Radiological Impact Assessment with AtomCARE

Dong Myung, LEE
(k320ldm@kins.re.kr)

Dept. of Nuclear Emergency Preparedness

한국원자력안전기술원
KINS KOREA INSTITUTE OF NUCLEAR SAFETY

Transparency

Responsibility

Excellence

KINS

Independence

What does AtomCARE stand for?

◆ **It stands for Atomic Computerized Technical Advisory System for a Radiological Emergency**

- A kind of software platform for supporting decision makers(government)

- Walk in step with IAEA GSR Part 7 Requirement 1(Emergency Management System)
  - The system shall be designed to be commensurate with the results of the hazard assessment and shall enable an effective emergency response to reasonably foreseeable events.

◆ **The official Korean name of AtomCARE is "radiological impact assessment information system"**

- In accordance with Article 32 (4) of the Act on Physical Protection and Radiological Emergency

- Article 32(Technical support for Radiological Emergency Managements, etc.)

  (4) The President of the KINS under paragraph (1) shall build and operate an information system necessary for radiation impact assessment, etc. in order to prepare against any possible radiological disasters, etc..

  <Newly Inserted by Act No. 15280, Dec.19, 2017>

◆ **The system is now operating 24 hours a day without a break.**

Past, Current, and Future of AtomCARE

◆ **Launched in 1993**
- KINS started in developing the computerized technical advisory system for a radiological emergency in 1993, which named "CARE"

◆ **Branded for globalization in 2006**
- Changed the name of CARE with "AtomCARE"
- Transferred AtomCARE technology to the IAEA/IEC
- Patented in 2008(domestic patent No. 10-0841947)

◆ **Legalized a basis for operation of AtomCARE in 2018**
- Enforcement Rule of the Act on Physical Protection and Radiological Emergency
    - Article 17-2(Establishment and Operation of Radiological impact Assessment Information System)
    1. Meteorological information(i.e., met. observation/prediction and dispersion prediction
    2. Social geographical information(i.e., population, evacuation route, etc.)
    3. Information on the status of nuclear facilities(i.e., Rx temp., containment pressure, etc.)
    4. Information on the environmental radiation dose rates and radioactivity in samples
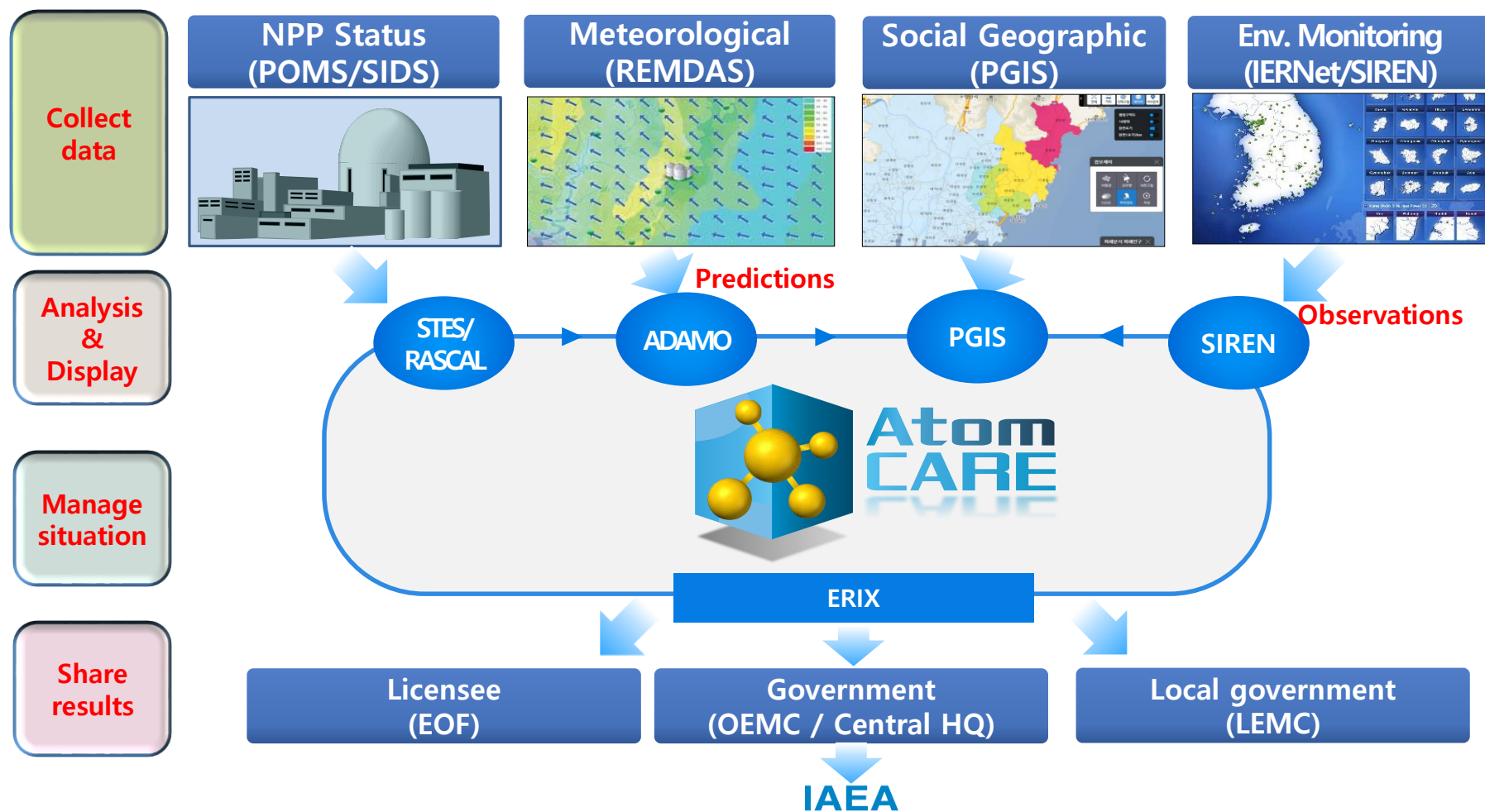
◆ **Keep evolving at present**
- Multi-model ensemble dispersion prediction system
- Decision support system framework for nuclear emergency
- Inverse modeling to estimate emission rates using environmental radiation measurements, etc…

# Objectives and functions of AtomCARE

- Collects information on NPPs status, meteorological data, social geographic data, and environmental radiation/radioactivity monitoring data nationwide(normally)
- In case of emergency, the functions move on to the characterization and management of a nuclear accident and the assessment of radiological consequences, and then it provides recommendations for the public protective actions to the government.

Collect data

| NPP Status (POMS/SIDS) | Meteorological (REMDAS) | Social Geographic (PGIS) | Env. Monitoring (IERNet/SIREN) |

Analysis & Display

STES/RASCAL → ADAMO → PGIS ← SIREN

Predictions   Observations

Manage situation

AtomCARE

ERIX

Share results

| Licensee (EOF) | Government (OEMC / Central HQ) | Local government (LEMC) |

IAEA

4

Algorism for information process

- Operated separately before and after the major radioactive releases into the environment.

- Before release (expecting), source term evaluation using real-time NPP status information, and the results are input to ADAMO along with weather prediction data to predict the dispersion of radioactive materials and dose. This result is automatically linked to PGIS and used to recommend, make a decision and implement for PPA.

- After end of release, env. monitoring data collected through various devices are integrated and analyzed in SIR EN, and the results are used to recommend, make a decision and implement additional PPA.
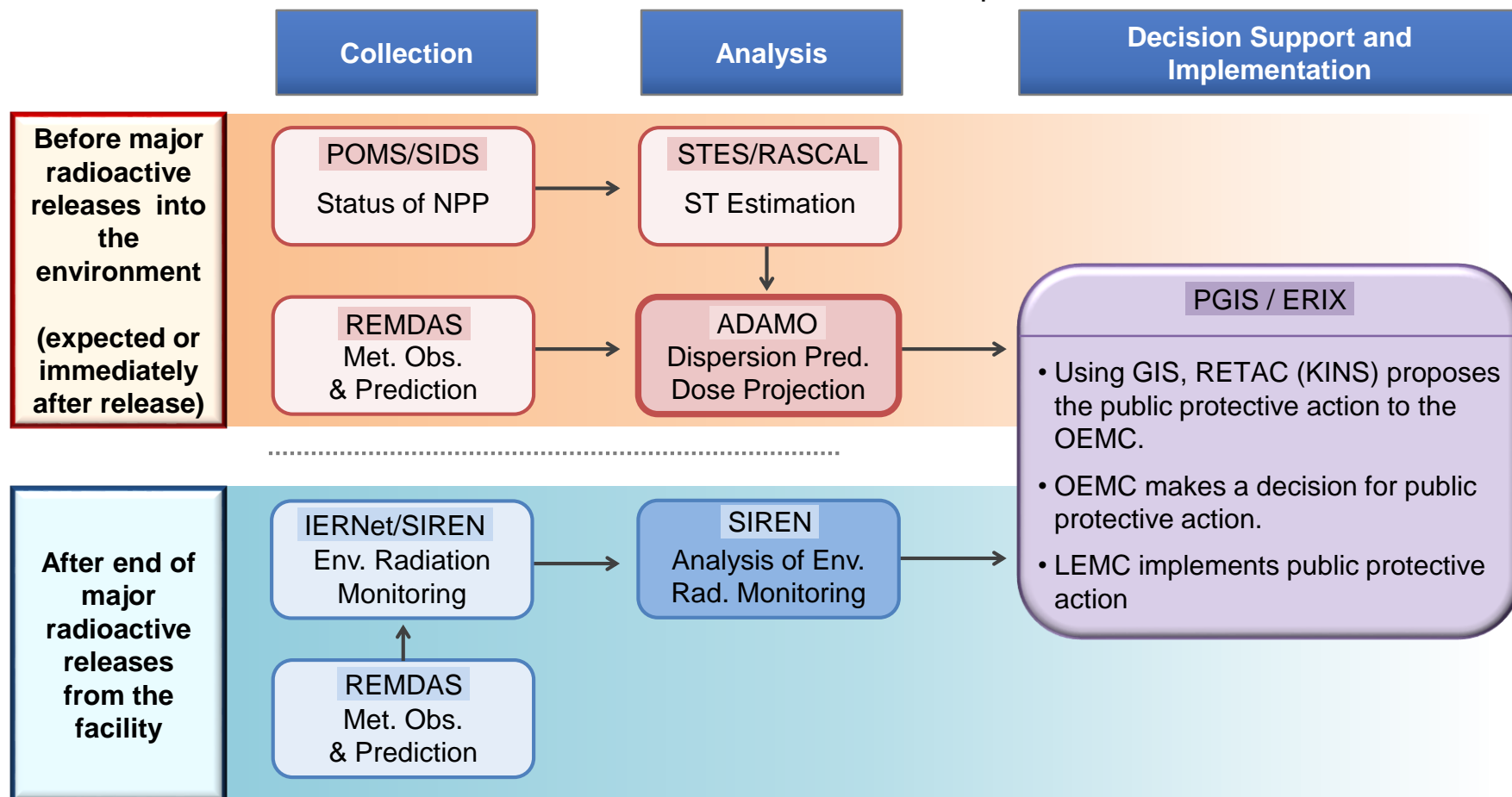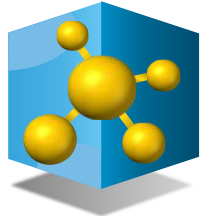
(1) Status of the Nuclear Facility (SIDS, POMS, and STES)

SIDS(Safety Information Display System)
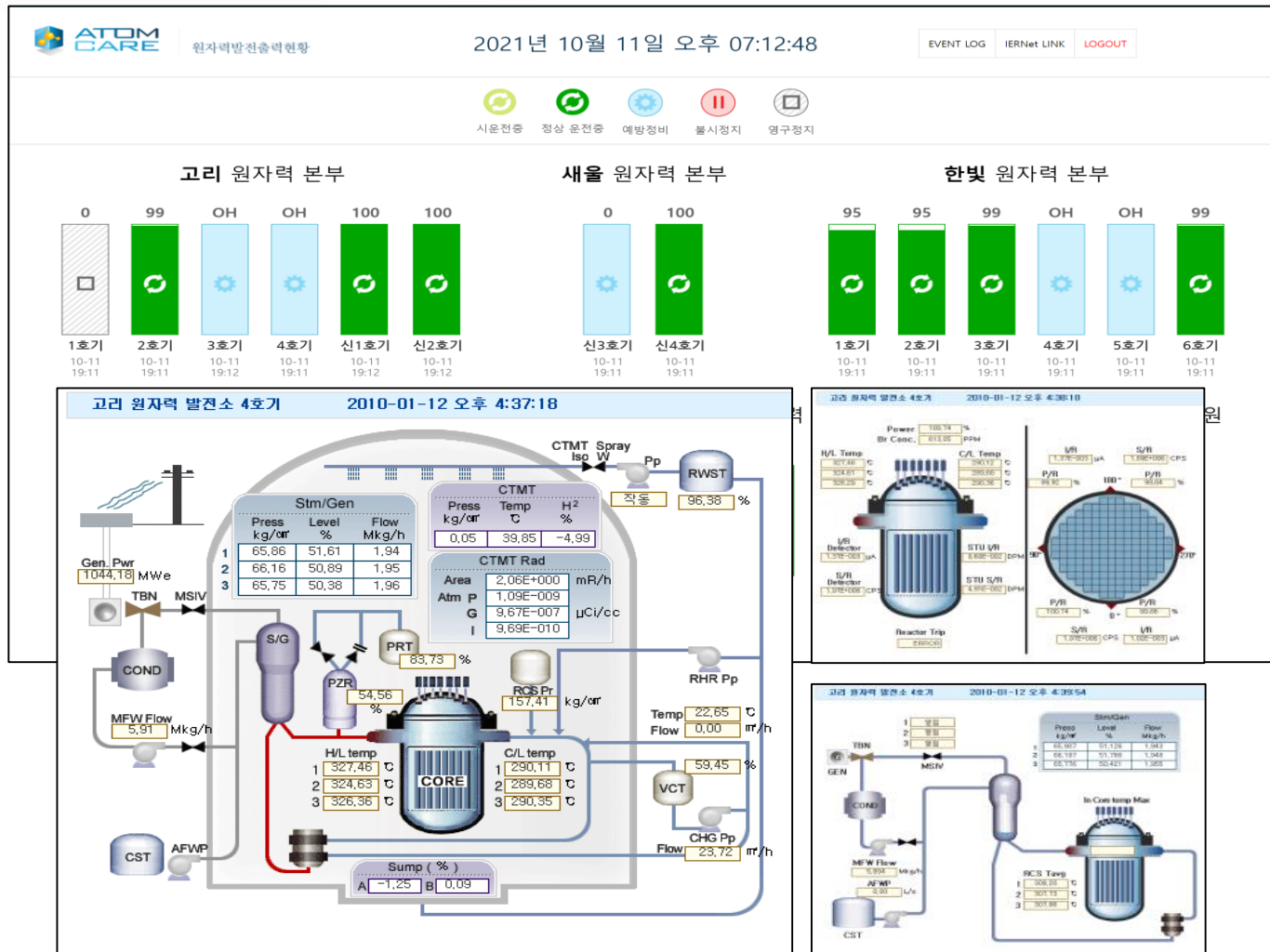
✓ SIDS displays 200-300 parameters in each unit to confirm the integrity of the core, RCS, containment, and release of radioactive material. The experts can review and analyze the trends for all parameters.

POMS(Plant Operation Monitoring System)
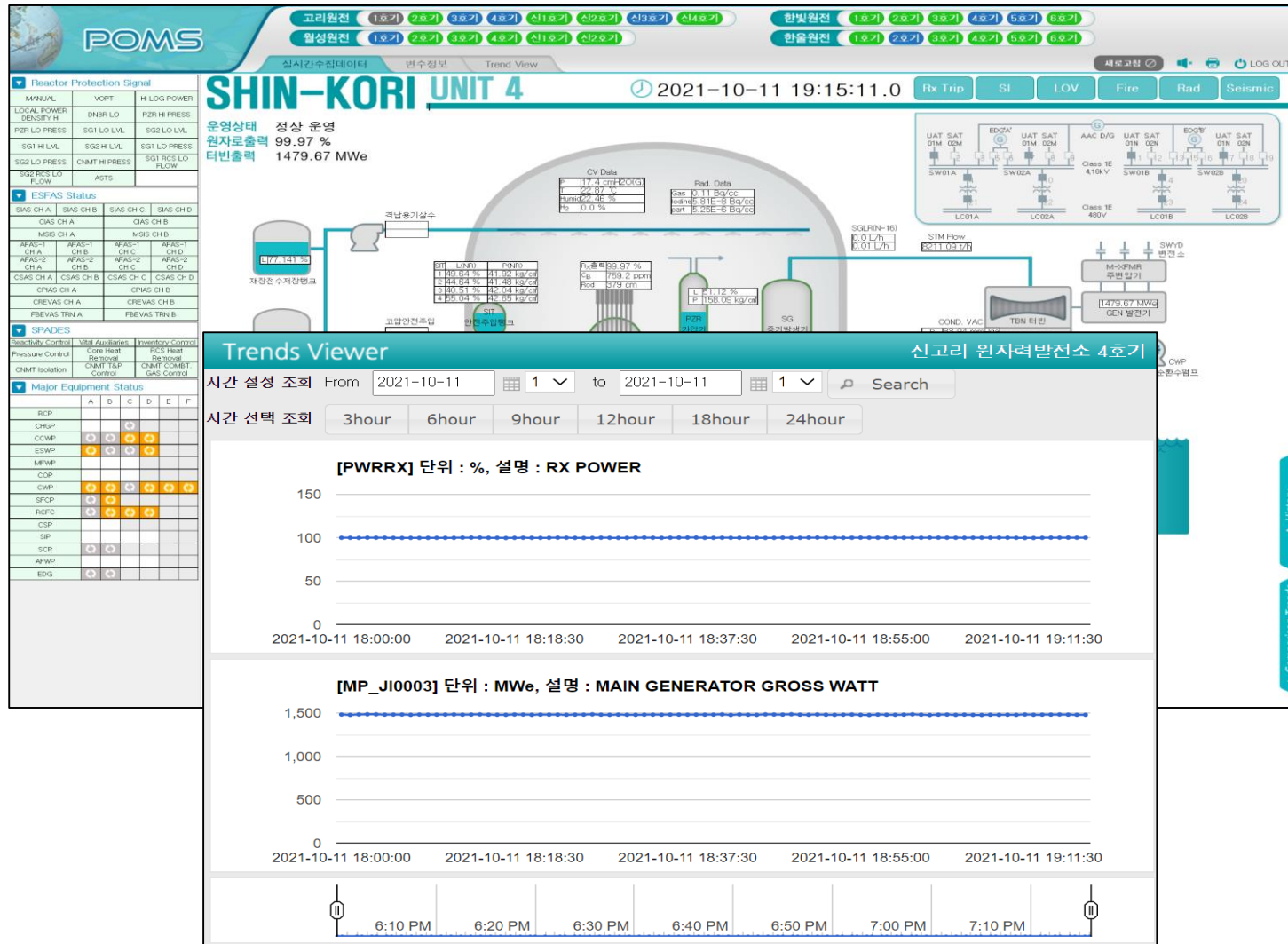
✓ POMS was developed to check for abnormalities in the status of the reactor protection system, the engineered safety features actuation system, the critical safety function, safety-related equipment operation, power supply system and so on.

STES(Source Term Estimation System)

◆ **Analyzes current status and estimates the source term**

- Assesses the degree of reactor core damage
- Estimates the reduction factor & pathways of radio. materials
- Estimates the amount of released radioactive materials

<**Process of source term estimation**>

Basic information (Type, Reactor power, etc)

↓

Core/RCS damage estimation (Rx shutdown time, ECCS, etc)

↓

(1) CV failure (CV temp/pres, etc) → CV leakage (2) Facility status (RCS, S/G, etc) → Release

↓

Source term estimation

Radiological Assessment System for Consequence Analysis

RASCAL 4.3.3

September 2017

Radiological Assessment System for Consequence Analysis

Primary Tools
- Source Term to Dose (STDose)
- Field Measurement to Dose (FMDose)

Additional Tools
- Create Reactory Inventory Base File
- Source Term Merge / Export
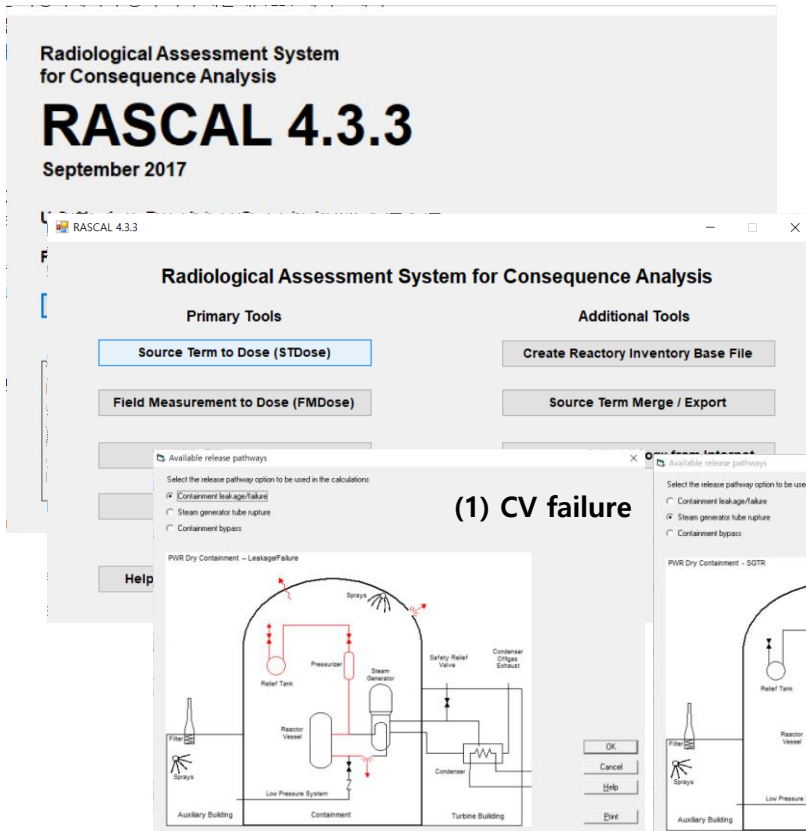
(1) CV failure

(2) SGTR

(3) Containment bypass

<Release pathway (NUREG-1940)>

9

(2) Meteorological Information (REMDAS, ADAMO)

REMDAS
(Meteorological Data Acquisition System for Radiological Emergency)

Atom CARE

◆ Collects and Generates Meteorological Information (3-D Wind Fields)

- Automatic weather stations in nuclear facilities sites
- AWS weather information every 10 minutes from KMA, KFS, etc (about 800 sites)
- Numerical weather prediction data every 6 hours from KMA (resolution: 10 and 1.5km)
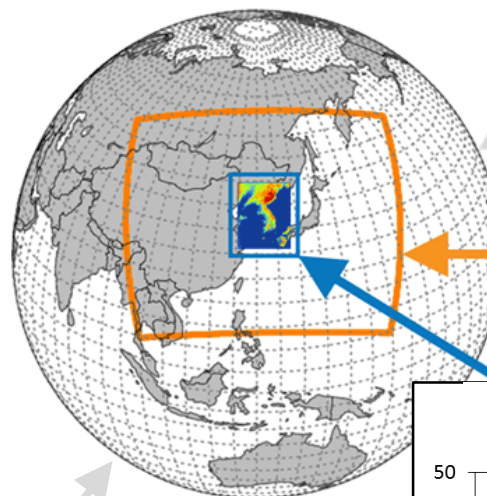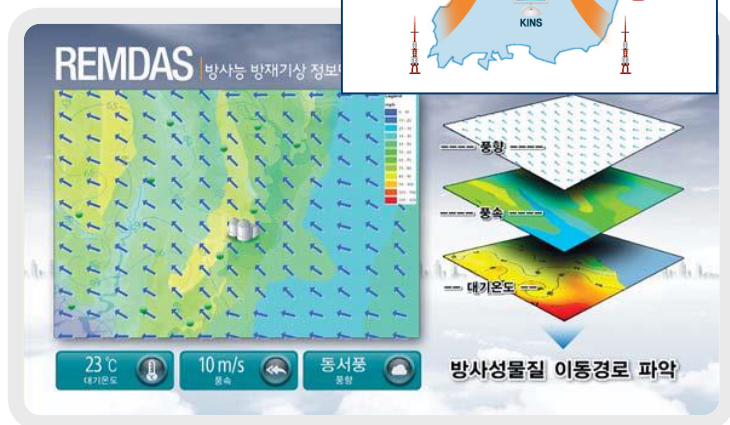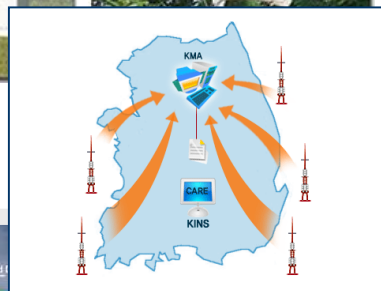
Global (GDAPS)
- Horizontal res. : 10 km
- Vertical layers : 70
- Target length : 12 days (00/12 UTC)
  87 hrs (06/18 UTC)
- Init : Hybrid Ens 4DVAR

East Asia (RDAPS)
- Horizontal res. : 12 km
- Vertical layers : 70
- Target length : 87 hrs (6-hourly)
- Init : 4DVAR / 3DVAR

Global (Other centers)
- NOAA-GFS, CMC-GDPS (~25km, 10 day

Comparison of 5-day forecast

NH 500 hPa RMSE Day 5 (JJA 2016)
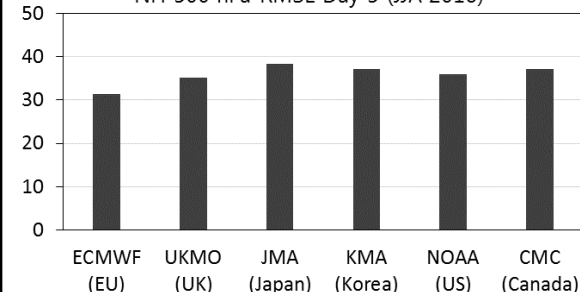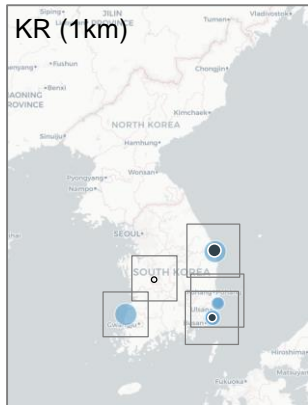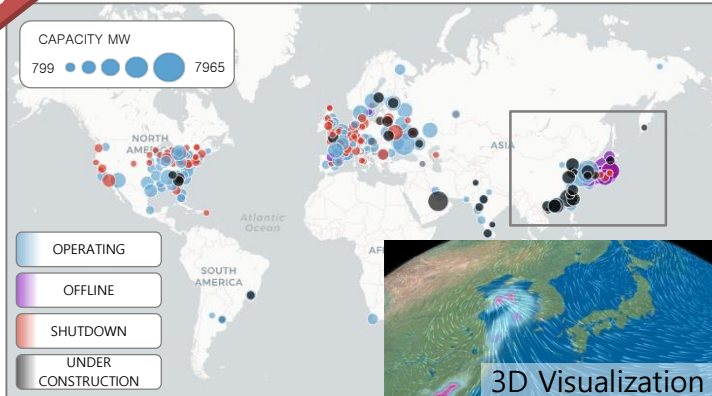
ADAMO(Accident Dose Assessment Modeling)
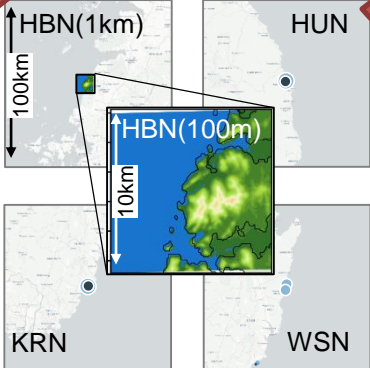
◆ **Weather/Dispersion Prediction and Dose Assessment for Public Protective Actions(PPAs)**

- Carry out weather predictions based on meteorological observations
- Assess the projected radiation dose using the predicted weather and the estimated source term.
- Provides recommendation for the PPA area with Generic Intervention Levels(GILs)
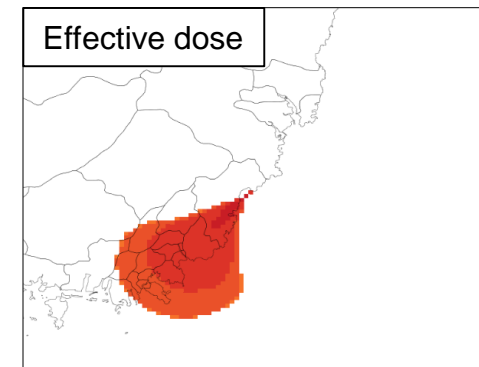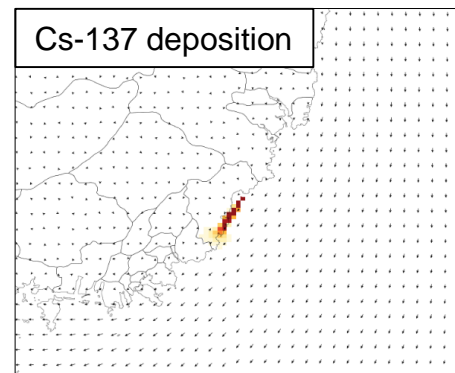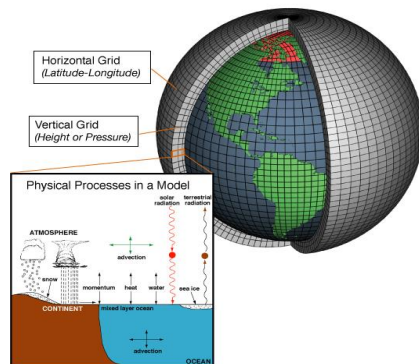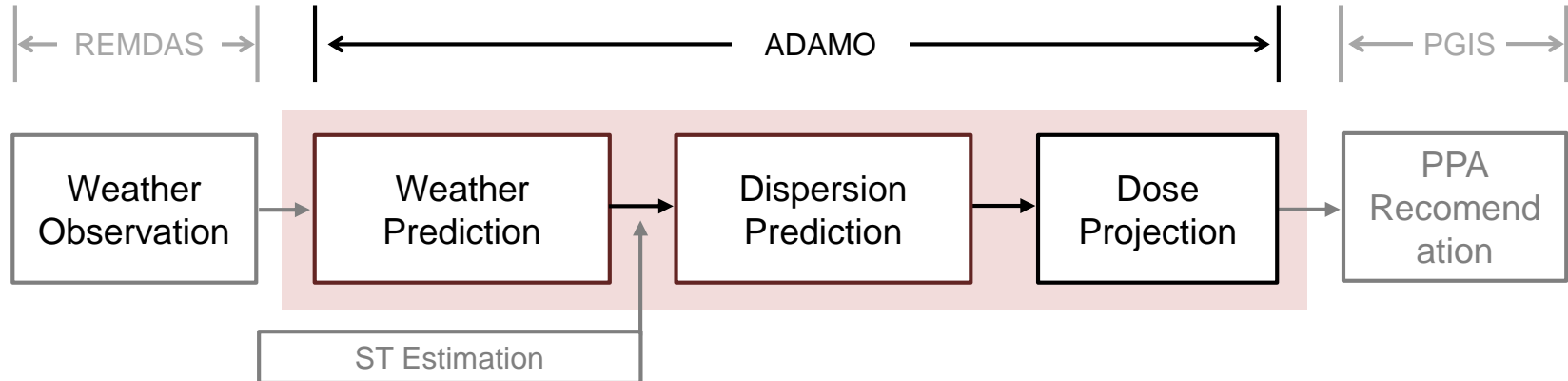
Model Configuration of ADAMO

Accident	Domestic		Overseas		
Domain	**Local (4 NPP and 1 RR sites)**	**Nationwide (Korean Peninsula)**	**Global**		
	HBN(1km) HUN 100km HBN(100m) 10km KRN WSN	KR (1km)	CAPACITY MW 799 ● ● 7965 OPERATING / OFFLINE / SHUTDOWN / UNDER CONSTRUCTION 3D Visualization		
Weather Prediction	KMA-LDAPS (1.5km) KMA-RDAPS (12km)	KMA-RDAPS (12km)	KMA-GDAPS* (10km)	NOAA-GFS* (25km)	CMC-GDPS* (15km)
Downscaling	CALMET (1km)	WRF (2km)	* Ensemble mean prediction using multi-model		
Dispersion Model	CALPUFF (1km)	FLEXPART (1km)	FLEXPART*		HYSPLIT*
Dose projection	External - FGR13, Internal (respiration)-ICRP60(119), Internal (Ingestion)-TECDOC-1162				
Target length	3 days	3 days	10 days		

✓ To efficiently respond domestic and overseas accidents, ADAMO was developed separately to quickly predict radiation effects in the area around NPPs and in detail in the Korean Peninsula area.

✓ In case of accident in neighboring countries, a multi-model ensemble prediction technique is applied to the A DAMO to minimize the increase in prediction uncertainty as the range and time increase. Using three global f orecasting and two dispersion models, six meteorology-dispersion combinations are constructed.
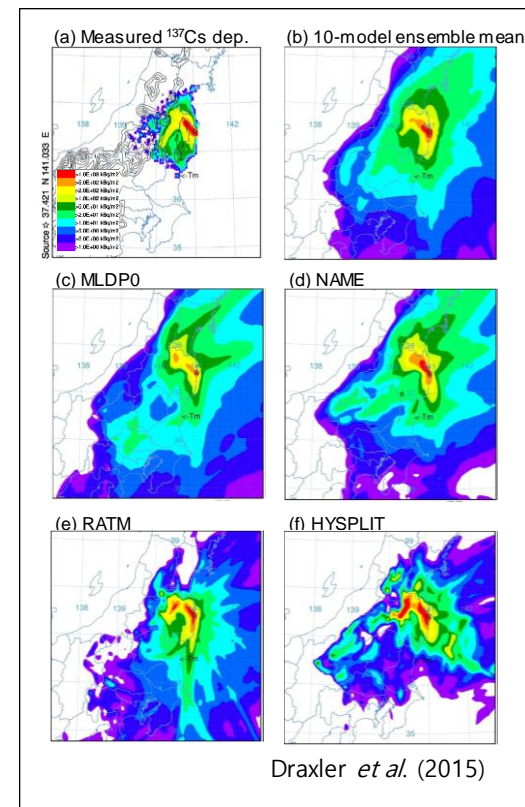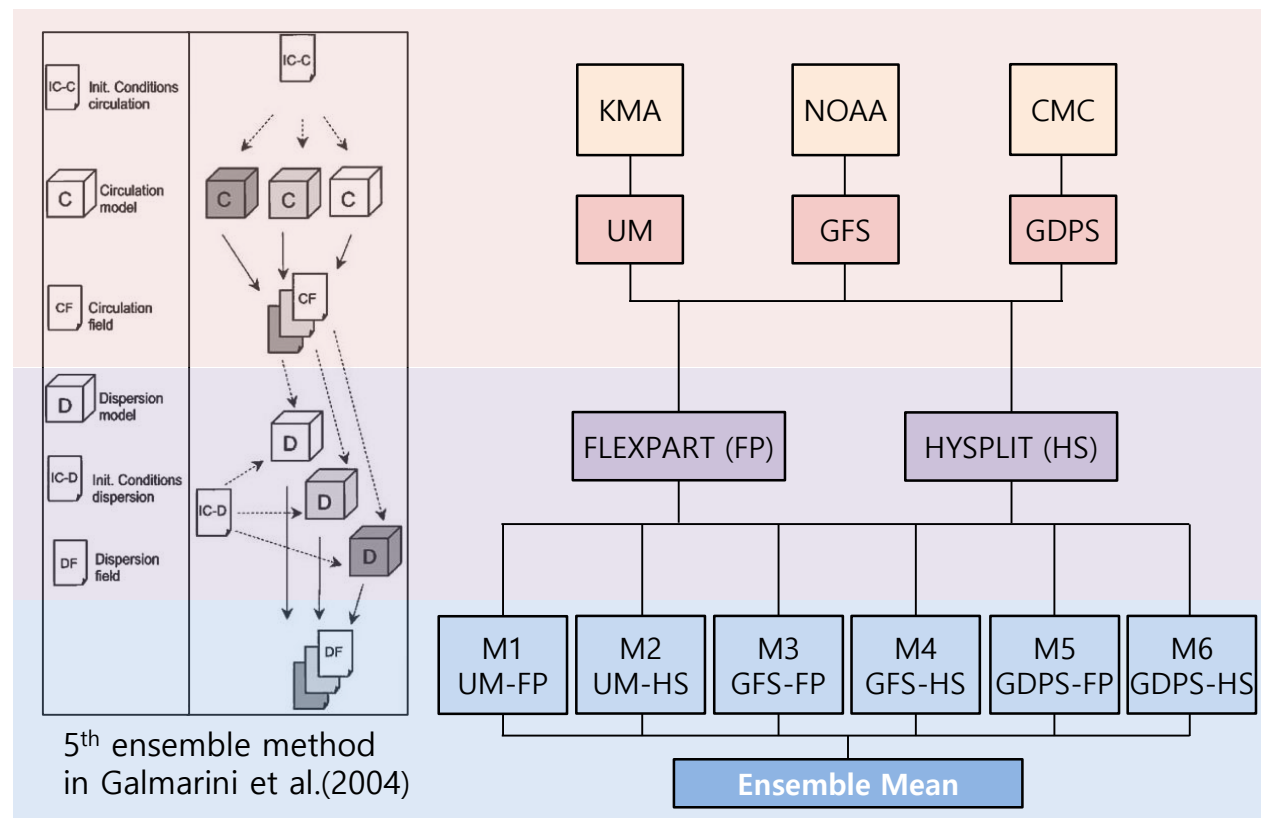
Multi-model Ensemble for ADAMO

◆ **Multi-model Ensemble Prediction**

- Reduces uncertainty by a single model, provide comprehensive analysis and various scenarios
- Using three weather models and two dispersion models with proven predictability

Composition of MME

Result of previous study

5th ensemble method in Galmarini et al.(2004)

Draxler *et al*. (2015)

According to Draxler et al. (2015), 10-model ensemble mean provided more consistent pattern of Cs-137 deposition than individual models.

3D Visualization of ADAMO

◆ **Horizontal and vertical distribution of weather and dispersion prediction results**

- Provides 3D visualization of large datasets such as weather/dispersion prediction, etc
- Intuitively expresses the real atmospheric structure compared to traditional 2D charts
- Example (2018 Korea-China-Japan Joint Emergency Drill)
  - Postulated release point: Shimane NPP in Japan
  - Release period: 2018.11.06 ~ 11.11 (5 days)
  - Visualized info: wind fields, horizontal distribution and vertical cross section of I-131 concentration
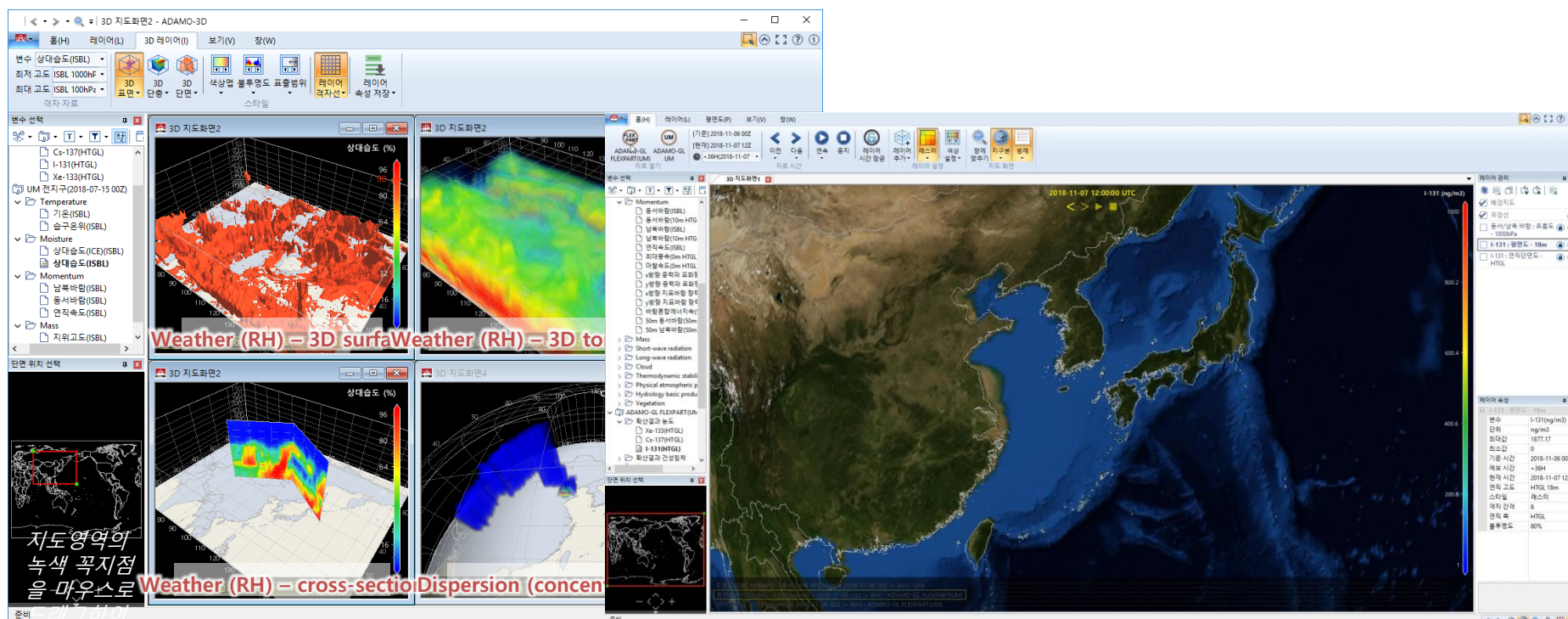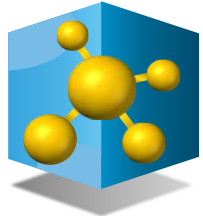
(3) Social Geographical Information (PGIS)

PGIS
(Geographic Information System for Public Protective Action)

◆ **Functions**

- Manages the database (geographical, social and environmental information)
- Identifies the affected area divided into sectors and administrative districts
- Provides of information on public protective action to relevant organizations

ADAMO

PGIS
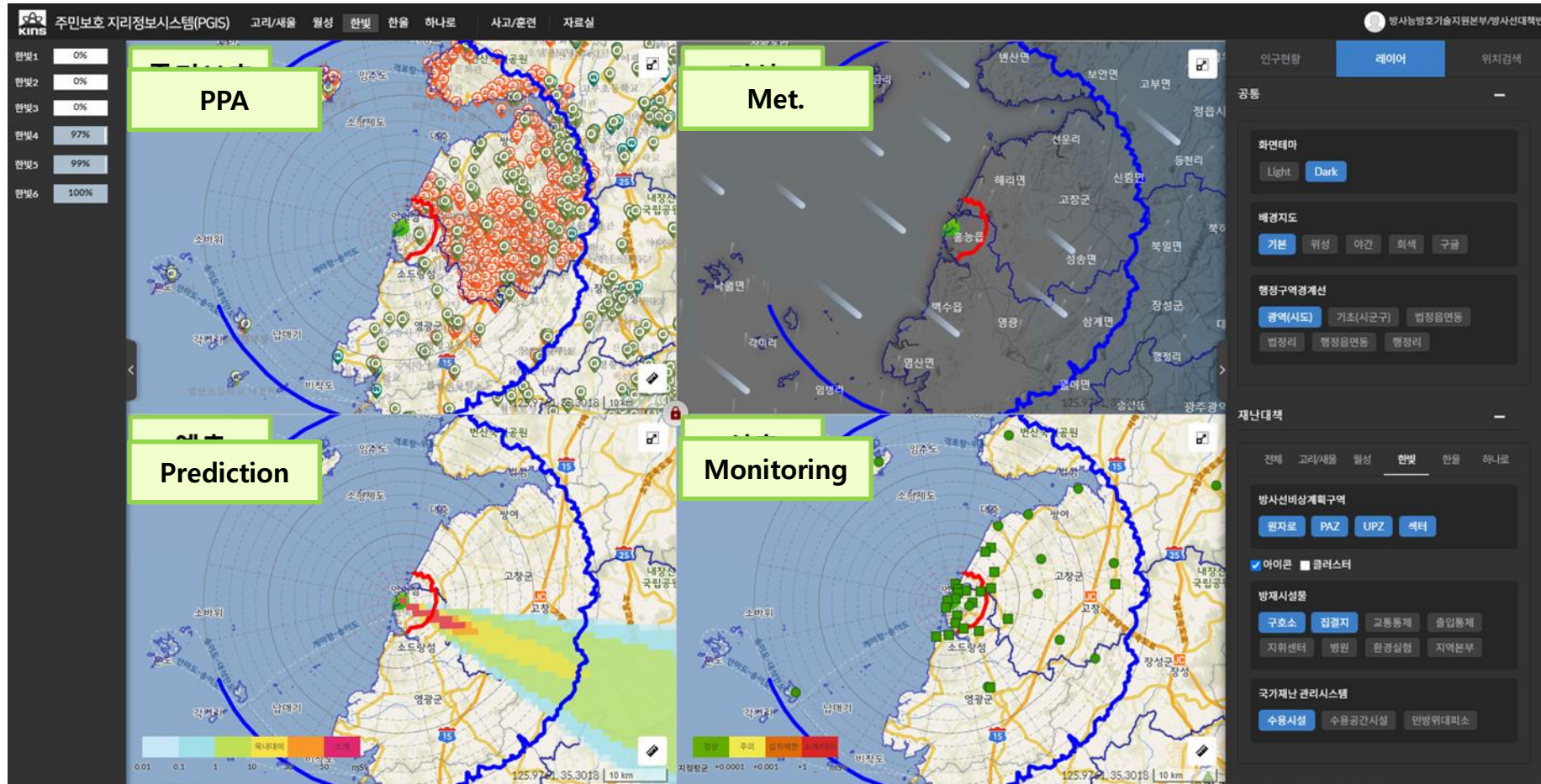

Cs-137 concentration

Effective dose

Dose (sectors)

Dose (admin. district)

Dose (locations)

Evacuation route

User Friendly Interface(UFI) of PGIS

◆ **Quadruple Screens for Supporting Decision-making**

✓ Previous (single map, slower loading, Openlayers) vs. Current (five maps, faster loading, Leaflet)
✓ UI-redesign and speed-up to intuitively display various emergency response information
  (PPA, met., prediction and monitoring)

Improvement of PPAs Area using PGIS

◆ **Administrative District based Public Protective Actions(PPAs) Area**

• Sector-based (16 directions and 2 km) → Administrative district-based

Projection
(Contour)

Current
Downwind 1 sector + adjacent 2 sectors
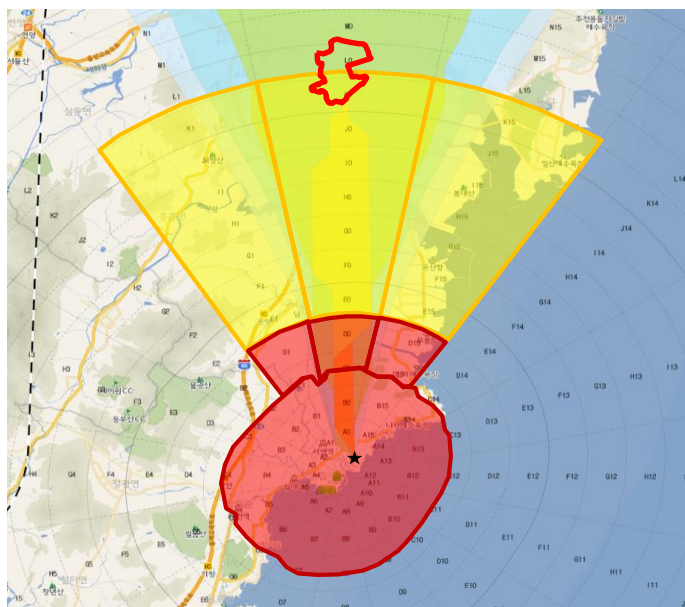
Improvement
Downwind 1 sector + adjacent admin. district
(adjacent 2 sector: collecting opinions from LEMC)

Example

w/o shelter in place

신정동

w/ shelter in place
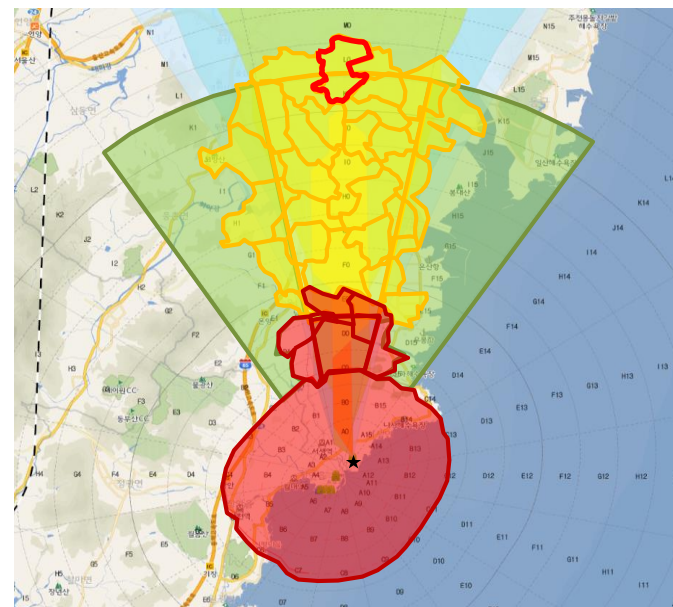
✓ The PPAs area is traditionally selected in the 16-direction sector (key-hole) by referring to the dose prediction results (contour).

✓ However, it is very difficult and unpractical that LEMC implements PPAs for such geometrical area.

✓ To solve this problem, the PPAs area can be selected in the minimum unit of the administrative district. **19**

Information Sharing Model of PGIS

◆ **Efficient Sharing of PPAs decision-making information using API or URL**

- API : Application Programming Interface is a S/W intermediary that allows two apps to talk to each other
- URL : Universal Resource Locator(web address: http://www.⋯⋯⋯)

Pred./Monitor.	PPAs Decision	Sharing with API or URL
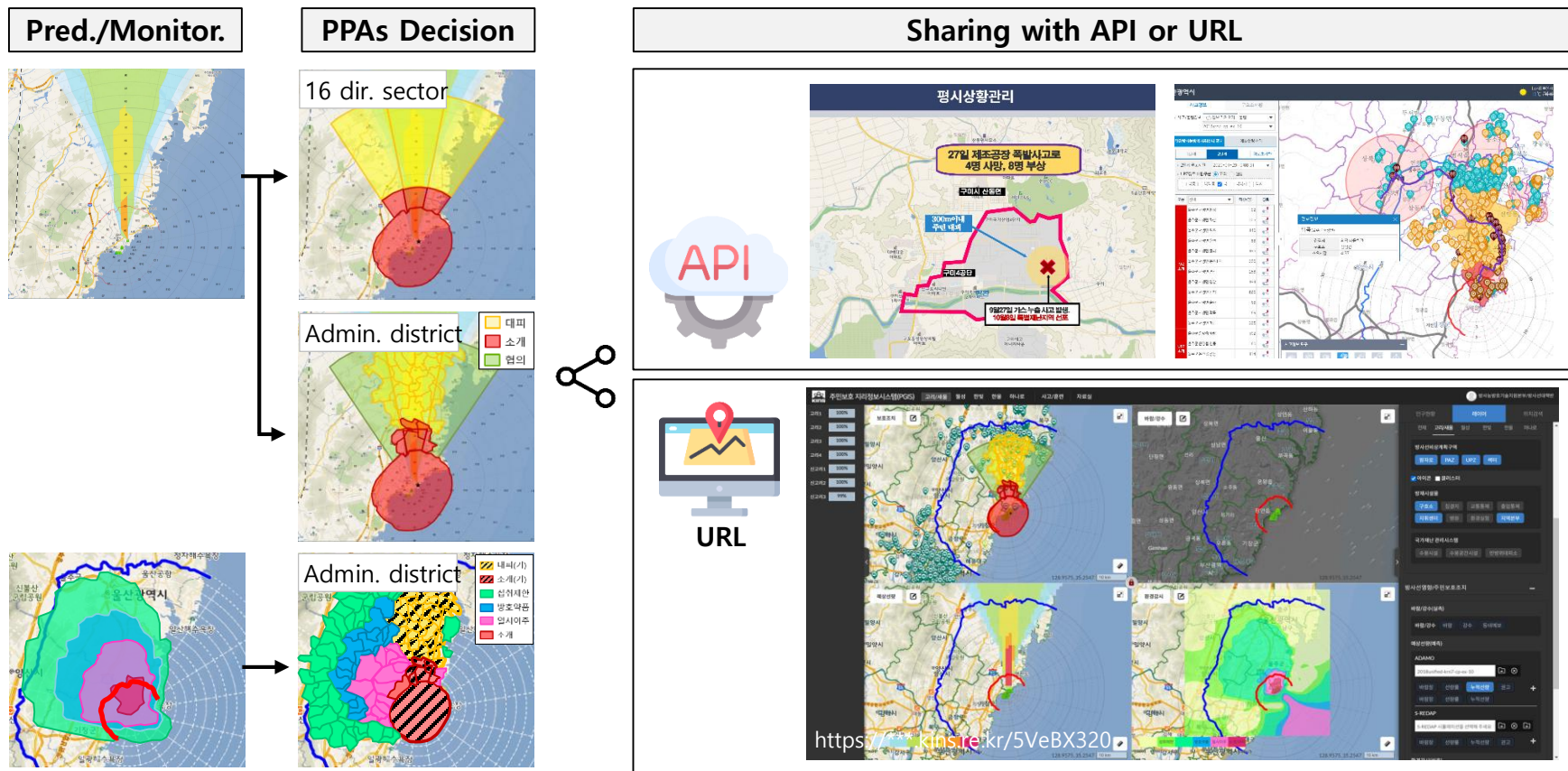
✓ PPAs decision-making and related results can be quickly disseminated to emergency organizations by API or URL.

✓ If an emergency response system is operated, the information can be provided directly using the API.

✓ If the emergency response system is not operated, the information can be shared by URL.

Decision-making Processes of PGIS

◆ **Recommendation, Decision-making and Implementation Processes by situation of an accident**
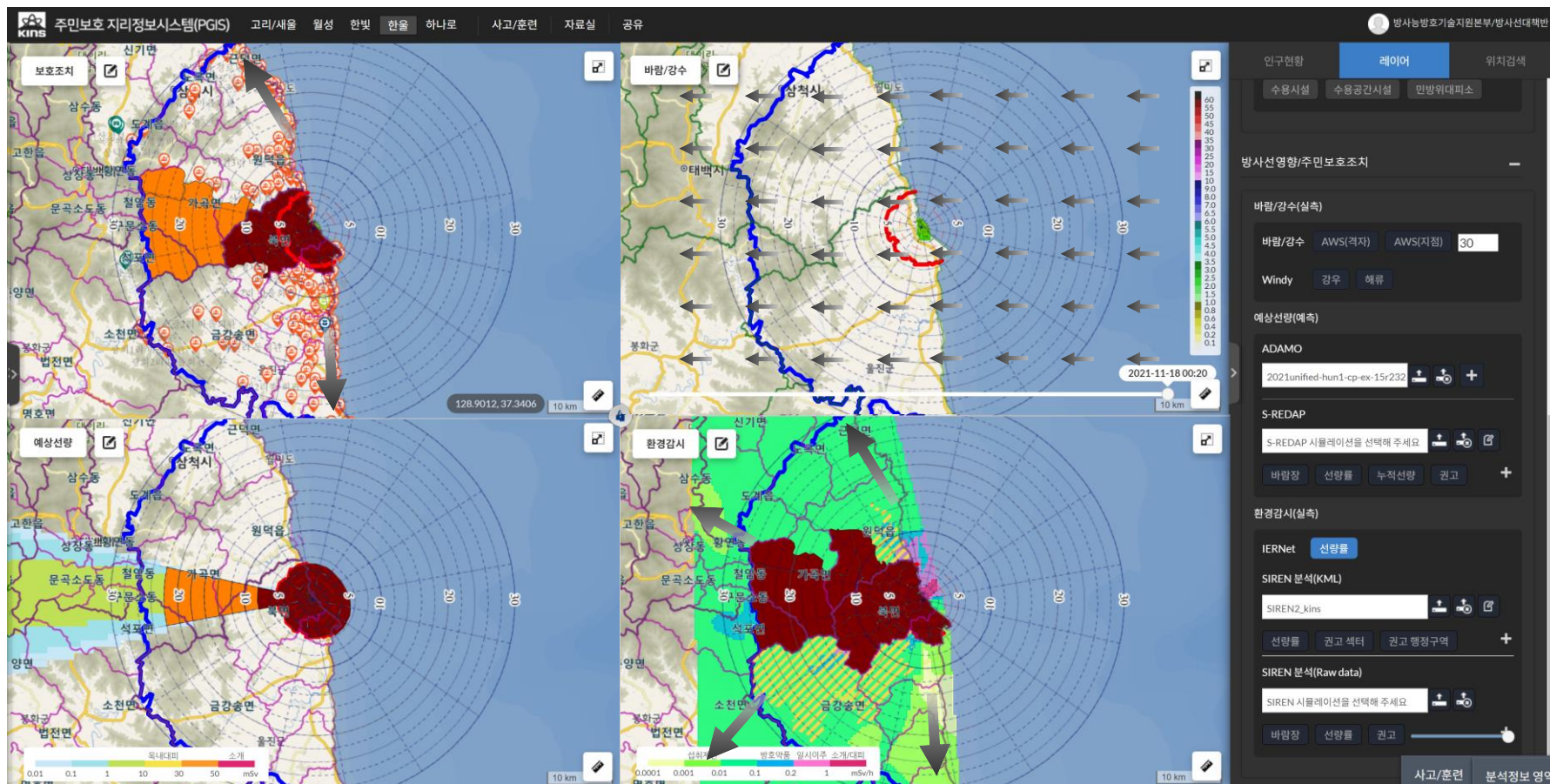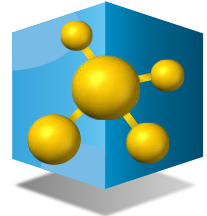

| Projected Dose | PPA Recomm. | PPA Deci. mak. | PPA Impl. | Env. Monitor. | PPA Recomm. | PPA Deci. Mak. | PPA Impl. |

(4) Environmental Rad. Monitoring
(IERNet, SIREN)

IERNet
(Integrated Environmental Radiation Monitoring Network)

◆ **Real-time monitoring network system for environmental radiation levels nationwide**

- Collects the ambient dose rates every 15 min.
  - 215 monitoring posts(as of Dec. 31, 2022)
  - Radiation detectors : HPIC(High Pressurized Ion Chamber) and NaI(Tl) Scintillation detector

- Checks radiation abnormality by outlier algorism, automatically

- Opens to the public using Website and mobile phone application

https://iernet.kins.re.kr
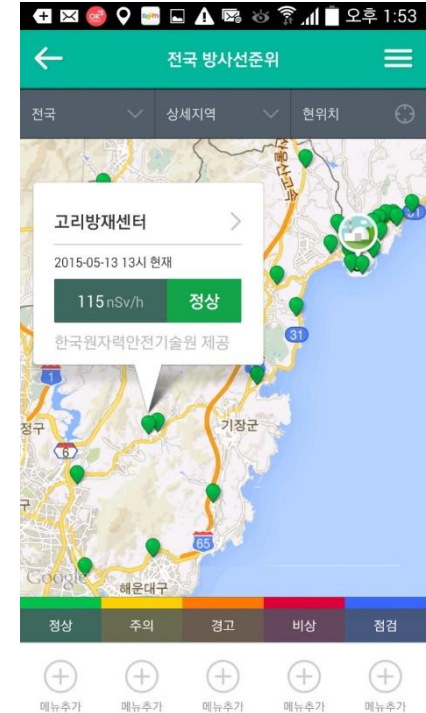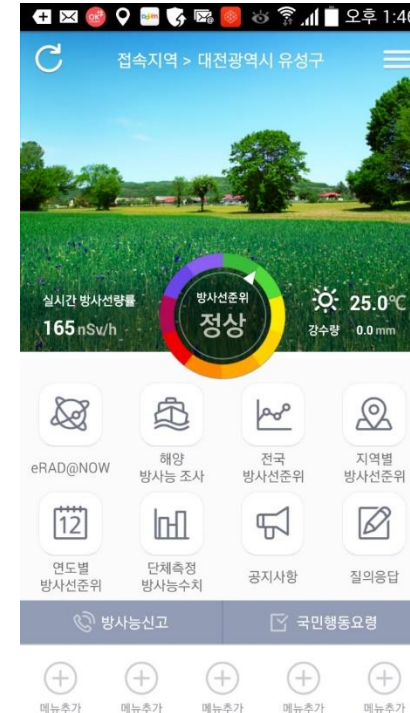
SIREN
(System for Identifying Radiation in the Environment)

◆ **Monitoring Cooperation System in case of Emergency**

- Set up the JREMC(Joint Radiation Environmental Monitoring Center)
  - Emergency call for joint monitoring personnel (KINS, army, licensee, etc.)
- Collect environmental radiation/radioactivity monitoring data
  - through aerial, marine, vehicle and portable monitoring, etc…
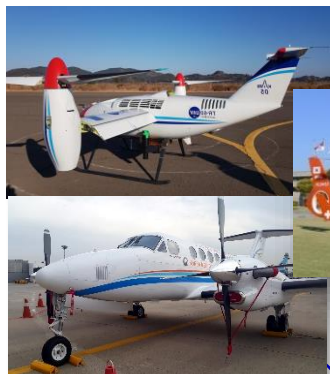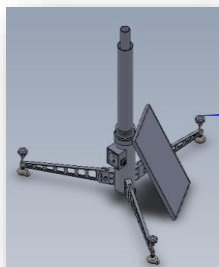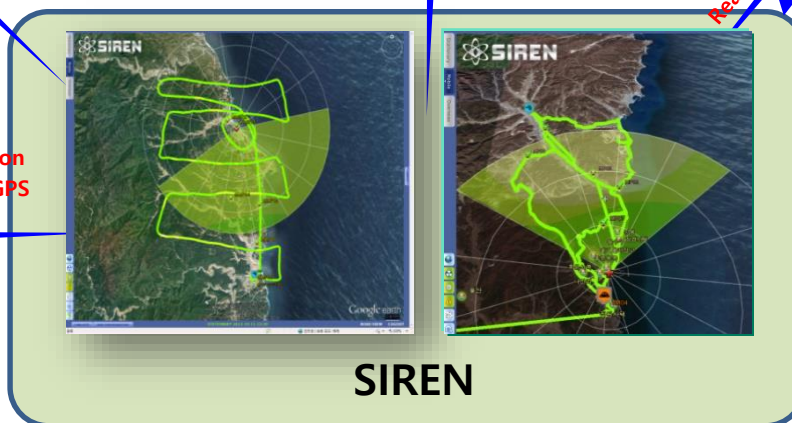
**Aerial
(fixed/rotating/drone)**

Aircraft sampling

Marine

Vehicle

Transmision Reading/GPS
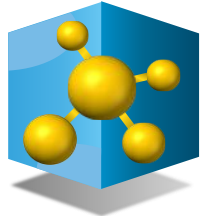
Transmision Reading/GPS

SIREN

Portable

In-situ

24

Demonstration of SIREN
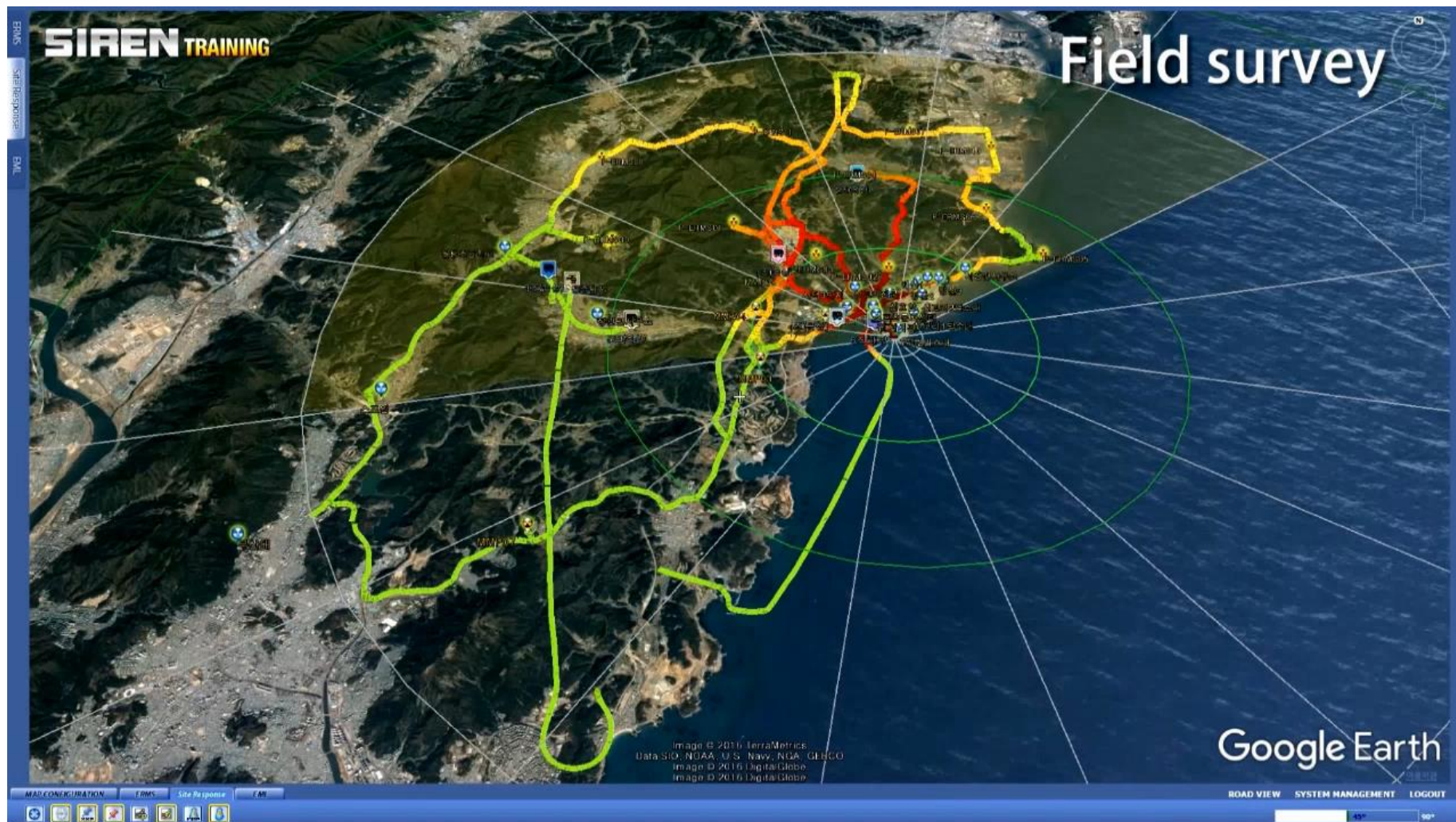
(5) Emergency Response Information Exchange System (ERIX)

ERIX
(Emergency Response Information Exchange System)

◆ **Exchange and share response information between the various response organizations**

  • Assigned to each response organizations and the regulatory body(NSSC, MoAS)
    - a given ID and PW(https://erix.kins.re.kr)

  • Will be linked with the National Disaster Management System(NDMS of MoAS in near future
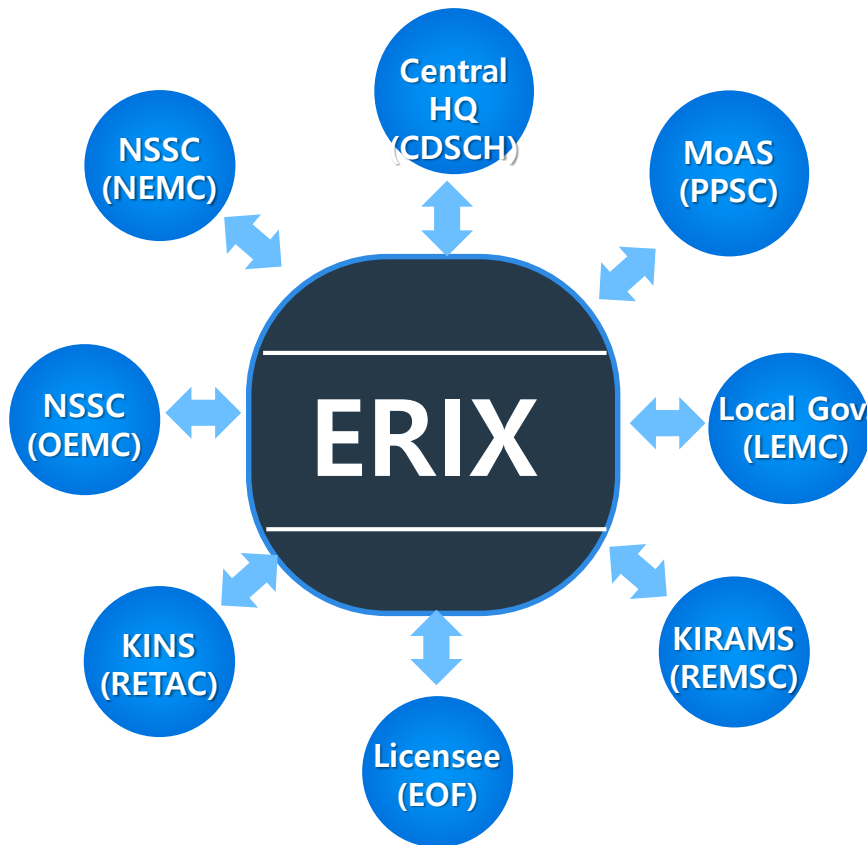
• CDSCH : Central Disaster and Countermeasure Headquarters

• NSSC : Nuclear Safety and Security Commission

• MoAS : Ministry of Administration and Safety

• KINS : Korea Institute of Nuclear Safety

• KIRAMS : Korea Institute of Radiological and Medical Sciences

• NEMC : National Emergency Management Center

• OEMC : Off-site Emergency Management Center

• LEMC : Local Emergency Management Center at City/Province

• RETAC : Radiological Emergency Technical Advisory Center

• PPSC : Public Protective Support Center

• REMSC : Radiological Emergency Medical Support Center

• EOF : Emergency Operations Facility

https://erix.kins.re.kr

In the near future

◆ System Integration

• Operation of the AtomCARE Portal based on single sign on

As Is (Current) → **Evolution** → **To be(Future)**

As Is (Current)

- SIDS/POMS (Nuclear Safety Information System)
- ADAMO/ESTES (Dose Projection System)
- PGIS (Public protective Geo. Info. System)
- ERIX (Emerg. Response Info. Exchange system)

To be(Future)

AtomCARE Portal (Single Sign On)
- NEIS (Nuclear Safety Information System)
- ADAMO (Dose Projection System)
- PGIS (Public protective Geo. Info. System)
- ERIX (Emerg. Response Info. Exchange system)

Atomic Computerized technical Advisory system for a Radiological Emergency

SIDS | ADAMO | PGIS | ERIX

29

THANK YOU

Excellence

Independence

Transparency

Responsibility

KINS
KOREA INSTITUTE OF NUCLEAR SAFETY

Demonstration of SIREN