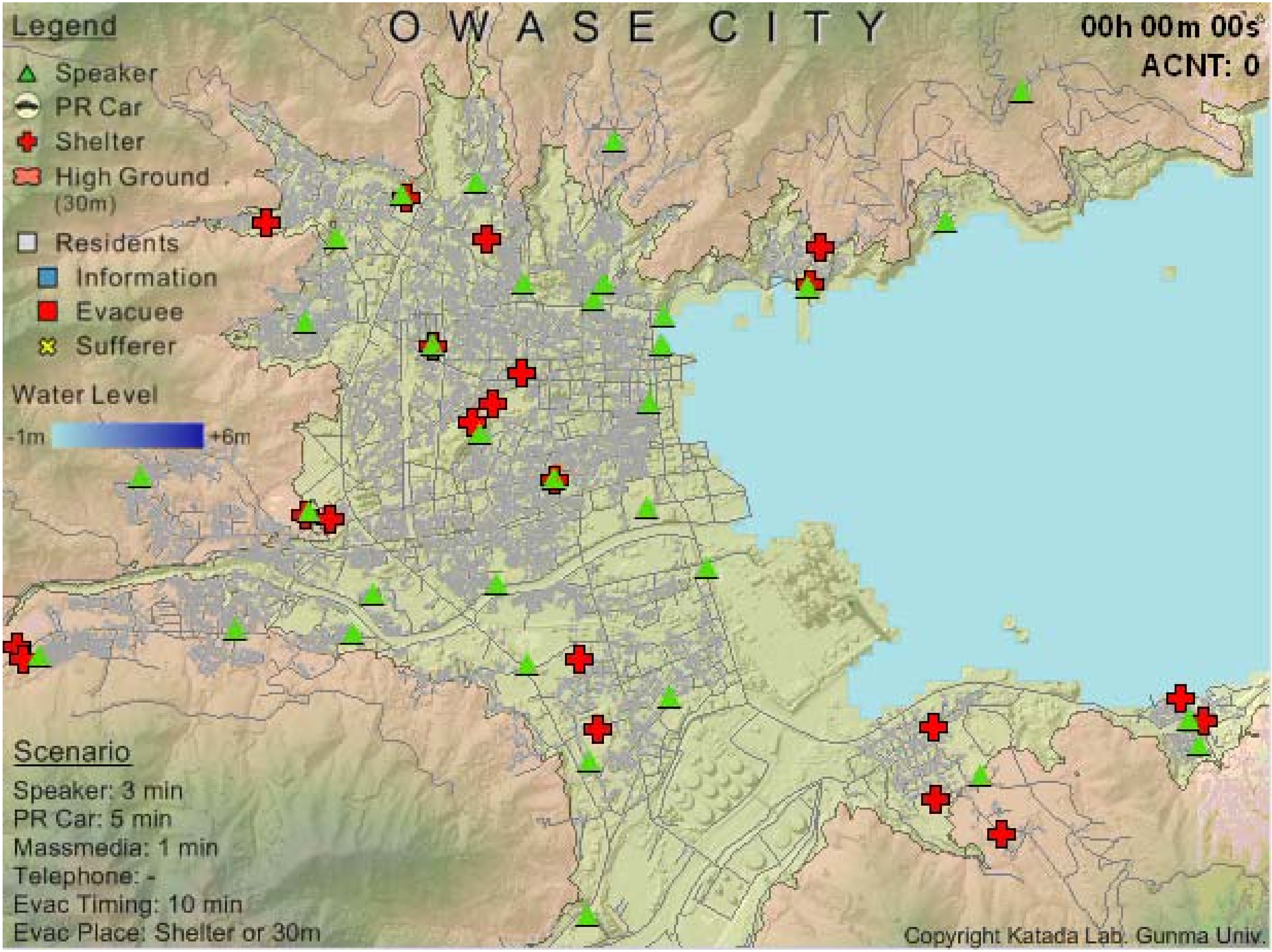
O W A S E C I T Y
00h 00m 00s
ACNT: 0
Legend
Speaker
PR Car
Shelter
High Ground
(30m)
Residents
Information
Evacuee
Sufferer
Water Level
-1m
+6m
Scenario
Speaker: 3 min
PR Car: 5 min
Massmedia: 1 min
Telephone: -
Evac Timing: 10 min
Evac Place: Shelter or 30m
Copyright Katada Lab. Gunma Univ.

Tsunami Scenario Simulator

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Gunma University, Japan

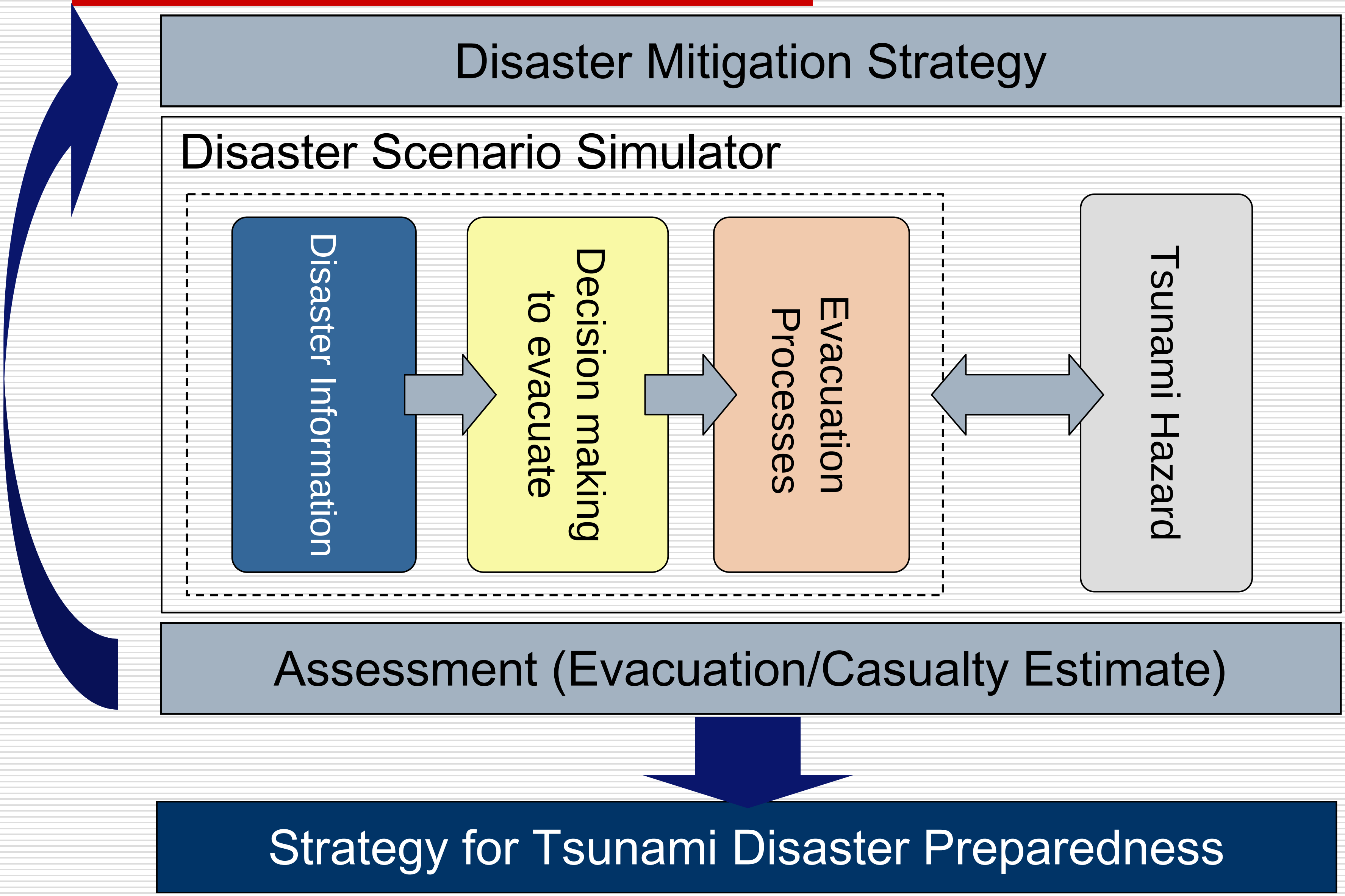
Noriyuki Kuwasawa
Gunma University, Japan

Harry Yeh
Oregon State University

Tsunami Scenario Simulator

- Integration of
  1. Warning Transmission Simulation
  2. Evacuation Simulation
  3. Tsunami Simulation
- Estimation of the casualties
- Visualization in the GIS Framework

The Comprehensive Disaster Scenario Simulator



Tsunami Simulation

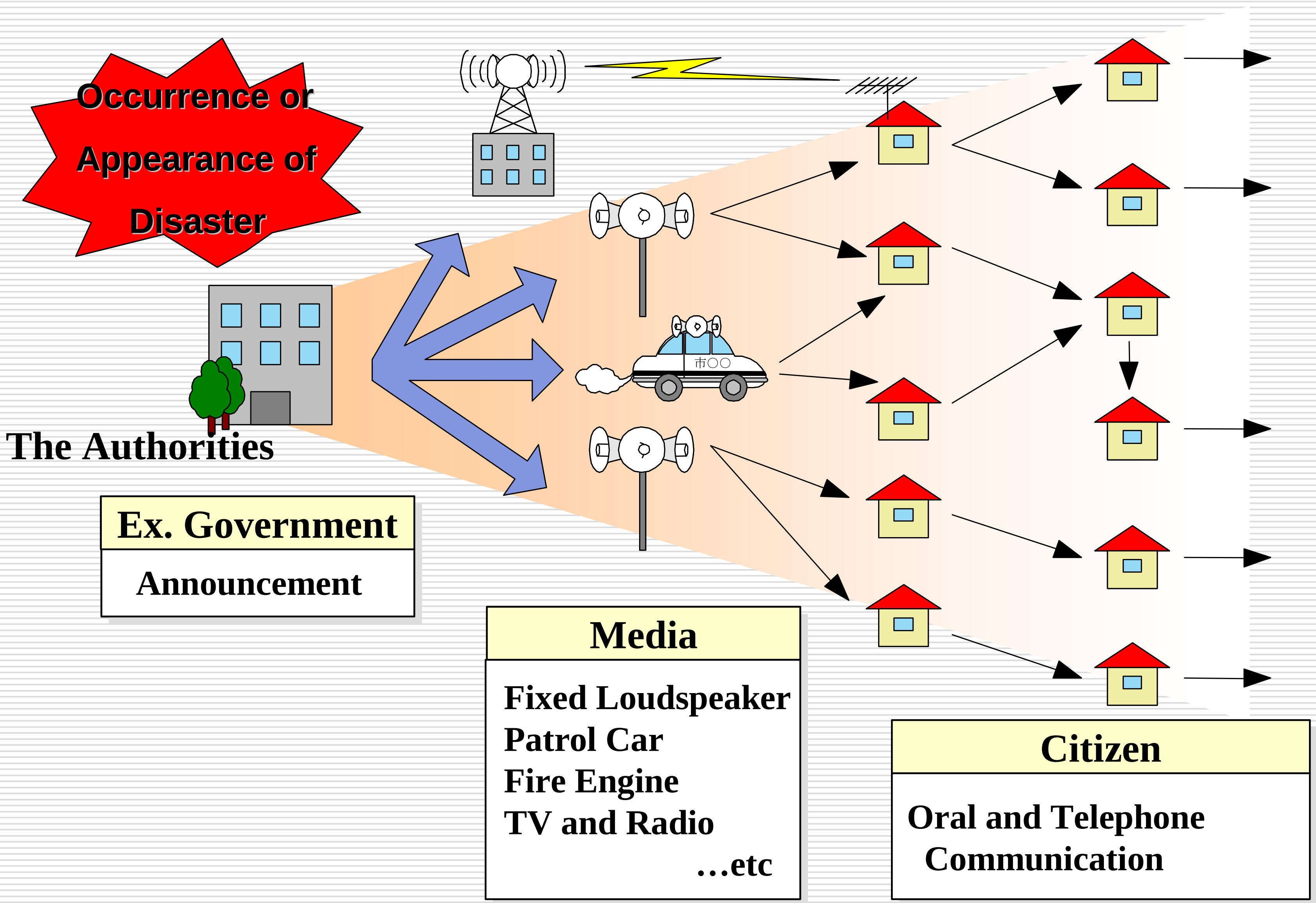
- This simulation is made separately from the other simulations for warning transmission and evacuation.
- The simulator uses the pre-prepared results of various scenarios.
  - Ex.: Quake Scale, Arrangement of embankment

Evacuation Simulation

The present simulation is very simple.

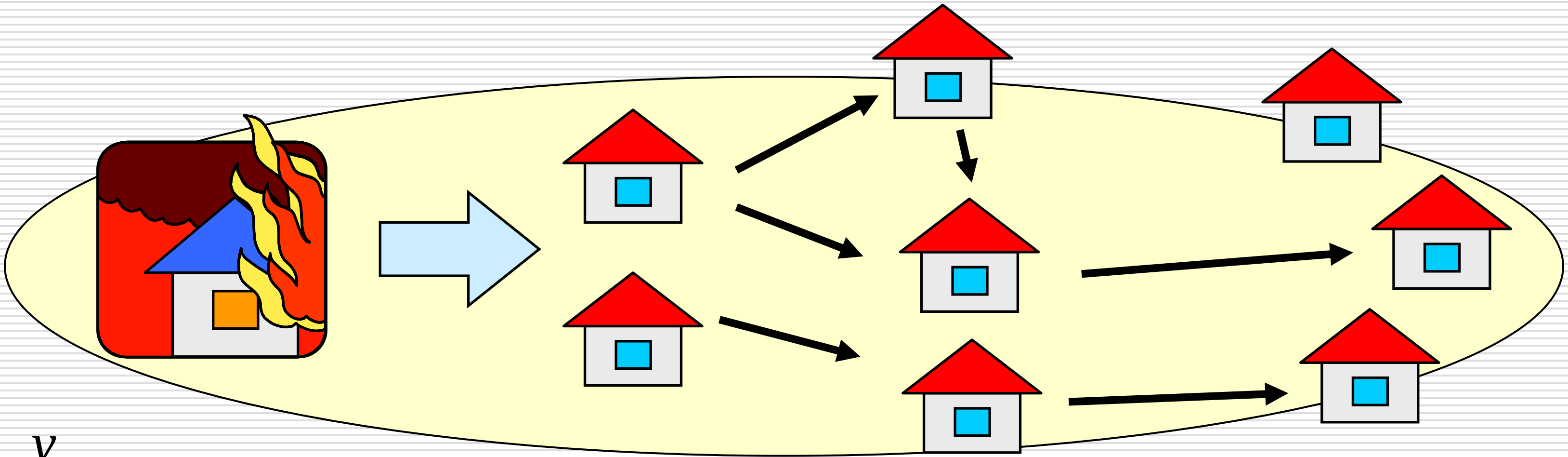
- Evacuee Unit
  - Family. Evacuation starts from a house.
- Speed
  - A fixed speed from a start to arrival
- Shelter locations
  - Pre-set the locations.
- Route
  - An evacuee takes the shortest route following the road network.

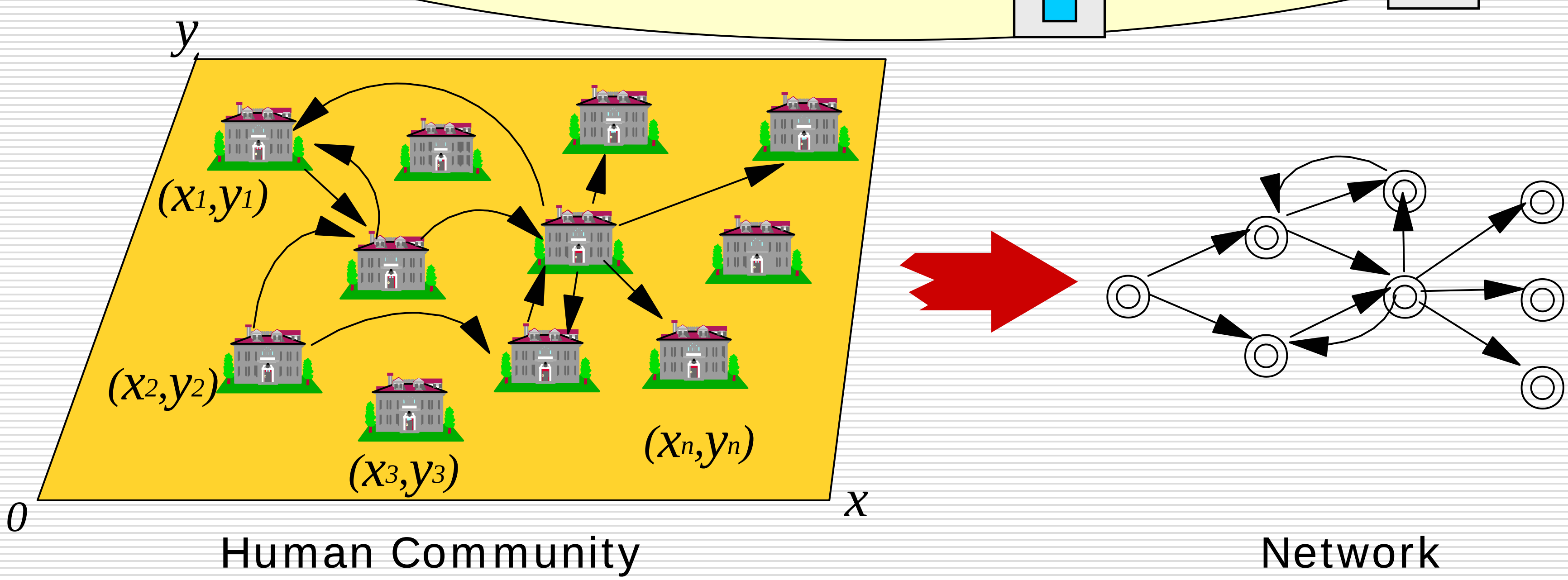
Simulation for Warning Transmission



Expression of Oral Communication Network

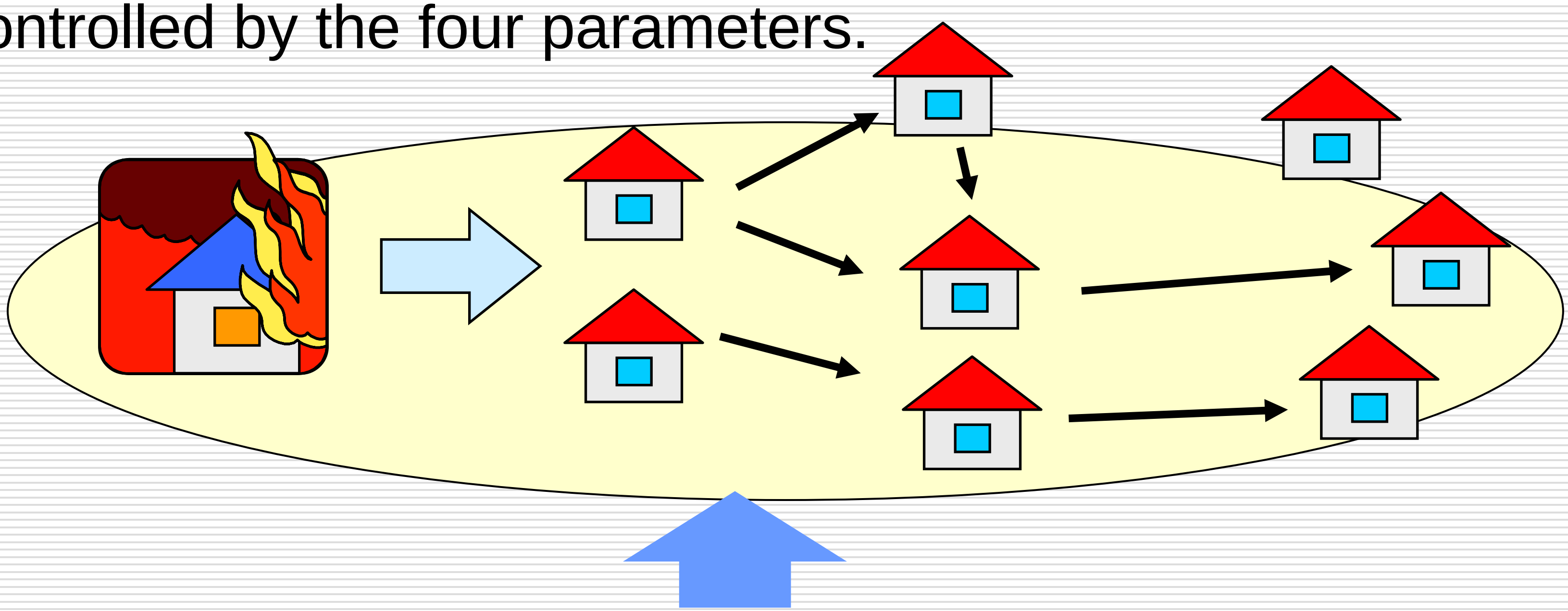
The base network is composed of oral communication network.
The media will be added to this base network.





Expression and Control of Oral Communication

The generation of oral communication network is controlled by the four parameters.



The Control Parameters of Oral Communication Network

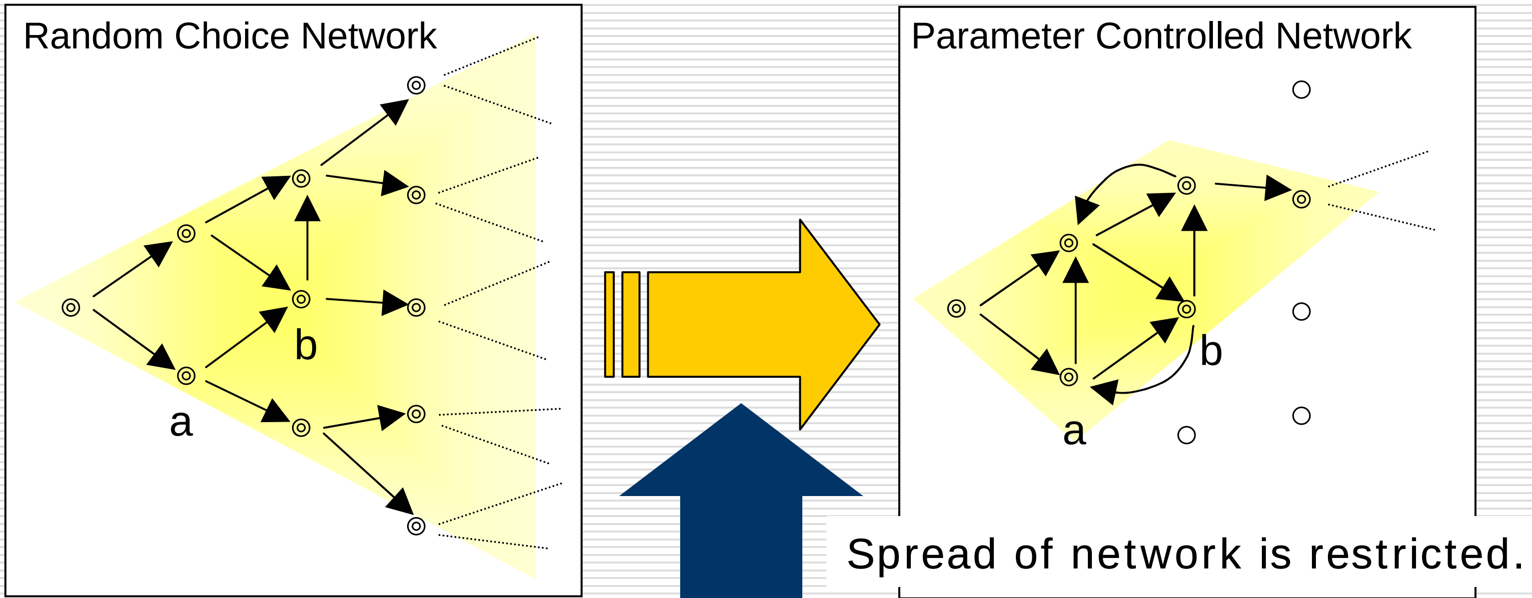
Number of Contacts(Receivers)

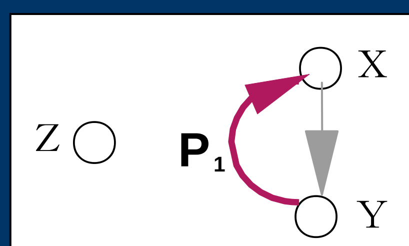
Distance of Each Contact

Timing of Each Contact

Communication Parameters

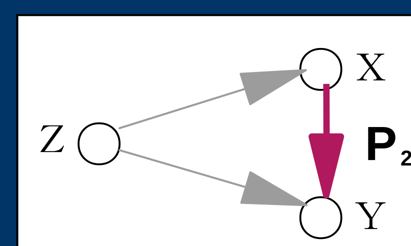
Communication Parameters





Reflection Linkage

$$P_1 = \pi + (1 - \pi)d$$



Mutual Linkage

$$P_2 = \sigma + (1 - \sigma)d$$

π : Reflection Bias Parameter

σ : Mutual Bias Parameter

The Differences in The Control Parameters between Normal Days and During Disaster

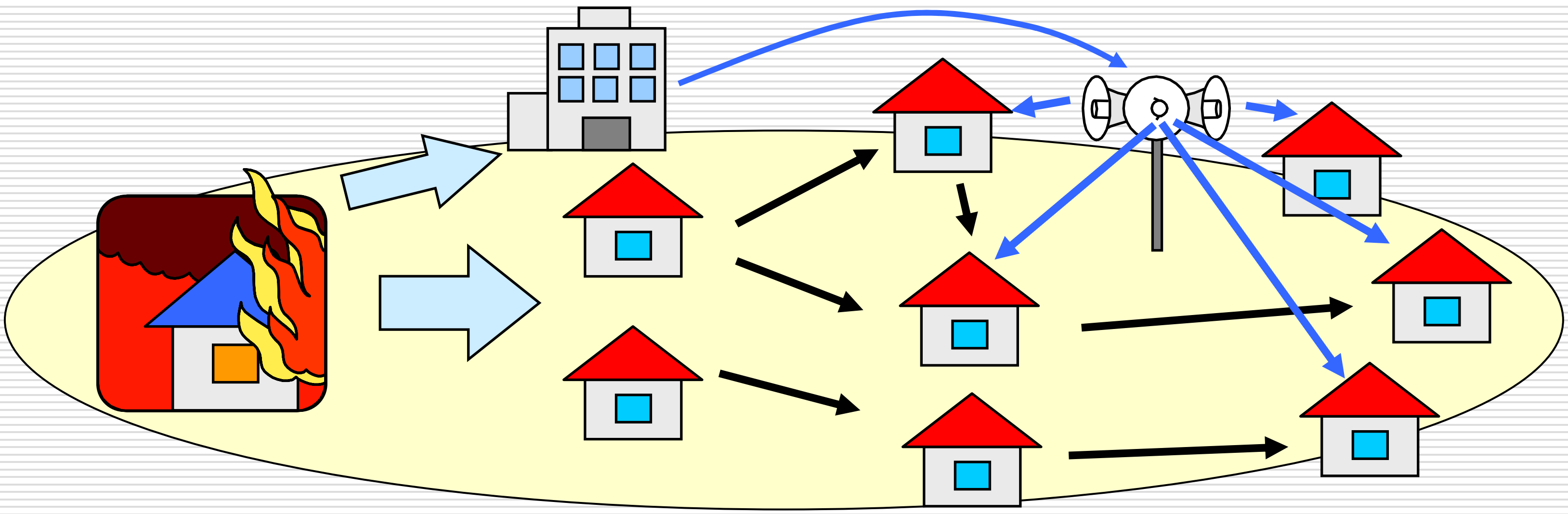
By using these control parameters, this simulation expresses the transmission condition at the normal days and during disaster.

	Normal Days	During Disaster
The Number of Contacts (Receivers)	**small**	**large**
The Distance to Each Receiver	**long**	**short**
The Timing of Each Contact	**-**	**-**
Communication Parameters	**large**	**small**

The control parameters were determined by questionnaire survey.

Media (in case of Fixed Loudspeakers)

- The Loudspeaker is combined into oral communication network.



The Parameters for Loudspeaker

#1 Location , #2 Audible Distance, #3 Audience Rating,

#4 Announcement Frequency and Each Timings

Description of Transmission Media and Its Functions

- The functions of each media is described by using following parameters in the simulation.

Media	Parameter
Oral Communication	**The Distribution of Number of Contacts, Walking-speed, The Distribution of Distance to Receiver, Commu. Para.**
Telephone	**The Distribution of Number of Contacts, Connecting Ratio**
Patrol car, Fire Engine (With Loudspeaker)	**The Route and Speed, Departure Time, Audible Distance, Audience Rating**
Fixed Loudspeaker	**Audible Distance, Audience Rating, Announcement Frequency and Timings**
TV, Radio	**Audience Rating, Announcement Frequency and Each Timings**

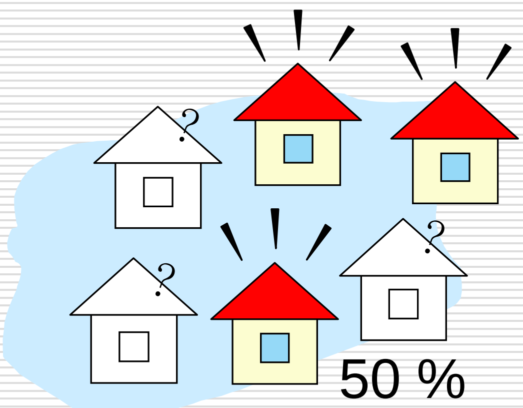
Evaluation of the Simulation Result

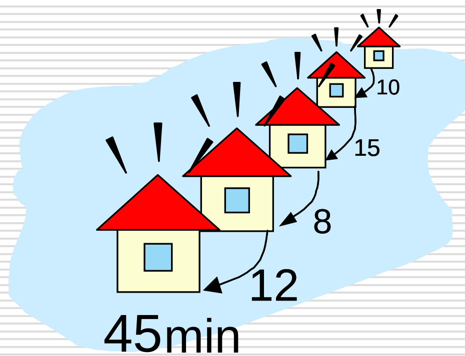
- Evaluation Factors <<Personal Level ⇒ Regional Level>>

  #1 Info-Receive Count ⇒ Ratio of Info-Receiver

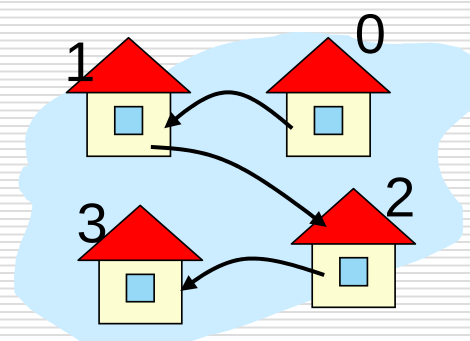
  #2 Info-Receive Time ⇒Timing Distribution of Info-Receiving

  #3 Step Count by Human communication ⇒ Ratio of Correct Info.





45 = 12 + 8 + 15 + 10



#1: Info-Receive Count
▼
Ratio of Info-Receiver

#2 Info-Receive Time
▼
Timing Distribution of Info-Receiving

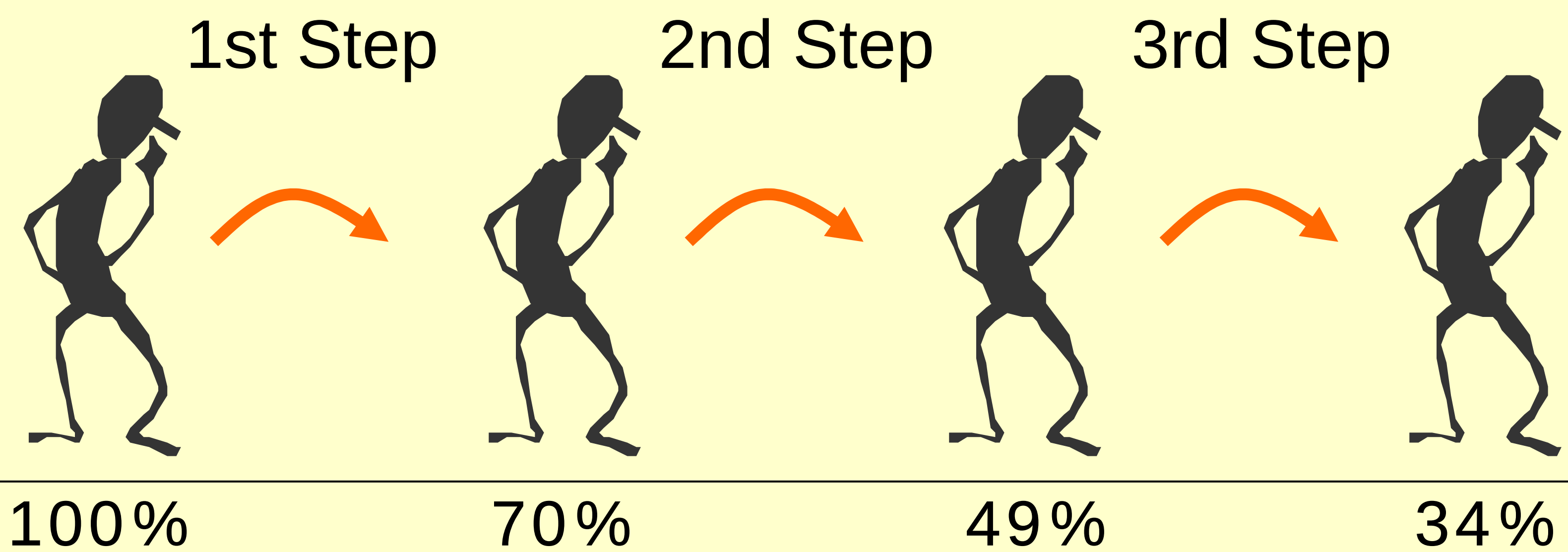
#3 Step Count by Human communication
▼
Ratio of Correct Info.

The Process of Correct Information Transmission

- Human Communication(Oral,Telephone) is apt to change contents of the information.

  ex. Evacuate to the Building! ⇔ Evacuate from the Building!

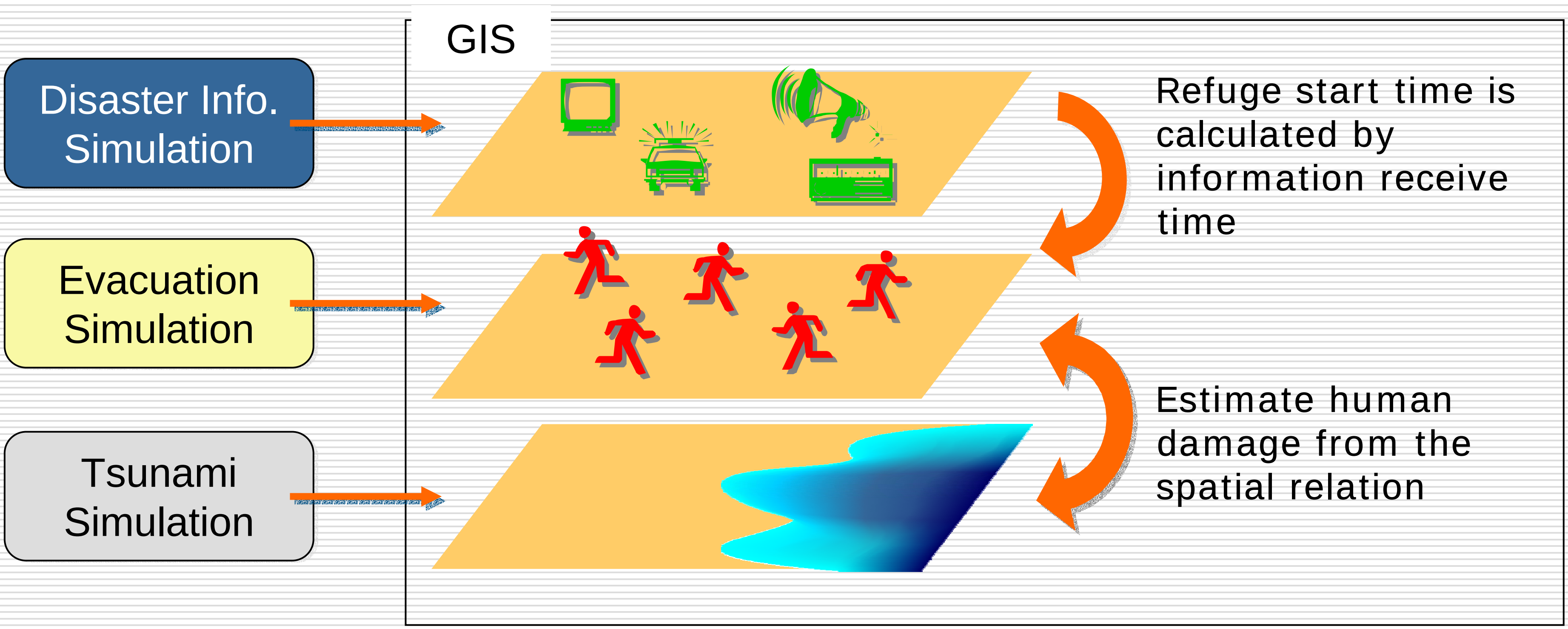
If information change in probability of 30%,….



Correct Information

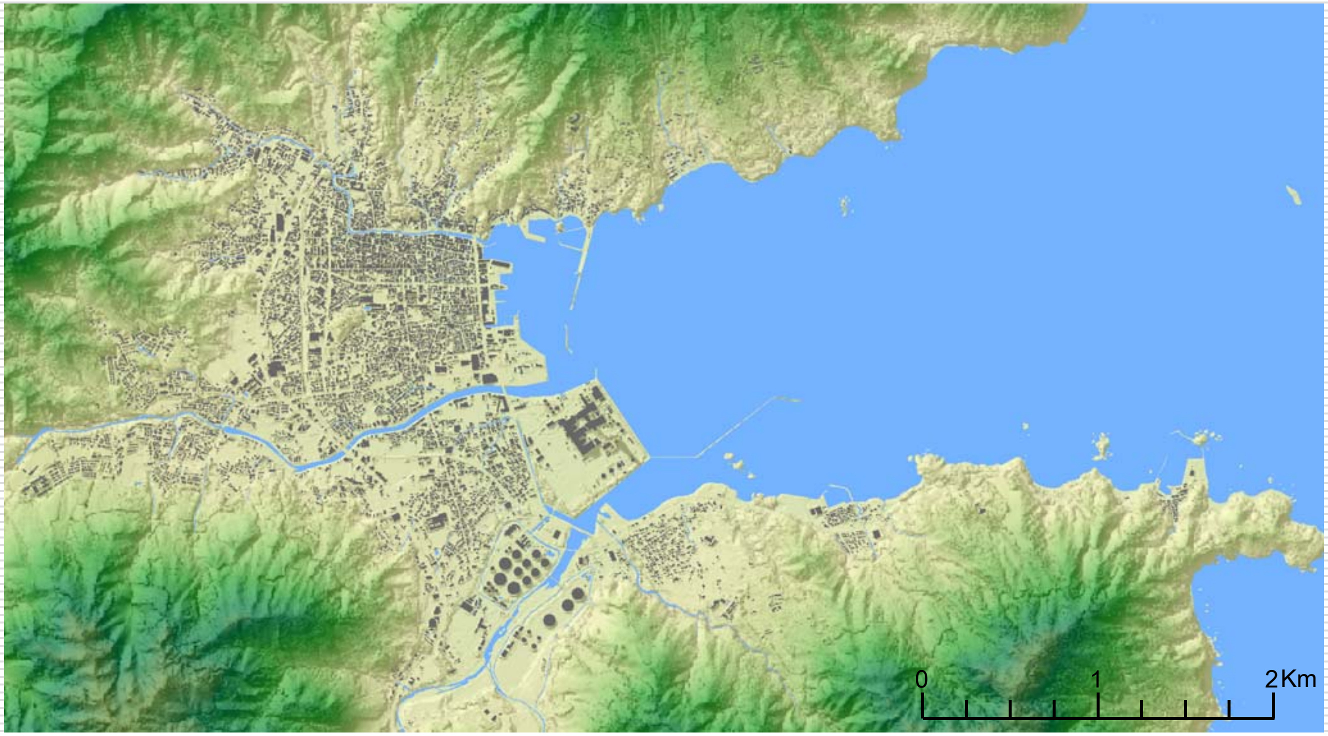
Integration of simulation

- The simulator integrates the results of each simulation by using GIS.
  - Evacuation start time is calculated by information receive time.
  - Estimate casualties from the spatial relation between a distribution of evacuee and inundation area of tsunami.

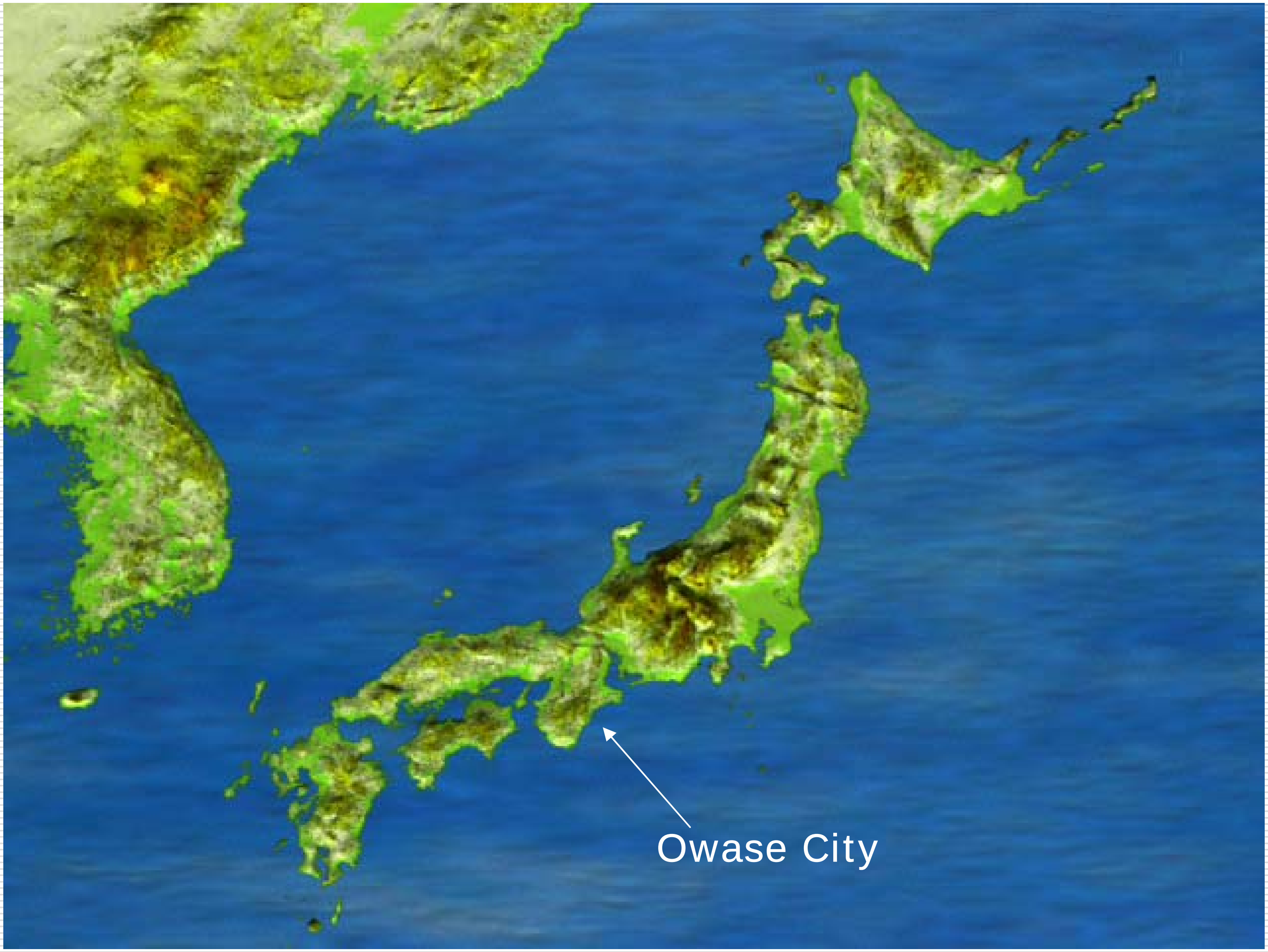


Owase City

- Tsunami-prone area
  - (1944 Tounankai-oki, 1946 Nankaido-oki, 1960 Chilean)
- The big tsunami is expected by a Nankai-Tonankai earthquake that will probably occur in the near future.



Tsunami Scenario



Setting of Basic Condition

- Input the information facilities and evacuation facilities

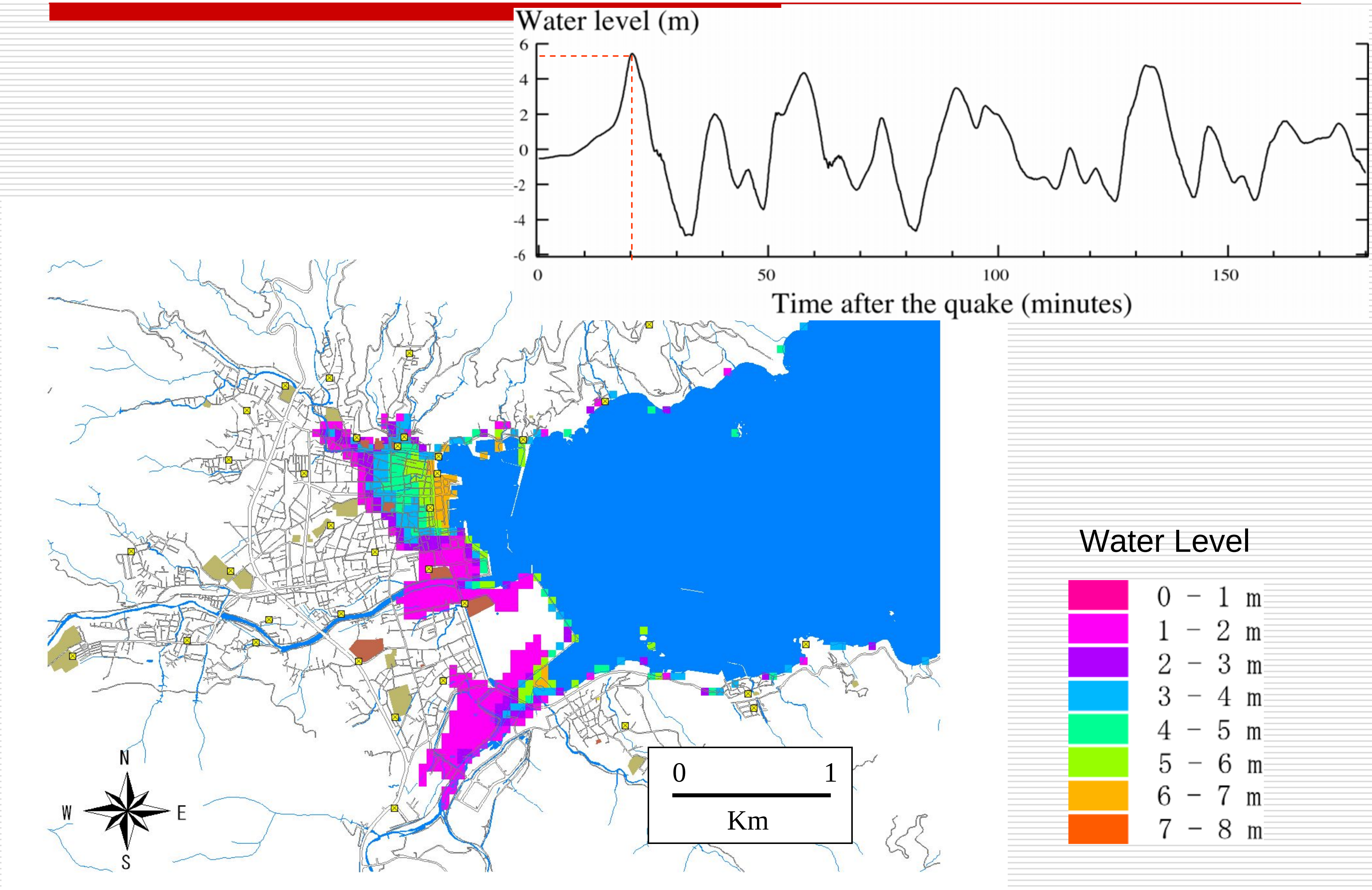
Households: 6,651

Loudspeakers : 35

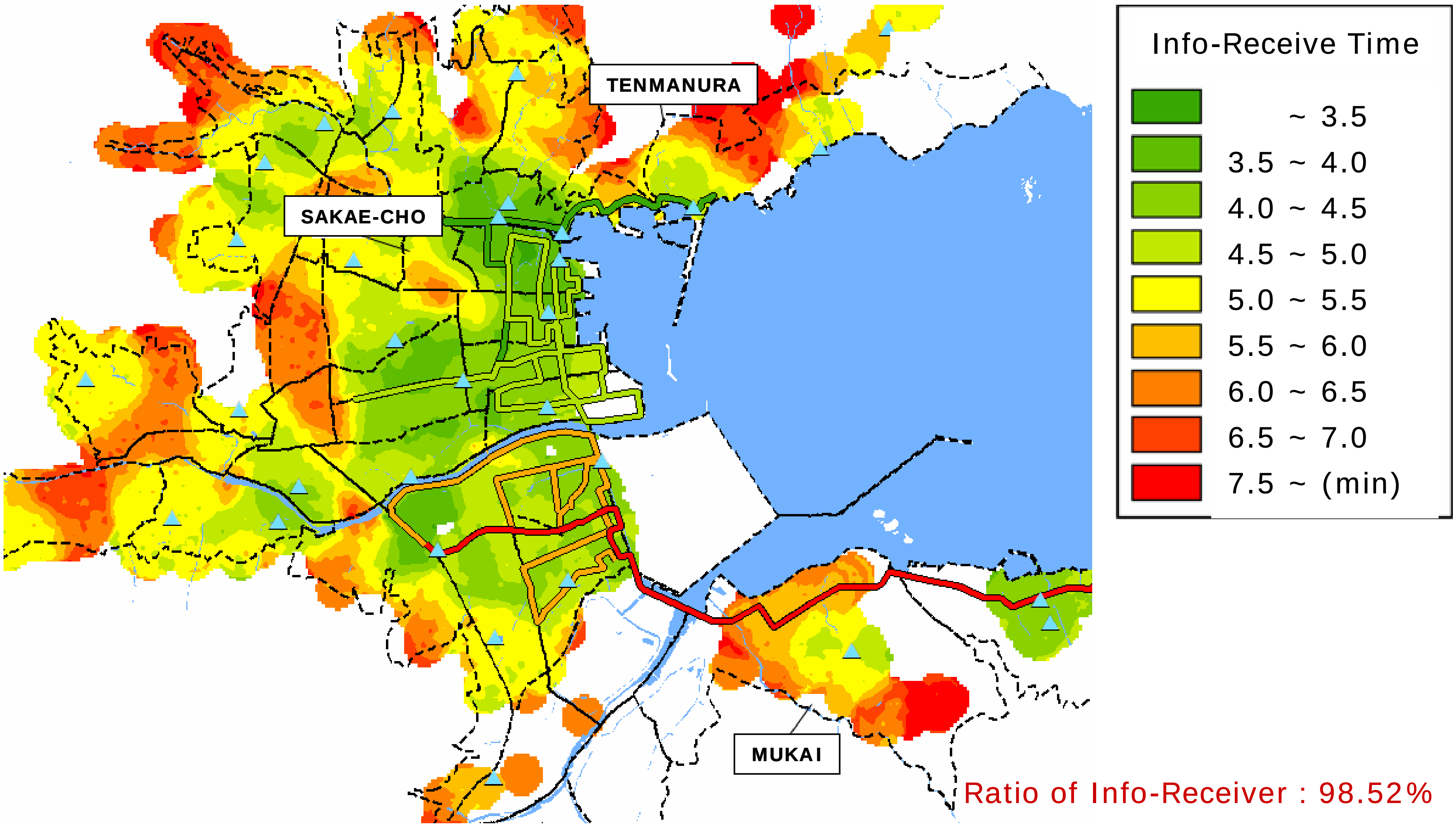
Patrol Cars : 4

Shelters : 25

Inundation Area



Result of the Information Simulation

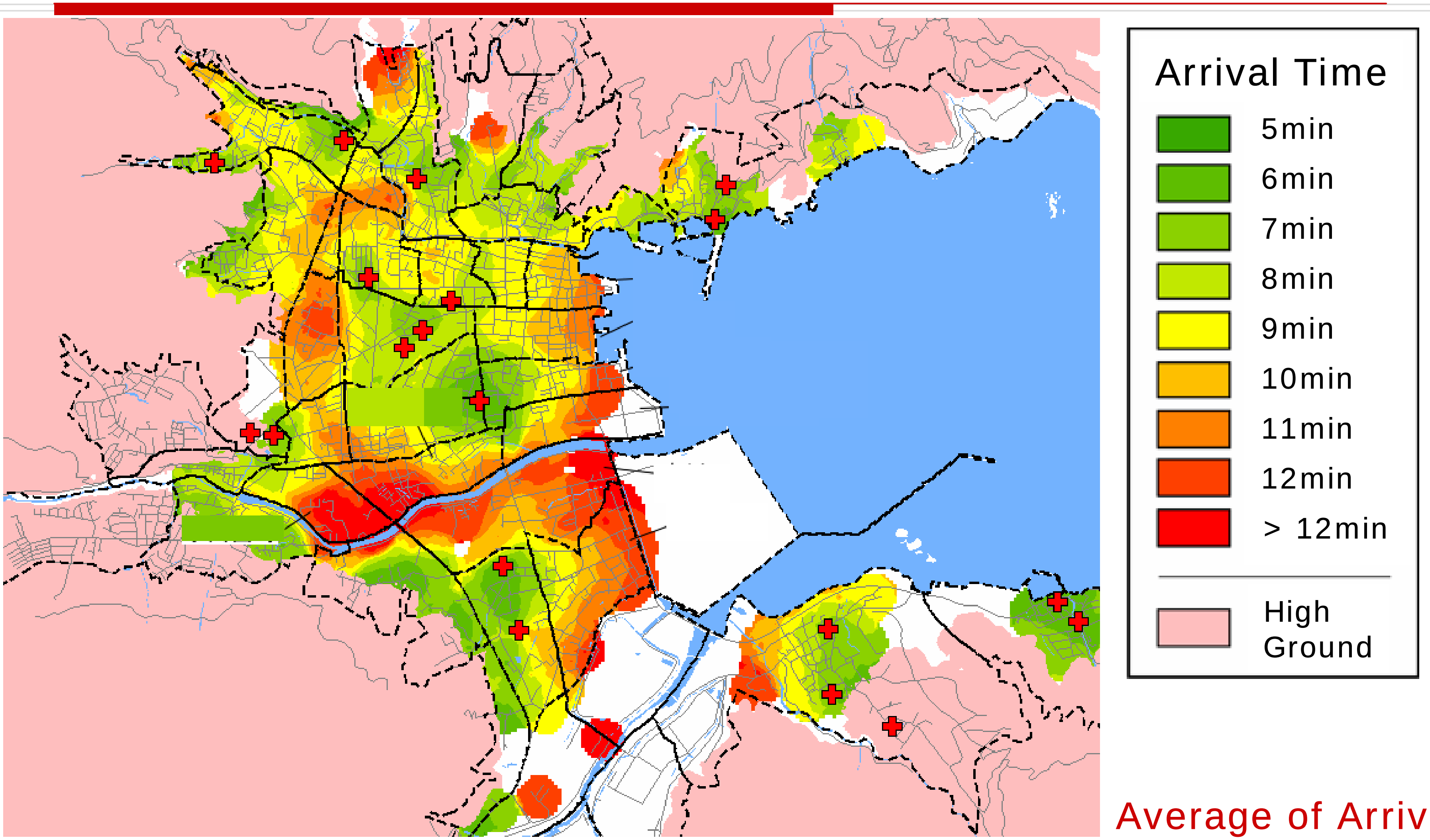


Ratio of Info-Receiver : 98.52%

※Loudspeaker and Patrol Car	3min
※Mass media (Audience Rating 30%)	3min

Ave. of Info-Receive Time :
4min 58sec

Result of Evacuation Simulation



Average of Arrival Time:
8min 27sec

Scenario: Residents start to evacuate immediately after information received.

Scenario Analysis

- Disaster Information Scenario
  - If the transmission of disaster information is delayed…
    - Loudspeaker, Patrol Car Start Timing
      1 min, 2 min, 3 min,.....20 min, 30 min, 60 min
  - Mass media broadcast timing is fixed. (3 min)

- Evacuation Scenario
  - If the evacuation is delayed…
    - Evacuation Start Timing
      0 min ~ 10min

Simulated Number of Causalities

Evacuation Start Timing (min)	Timing (min) of Authorized Tsunami Warning												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**20**	**30**	**60**
0	0	0	0	0	0	0	0	0	0	0	1	1	7
1	0	0	0	0	0	0	0	0	0	0	1	1	10
2	0	0	0	0	0	0	0	0	0	0	2	2	17
3	0	0	0	0	0	0	0	1	1	1	4	6	32
4	0	0	0	0	0	1	2	2	4	3	7	14	50
5	0	0	0	1	2	4	6	7	8	7	12	20	75
6	0	1	2	5	8	9	9	9	11	10	17	44	120
7	1	2	7	9	9	13	14	13	12	12	36	94	190
8	1	8	10	10	12	15	17	19	16	19	81	148	302
9	9	11	13	12	12	24	26	51	53	56	189	273	440
10	11	14	14	17	41	72	91	124	148	165	373	463	566

The Number of Causalities :

0	1 ~ 5	6 ~ 10	11 ~ 50	51 ~ 100	101 <

The Scenario Simulator can be used for:

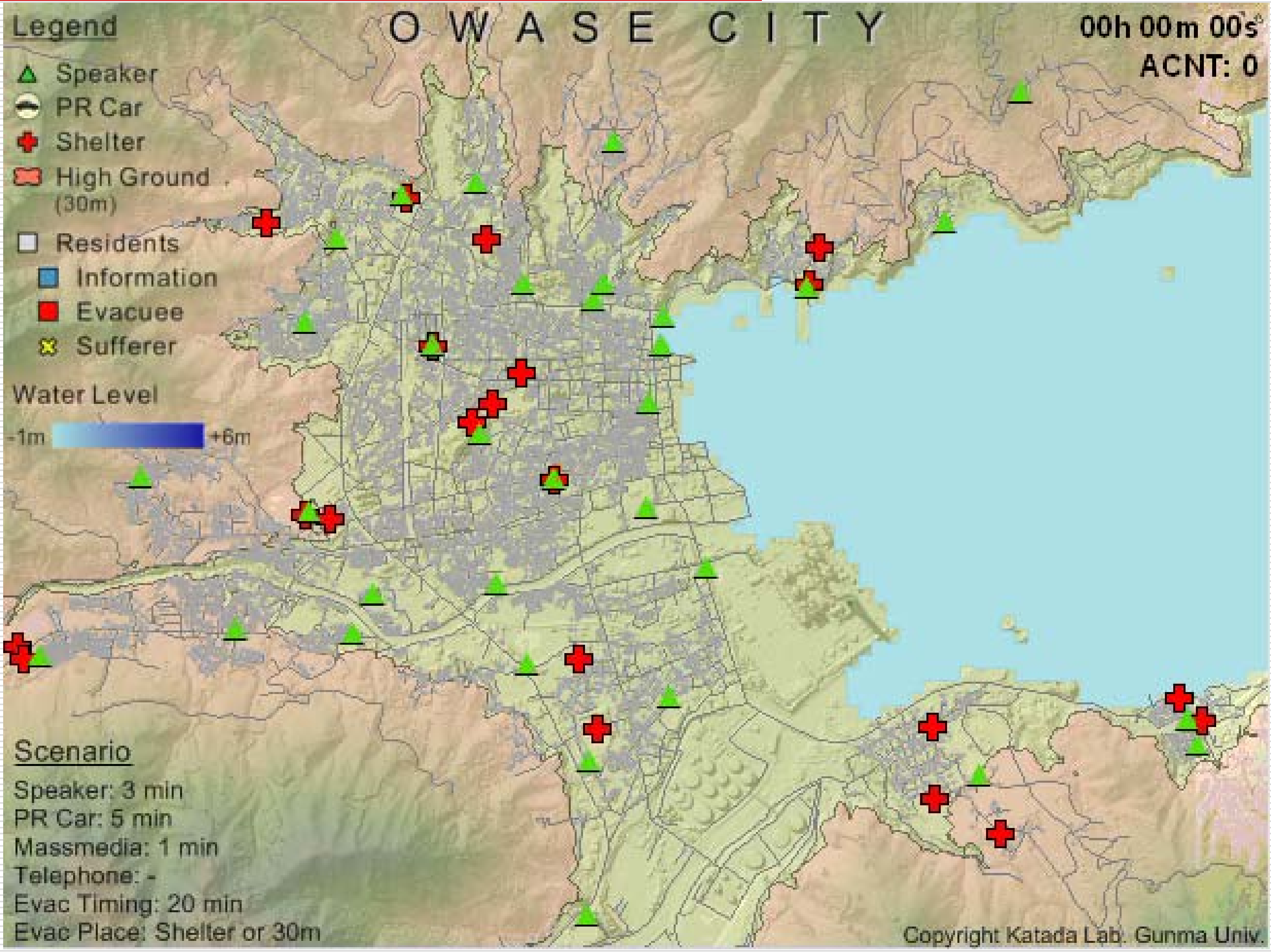
- Disaster Preparedness
  - Evaluate the Existing Disaster Preparedness: Strategy and Conditions
  - Develop or Improve the Mitigation Strategy
- Educational Tool
  - Dynamic Hazard Map

Dynamic Hazard Map

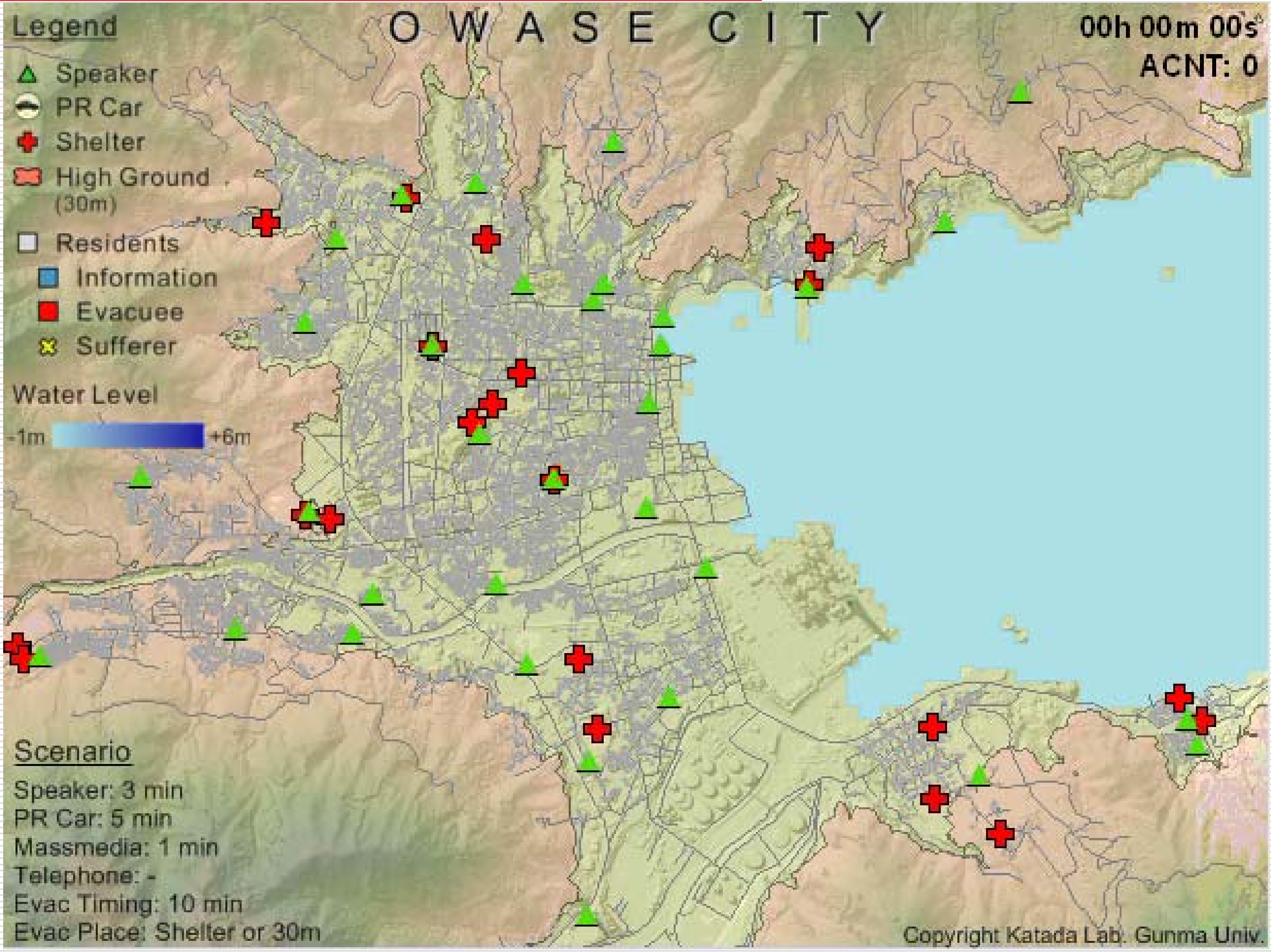
Simulation Scenario Pattern

		Loudspeaker	Patrol Car	Mass Media	Refuge Timing
Scenario 1	If the residents refuge is more delayed	3min	5min	1min	20 minutes after information received
Scenario 2	If the residents refuge is delayed	3min	5min	1min	10 minutes after information received
Scenario 3	If the resident take refuge immediately	3min	5min	1min	Immediately after information received
Scenario 4	Refuge based on an own judgment	-	-	-	5 minutes after earthquake

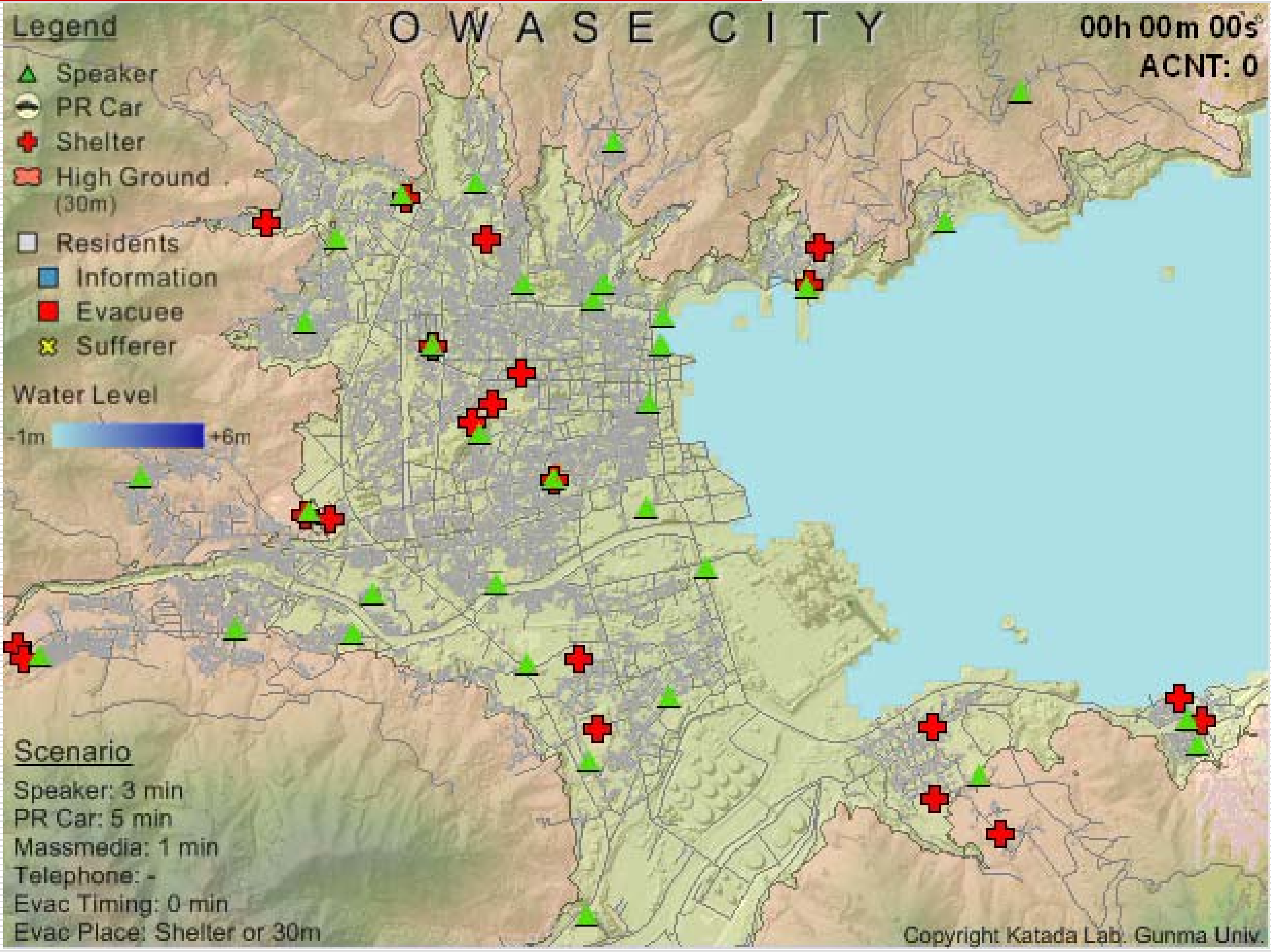
Scenario1 (ACNT:1160)



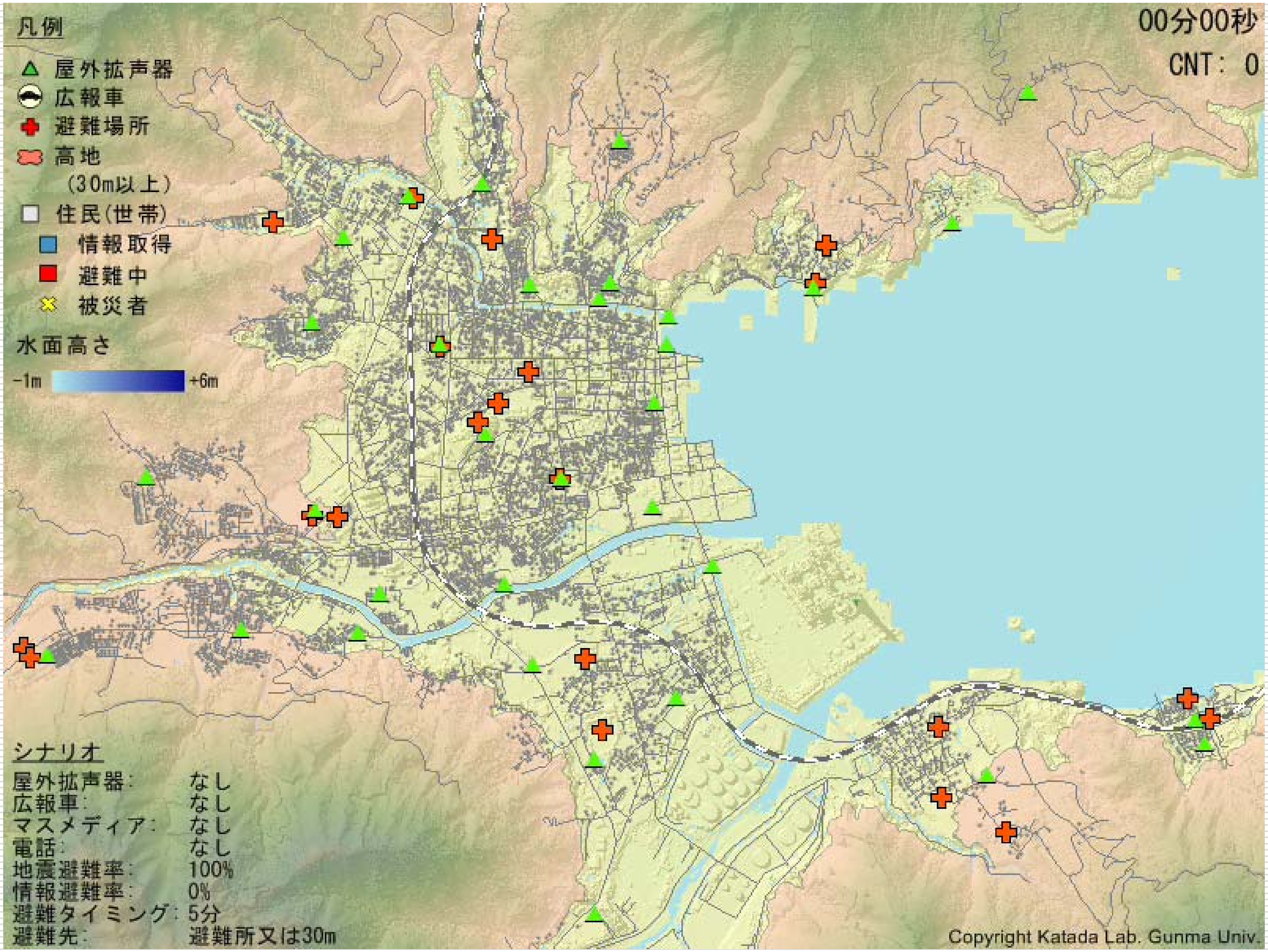
Scenario2 (ACNT:139)



Scenario3 (ACNT:36)



Scenario 4 (ACNT:0)



Problem of previous simulation model

- At the event of disaster, all the people are assumed to be in their house just like the condition at midnight.
- Evacuees' behaviors are determined as the family units: no individual response is considered in the model.
- In the previous system, each simulation model was run independently. Therefore, there is no interaction or feedback among the three simulation runs: info transmission, evacuation, and tsunami-runup models.
  - For example, the previous model **cannot** simulate:
    1. No information transmission during the evacuation. We need (Evacuation <-> Info. transmission)
    2. Evacuation route is independent from tsunami situation. We need (Evacuation <-> Tsunami)

Changes in the simulation concept

- Old Simulation: Stopwatch Model
  - The previous simulation can be called a “stopwatch” model because the simulation commenced at the event of earthquake.
  - This model doesn't consider the timing of the earthquake.
- New Simulation: Clock Model
  - The new simulation model can handle the situation which the disaster occurs at arbitrary time.
    - How much the damage will be if the earthquake strikes at 9 am and the tsunami attack at 9:20 am?
  - Advantages of Clock Model
    - This model can keep track the behavior of each individual.
    - This model can estimate the damage that changes by the occurrence time of the disaster.
    - This model can include the interactions of all the simulations (evacuation, warning-transmission, and tsunami-runup).

Outline of Clock Model

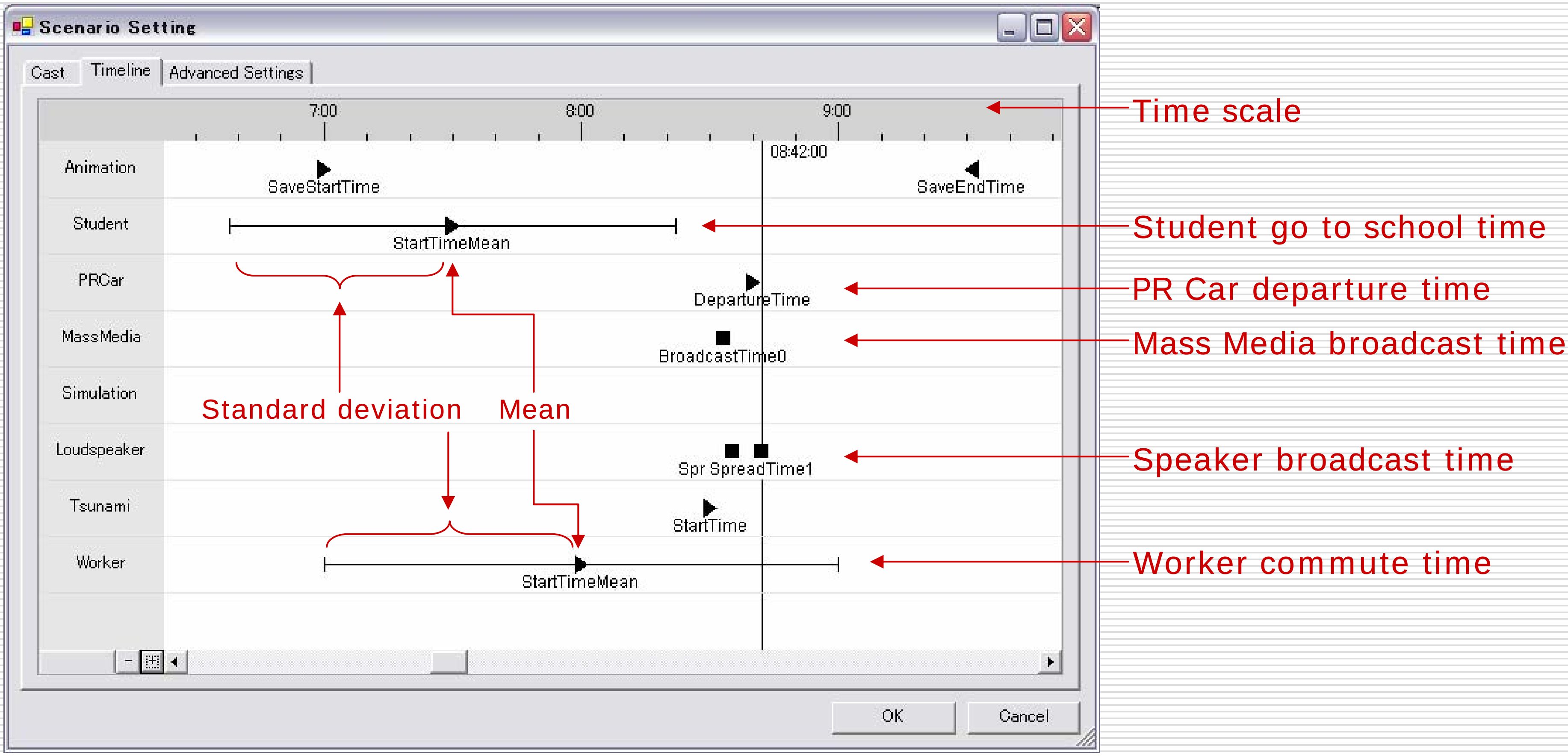
- Expression Content
  This model expresses the change in the distribution of population during a day.
  - Population
    - Population at daytime and nighttime
      *Population inflow and outflow
  - Traffic
    - go to work, go to school, sightseeing, shopping, etc.
- Modeling Policy
  - This model may not be able to describe accurately human activities in detail. But, the gross pattern of the community can be adequately represented.
  - Because we apply Monte-Carlo simulations, population distribution changes slightly at every simulation. However, the statistics of the community activities remain the same.
  - We designed the model so that it requires information that is readily available, for example census data.

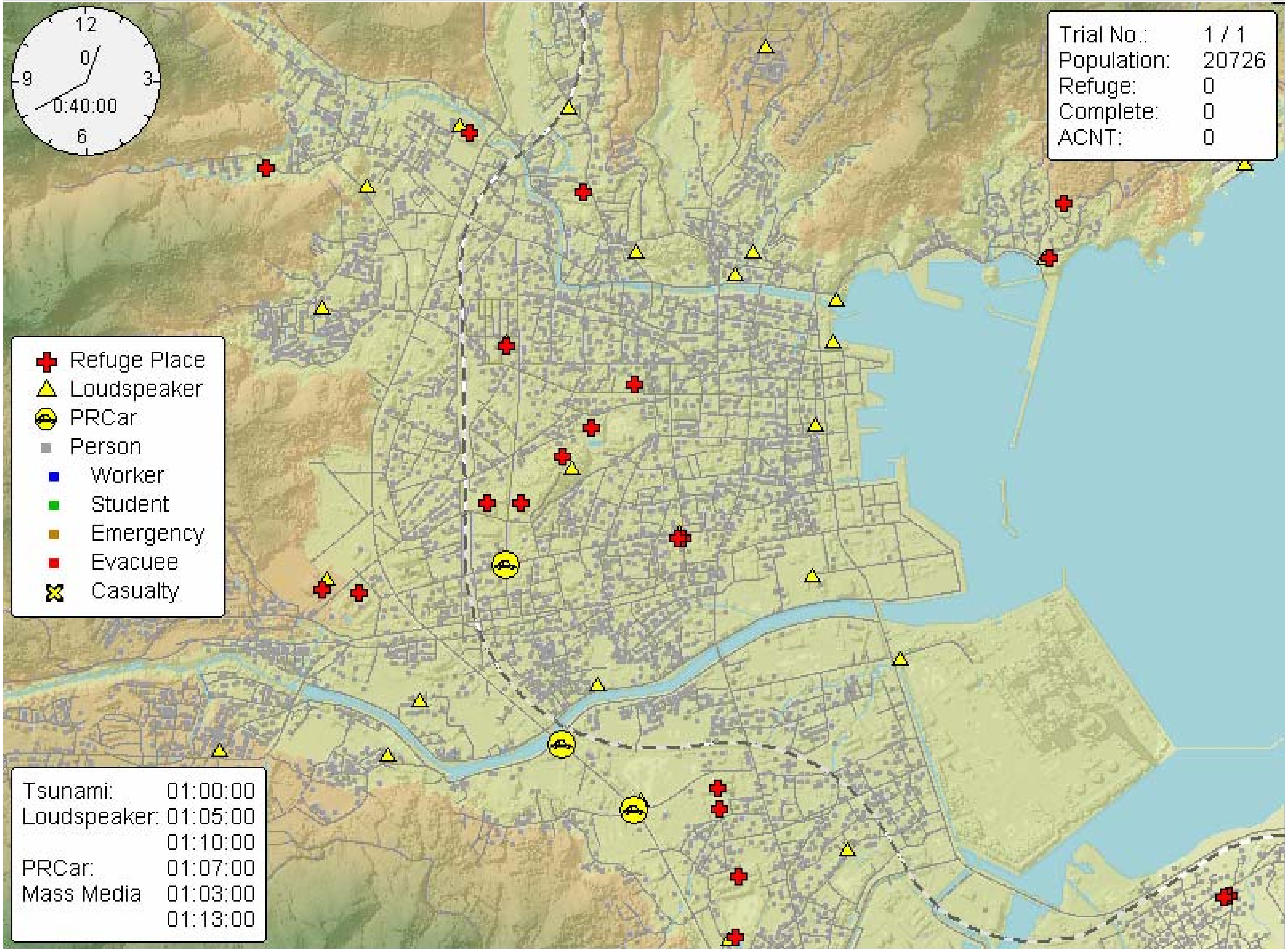
Sample Case 1

- If the earthquake occurs at midnight
  - Earthquake 1 : 00 AM
  - Mass media 1 : 03、1 : 13
    Audience Rating 30%
  - Loudspeaker 1 : 05、1 : 10
  - P.R. Car 1 : 07
  - Refuge timing 5 min. after info. received
  - Refuge Ratio Quake 0.1% Info. 100%

Time Scenario Setting

- Scenario is set by a timeline control panel

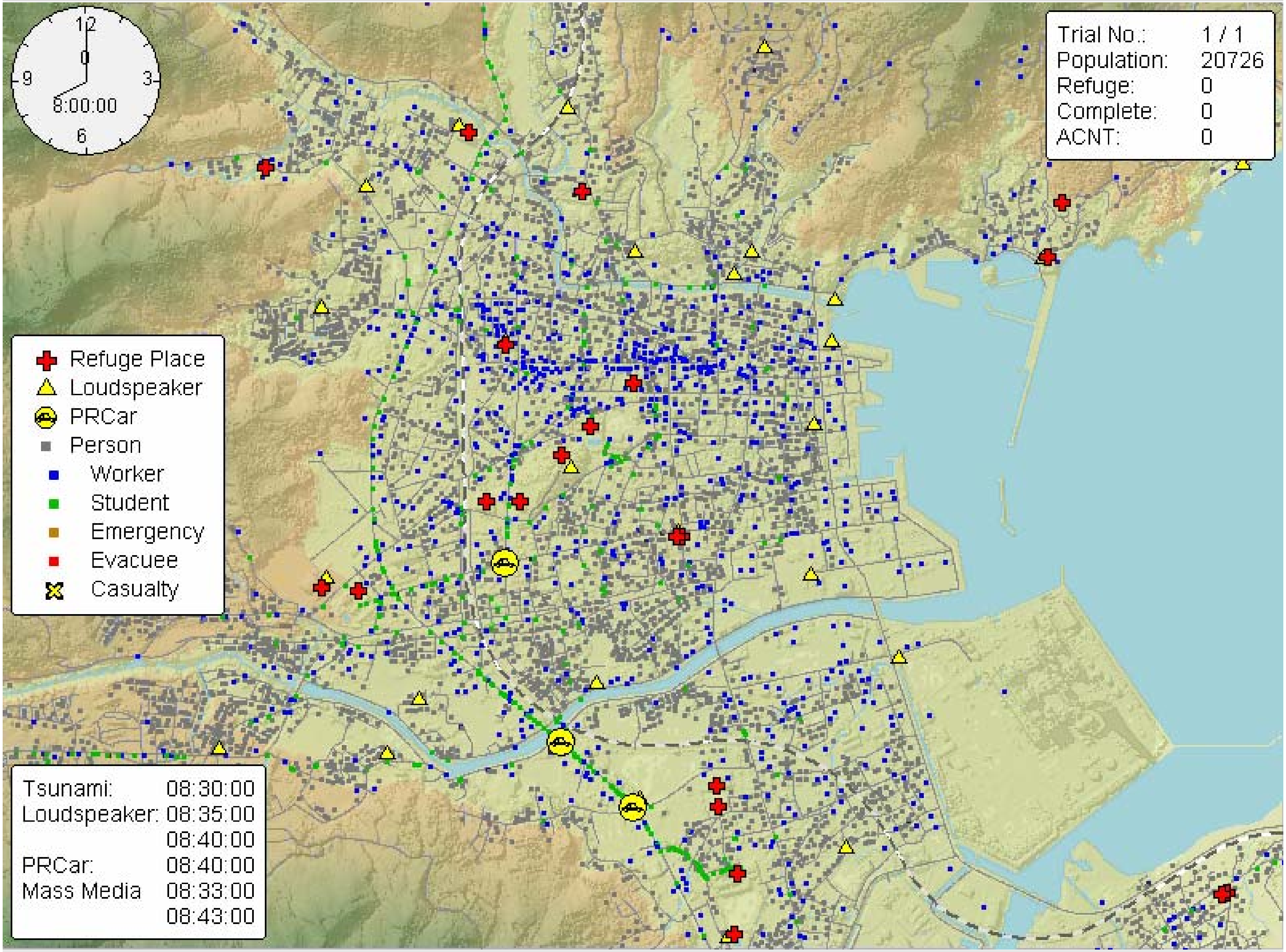




12
0
9
3
6
0:40:00
Trial No.: 1 / 1
Population: 20726
Refuge: 0
Complete: 0
ACNT: 0
Refuge Place
Loudspeaker
PRCar
Person
Worker
Student
Emergency
Evacuee
Casualty
Tsunami: 01:00:00
Loudspeaker: 01:05:00
01:10:00
PRCar: 01:07:00
Mass Media 01:03:00
01:13:00

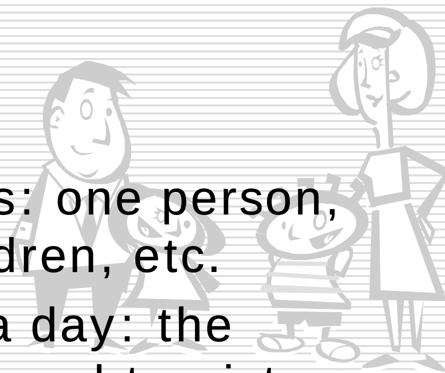
Sample Case 2

- If the earthquake occurs at commuting time
  - Earthquake 8 : 30 AM
  - Mass media 8 : 33、8 : 43
    Audience Rating 40%
  - Loudspeaker 8 : 35、8 : 40
  - P.R. Car 8 : 40
  - Refuge timing Immediately after info. Received
  - Refuge Ratio Quake 0.1% Info. 100%

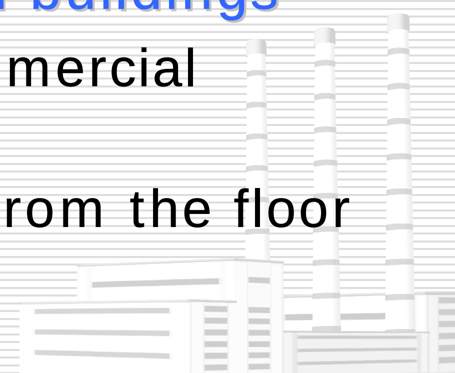

12
3
6
9
0
8:00:00
Trial No.: 1 / 1
Population: 20726
Refuge: 0
Complete: 0
ACNT: 0
Refuge Place
Loudspeaker
PRCar
Person
Worker
Student
Emergency
Evacuee
Casualty
Tsunami: 08:30:00
Loudspeaker: 08:35:00
08:40:00
PRCar: 08:40:00
Mass Media 08:33:00
08:43:00

Population Distribution

- Expression of population
  - Census
    - Total population, gender, age.
    - Total number of households and the types: one person, the couple, the couple with a child or children, etc.
    - Change in population distribution during a day: the inflow & outflow rates of worker, student, and tourists.



- Expression of Residential and Commercial buildings
  - Identify and classify residential and commercial buildings from the digital housing map
  - The number of employees is estimated from the floor area.



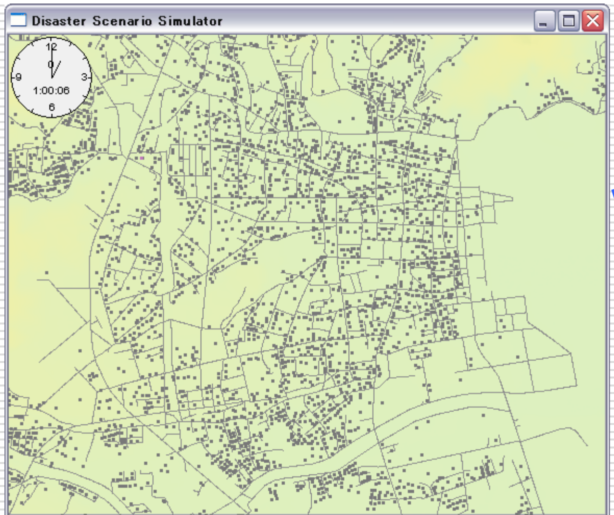
Expression of Traffic

- Traffic
  - Individual’s working place is assigned randomly from space designated as commercial buildings. Each individual is assumed to commute by car.
  - Individual’s school is determined based on the residence and the school district. (commute on foot)
  - Considering the road width and speed limit, the shortest route is used for the individual’s commute.
- Timing

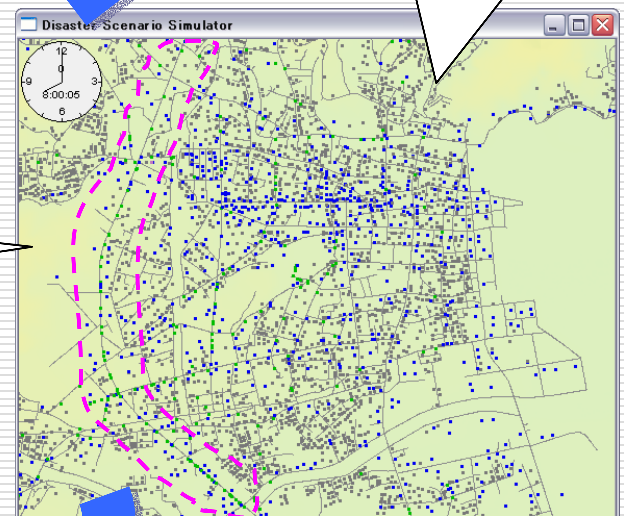
  Timing of the individual’s commute is set stochastically: in the simulation, the timing is expressed by the averaged starting time for commute with its standard deviation. The required input parameters are:
  - Attendance at work time、Working time
  - Attendance at school time, Go home time, etc.

Transition of population distribution by Clock Model

1 : 00 AM
A lot of people are in the house.

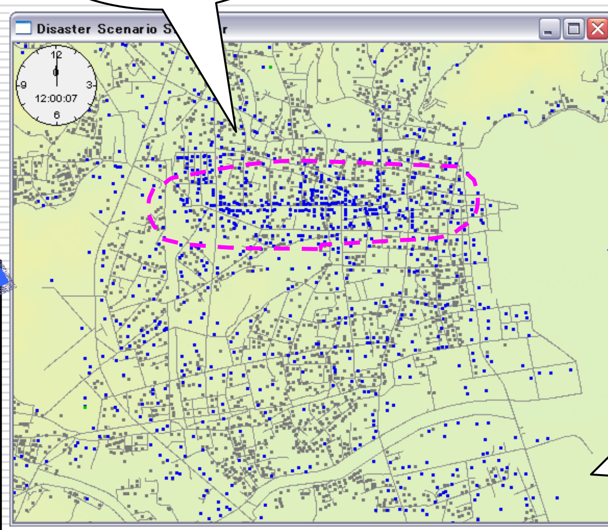


8 : 00 AM
The morning traffic increases. Congestion occurs in part.



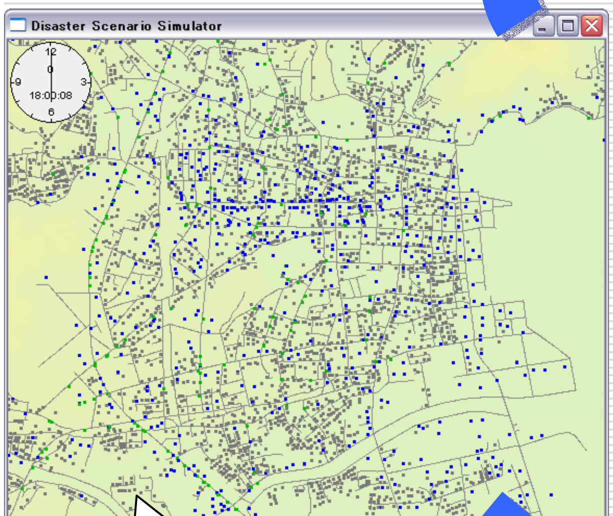
Bypass

0 : 00 PM
The traffic decreases. The population concentrates in central business district.



Central Business District

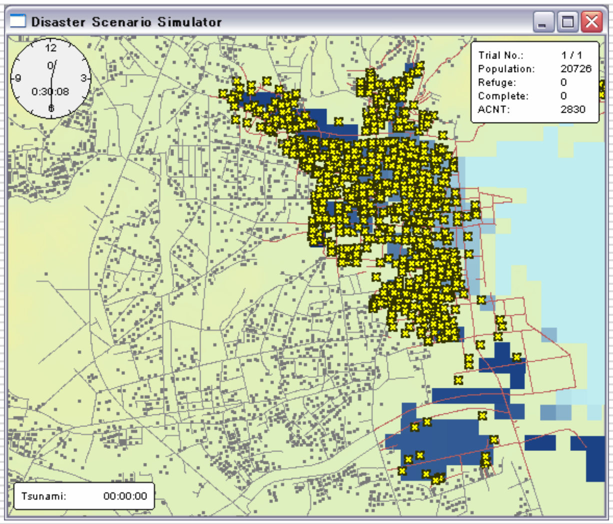
6 : 00 PM
The evening traffic increases. Traffic is lighter compared with the morning.



Variations in damage due to the time of tsunami attack

If the resident doesn't evacuate at all.

In a current simulation…

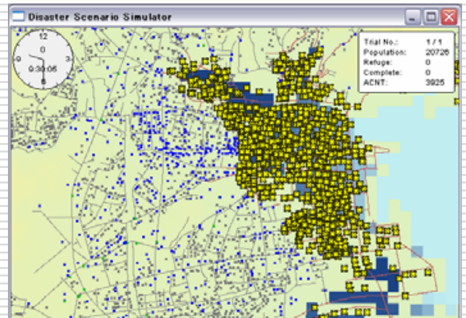


When it is at midnight
The earthquake occurs at 0 o'clock
0 : 30AM
Casualties : 2830

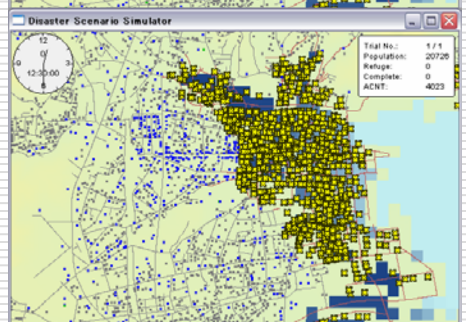
Casualty

The number of casualties greatly influenced by the occurrence time of tsunami

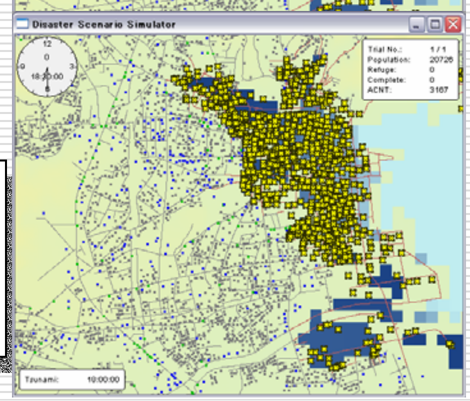
When occurrence time changes…



At the commuting time
The earthquake occurs at 9 o'clock
9 : 30AM
Casualties : 3925



At the daytime
The earthquake occurs at 12 o'clock
0 : 30PM
Casualties : 4023



At time of coming home
The earthquake occurs at 18 o'clock
6 : 30PM
Casualties : 3167