Consideration of the Single Release Location for the Multi-Unit Accidents

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Multi-Unit Risk Research Group, Hanyang University, Seoul, Korea
Yein Seo, Hyunae Park, Byeong-Mun Ahn, and Moosung Jae

Contents

Introduction

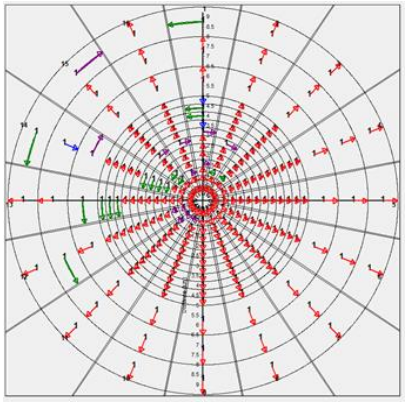
Background

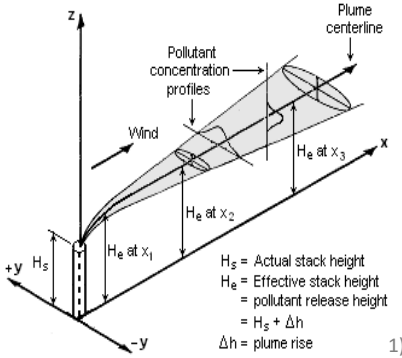
Multi-Unit Risk Research Group (MURRG)

- Regulatory PSA model & framework development for site risk assessment

Spatial Difference in Multiple Units Issue

Limitation of Current L3 PSA Code for Multi-Unit





1)

- **MACCS**
  - Estimates radioactivity concentration, doses, health risks, and etc.
  - Polar coordinate spatial discretization
  - Gaussian plume model for atmospheric transport
  - Multi-source term ability to reflect the time difference
  - Unavailable to consider the spatial difference of the multiple units

Reasonable single release location representing multi-unit

1) WIKIPEDIA (2017). Outline of air pollution dispersion, https://en.wikipedia.org/wiki/Outline_of_air_pollution_dispersion

Consideration of Weight

How to find a reasonable single release location

Considerations for single release location

- Location of each unit
- Magnitude and probability of accidents
- Characteristics of the site, and etc.

Weighted Average

$$p_{new} = \frac{\sum_i p_i w_i}{\sum_i w_i}$$

p_{new} : The coordinates (x, y) of the new determined single release location

p_i : The coordinates (x,Y) of the considered unit i's location

w_i : The Weight for the unit i

Classification of the Influence Elements

Triplets of Risk

$$R =< S_i, P_i, C_i >= \sum P_i \times C_i \ \ (i = 1, 2, 3, \cdots n)$$

S_i : Accident Scenario of the Event *i* for the Defined Risk
P_i : Probability of the Event *i*
C_i : Consequence of the Event *i*

	Characteristics of Site and Units	Results of Level 1	Results of Level 2
Event Identification	Location, Wind Speed and Direction, Population, and Structure of On-site -Facilities	-	-
Probability	-	Core Damage Frequency	Large Early Release Frequency & Containment Failure Frequency
Consequence	Power (Electric, Thermal) & Core Inventory	-	Release Fraction

Selection of Weight

Requisites for Weight

- Relatively simple or often used in traditional PSA
- Currently available data
- Not required of further study for data analysis

5 Options for Weight

1. Simple location average
2. Electric power
3. Thermal power
4. Released inventory
5. Population

Application & Results

Application to Reference Plants

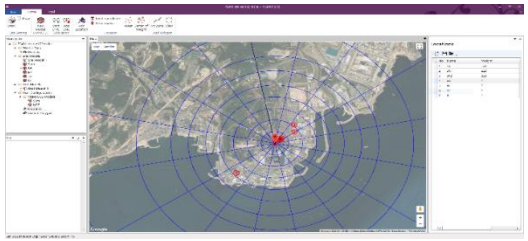
Reference Plants

- Kori 2 – WH600, 650 MWe, 1882 MWth, Closest to Busan
- Shin Kori 1 – OPR1000, 1000 MWe, 2825 MWth
- Shin Kori 2 – OPR1000, 1000 MWe, 2825 MWth

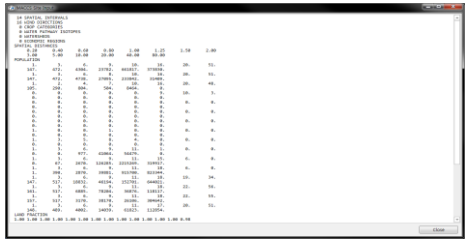
	Simple Average	Electric Power	Thermal Power	Released Inventory ($\times e^{+18}$)	Population
K2 (WH600)	1	650	1882	1.25	1
SK1 (OPR1000)	1	1000	2825	2.23	0
SK2 (OPR1000)	1	1000	2825	2.23	0

Development of MSPAR-SITE

MSPAR-SITE

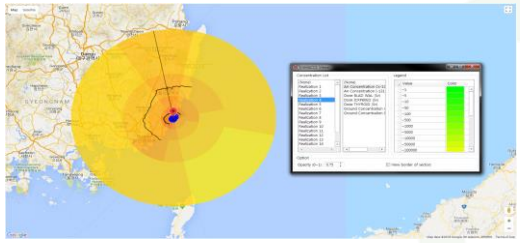


Population Calculation
by Grid Element



MACCS Input (Site File) Creation

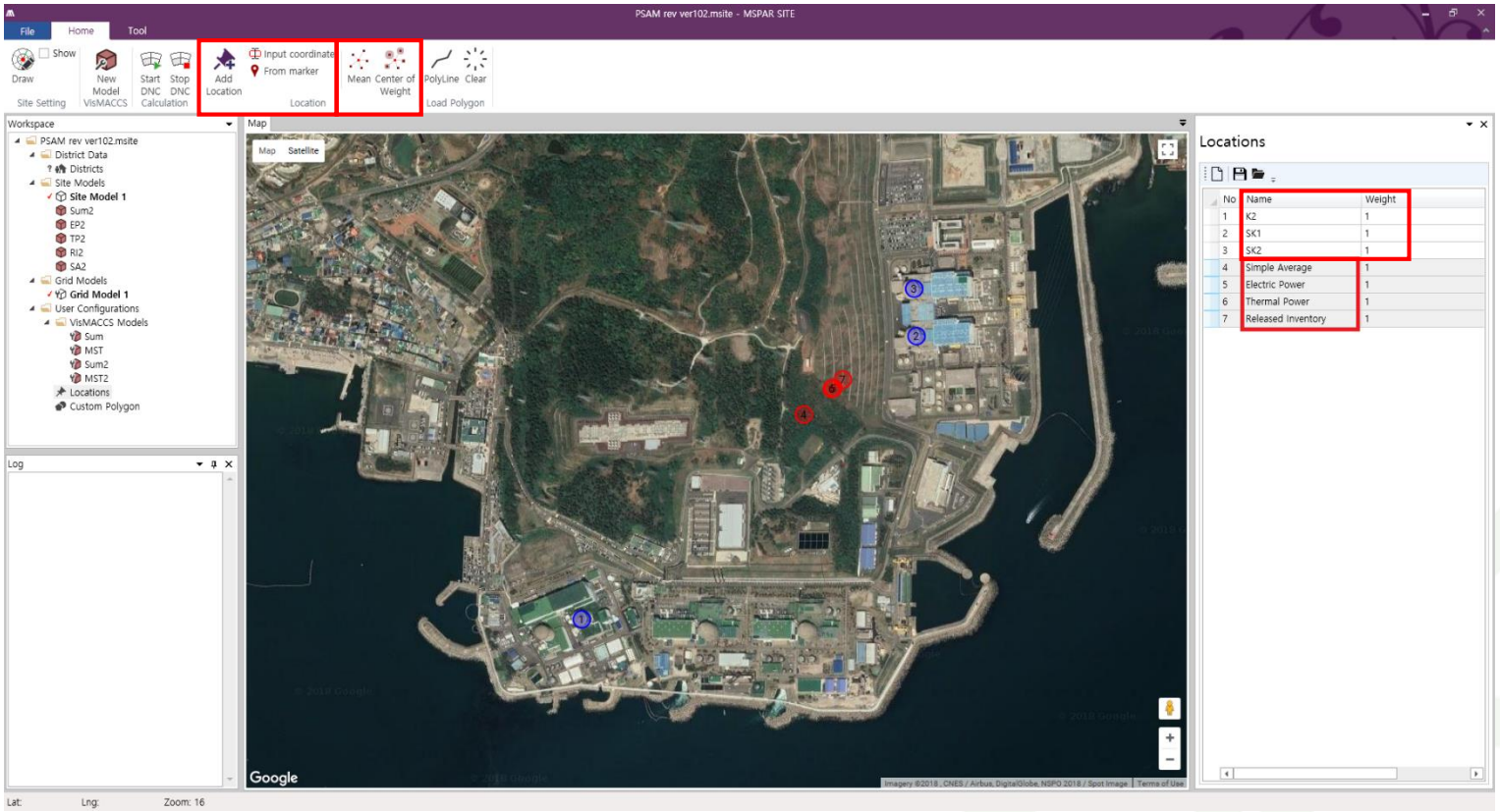
PAZ, UPZ Boundary Display



Concentration and Dose
by Grid Element Visualization

- Designate units' location and weighted average single release location
- Reduce the effort involved in converting the population and geographic characteristics data into the site file
- Visualize site information and the results of MACCS on the map

Weight Options in MSPAR-SITE



	K2	SK1	SK2	Simple Average	Electric Power	Thermal Power	Released Inventory	Population
Distance from the simple average (m)	845	343	414	0	99	94	129	845

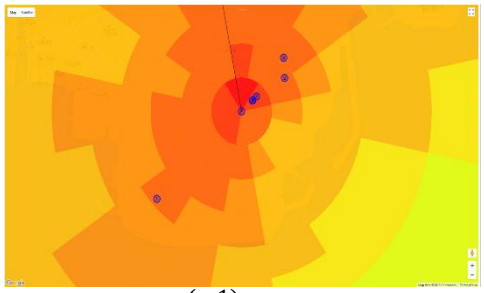
Results on the Radionuclide Concentration

Model Descriptions

- SGTR in 3 reference plants simultaneously
- 2009 Kori site meteorological data
- Source term data derived from previous L2 reports[1)]
- Reflect Korea characteristics as much as possible[2)]
- US SOARCA project data applied if the Korean data is scarce[3)]
- Applicate Multi-source term function in WinMACCS
- Draw the output of WinMACCS, the radionuclide concentration for each grid element, using MSPAR-SITE

1) KHNP, Shin-Kori 1, 2 Probabilistic Safety Assessment Report Part.2
2) Moosung Jae et al. "A Study on MACCS Input Parameters for A Level 3 PSA Model for Regulation Verification", NSTAR-18NS-24, 2018. (KOREAN)
3) US NRC, MACCS Best Practices as Applied in the State-of-the-Art Reactor Consequence Analyses(SOARCA) Project, NUREG/CR-7009, 2017.

Results on the Radionuclide Concentration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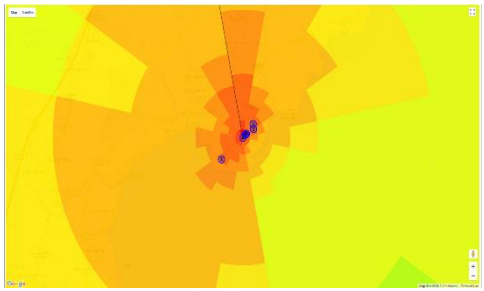
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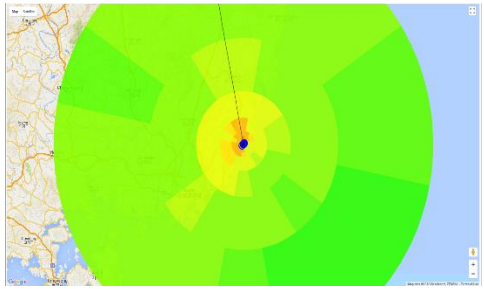
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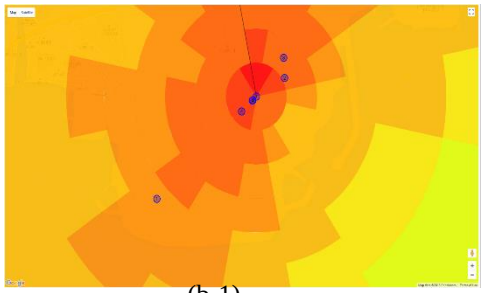
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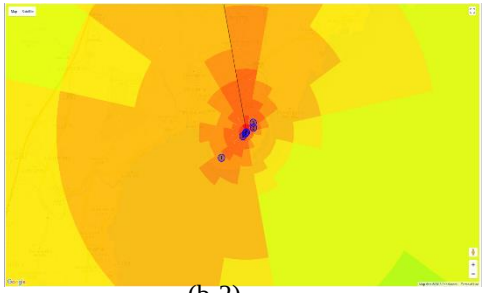
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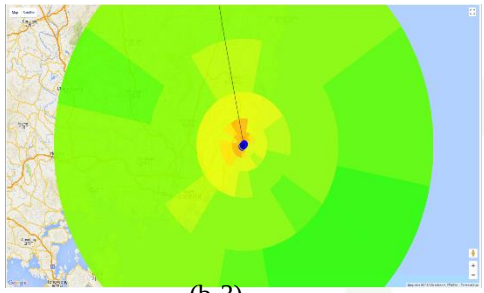
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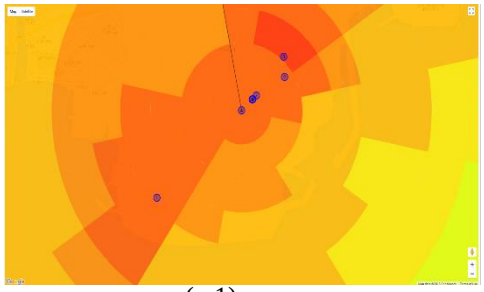
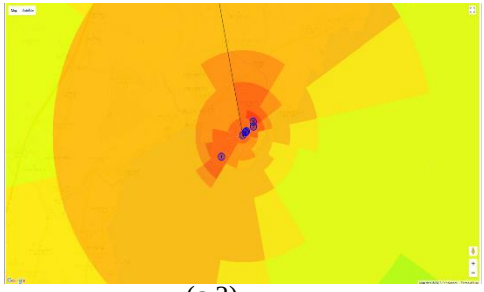

(c-1)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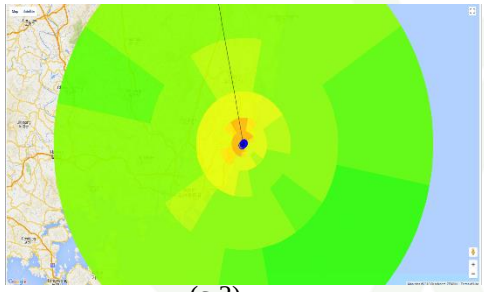
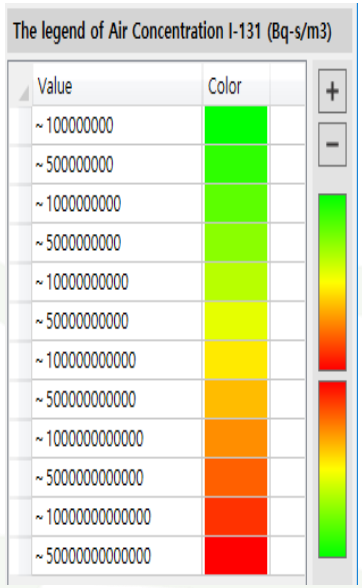
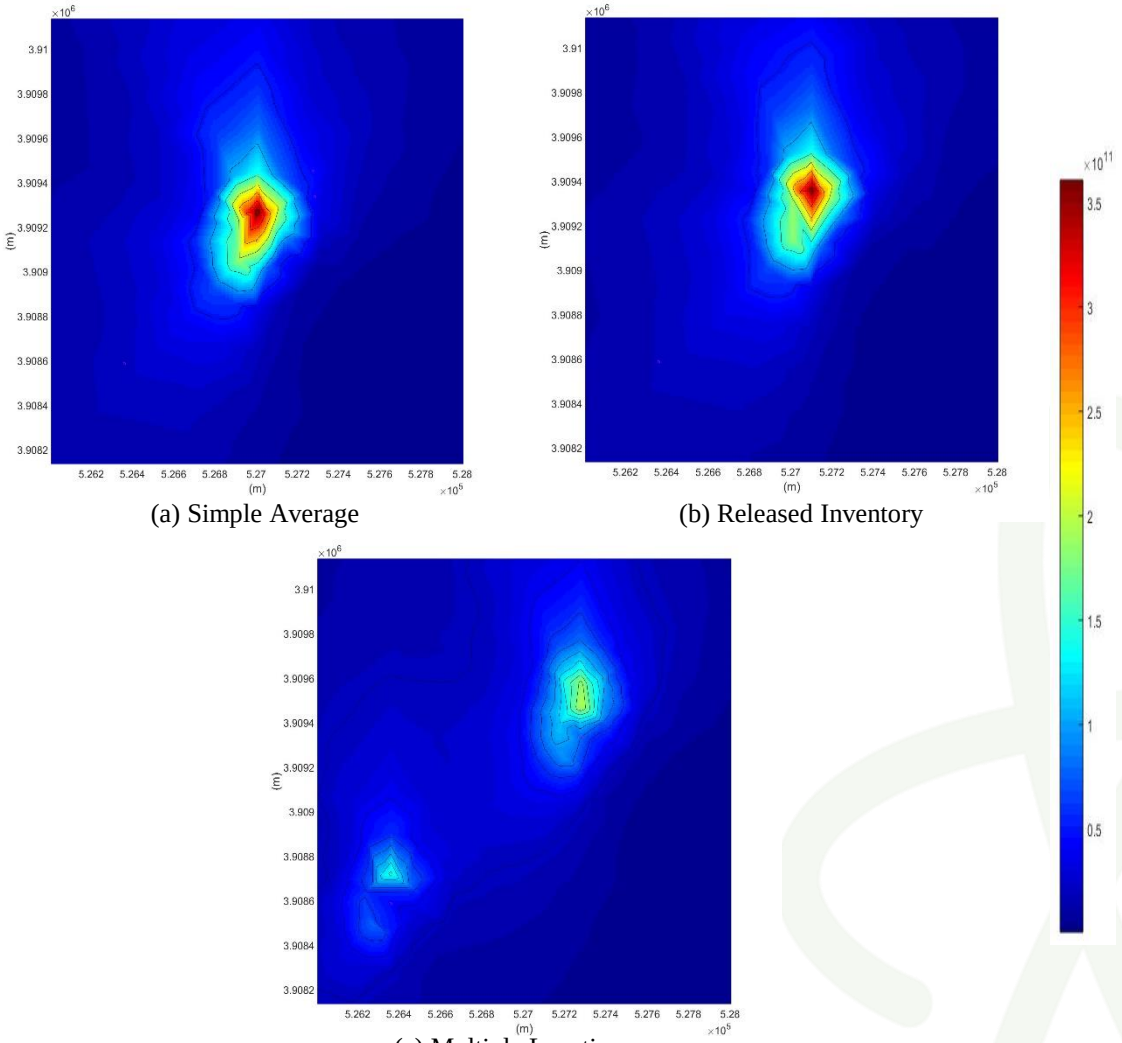

(c-3)



* a: Simple Average Location, b: Release Inventory Location, c: Multiple Locations
1: Zoom 16, 2: Zoom 14, 3: Zoom 16

Results on the Radionuclide Concentration



(a) Simple Average

(b) Released Inventory

(c) Multiple Locations

Results on the Early Fatality Consequence

Model Descriptions

- Basically same as the model used in the concentration evaluation
- Population data derived by MSPAR-SITE
- Only the emergency phase for 7 days considered
- Health effects risk factors from US SOARCA project[1)]
- No emergency response
- Releases from multiple locations not modeled due to the code limitation

1) US NRC, MACCS Best Practices as Applied in the State-of-the-Art Reactor Consequence Analyses(SOARCA) Project, NUREG/CR-7009, 2017.

Results on the Early Fatality Consequence

Population Weighted Risk Ratio

Radius from 0 km (km)	Simple Average	Electric Power	Thermal Power	Released Inventory	Population
1	1.00	1.05	1.06	1.05	1.48
2	1.00	0.98	0.98	0.97	1.36
3	1.00	1.00	1.00	1.00	0.98
5	1.00	1.00	1.00	1.00	0.98
10	1.00	1.00	1.00	1.00	0.98
20	1.00	1.00	1.00	1.00	0.98
80	1.00	1.00	1.00	1.00	0.98

- All cases except the population option showed variations within 5%
- The results of the population option to the 2km radius were about 36 ~ 48% higher and those from 3km were about 2% smaller

Results on the Early Fatality Consequence

Simple Average VS Population Weighted

Radius from 0 km (km)	Population Weighted Risk		Health Effects Cases		Total Number of Population	
	Simple Average	Population	Simple Average	Population	Simple Average	Population
1	1.00	1.48	1.00	1.00	1.00	0.68
2	0.88	1.20	1.36	1.35	2.68	2.15
3	0.41	0.40	32.69	33.54	5.51	5.12
5	0.41	0.40	32.69	33.54	16.20	16.75

- The number of health effects cases showed little difference
- the total number of the population to 3km in the population option was less than that in simple average option
- These two results can explain the results of the population weighted risk
- It is expected to be due to the interaction between the population distribution by directions and the meteorological data

Conclusion

Summary

- The objective of this study is to consider **a single release location** that can represent multiple units for the **level 3 multi-unit PSA**, based on the current limitation of computational codes.
- we proposed the method using the several options of **weighted average**, developed **MSPAR-SITE**, and compared the results on the concentration and early health effect between the options.
- If the **distance between the units is very close**, the use of the single location may not substantially impact on the results
- A **simple option** considering the number of units and power is recommended.
- The further study of **site meteorological characteristics**, **multi-unit accident scenario and its probability**, and **population distribution** will be needed for more accurate analysis.

Thank you for your attention!