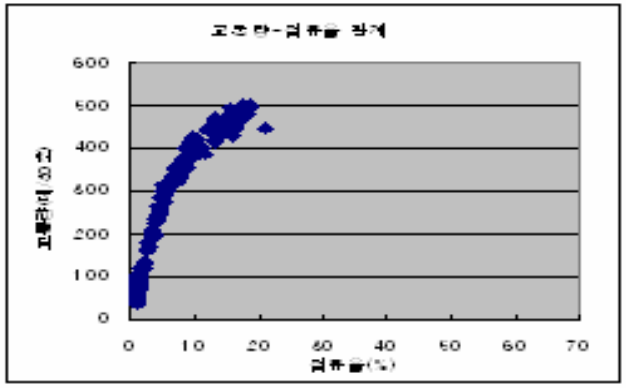
- Critical Occupancy
  - Loop(15%)
  - Video(20%)
  - Magnetic(10%)

➡ Using Different Parameter by Detector Type

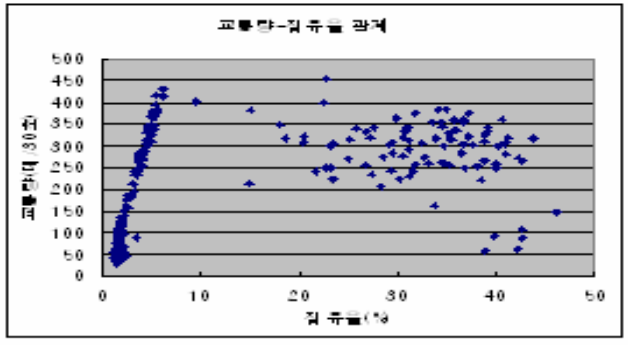
➢Loop



➢Video



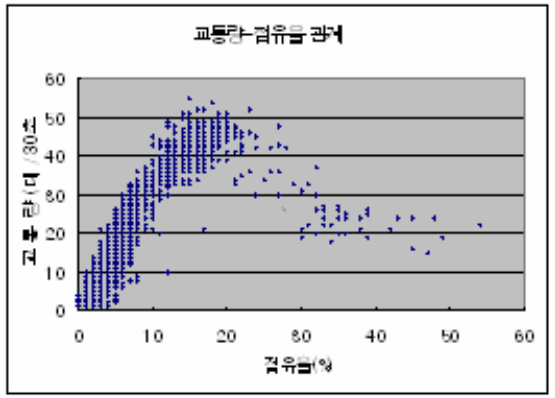
➢Magnetic



Aggregation Interval

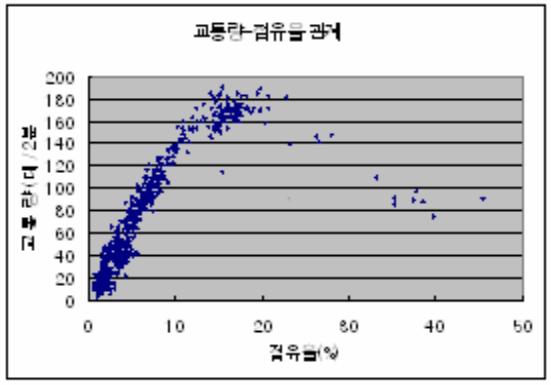
- Difficult to identify with short aggregation interval (stable to unstable)

➢30sec



- Big occupancy difference for short aggregation interval

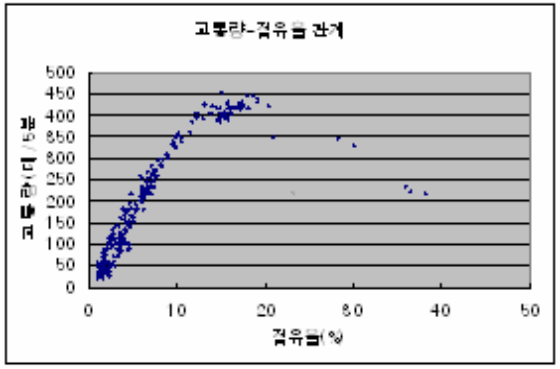
➢2min



➡ Polling Cycle

Time to Detection

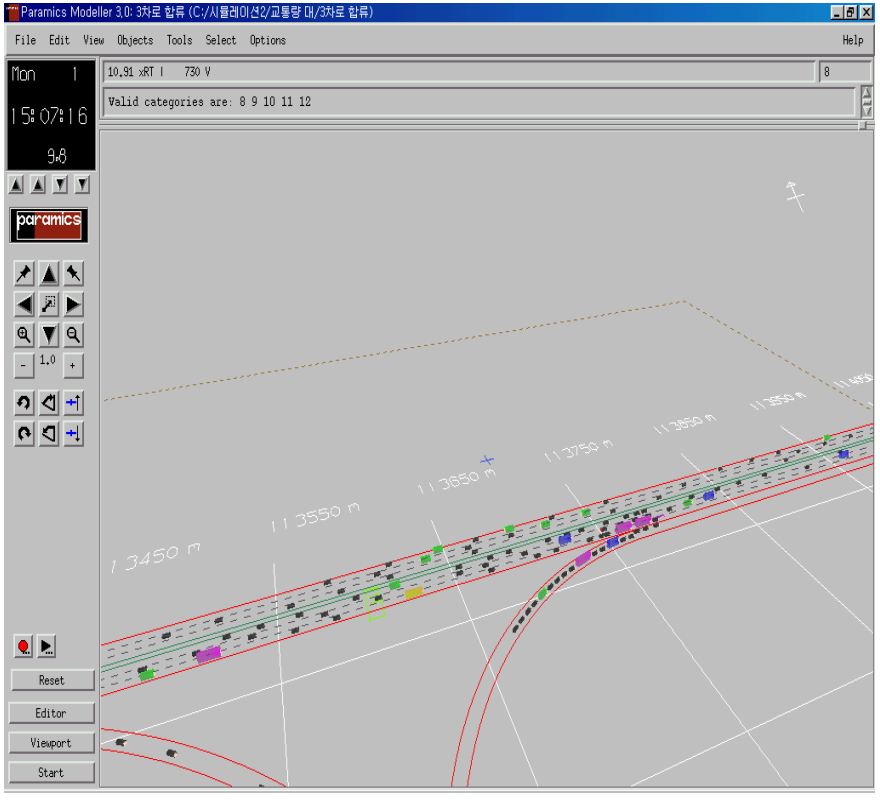
➢5min



Traffic Simulation

❑ Model Selection

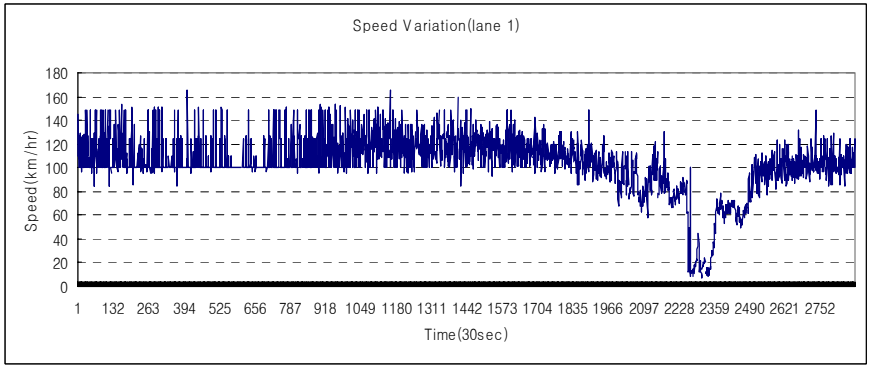
- Microscopic Simulation Package
- Virtual Traffic Environment
- Paramics
- 37 scenarios
- 30sec time interval

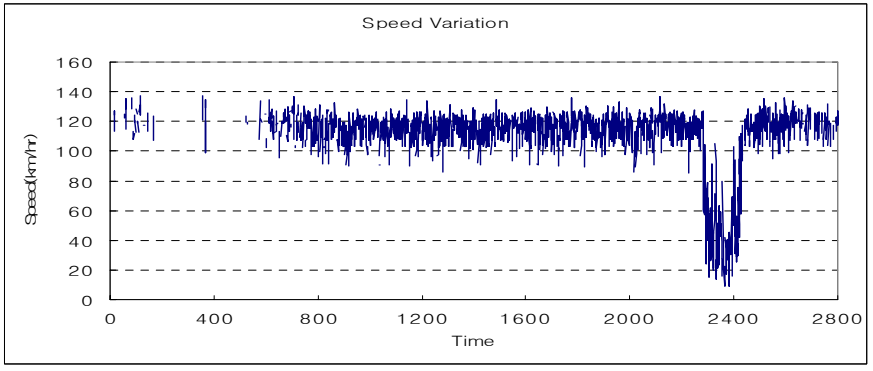


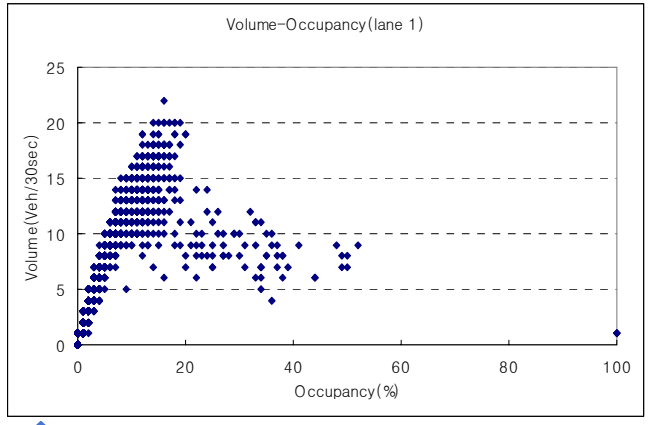
Validation Process

Process

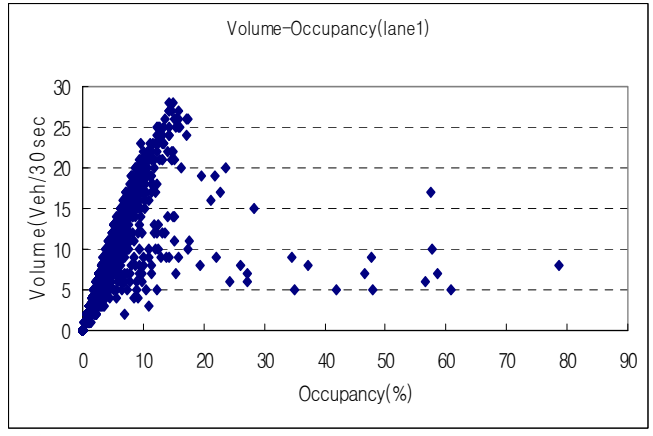
- Real data
- Speed Variation
- Flow-Occupancy





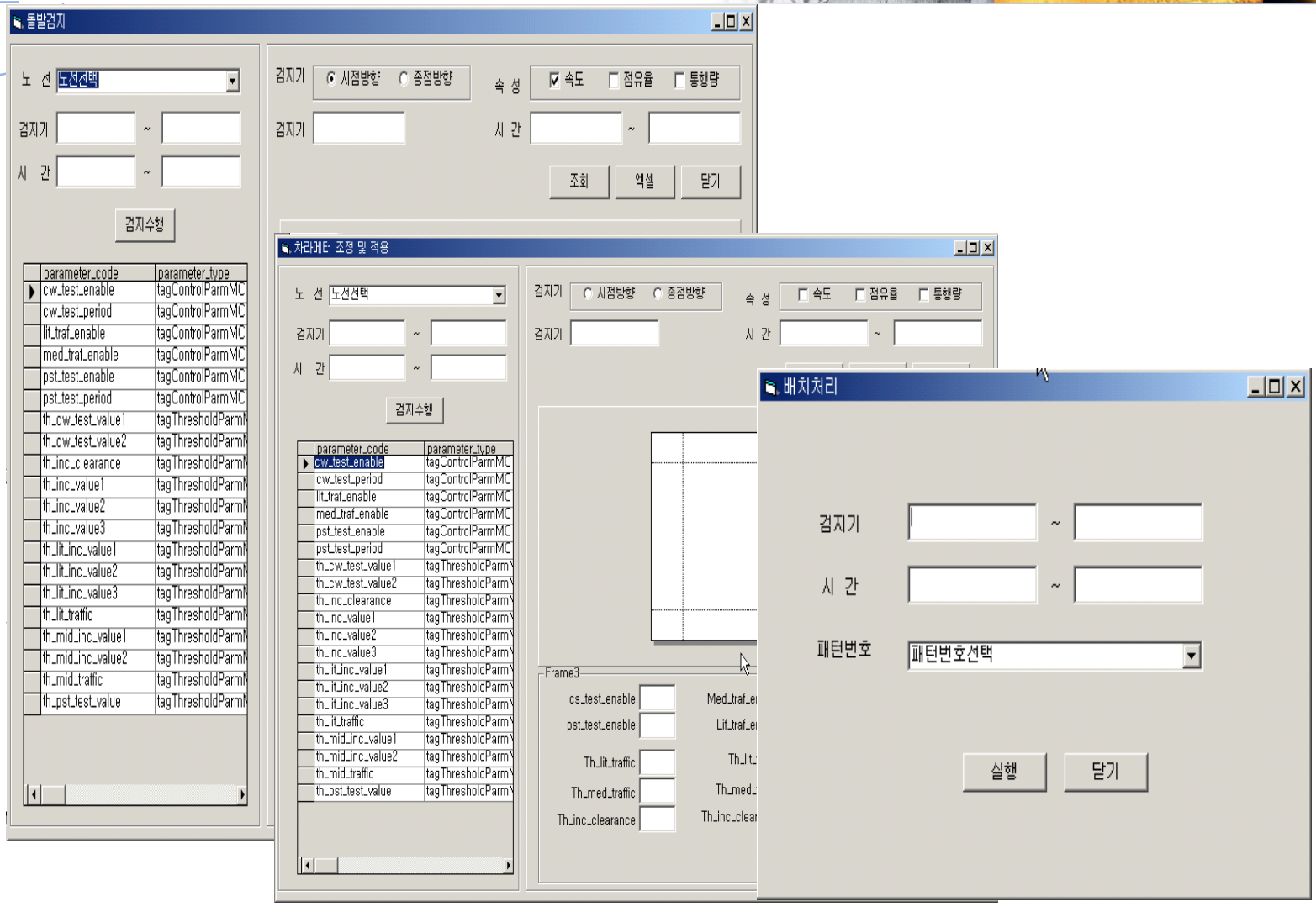


Real Data

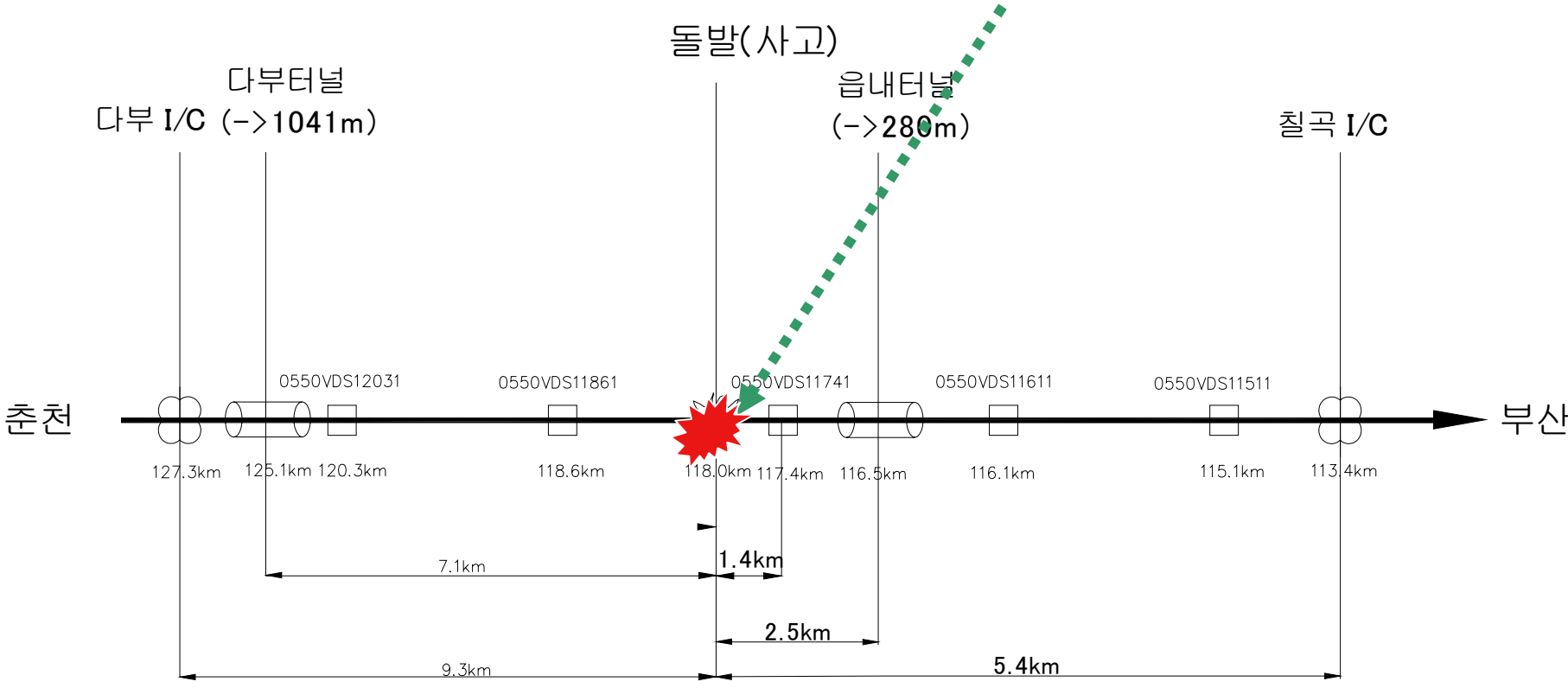


Data from Simulation

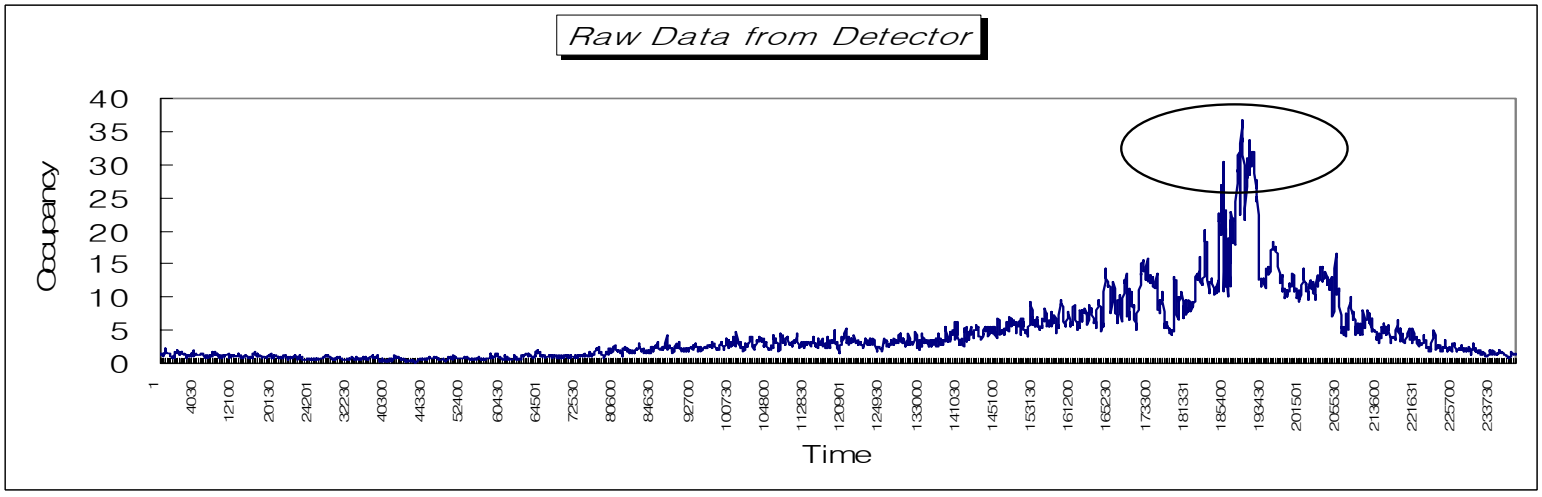
Incident Detection Testing Simulator

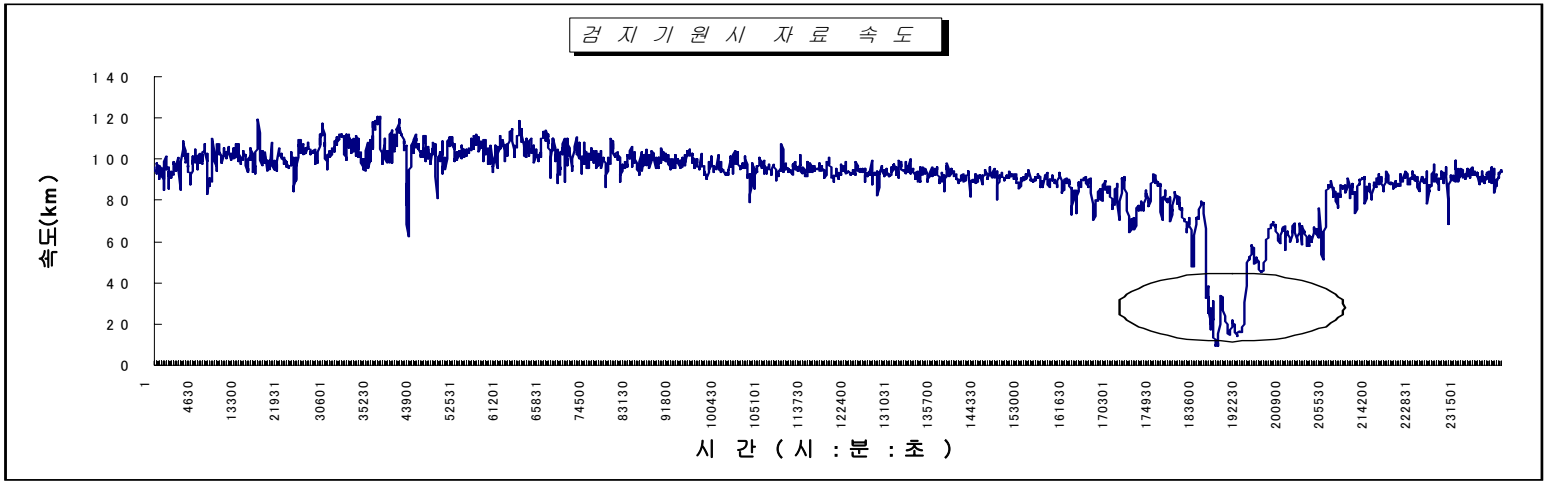


Example

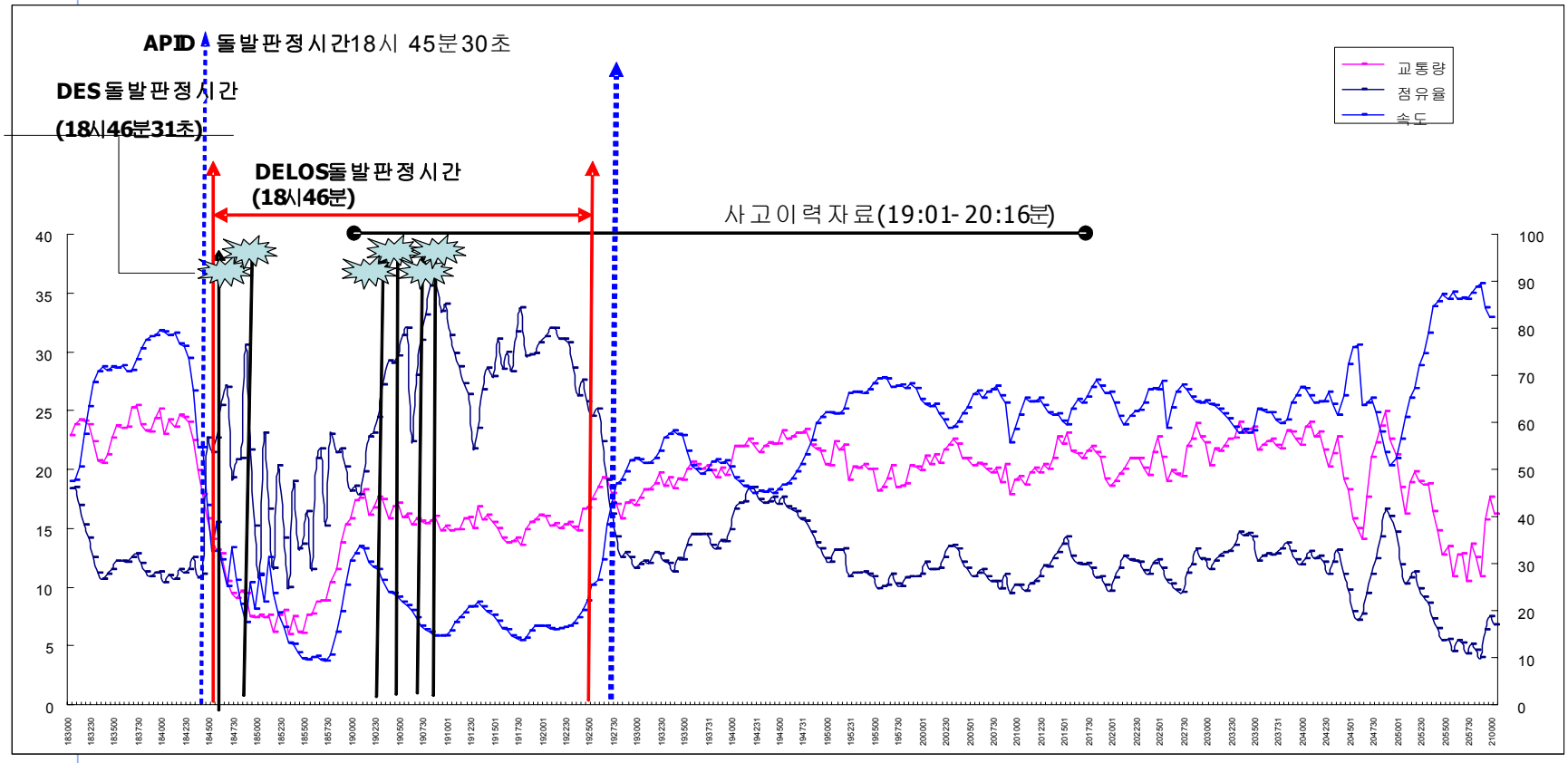

돌발(사고)
다부터널
다부 I/C (->1041m)
읍내터널
(->280m)
칠곡 I/C
춘천
부산
0550VDS12031
0550VDS11861
0550VDS11741
0550VDS11611
0550VDS11511
127.3km
125.1km
120.3km
118.6km
118.0km
117.4km
116.5km
116.1km
115.1km
113.4km
7.1km
1.4km
2.5km
9.3km
5.4km

Occupancy and Speed





Detection Time by Algorithm



Incident Detection Algorithm MOE

- Mean Detection Time and False Alarm Rate: APID
- Detection Rate and Time to Detect: McMaster
- Detection Rate: DELOS
  - APID: Type 0,1
  - DES: Type 1
  - DELOS: Type 2

Incident Detection Algorithm

- APID, DES, DELOS

  - Heuristic Parameter Search

    : Not related with historical data

    : High sensitivity – Difficult to find optimum parameters

  - APID: Need two continuous detector data

    : Not good for IC and JC

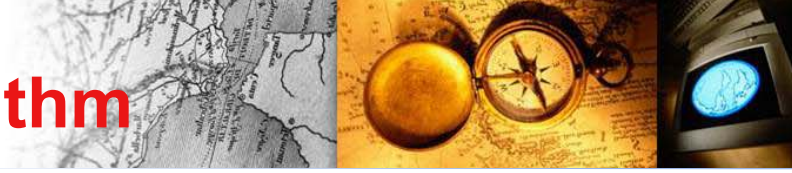
  - DES: Long detection time, low detection rate

    : High Sensitivity

    : Depend on occupancy data

  - DELOS: Long detection time caused by smoothing

Incident Detection Algorithm



- McMater

  - Parameter estimation by historical data

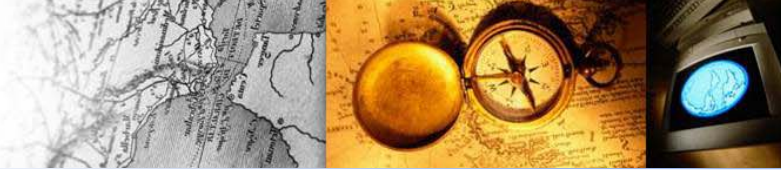
  - Parameter estimation by detector type and lane group

  - Can use various detector data

    : -1, 0 +1 at least three detectors

  - At least one week data needed

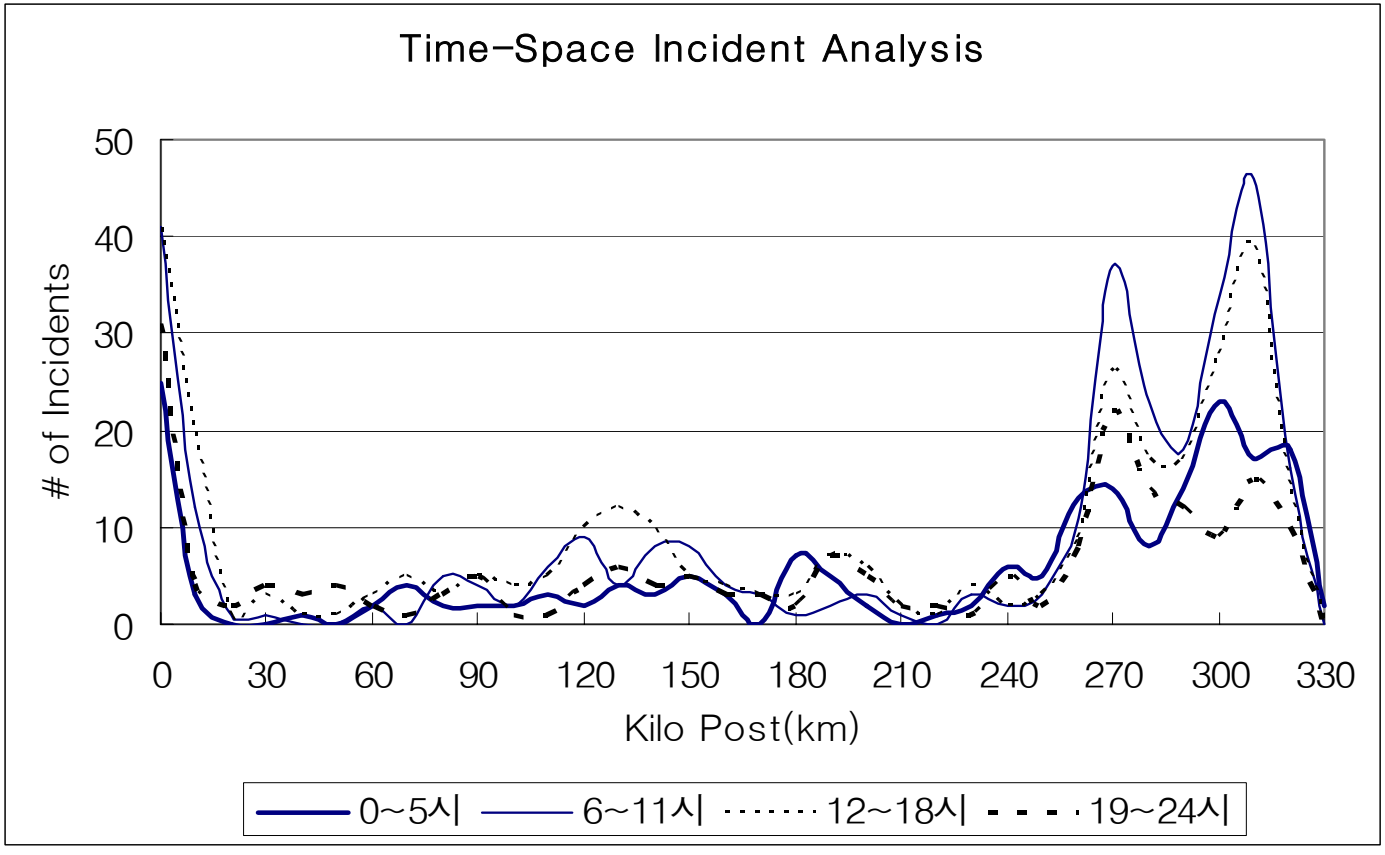
Development Direction



- Average Data ➡ Individual Data
- Different Parameter for detector type
- Automatic parameter generation by traffic characteristics
- Need different parameter near IC, JC and Weaving Area
- Using several different aggregation interval
- Decision Matrix using DELOS and McMaster
- Garbage In, Garbage Out

Incident Prevention

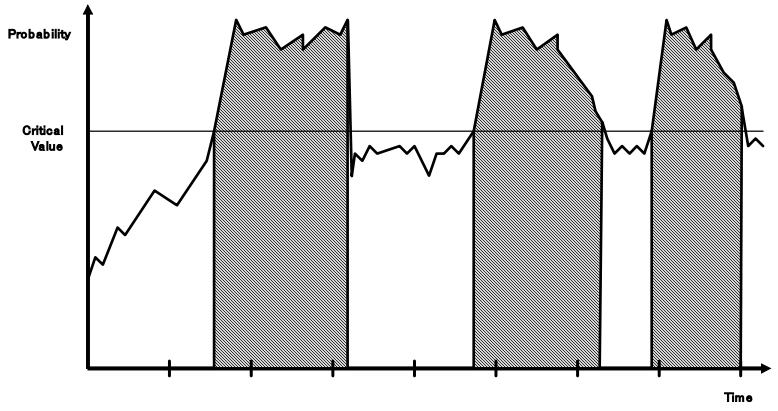
- Patrol
- Optimum resource management
- Historical data analysis:
  : time, route, location, incident type, weather etc.

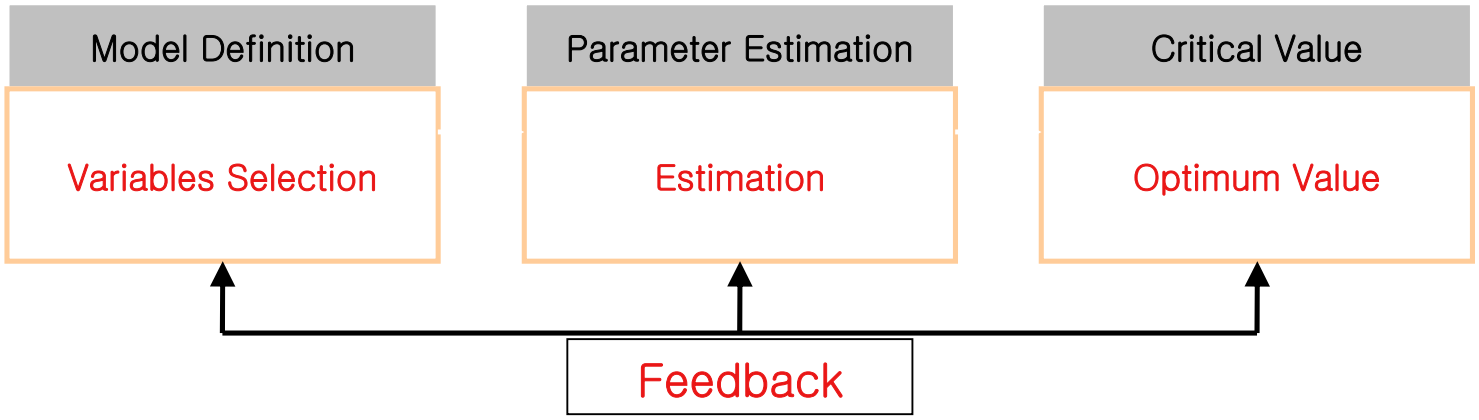


Estimation of Incident Probability

Estimation of Incident Probability

- Statistical Analysis using geometric, weather and traffic characteristics
- **Using decision support system to determine problem area for special surveillance and management**





Estimation of Incident Probability

LOGIT Model

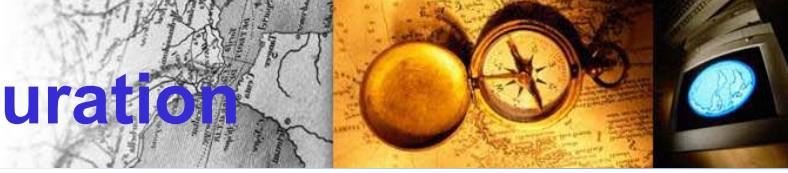
- SPEEDVOL: Volume weighted average speed
- SCHOM_VC: Average volume/capacity ratio
- D1_D2: Density Difference(lane1, lane2)
- V1_V2: Volume difference (lane1, lane2)

$$P_{ij} = \left[\sum_{k=0}^{m} \exp(x_{ik}'\beta)\right]^{-1} \exp(x_{ik}'\beta),$$

$$i = 1,2,\ldots\ldots,n \quad \text{and} \quad j = 0,1,\ldots\ldots m_i$$

Parameter	Coefficients	standard error	Coeff./S.E.
SPEEDVOL	-.03046	0.00545	-5.58987
SCHOM_VC	-14.92854	2.72016	-5.48810
D1_D2	-0.02024	0.00939	-2.15662
V1_V2	0.00066	0.00034	1.96663

Estimation of Incident Duration



1. **Simple Statistical Methods**
   - ❑ Lognormal distribution – Golob et. Al. (1987)
   - ❑ Variance Analysis – Guiliano (1989)
   - ❑ Truncated regression – Khattak et. Al. (1995)

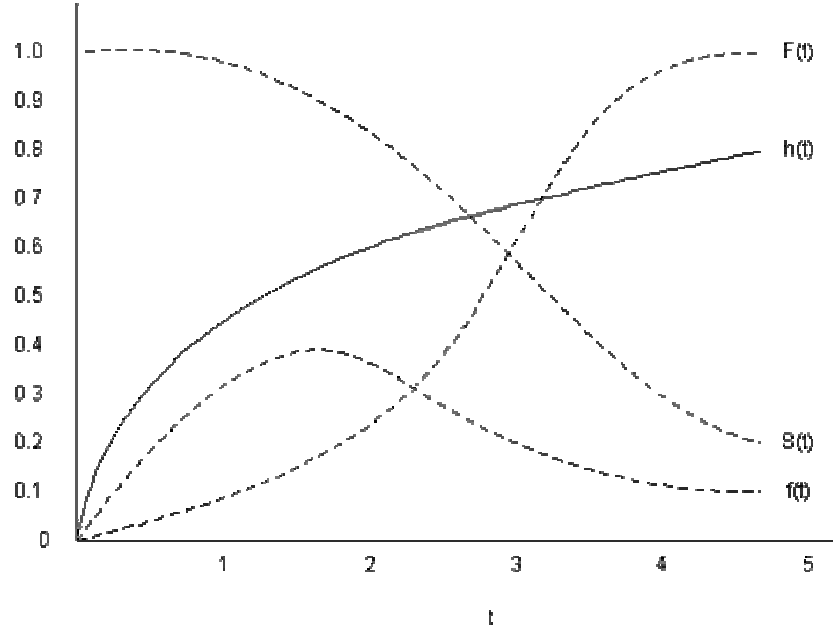
2. **Decision Tree**
   - ❑ Advance Project
     - Simple categorization of incident characteristics

3. **Advanced Modeling Approaches**
   - ❑ Hazard Based Duration Modeling (Nam, 2001)

     Consider duration effect

Estimation of Incident Duration

- **Hazard Based Incident Duration Model**
  - Duration Effect
  - Different models for incident step(detection, response, clearance)
  - Model construction based on available data by each step

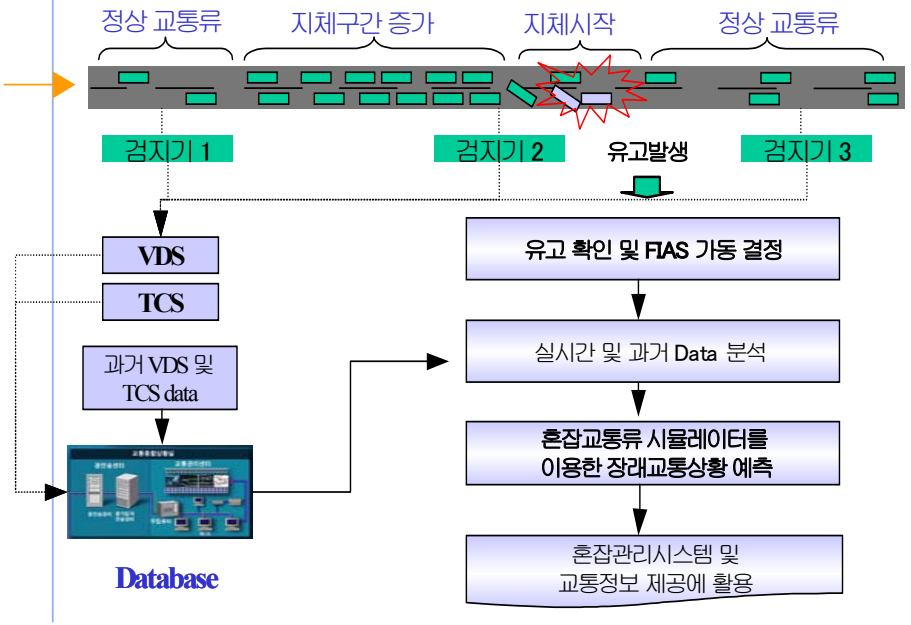


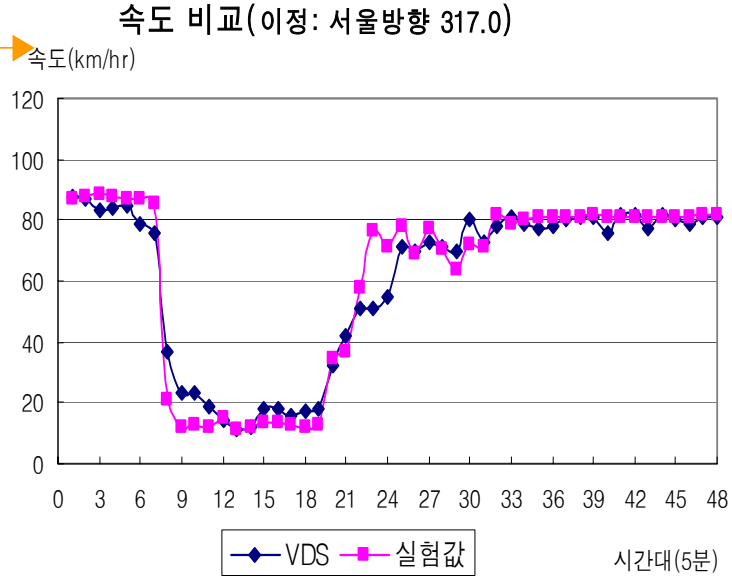
Distribution	Hazard Function
Exponential	λ
Weibull	$\lambda p(\lambda t)^{p-1}$
Lognormal	$f(t)=(p/t)\Phi(p\ ln(\lambda t))$
Log-Logistic	$h(t)=\lambda p(\lambda t)^{p-1}/[1+(\lambda t)^{p}]$

Traffic Impact Estimation

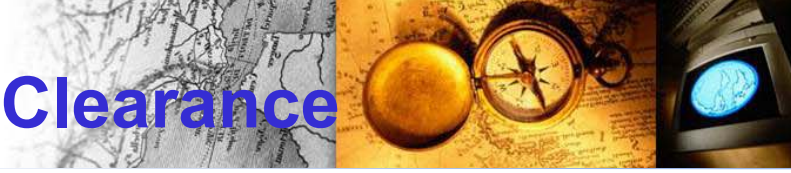
❑ Traffic Impact Estimation by Incident

- Used for Response level and detour plan
- Minimize impact by planned incident(i.e. construction, special events)
- Reduce secondary incident





Incident Response and Clearance

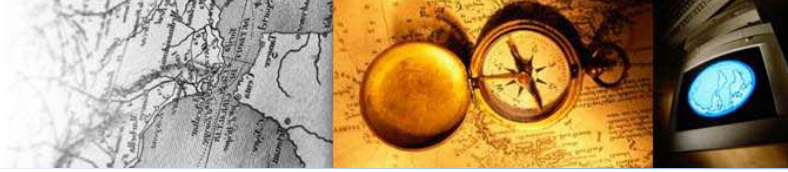


1. Reduce Incident Detection Time

- Communication network with various driver group
- Using Information Technology: RFID, Ubiquitous
- Cellular Users
- Increase CCTV Coverage
- Real-time video and data feed from response team

2. Traffic Management

- Optimize VMS message
- HAR, Cellular, Radio, Internet(hotspot)
- Response and Clearance Manual
- Law and Policy Change
- Incident Team
- Unified Command Team



Thank you.

Yesterday is History, Tomorrow is Mystery and
Today is a gift; that's why we call it Present.