Establishment of Infrastructure for Domestic-Specific Level 3 PSA based on MACCS2

Seung-Cheol Jang [a*], Seok-Jung Han [a], Sun-Yeong Choi [a], Seung-Jun Lee [a], Wan-Seob Kim [b]
[a]*Korea Atomic Energy Research Institute, 150, Dukjin-dong, Yuseong-gu, Daejeon, 305-353*
[b]*Korea Reliability Technology & System, Cheongsa officetel 1110, 915 Dunsan-dong, Seo-gu, Daejeon, 302-828*
[*]*Corresponding author: scjang@kaeri.re.kr*

1. Introduction

Today, probabilistic safety assessment (PSA) become accepted as an effective decision-making means by prioritizing significant risk contributors and characterizing major uncertainties on results. Instead of using Level 3 PSA, however, the core damage frequency (CDF) and large early release frequency (LERF) are used respectively as the reactor-specific risk surrogates for the latent cancer risk and prompt fatality risk quantitative health objectives (QHOs). Unfortunately, subsidiary numerical objectives based on CDF and LERF were determined for regulatory decision-making involving plant-specific applications without any information and experience of domestic-specific Level 3 PSA in Korea. Research activities related to the Level 3 PSA have naturally disappeared since the use of risk surrogates. Recently, Level 3 PSA was only performed to the extent of the purpose of operating license for the plant under construction.

Since the Fukushima accident, concern about a comprehensive site-specific Level 3 PSA has been raised for some compelling reasons, especially the evaluation of the domestic multi-unit site risk effect including other site radiological sources (e.g., spent fuel pool, multi-units). Unfortunately, there are no domestic-specific consequence analysis code and input database required to perform a site-specific Level 3 PSA.

The paper focuses on the development of the input data management system for domestic-specific Level 3 PSA based MACCS2 (MELCOR Accident Consequence Code System) [1]. The authors call it KOSCA-MACCS2 (Korea Off-Site Consequence Analysis based in MACCS2). It serves as an integrated platform for a domestic-specific Level 3 PSA. Also, it provides the pre-processing modules to automatically generate MACCS2 input from diverse types of the domestic-specific data including numerical map data, e.g., meteorological data, numerical population map, digital land use map, economic statistics and so on. It facilitates the preparation of MACCS2 input files for a domestic plant-specific Level 3 PSA. Note that some functions should be still developed and added on it, e.g., post-processing module to convert MACCS2 outputs to graphic report forms, auxiliary module for supporting sensitivity study (e.g., evacuation time simulation using digital road map) and so on. Henceforth, it is necessary to develop a Korean-specific Level 3 PSA code as a substitution for the foreign software, MACCS2.

2. Overview of the KOSCA-MACCS2

Functionally, KOSCA-MACCS2 is similar to WinMACCS in the point that it provides user interface to perform a Level 3 PSA based MACCS2 code. KOSCA-MACCS2 is specialized to enable site-specific consequence analysis for Korean nuclear power plant. It means that it has some useful modules to facilitate the generation of domestic site-specific MACCS2 input files. The development environment and system requirement of KOSCA-MACCS2 are given in table 1.

Table 1. Development Environment and System Requirements of KOSCA-MACCS2

Type	Environment and Requirements
OS	Windows XP and over
Hardware	CPU: Intel® Pentium 4 (Multicore) RAM : 2GB and over
Software used	Environment: Microsoft .Net 3.5 and over Language: C#

KOSCA-MACCS2 consists of four parts: 1) input data management, 2) run case generation (base and sensitivity case), 3) MACCS2 execution, and 4) output file management (See the right hand-side in Figure 1). As mentioned in the previous section, note that post-processing module should be still developing.

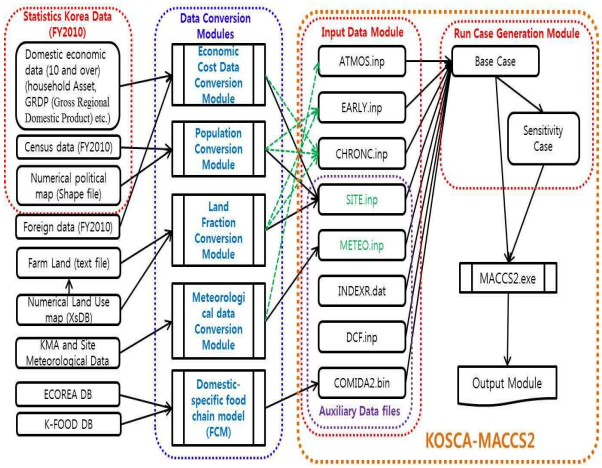

Figure 1. Overview of Data Flow and Pre-processing Modules in KOSCA-MACCS2

There are eight input data files required to execute MACCS2. Of them, top three input files (ATMOS, EARLY, CHRONC) are necessary to execute MACCS2. The 'SITE.inp' and 'METEO.inp' contain lots of site-specific inputs and can be activated by an option of the

MACCS2 execution, e.g., 'File' option not 'Uniform'. 'DCF.inp' input file contains information of dose conversion factor (DCF) without modification of the DCF information given in MACCS2 [2]. 'INDEXR.dat' just has information on radionuclides. Finally, 'COMIDA2.bin' covers domestic-specific food chain model. Since MACCS2 allows only the binary file type of COMIDA2 input/output [2], it is impossible to read the contents of the files.

Finally, the display of the KOSCA-MACCS2 is illustrated in Figure 2.

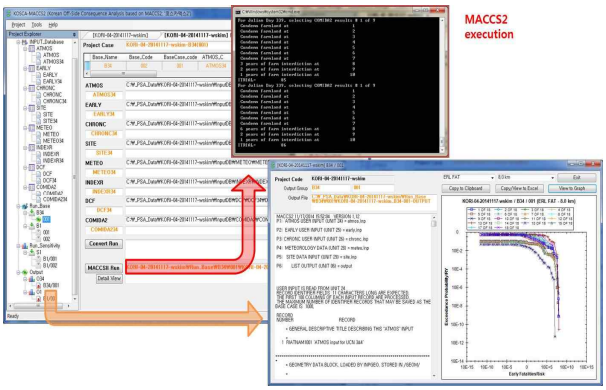

Figure 2. An illustration of KOSCA-MACCS2 Display

3. Pre-Processing Modules in KOSCA-MACCS2

As shown in Figure 1, KOSCA-MACCS2 provides five data conversion modules for preparing domestic-specific input files.

1) Economic cost data conversion module
2) Population census data conversion module
3) Land fraction conversion module
4) Meteorological data conversion module
5) Domestic-specific food chain model (FCM)

More details of the economic cost conversion method and the food chain model of COMIDA2 input format are provided by another conference papers ([3],[4],[5]). Here, we briefly introduce population data conversion module that has the largest impact on the results of the plant-specific Level 3 PSA.

This module is the software to generate the population of population density for the sectors defined in a radial field used in MACCS2. Using 2010 census data and the recent digital geographic map of the administrative district, the sector population can be calculated by one of three methods.

1) Allocation of population by the ratio of area belonging to the sector.
2) Allocation of population to the sector containing center point of administrative district
3) The use of the point population data (resolution: 1km^2 population data)

Table 2 shows the results of the comparison among three methods.

Table 2. Comparison among three population calculation methods

methods	Area	Center	Point
Total population (48,580,293) (Statistics Korea)	48,580,293	48,367,271.38	50,911,697.65
Area (101,160.69) (Statistics Korea)	101,160.69	101,151.34	101,151.34
Population error (%)	0	0.43	0.00014
Area error (%)	0	0.009	0.009
Computation time	4~7hours	5~10min	5~10min

The results are saved at the 'SITE.inp' file following the population input format defined in MACCS2. Figure 3 illustrates the results of a population data conversion.

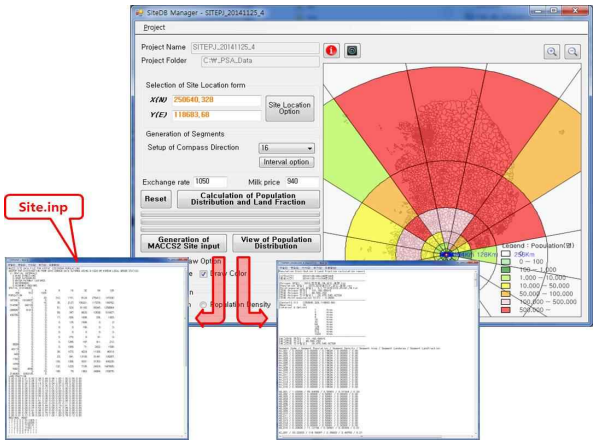

Figure 3. An Illustration of the Population Conversion Module

4. Conclusions

The paper developed the input data management system for domestic-specific Level 3 PSA based MACCS2, so-called KOSCA-MACCS2 (Korea Off-Site Consequence Analysis based in MACCS2). It serves as an integrated platform for a domestic-specific Level 3 PSA. The pre-processing modules involved in KOSCA-MACCS2 facilitate the preparation of MACCS2 input files for a domestic plant-specific Level 3 PSA. Note that some functions should be still developed and added on it, e.g., post-processing module to convert MACCS2 outputs to graphic report forms, and so on. Henceforth, it is necessary to develop a Korean-specific Level 3 PSA code as a substitution for the foreign software, MACCS2.

Acknowledgements

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