

# On-site Radiation Emergency Medical Preparedness of KHNP

Seung Jin Choi<sup>1</sup>, Moo Hyun Choi<sup>1</sup>, Young Hoon Song<sup>1,\*</sup>

<sup>1</sup>Radiation Health Institute, Korea Hydro and Nuclear Power Co., Ltd  
172, Dolma-ro, Bundang-gu, Seongnam-si, Gyeonggi-do, 13605, Korea

\*Corresponding author's e-mail: sjchoice@naver.com

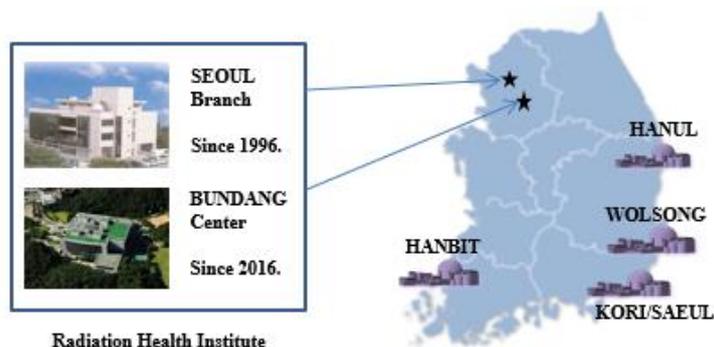
**Abstract.** In Korea, National Radiation Emergency Medical System (NREMS) provides medical response to nuclear power plant accident. In addition, Korea Hydro & Nuclear Power Company (KHNP) has been operating its own medical response organization. When disaster occurs in nuclear power plant (NPP), Radiation Health Institute (RHI) affiliated to KHNP since 1996, located in Healthcare Innovation Park of Seoul National University Bundang Hospital, dispatch radiation emergency medical preparedness team (NPP dispatch team) which is consist of personnel such as medical doctor, nurse, health physics and supports, with mobile dosimetry laboratory, advanced ambulance and decontamination system. The other five teams including off-site medical, situation, dosimetry, administrative and assistance team provide advanced medical care to the NPP workers, response the radiation medical issues and risk communication. From the lessons of the Fukushima nuclear accident, the need for organization to take immediate medical response at the NPP site emerged. In December 2014, the Radiation Emergency Medical Center (REMC) was launched at each NPP site. Three nurses, one emergency aid worker and one support are on 24-hour duty. It was equipped with advanced ambulance and emergency medical facility. In case of radiation emergency, on-site radiation medical clinic is organized by NPP dispatch team and REMC at REMC facility of NPP site, controlled by emergency operation facility (EOF) and provide on-site prehospital care and transportation to hospital in cooperation with NREMS. Recently, as safety issues are highlighted by earthquakes in Korea, on-site emergency facility with isolation system which is headquarter facility of NPP disaster that played important role in the Fukushima nuclear accident are planned to be built in all of the NPP sites. The place isolates facility from ground to absorb the energy of earthquake. It will have medical facility including emergency room, dosimetry room, admission room, isolation room and EOF. When on-site facilities collapse, situationally changeable off-site emergency response preparedness, located at the borderline between controlled area and safe area, is considered using existing EOF buildings, schools or public buildings. It functions as basecamp of NPP's radiation emergency response including medical response, as like J-village in Fukushima. In the future, further considerations of disasters other than earthquakes, multi-unit NPP accident and road breakdown are needed.

**KEYWORDS:** Nuclear power plants; Radiation; Emergency

## 1 INTRODUCTION OF RADIATION HEALTH INSTITUTE

All the NPPs in South Korea are operating by the Korea Hydro & Nuclear Power Company (KHNP). 24 units including Hanul, Wolsong, Kori, Saeul and Hanbit nuclear power plant (NPP) sites are in operation and 2 units are under construction in Saeul NPP site. Radiation Health Institute (RHI) has been affiliated to KHNP since 1996. The headquarters is located in Healthcare Innovation Park (HIP) of Seoul National University Bundang Hospital and the branch facility in Seoul [Fig. 1].

**Figure 1:** 24 units in 5 sites are in operation and 2 units in Saeul site are under construction in South Korea. RHI is located in Seoul as branch facility and Bundang as headquarters, respectively.



RHI was established to achieve the NPP workers' health and social safety by operating radiation health system and expertise acquisition. It performs on-site radiation emergency medical preparedness and response, NPP workers' health evaluation and promotion. It is doing research on physical dose assessment, biological safety of low dose radiation, epidemiology of NPP workers and residents.

## **2 RADIATION EMERGENCY PREPAREDNESS OF KHNP**

### **2.1 NPP's Radiation Disaster**

Plenty of radioactive substance in nuclear facility possibly spill into environment and public if facility collapses due to radiation disaster. These radiation exposures result in acute radiation syndrome, local injury, long-term carcinogenic effect and powerful psychological effect to public. For radiation emergency preparedness, in addition to radiation experts, radiation detection is required because we cannot detect radiation with five senses and radiation protection equipments including personal protective equipment (PPE), personal dosimeter, potassium iodide (KI) for thyroid and respirators are needed [1]. As duty of KHNP by law, emergency planning zone (EPZ), radiation emergency response facility & equipment, response and recover of radiation disaster, radiation emergency education & exercise should be established before operating NPP [2].

### **2.2 Classification of Radiation Emergency**

United States Nuclear Regulatory Commission (USNRC) and International Atomic Energy Agency (IAEA) classified radiation emergency as unusual event, alert, site area emergency and general emergency. Alert poses a potential threat to the overall safety of the NPP site due to damaged equipment, but it does not require an emergency response to the public. This corresponds to white emergency in South Korea. In site area emergency, minor to major damage to equipment in NPP site can spread nuclear chemicals through air or water, which can have harmful effects on workers. However, no immediate response is required because it does not affect the public. General emergency is the most serious situation in which nuclear chemicals is leaked and released due to severe damage to equipment in the NPP, but the safety system is not controlled due to insufficient operation, which can have harmful effects to public and requires emergency response. Site area and general emergency correspond to blue and red emergency, respectively [3, 4].

### **2.3 Emergency Response Organizations**

Emergency response organizations while NPP's disaster consists of Technical Support Center (TSC) which prevent and relieve critically accident, Operational Support Center (OSC) which examine and repair system & instrument, Emergency Operation Facility (EOF) as headquarter of emergency response [5]. They immediately enter an appearance at appointed facility when NPP emergency occurs.

TSC and OSC on-site launch when white emergency occur. TSC takes charge of headquarter before EOF launches. EOF off-site launch after blue emergency occurs although early launch is possible if needed. EOF takes charge of headquarter at the NPP accident scene [Fig. 2].

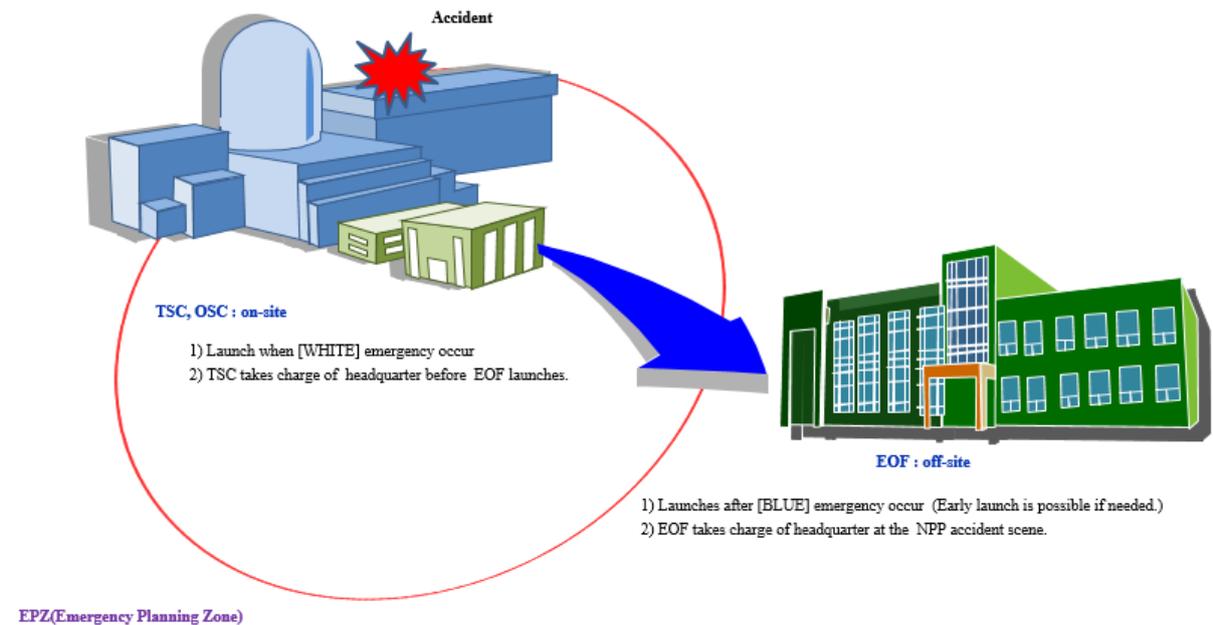
## **3 MEDICAL RESPONSES: KHNP AND NATIONAL SYSTEM**

### **3.1 Radiation Emergency Medical Preparedness in KHNP**

In RHI, there is NPP dispatch team consists of medical doctors, nurses, health physics and supporters. This team is equipped with mobile dosimetry laboratory (MDL), advanced ambulance, decontamination system and dispatched to NPP and controls the on-scene emergency medical response. Also, five teams including off-site medical, situation, dosimetry, administrative and assistance provide advanced medical care to the NPP workers and response the radiation medical issues & risk communication.

Dose assessment for emergency workers was delayed due to the collapse of the dose evaluation system at the site during the Fukushima nuclear accident. Prior to the accident, only fixed whole body counters (WBCs) were fitted, so the role could not be performed by the tsunami [6]. KHNP has been operating stand-type and bed-type WBC using NaI and HpGe, respectively. Compared to pre-accident Fukushima NPP, it maintains a good operating system in terms of analysis of radionuclide and shielding design. However, it has been operated on a fixed basis. Therefore, KHNP introduced MDL which is a trailer equipped with scintillator detector of high measurement efficiency, radiation portal monitor and also in-vivo electron spin resonance spectroscopy (in-vivo ESR) provided for external dose evaluation [Fig. 3].

**Figure 2:** Launches and responsibilities of TSC, OSC and EOF as emergency response organizations.



**Figure 3:** Specification of MDL with WBC, radiation portal monitor and in-vivo ESR.

Length (mm): 9,640	Width (mm): 2,495	Height (mm): 3,980	Weight (kg): 13,970
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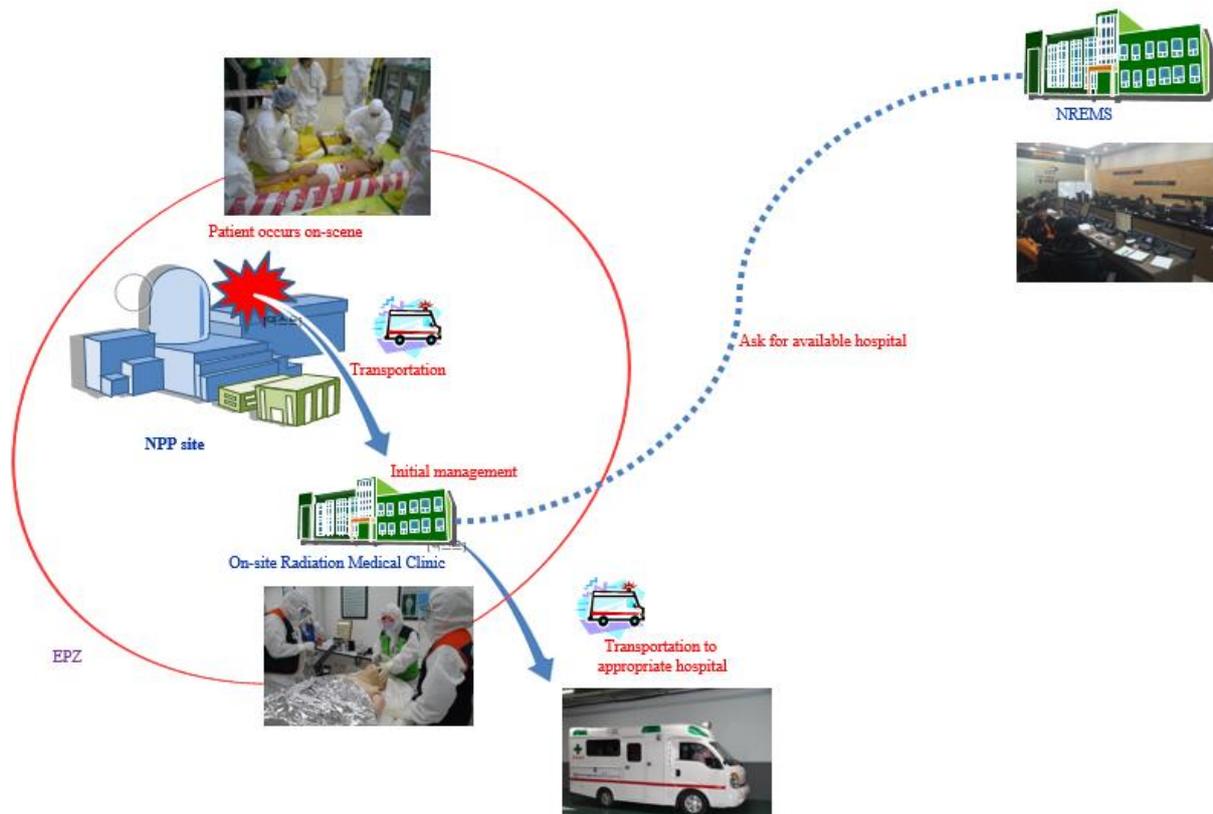
Radiation Emergency Medical Center (REMC) was established at each of 5 NPP sites in 2014. There are 3 nurses, 1 emergency medical technician, 1 supporter, advanced ambulance and emergency medical facility. It provides initial prehospital care and transportation to the hospital [Fig. 4].

**Figure 4:** There are healthcare room and decontamination room in REMC. The personnel of REMC participate in exercise and training.



NPP dispatch team and REMC are combined to form on-site radiation medical clinic, which is located on REMC facility of NPP site, provide on-site prehospital care and transportation to hospital and controlled directly by EOF. If patient occur on-scene, he is taken to on-site radiation medical clinic and given initial management. In cooperation with national radiation emergency medical system, asked for available hospital and then transported to appropriate hospital [Fig. 5].

**Figure 5:** On-site radiation medical clinic performs initial management and then transportation to appropriate hospital in cooperation with national radiation emergency medical system.



### 3.2 National Radiation Emergency Medical System

National radiation emergency medical system (NREMS) is organized by national radiation medical center in Seoul and primary and secondary designated hospitals throughout the country. The former is

general hospital near NPPs and provide initial management. The latter is military or university hospital and provides expertise treatment for combined injury or acute radiation syndrome. RHI is a primary designated hospital.

### 3.3 Limitations of Current On-Site Medical Response System

There are limitations of current on-site medical response system. First, WBCs of NPP are located in environmental laboratory one to three kilometers from NPP. Loss of habitability can occur while NPP accident. Second, although a shadow shield method for WBC to minimize the impact of a high-level background were adopted and the vehicle's location and surrounding radiation dose rates while moving to the accident site were transferred to the accident control department in real time, there may be controversy over the reliability of operating WBCs on-site where background radiation is high.

## 4 FUTURE PLANS FOR ON-SITE MEDICAL RESPONSE

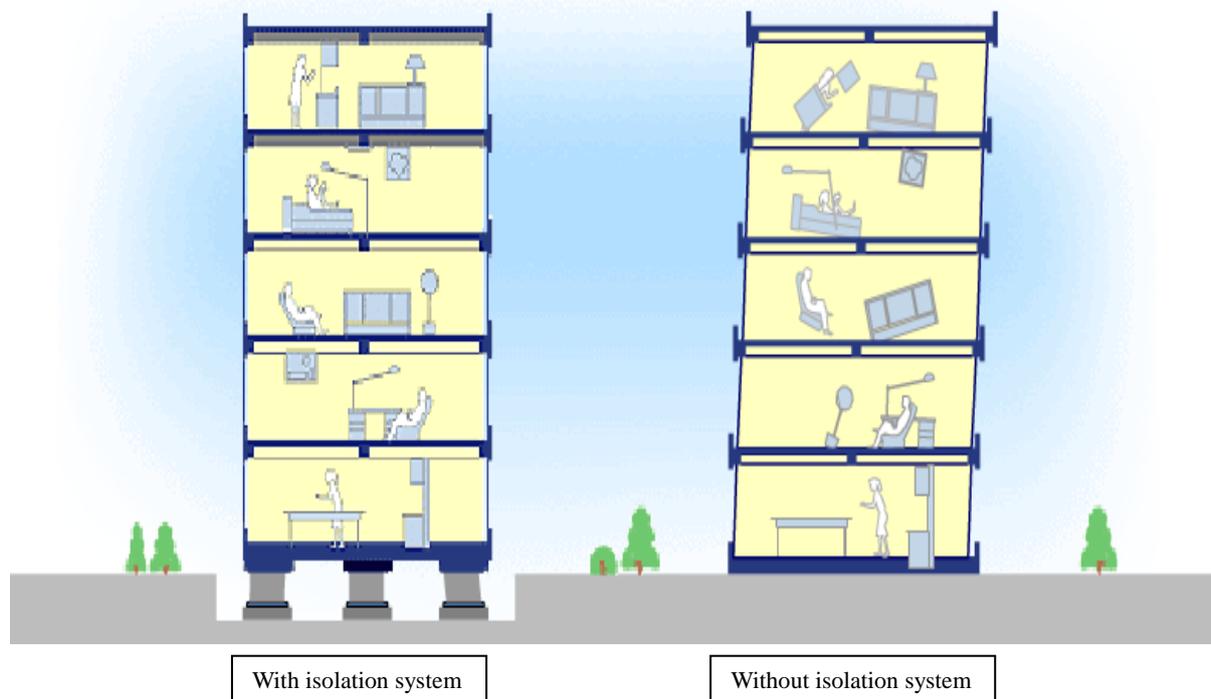
### 4.1 Safety Issues in South Korea

In Gyeongju on September 12, 2016 and Pohang on November 15, 2017, earthquakes with magnitude of 5.4 or greater occurred. The issue of whether nuclear power plants are absolutely safe and what to prepare medically for radioactive disasters caused by nuclear power plants has been raised.

### 4.2 KHNP's Plan for On-site Emergency Response: 2 strategies

First, KHNP is planning construction of on-site emergency facility with isolation system available in each NPP site from 2020 to 2023 [Fig. 6].

**Figure 6:** On-site emergency response facility with isolation system to prepare for a earthquake.



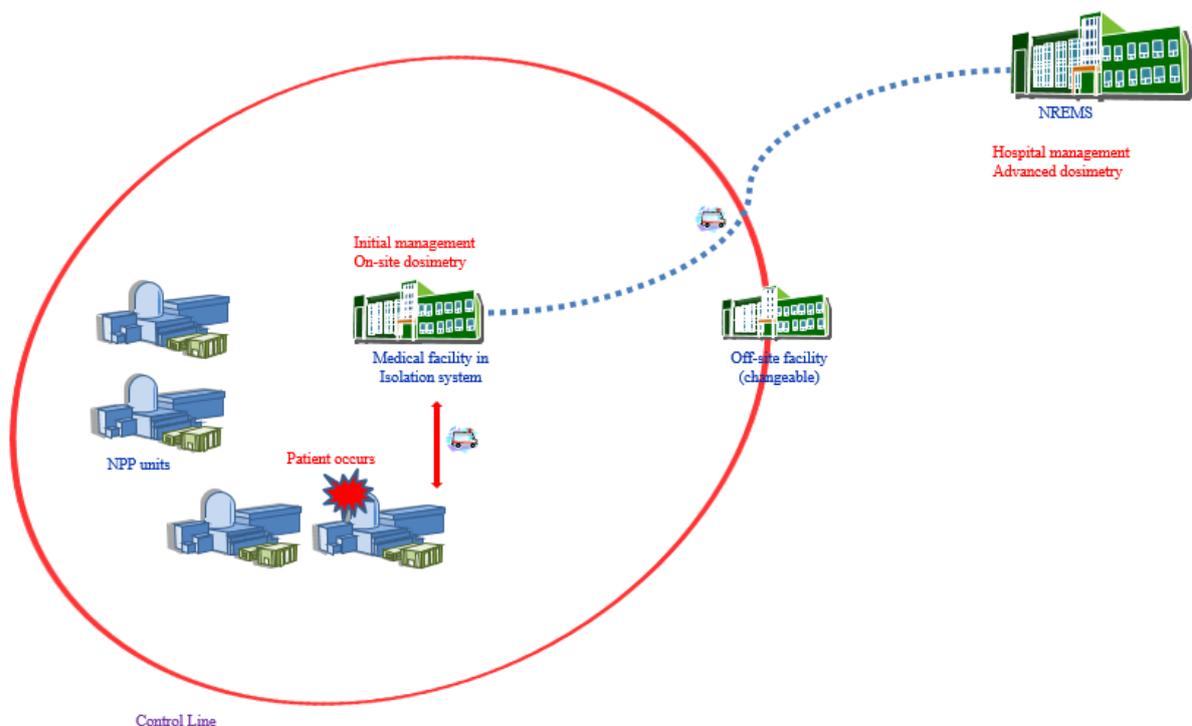
Its function is the on-site headquarter facility of NPP disaster. Emergency facility with isolation system isolates facility from ground to absorb the energy of earthquake and performed important role as emergency response basecamp while Fukushima NPP accident [6]. It has medical facility and emergency operation facility in South Korea. In medical facility, emergency room provide medical

triage to NPP accident's victims and decontamination procedure if external contamination. Dosimetry room provides on-site dosimetry for radiological triage to NPP accident's victims. Recovery/short-term admission room admits NPP accident's victims without contamination shortly if needed and provide health care service for worker in isolation room. Isolation room admits NPP accident's contamination victims shortly and initiate decorporation treatment if indicated. Second, off-site emergency response preparedness is located at the borderline between controlled area and safety area and considered large buildings near NPPs with wind direction including EOF buildings or schools or public buildings. It functions as basecamp of NPP's radiation emergency response, as like J-village in Fukushima and especially acts the main role when on-site facilities collapse. It has the emergency room for initial hospital care and transport time to nearby national designated hospitals is approximately 30 minutes. It provides radioactive decontamination, decorporation treatment, radiation dosimetry for internal contamination and external exposure using MDL as a key role. When isolation facility is available, medical facility in isolation system performs initial management and on-site dosimetry [Fig. 7]. However, when isolation facility is collapsed, off-site facility and MDL do it instead [Fig. 8].

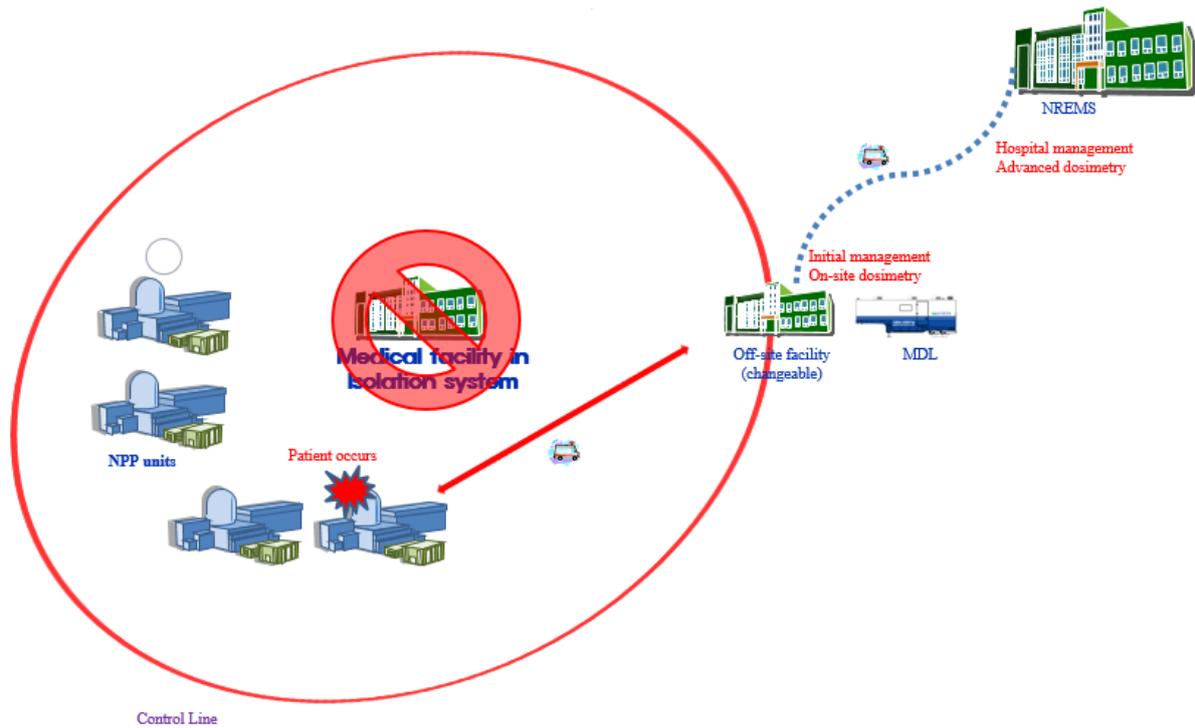
### 4.3 Further Considerations

As a matter of future consideration, first of all, it will be necessary to prepare for military attacks or terrorist attacks by enemies other than earthquakes. In the event of multi-unit nuclear power plant accidents, more demand is needed than available resources. Therefore, we need to prepare a lot of resources, but to find a point of contact with efficiency. Lastly, roads can be destroyed by natural disasters or terrorism. MDL cannot be deployed. So, alternative strategies for the move may be needed.

**Figure 7:** When isolation facility is available, on-site medical response is performed.



**Figure 8:** When isolation facility is collapsed, off-site facility performs medical response.



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