A Sensitivity Study for Emergency Preparedness Measures in Consequence Analysis

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Multi-Unit Risk Research Group

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1. Introduction

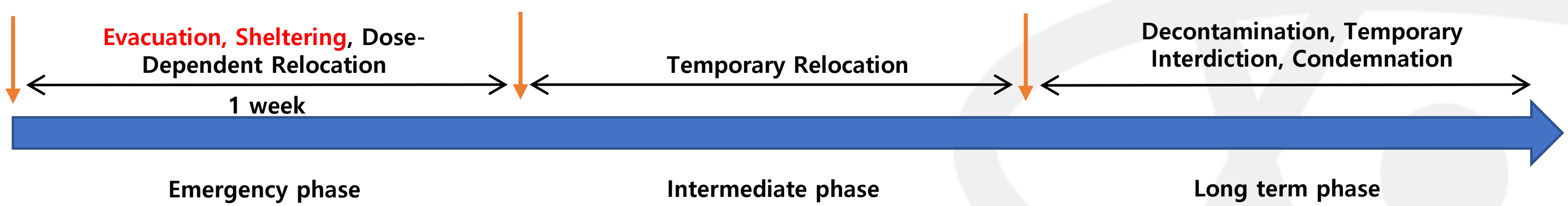
Introduction

- Consequence analysis needs to be more realistic and accurate in case that the population density is relatively very high such as Korea.
- Level 3 PSA code, reflecting domestic situations, is being developed by KAERI.
- Until the development is completed, we have to rely on the MACCS.
- This study focused on the emergency response model in EARLY modules.
- The emergency response model in the MACCS contains several limitations to reflect the real situation.
- Hence, in order to overcome such limitations, it is necessary to clarify the characteristics and influence of the input variables constituting the emergency response model.
- From this point of view, a sensitivity analysis for the parameters, associated with the emergency preparedness, was performed.

2. Background

Emergency Phase in MACCS

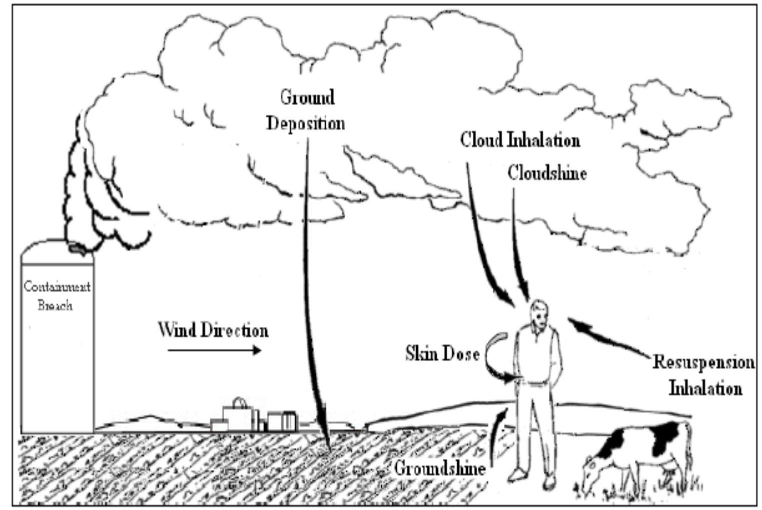
- The EARLY module models the time period immediately following a radioactive release.
- The emergency phase generally is set to one week after the arrival of the first plume at any downwind spatial interval. The subsequent intermediate and long-term periods are treated by CHRONC.
- In the EARLY module, the user may specify emergency response scenarios that include evacuation, sheltering, and dose-dependent relocation. In this study, only evacuation and sheltering are considered, not dose-dependent relocation.
  1. MACCS evacuation model incorporates a delay time before public movement
  2. Different shielding factors and breathing rates can be used while people await evacuation or are being evacuated



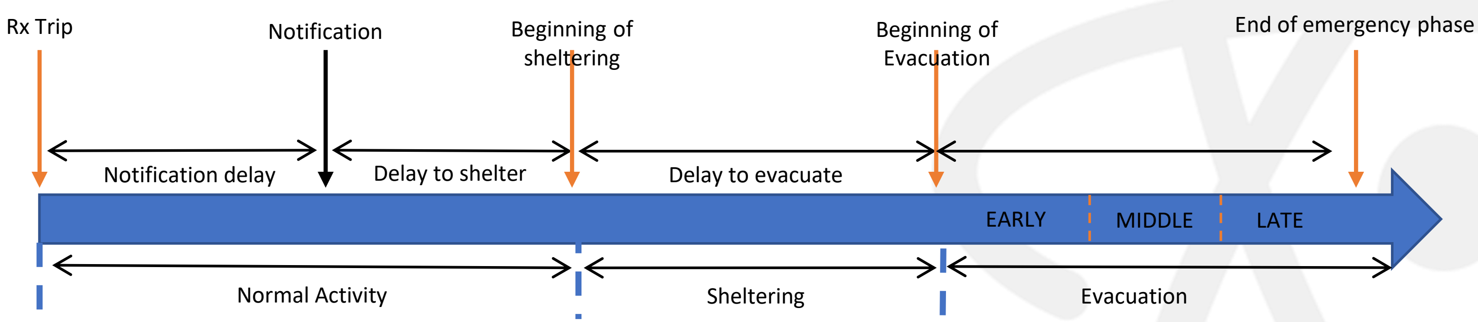
Entire time line of MACCS

Emergency Phase in MACCS

- The calculation of radiation dose from early exposure considers five pathways as follow.
  - ➢ Cloudshine, Cloud inhalation, Groundshine, Resuspension inhalation, Deposited on the skin
- Every evacuee travel from one grid to other grid in discrete steps (the delay time, speed and direction).
  - ➢ Notification delay(OALRM)
  - ➢ Delay to shelter(DLTSHL), Delay to evacuate(DLTEVA)
  - ➢ Evacuation speed(ESPEED), Evacuation direction(IDREC)



Relevant MACCS exposure pathways used in SOARCA*



Timeline in the early phase

*NUREG/CR-7009 MACCS Best Practices as Applied in the State-of-the-Art Reactor Consequence Analyses(SOARCA) Project

3. Base Model Description

Source Term Data

- Two source term scenarios, representing bypass accident, were selected.
  - Directly release to the environment, not to pass through containment atmosphere
  - No gravitational deposition of fission products and ESF can not be used
  - ➢ As a result, the bypass process releases a relatively large amount of the radioactive materials to the environment after core damage

	Source Term 1	Source Term 2
Reactor type	OPR1000: 1000MWe PWR Generation II reactor designed by South Korea	
Representative initiating event	ISLOCA	SGTR
Release time (s) after reactor trip	4275	11252
Core uncovery time	3422	9359
Release fraction after 72h	Xe: 100%, Cs: 69.8%, I: 81.4%	Xe: 94.3%, Cs: 21.1%, I: 37%

Network Evacuation Input Data

- LASMOV indicates the outer boundary of the evacuation movement zone.
- NUMEVA defines the outer boundary of the sheltering and evacuation region.
- ESPEED defines the travel speed of evacuees.
- DLTSHL defines the delay to take shelter for resident individuals.
- DLTEVA defines the duration of the sheltering period.

	Value		Note
LASMOV	27(30km)		Outer boundary of the evacuation movement zone
NUMEVA	22(20km)		Outer boundary of the sheltering and evacuation zone
ESPEED	5.5m/s(=20km/h)		It is assumed.
DLTSHL	0-5 (km)	3600	The delay time from OALARM to the sheltering. 1 (hr) is assumed in the area from NPP to 5km boundary. And, 10(min) increase per 3 (km).
	5-8 (km)	4200	
	8-11 (km)	4800	
	11-14 (km)	5400	
	14-17 (km)	6000	
	17-20 (km)	6600	
DLTEVA	0-20 (km)	3600	The delay time until evacuation occur

Shielding and Exposure Data

- *Shielding and Exposure Data* define the shielding factors for exposure to cloudshine, groundshine, inhalation, and deposition to skin for three types of activities(normal activity, evacuation, and sheltering) A breathing rate is also specified for each type of activity.
- CSFACT, GSHFAC and BRRATE were derived through Korean statistical data.
- The value of PROTIN and SKPFAC in SOARCA project was used.

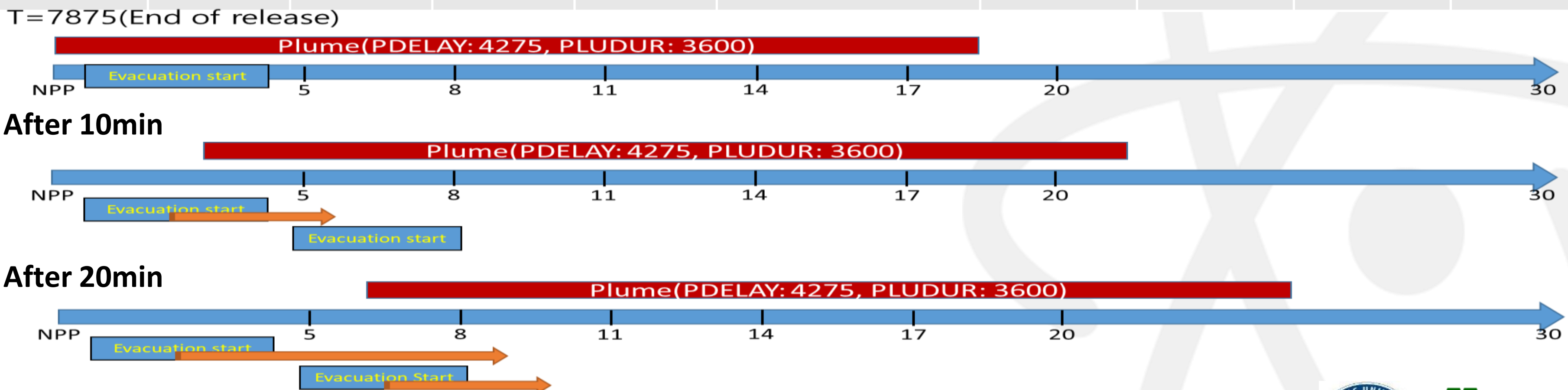
	Value			Note
	Evacuation	Normal Activity	Sheltering	
CSFACT	1	0.7	0.62	Cloudshine shielding factor
GSHFAC	1	0.3	0.11	Groundshine shielding factor
PROTIN	0.98	0.46	0.33	Inhalation protection factor
SKPFAC	0.98	0.46	0.33	Skin protection factor
BRRATE	2.14×10^{-4}	2.14×10^{-4}	2.14×10^{-4}	Breathing rates

4. Sensitivity Analysis

Sensitivity Analysis 1

- The initial response parameter in MACCS is OALARM, which define the time at which notification is given to off-site emergency response officials to initiate protective measures for the surrounding population.
  - ➢ Useful parameter if multiple analyses are being performed and the response timeline is being adjusted
  - ➢ Performed by WinMACCS 3.10. (OALARM can be defined for each cohort in WinMACCS 3.11)

OALARM (sec)	Case 1 (-3600)	Case 2 (-2700)	Case 3 (-1800)	Case 4 (-900)	Case 5 (Release Time)	Case 5 (+900)	Case 6 (+1800)	Case 7 (+2700)	Case 8 (+3600)
ISLOCA	**675**	1575	2475	3375	**4275**	5175	6075	6975	7875
SGTR	7652	8552	9452	10352	**11252**	12152	13052	13952	14852



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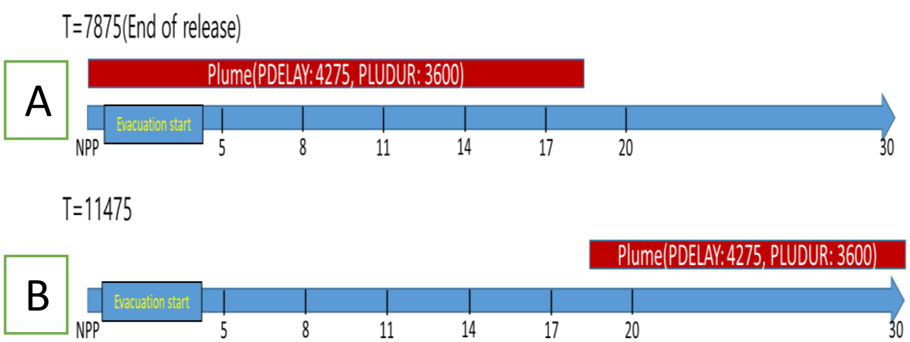
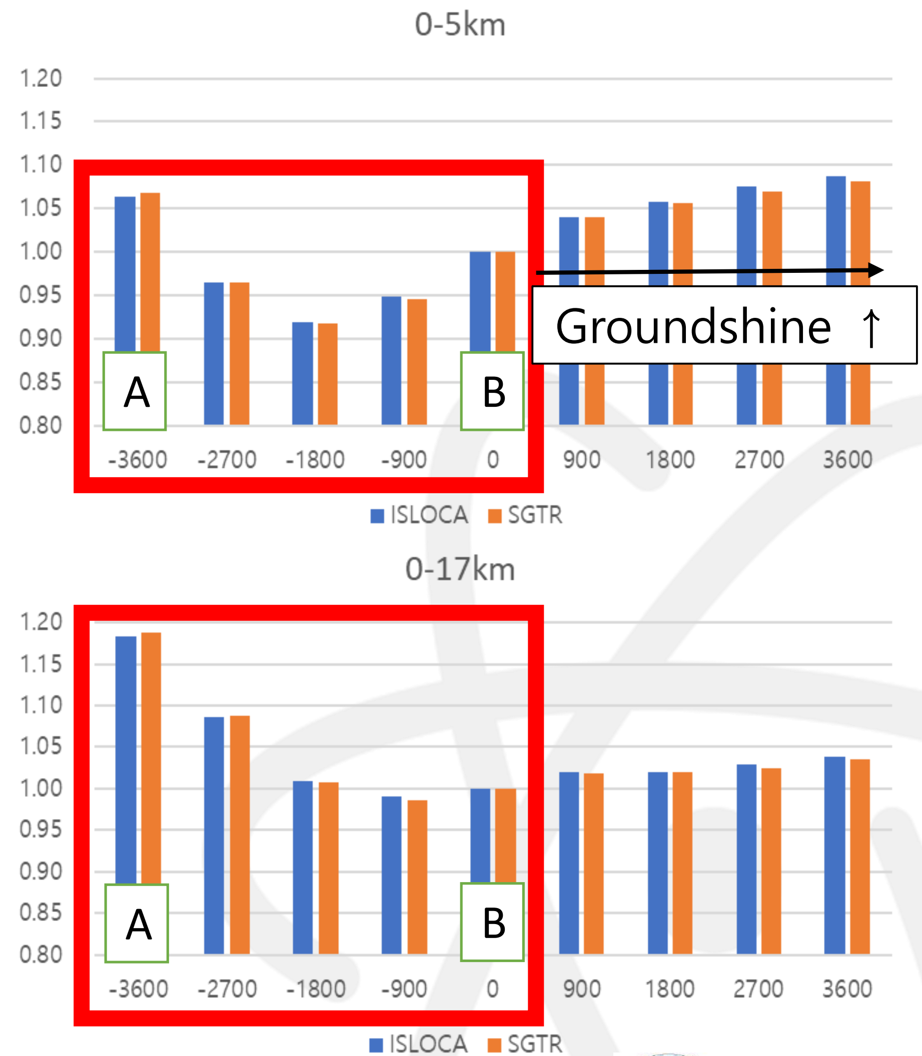
Sensitivity Analysis 1 - Result

- Population dose ratio according to difference in notification time
  - Unconditionally early notification time might be disadvantageous to residents in the PAZ.
  - when the plume is dispersed, some population might starts to evacuate under plume.
  - Especially in Korea where population density increased exponentially with distance, it is necessary to consider the stepwise alarm time.





Sensitivity Analysis 2

- In order to analyze an efficiency of staged evacuation, it is needed to figure out the influence of cloudshine and groundshine.

- The following scenarios were constructed.
  1. Evacuation 5 minutes before the tail of plume reaches the midpoints of each sector.
  2. Evacuation 5 minutes after the tail of plume reaches the midpoints of each sector.
  3. Scenario 2 with half of evacuation speed

- The DLTSHL for each sector was set as same as the sensitivity analysis 1.

- The DLTEVA for each sector was set by comparing the time at which the tail reaches the midpoint of each sector.

Sensitivity Analysis 2 - Result

0 - 5 km

- The shorter the OALARM, the higher the dose reduction effect.
- If the notification is later than the release time, the results of scenario 1 and 2 are the same because the plume has already passed.

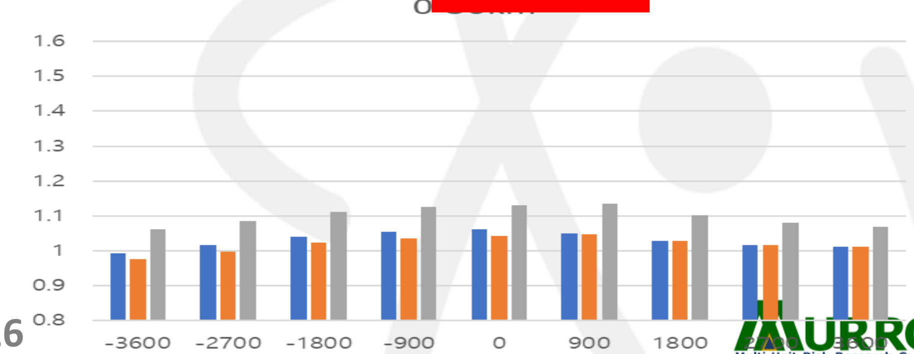
0 - 30 km

- Even though the cloudshine shielding factor is higher than groundshine shielding factor, the result of the scenario 3 is larger than the other scenarios.
  - ➢ By increase in population density with distance

➢ In point of view of dose reduction, it is best to plan for the public to be evacuated, after the plume has passed, at speed that does not exceed the average wind speed.

Scenario 1: Evacuation 5 minutes before the tail of plume reaches the midpoints of each sector.
Scenario 2: Evacuation 5 minutes after the tail of plume reaches the midpoints of each sector.
Scenario 3: Scenario 2 with half of evacuation speed

	Value		
	Evacuation	Normal Activity	Sheltering
CSFACT	1	0.7	0.62
GSHFAC	1	0.3	0.11



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Sensitivity Analysis 3 & Result

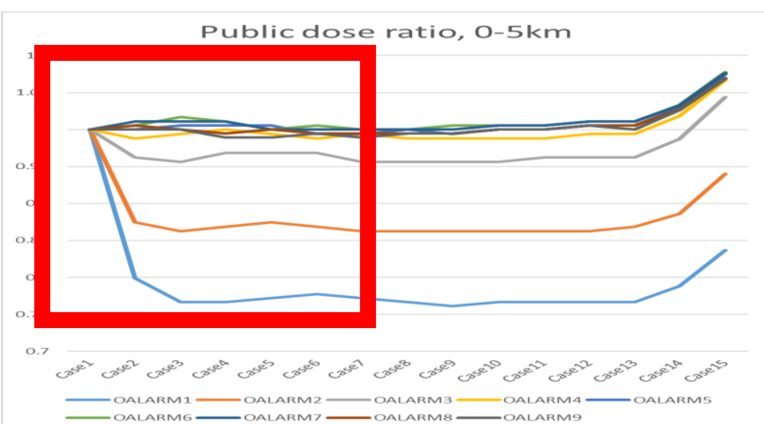
- To understand the effectiveness of sheltering duration, sensitivity analysis 3 was designed by increasing the DLTEVA of all sectors, comparing to the base case.

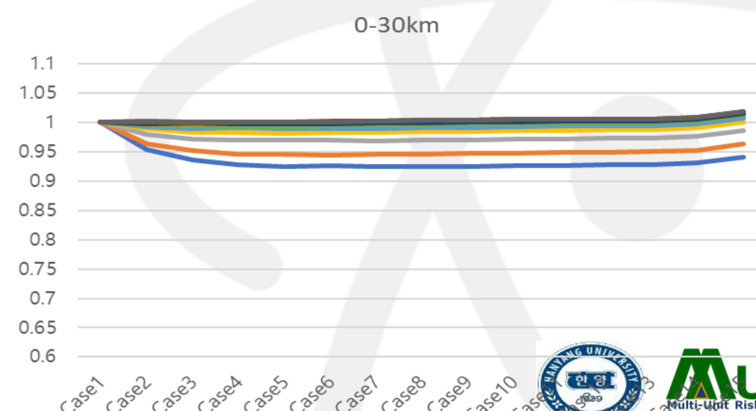
Case	1(Base)	2	3	4	5	6	7	8
DLTEVA	1h	1h 30m	2h	2h 30m	3h	3h 30m	4h	4h 30m
Case	**9**	**10**	**11**	**12**	**13**	**14**	**15**	
DLTEVA	5h	5h 30m	6h	6h 30m	7h	12h	24h	

➢ The shorter the notification time(OALARM1), the greater dose reduction by sheltering.

➢ Small fluctuation due to difference between dose increase for the population entering the plume and dose reduction by sheltering.

➢ Before evacuation, sheltering during appropriate period, especially in Korea, might be effective as a early protection measure.





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5. Conclusion and Limitation

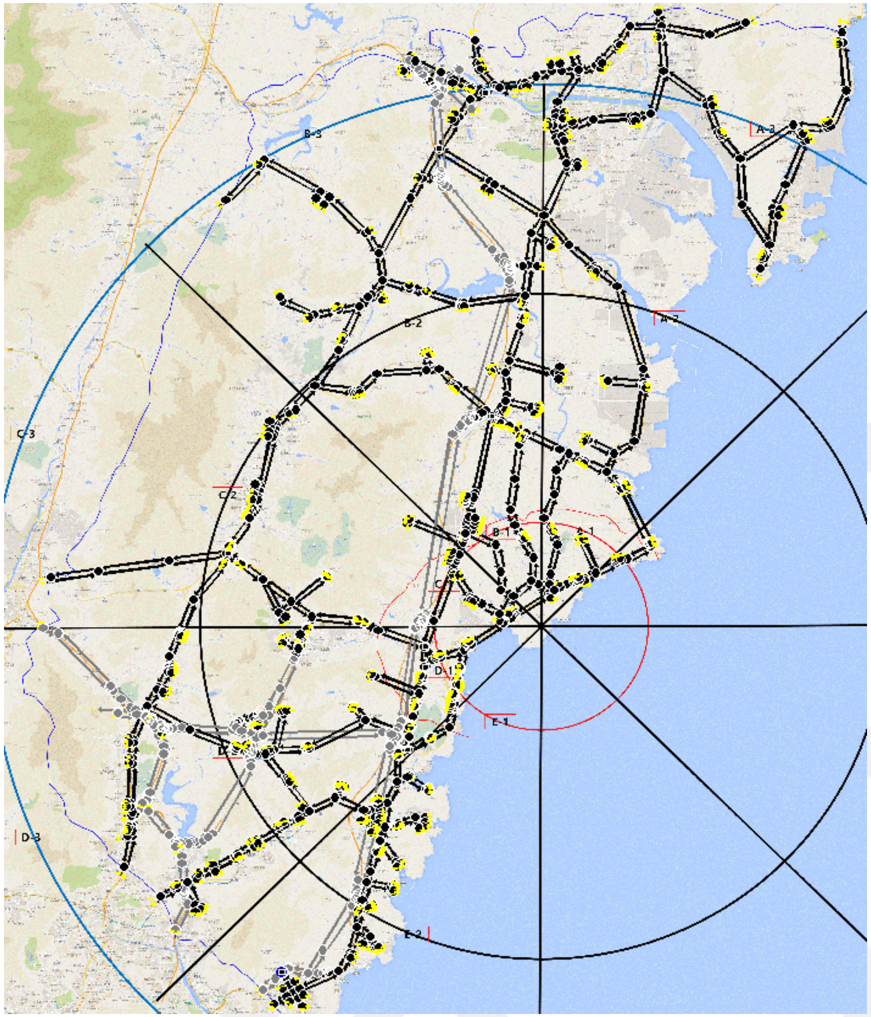
Conclusion and Limitation

- The emergency response model in MACCS is simplified and has many uncertainties.
- It is necessary to fully understand the effect of the key parameters of the model.
- In this study, the sensitivity analysis of the parameters essential to the emergency response model was conducted. And the results are summarized as follows.
  - Unconditionally early notification time might be disadvantageous to residents in the PAZ.
  - In case of Korea, it is necessary to consider the stepwise notification time.
  - It is best to plan for the public to be evacuated, after the plume has passed, at speed that does not exceed the average wind speed.
- Need to be analyzed based on the ETE analysis(being performed).
  - Classification of population, delay time, evacuation speed and etc.
- Need to calculate the notification time(OALARM) by reviewing organizations and communication systems in utility's manual.

*Evacuation Time Estimate (Additional)

Evacuation Time Estimate(Additional)

- ETE is defined as the calculation evacuation time for the all people resided in EPZ.*
- In Korea, the ETE analysis was not performed properly after the EPZ revision.
- In this regard, MURRG is conducting ETE analysis from this year, and its contents are summarized as follows.
  - ➢ Using TSIS-CORSIM to construct network model(surface road, Express way)
  - ➢ Developing 4 evacuation scenarios based on the scenarios, recommended by NUREG/CR-7002
  - ➢ Reflecting access control plan and evacuation routes for each village
- The newly designed sensitivity analysis is needed, based on the ETE results, after the ETE analysis will be completed.



Network model in Kori site by CORSIM

*NUREG/CR-0654, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness

Thank you for listening.