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IAEA Assessment Tools for Nuclear and Radiological Emergencies

Potential for the Development of Assessment Tools for Emergencies during Nuclear/Radiological Decommissioning Activities

Joseph Chaput
Incident and Emergency Assessment Officer
Incident and Emergency Centre
International Atomic Energy Agency

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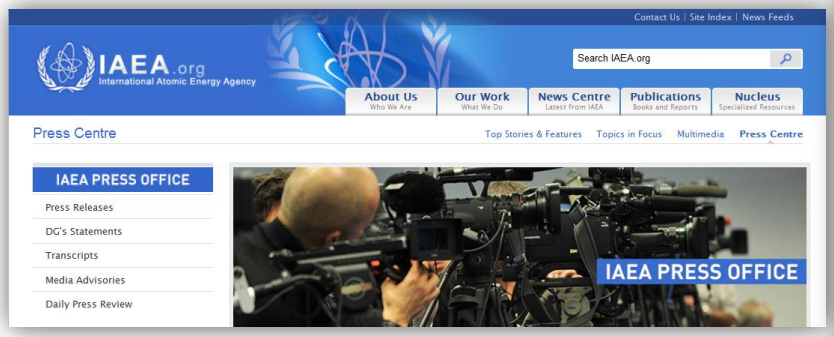
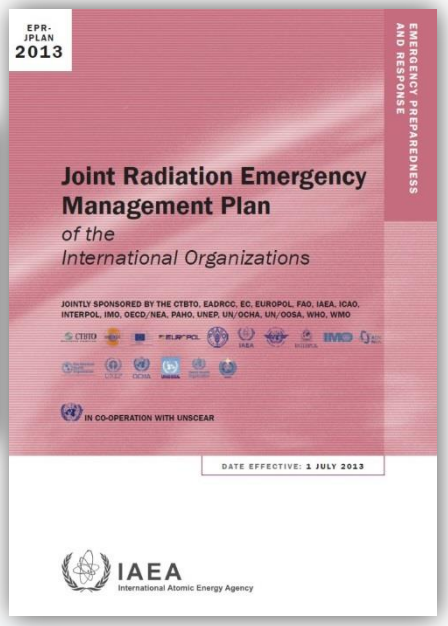
Background on the IAEA Incident and Emergency Centre

Roles and Responsibilities in Response

- Notification and official information exchange: USIE
- Provision of public information
- Assessment of potential emergency consequences and prognosis of possible emergency progression
- Provision of assistance on request
- Coordination of inter-agency response: IACRNE





Response Structure

Director General

DDG-NS

IES Steering Group
Policy matters and oversight

24/7 Coverage

Warning Point
Security Control Centre of UNSSS

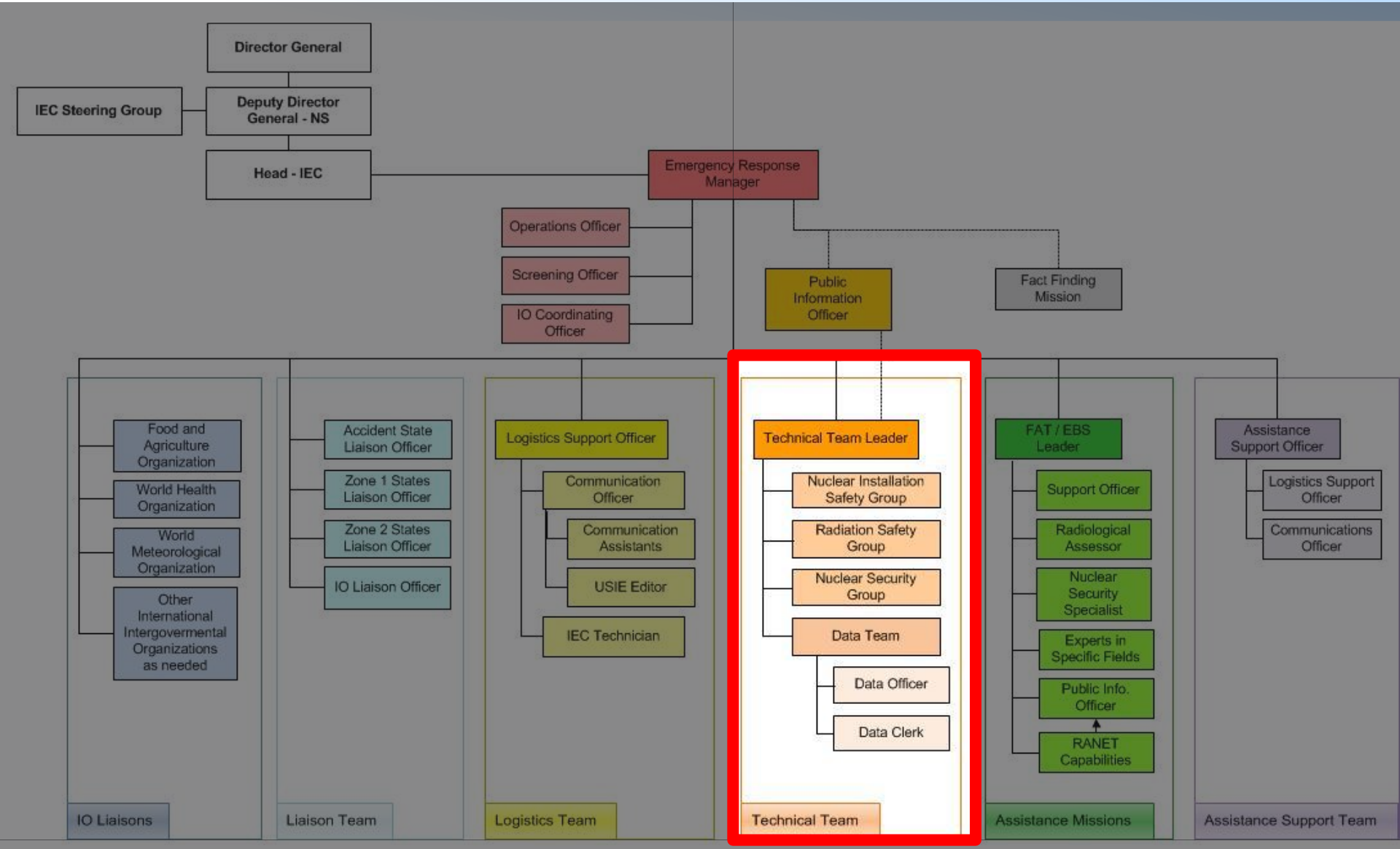
On-Call System
Initial response to incoming message

IEC

On-Duty System
Call-out list

ON-CALL:
- ☑ Emergency Response Manager
- ☑ Logistics Support Officer
- ☑ Radiation Safety Specialist
- ☑ Nuclear Installation Safety Specialist
- ☑ Nuclear Security Specialist
- ☑ External Event Specialist
- ☑ Public Information Officer

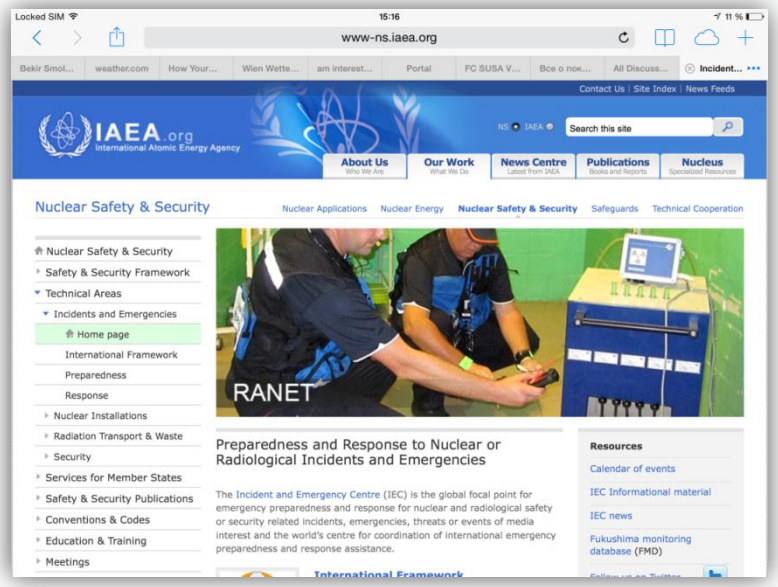
Full Response Mode



Remarks:
- Positions are activated based on needs
- On-call officers continue to be available at all times
- In Basic response mode, more than one function may be assigned to a person

EBS	External Based Support
FAT	Field Assistance Team
IEC	Incident and Emergency Centre
IO	International Organizations
OPIC	Office of Public Information and Communication
RANET	Response and Assistance Network
USIE	Unified System for Information Exchange in Incidents and Emergencies

Follow IEC-related news



On the website:
iec.iaea.org

On Twitter:
@iaeaiec

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Development of Tools to Support Assessment and Prognosis during any Nuclear or Radiological Emergency

Assessment and Prognosis

- Lesson from Fukushima Daiichi accident
  Assessment of potential consequences and prognosis of likely emergency progression

IAEA Action Plan on Nuclear Safety

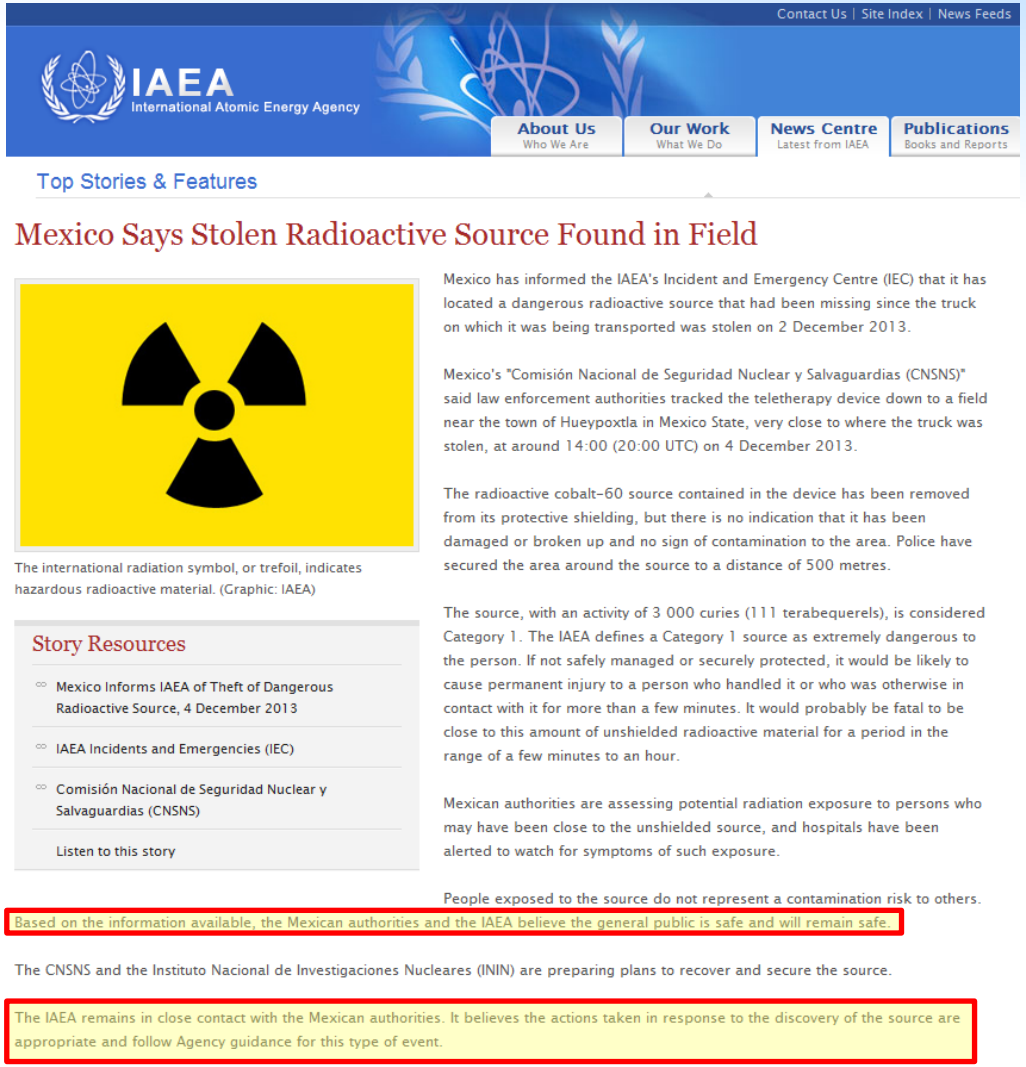
'Enhance transparency and effectiveness of communication and improve dissemination of information'

- "The IAEA Secretariat to provide Member States, international organizations and the general public with timely, clear, factually correct, objective and easily understandable information during a nuclear emergency on its potential consequences, including analysis of available information and prognosis of possible scenarios based on evidence, scientific knowledge and the capabilities of Member States."

Example of Clear Public Messages

…the Mexican authorities and the IAEA believe the general public is safe and will remain safe

…[IAEA] believes the actions taken in response to the discovery of the source are appropriate and follow Agency guidance for this type of event



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Mexico Says Stolen Radioactive Source Found in Field

The international radiation symbol, or trefoil, indicates hazardous radioactive material. (Graphic: IAEA)

Story Resources

- Mexico Informs IAEA of Theft of Dangerous Radioactive Source, 4 December 2013
- IAEA Incidents and Emergencies (IEC)
- Comisión Nacional de Seguridad Nuclear y Salvaguardias (CNSNS)

Listen to this story

Mexico has informed the IAEA's Incident and Emergency Centre (IEC) that it has located a dangerous radioactive source that had been missing since the truck on which it was being transported was stolen on 2 December 2013.

Mexico's "Comisión Nacional de Seguridad Nuclear y Salvaguardias (CNSNS)" said law enforcement authorities tracked the teletherapy device down to a field near the town of Hueypoxtla in Mexico State, very close to where the truck was stolen, at around 14:00 (20:00 UTC) on 4 December 2013.

The radioactive cobalt-60 source contained in the device has been removed from its protective shielding, but there is no indication that it has been damaged or broken up and no sign of contamination to the area. Police have secured the area around the source to a distance of 500 metres.

The source, with an activity of 3 000 curies (111 terabequerels), is considered Category 1. The IAEA defines a Category 1 source as extremely dangerous to the person. If not safely managed or securely protected, it would be likely to cause permanent injury to a person who handled it or who was otherwise in contact with it for more than a few minutes. It would probably be fatal to be close to this amount of unshielded radioactive material for a period in the range of a few minutes to an hour.

Mexican authorities are assessing potential radiation exposure to persons who may have been close to the unshielded source, and hospitals have been alerted to watch for symptoms of such exposure.

People exposed to the source do not represent a contamination risk to others.

Based on the information available, the Mexican authorities and the IAEA believe the general public is safe and will remain safe.

The CNSNS and the Instituto Nacional de Investigaciones Nucleares (ININ) are preparing plans to recover and secure the source.

The IAEA remains in close contact with the Mexican authorities. It believes the actions taken in response to the discovery of the source are appropriate and follow Agency guidance for this type of event.

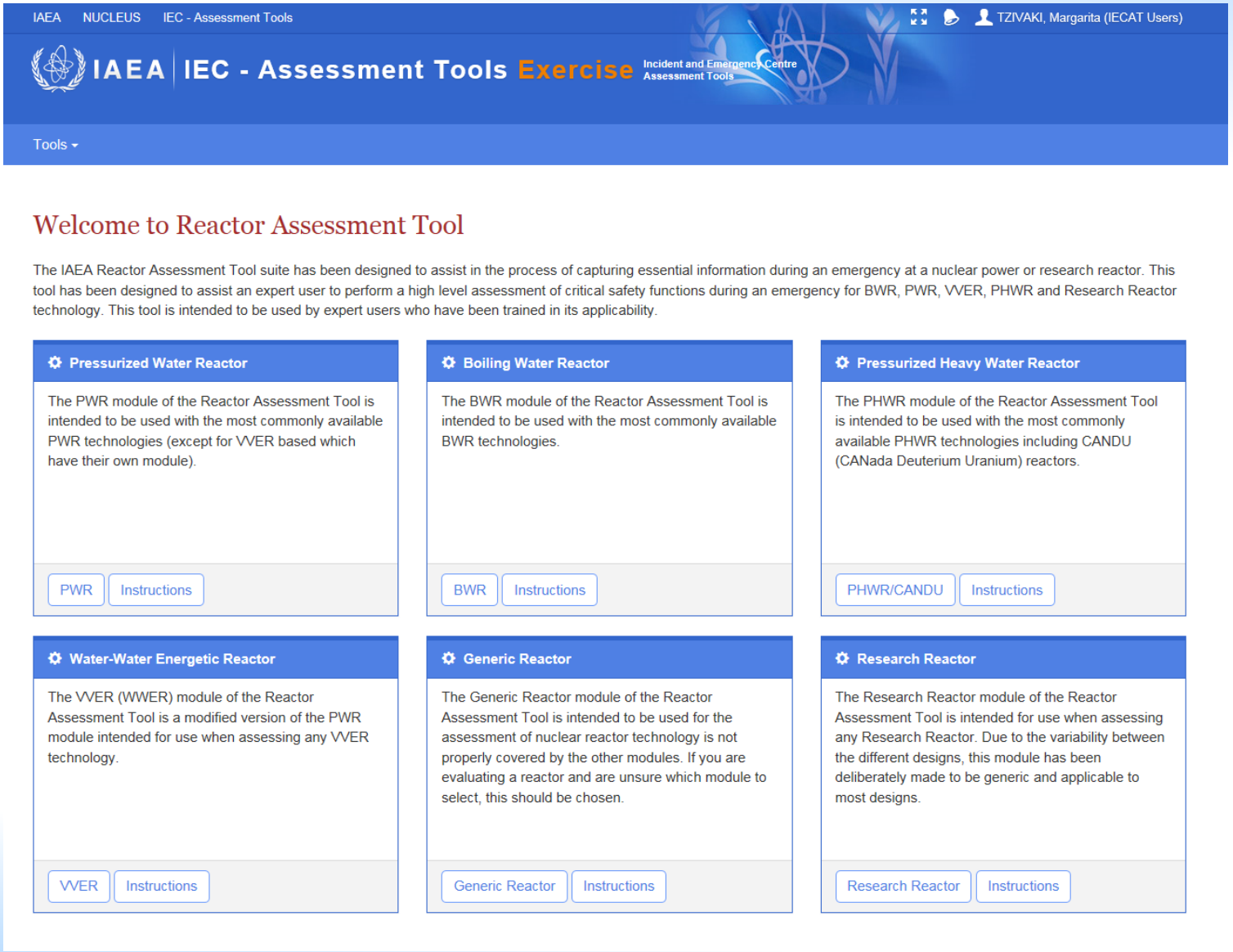
Challenges

- Assessment and prognosis needs to be based on IAEA Safety Standards
- Wide range of potential accident scenarios
  - Nuclear power plants emergencies (many potential technologies could be involved)
  - Radiological emergencies
  - Nuc/Rad emergencies triggered by nuclear security events
- Outputs from the IAEA Technical Team need to be consistent for each shift, scientifically accurate and high quality

Customized Assessment Tools and Procedures

- Based on experience gained during responses and exercises, IAEA has developed scenario specific assessment tools:
  - Reactor Assessment Tool
  - Protective Actions Assessment Tool
  - Internal/external Dose Assessment Tool
  - Radiological Source Assessment Tool
  - Others are actively in development

Example: IAEA Reactor Assessment Tool



Example: Critical Safety Function Assessment

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Generic Reactor Assessment

This is the IAEA Reactor Assessment Tool. Follow the step by step process and answer the questions as best you can. Press the button at the bottom to capture your results in a report.

Show more

Event details

In this section you will enter basic information about the event details. This information will be automatically filled into the Reactor Assessment Report which is generated at the end of this process.

Country* Germany

Name of facility* Essenbach

Reactor unit being assessed* Unit 1

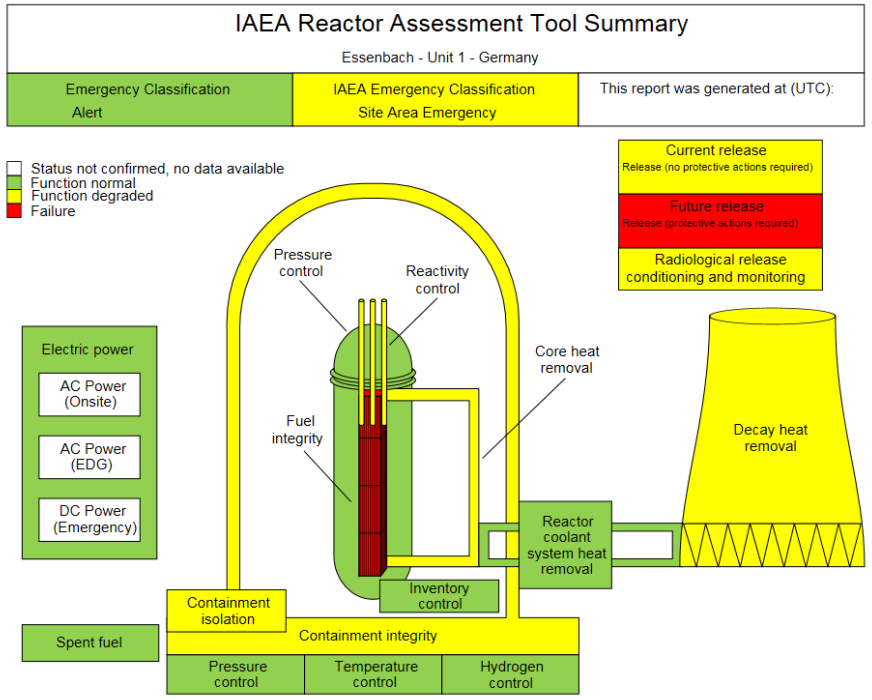
EMERGENCY CLASSIFICATION ASSESSMENT +

CRITICAL SAFETY FUNCTIONS AND KEY BARRIERS +

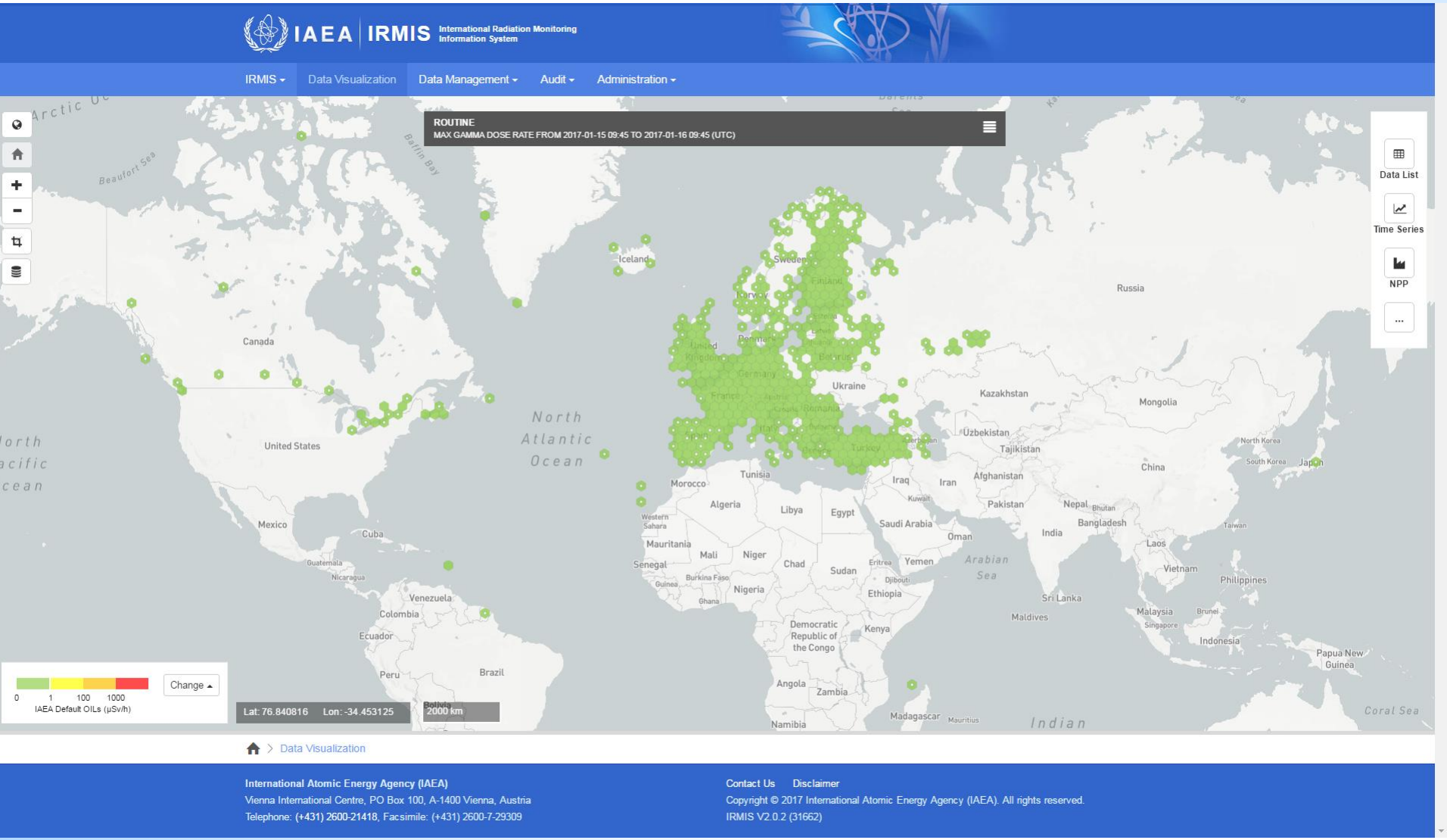
RELEASE +

SAFETY AND AUXILLARY SYSTEM STATUS +

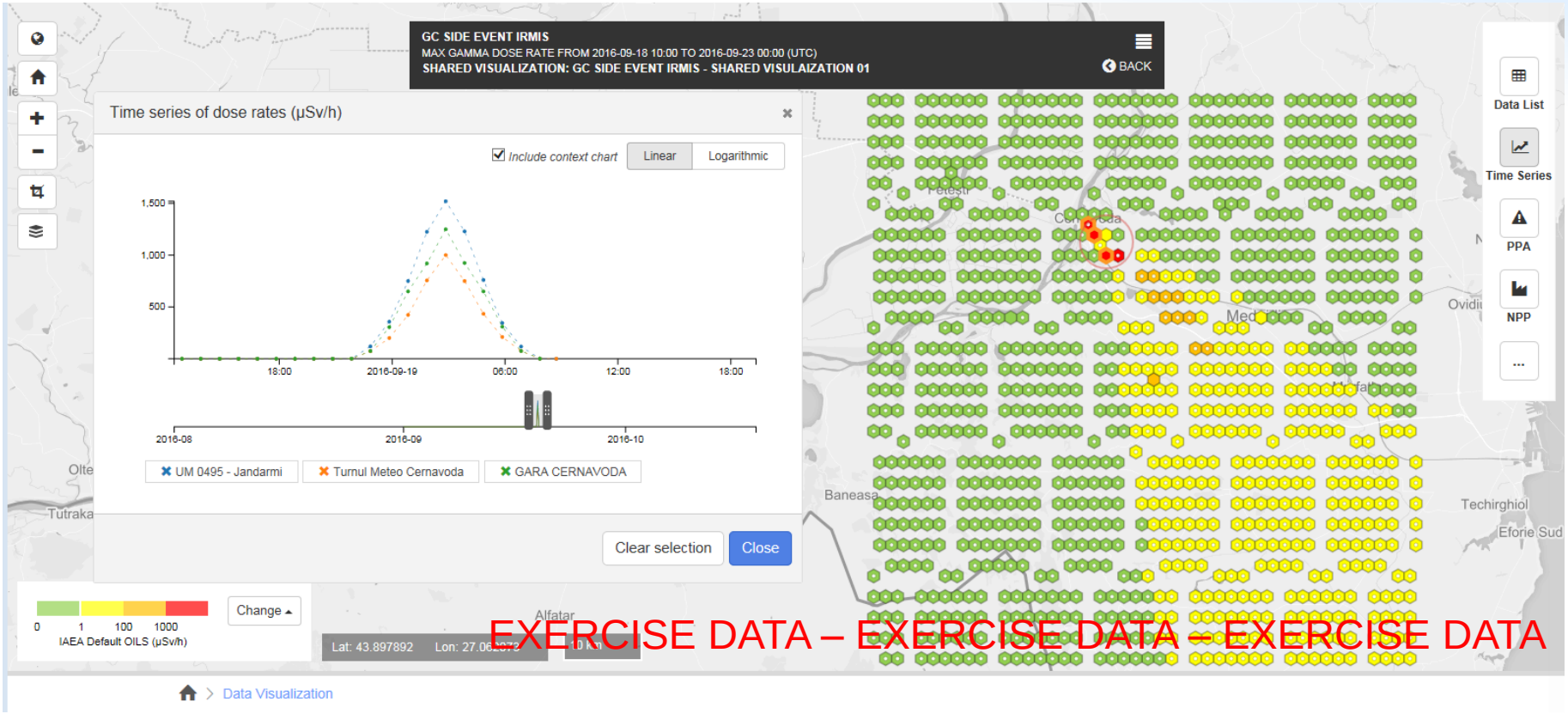
SITUATION PROGNOSIS +



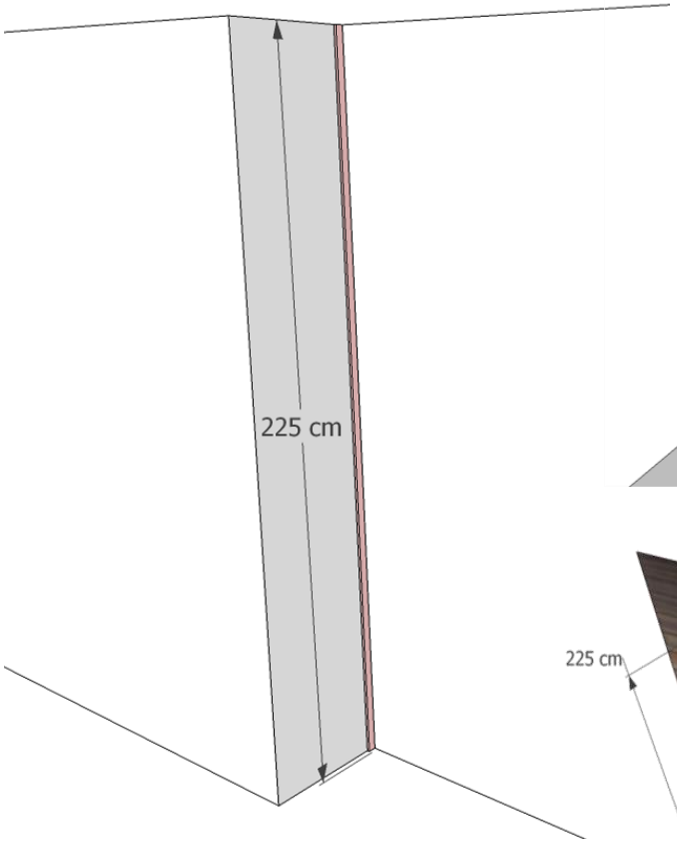
Example: Communication of Emergency Monitoring Data

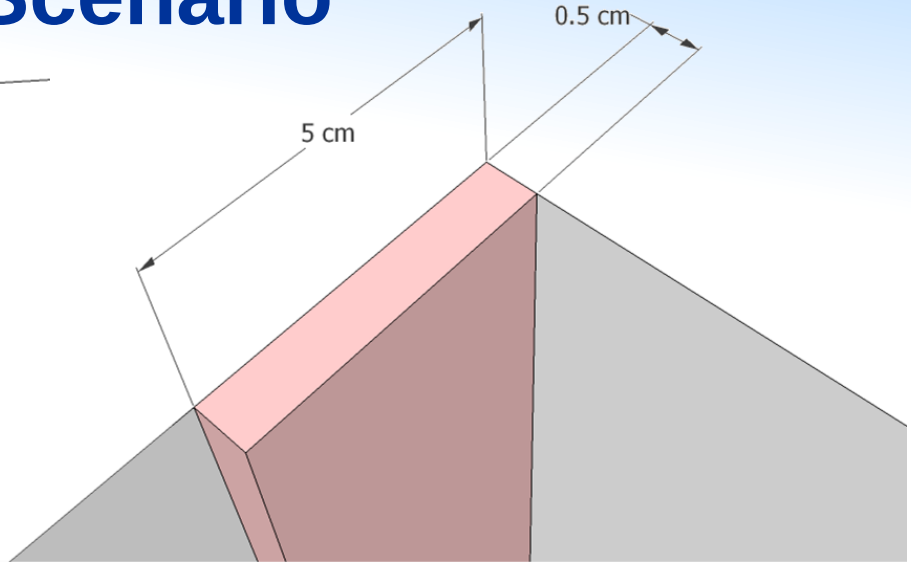


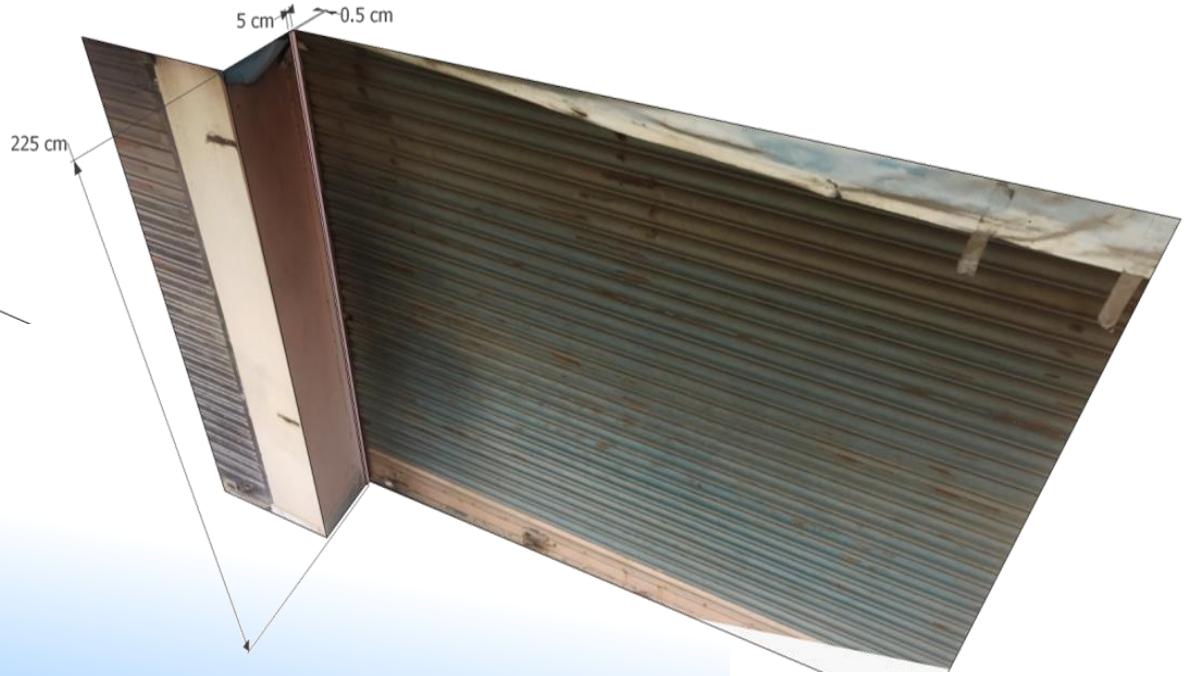
Example: Communication of Emergency Monitoring Data



Example: Communication of Measurement Scenario

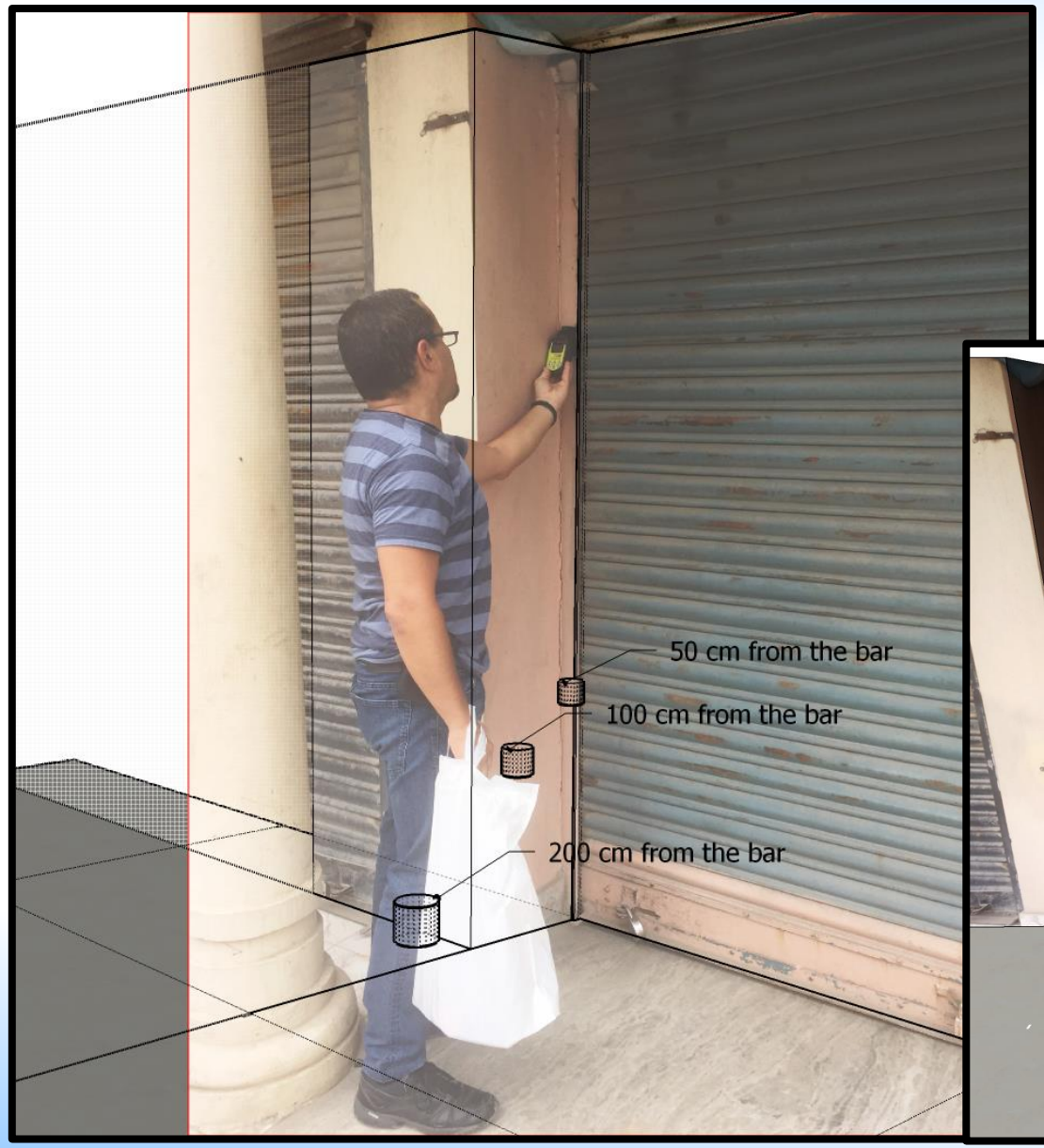




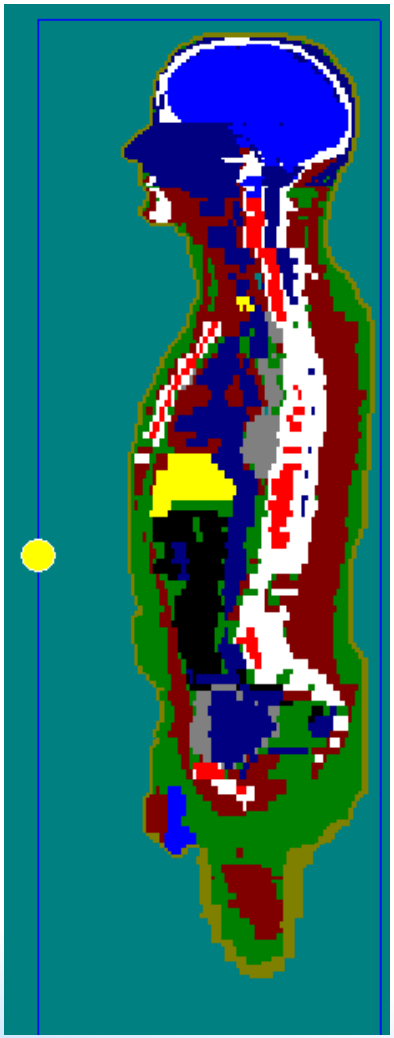


Example: Communication of Measurement Scenario

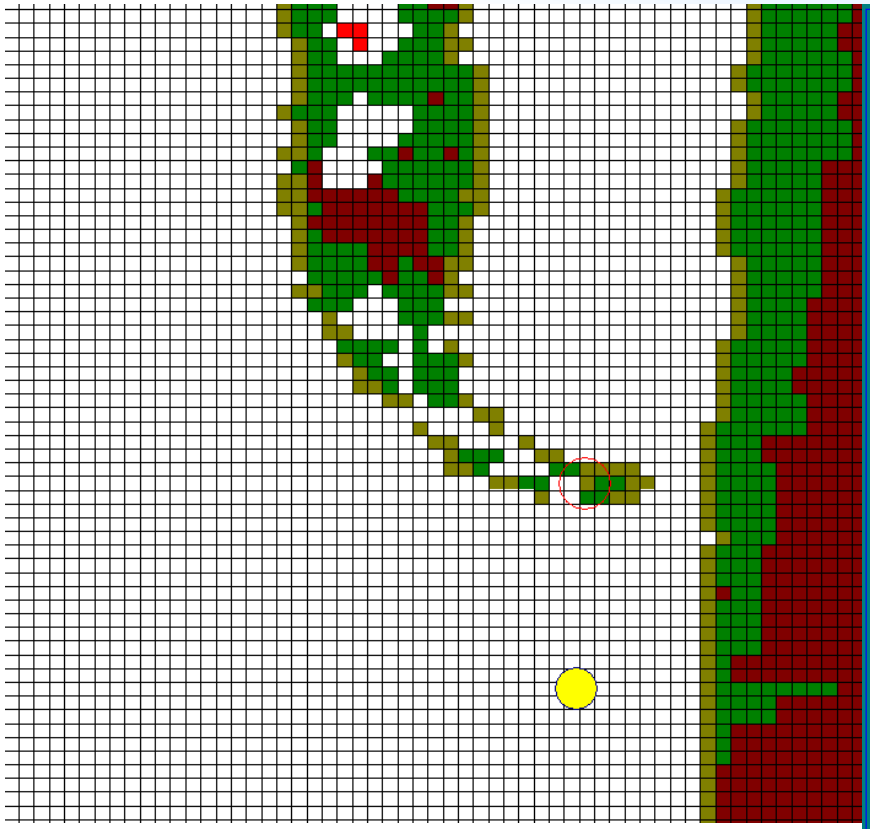
Communicating the geometry of a measurement scenario



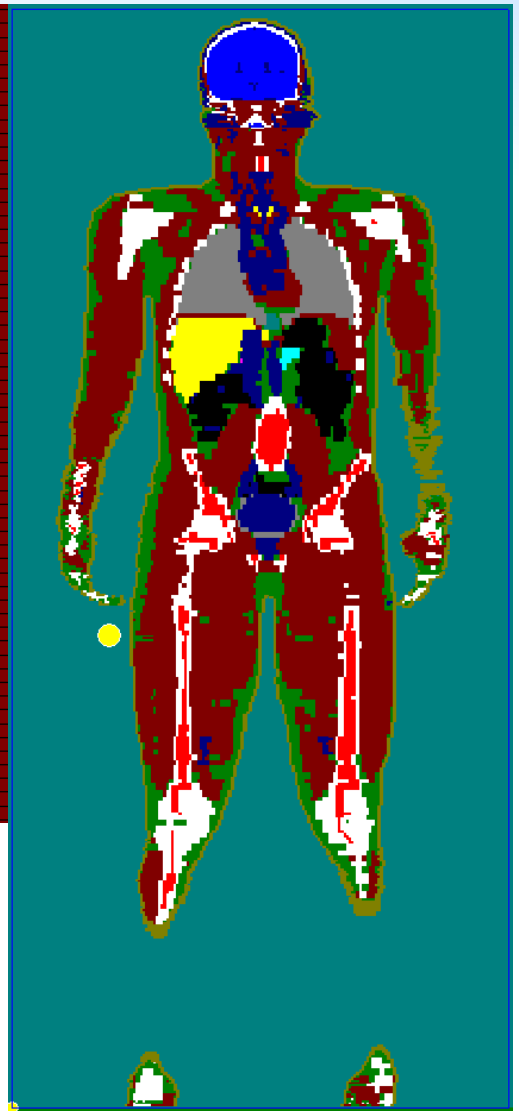
Example: Communication of Dose Calculation Scenario



Mid-chest



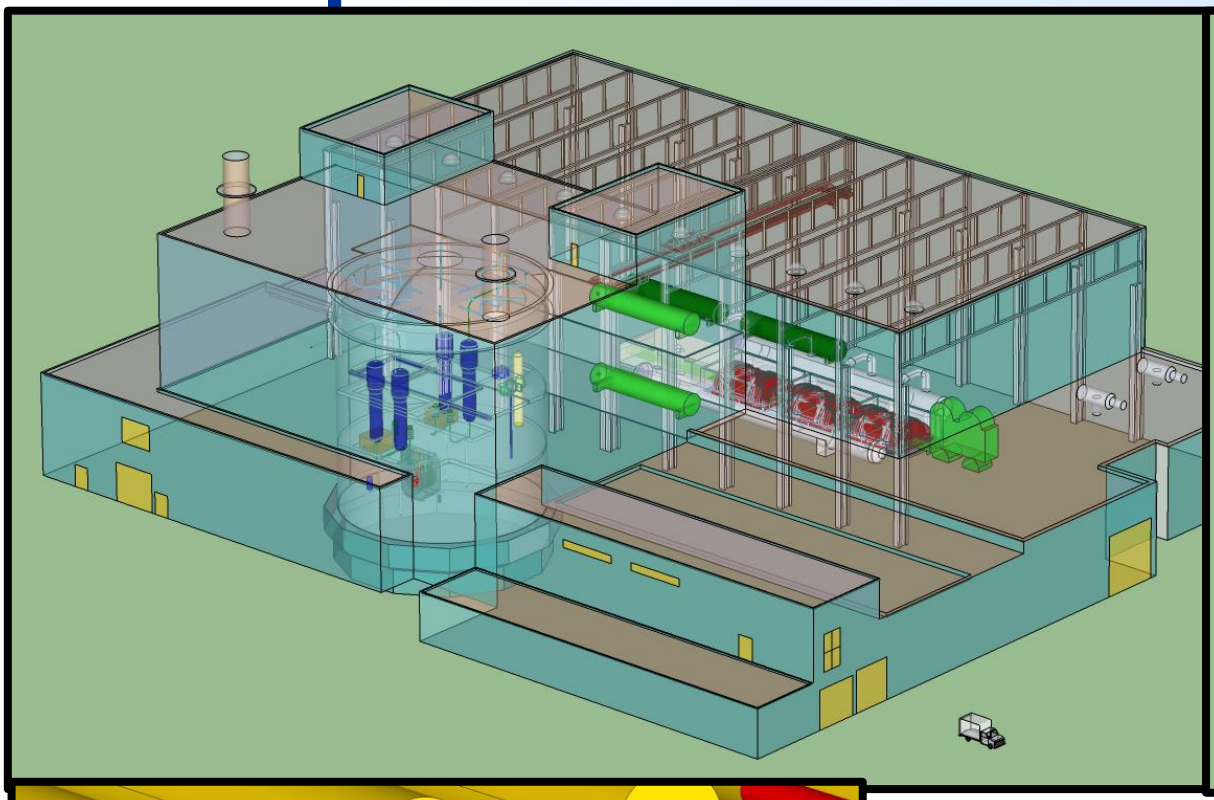
Hand/fingers

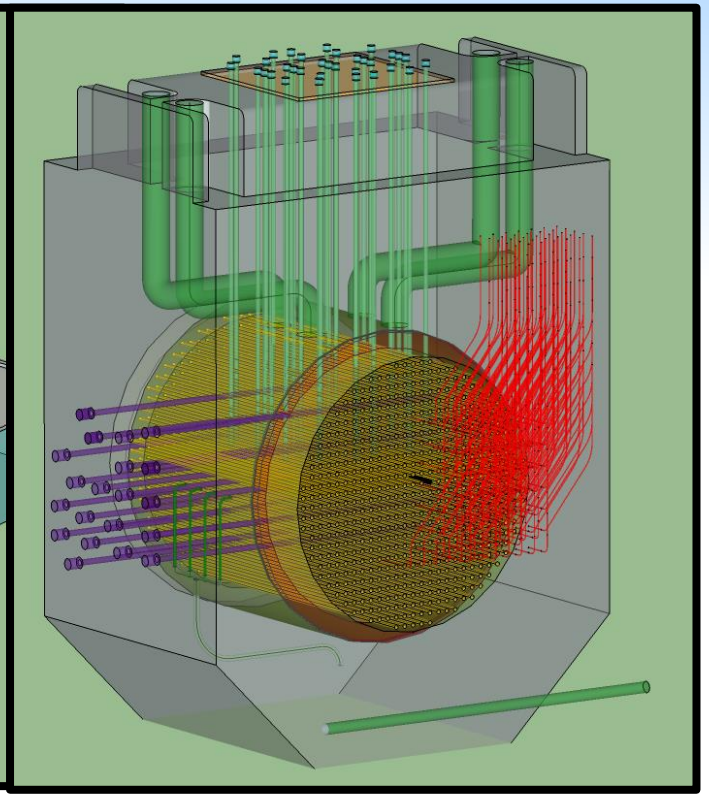


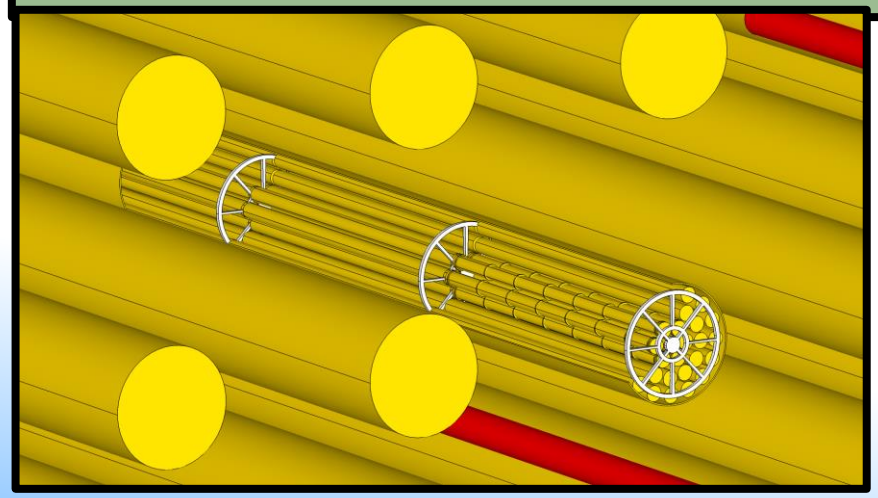
Future Direction

- Improve public communication capabilities
- Enhanced event timeline tracking
  - 3d reactor modelling and communication
- Simplified Gaussian based modelling for short field dispersions (e.g. RDD)
- Database of release terms
- Development of unique scenario assessment tools (e.g. decommissioning, UF6)

Example: 3d Communication

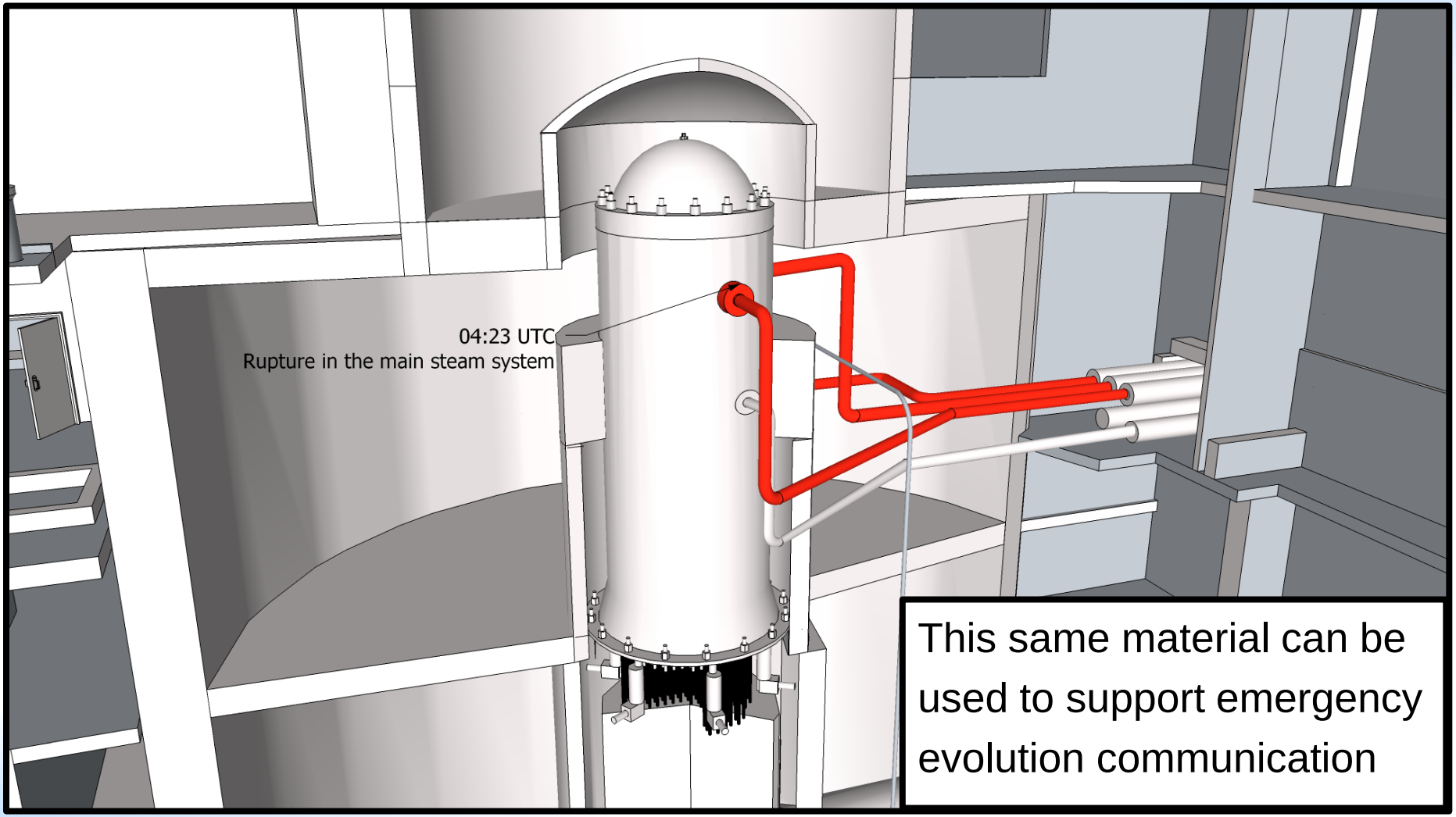






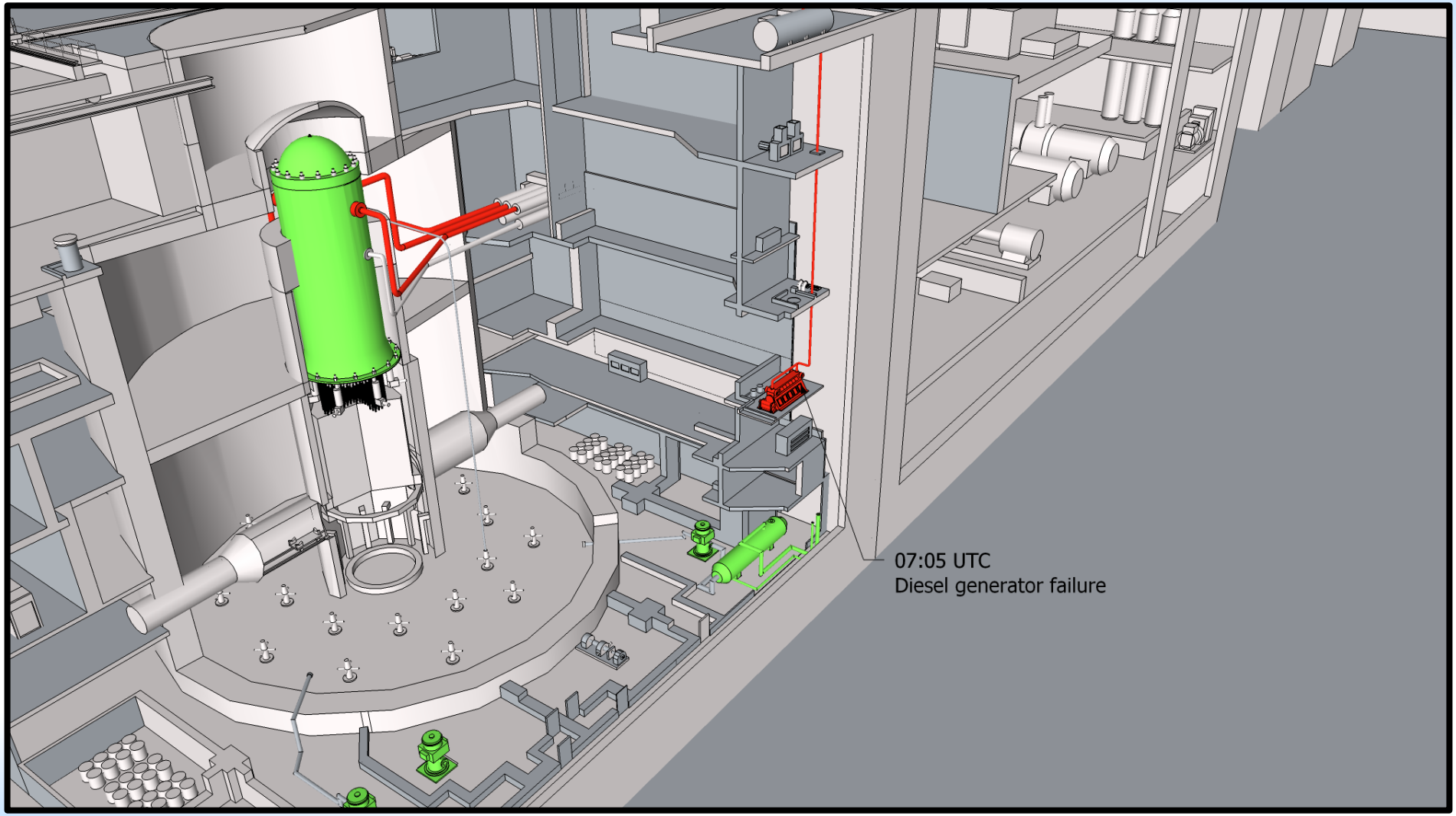
Material can be prepared in preparedness phase to explain technology

Example: 3d Communication

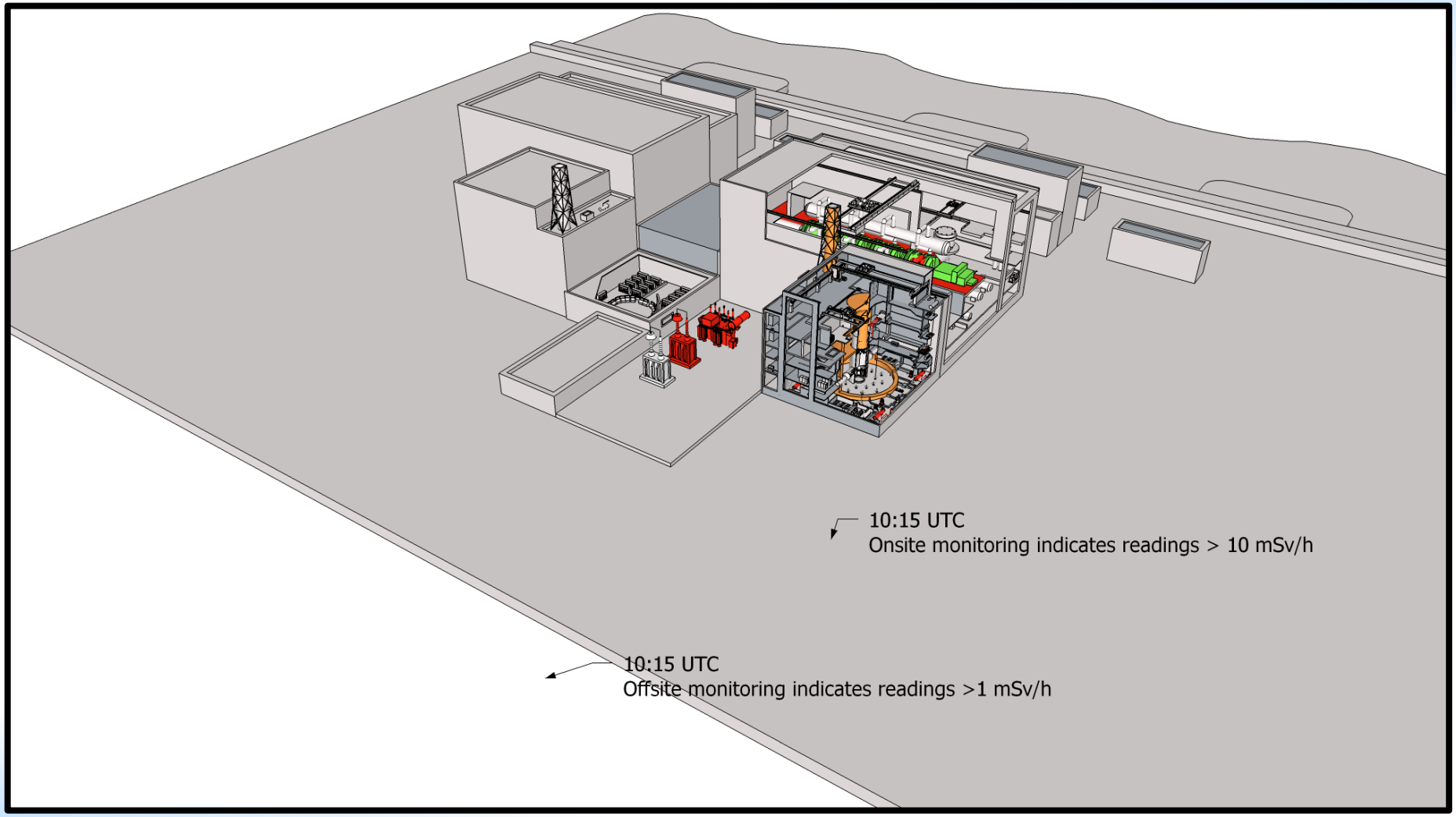


This same material can be used to support emergency evolution communication

Example: 3d Communication



Example: 3d Communication



Decommissioning Accident Scenarios?

- Scenarios during decommissioning operations can be unique compared to routine operations. For discussion:
  - What types of scenarios are possible?
  - Which scenarios are considered highest consequence?
  - Which scenarios are considered most likely?
  - Is there a potential to develop (or use existing) tools in this area?

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Thank you!

Joseph Chaput
j.chaput@iaea.org

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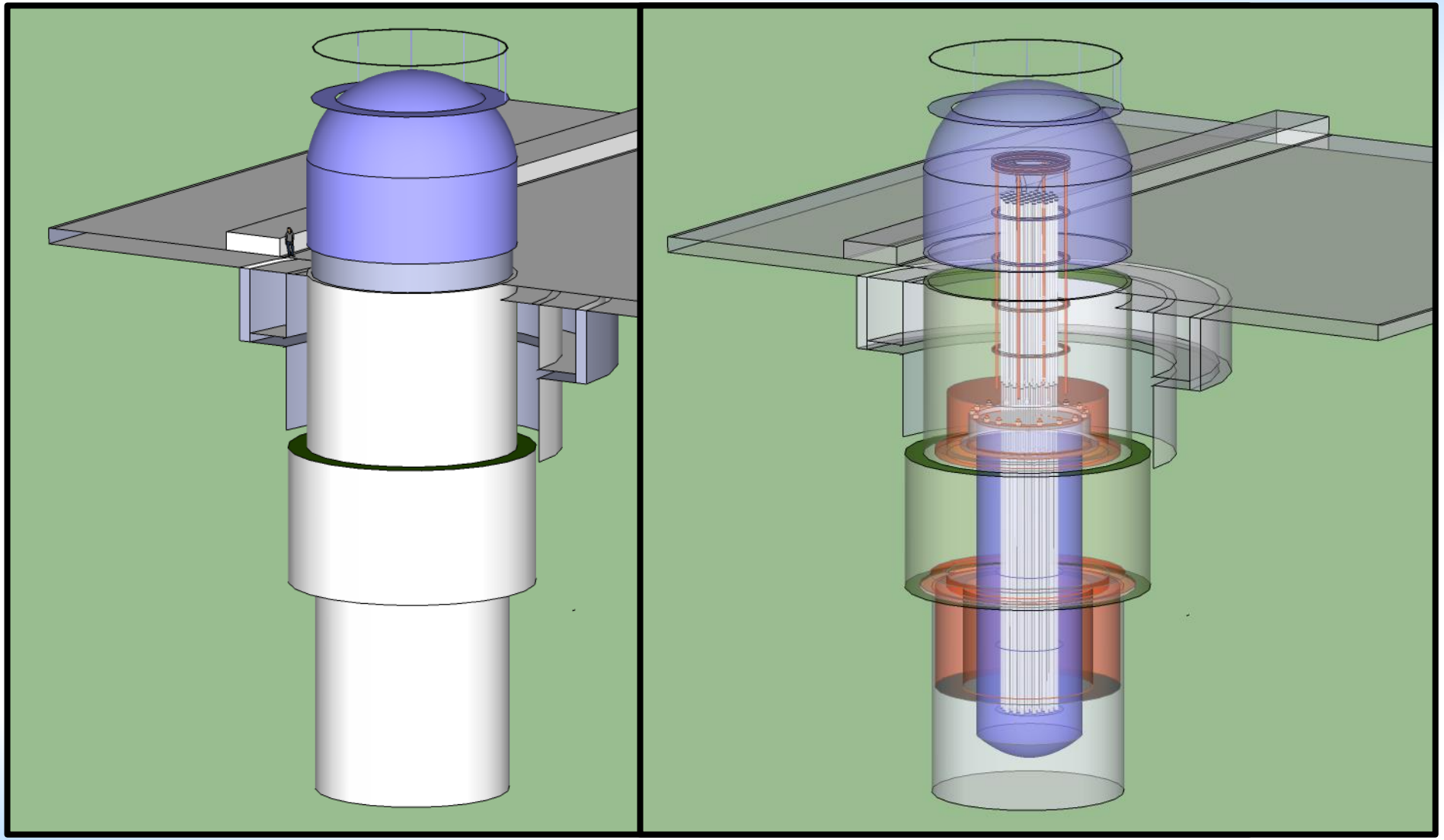
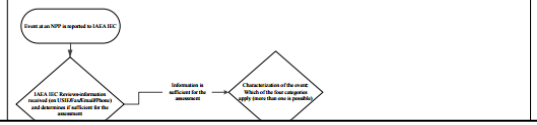
Additional images

Example: 3d Communication

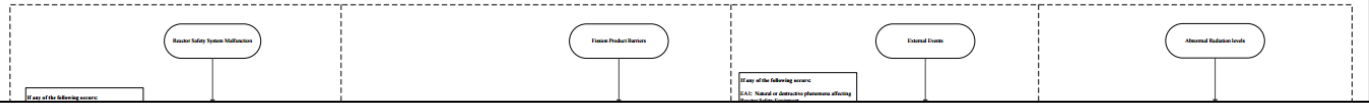


Example: Flowcharts

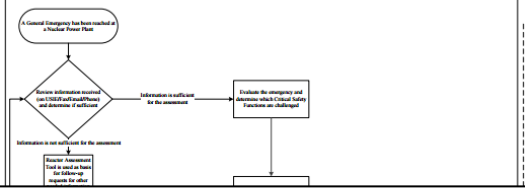
Process Overview



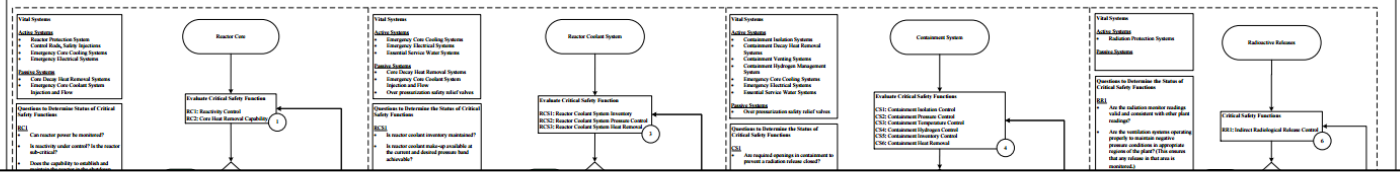
Event Classification Process during an Emergency at a Nuclear Power Plant



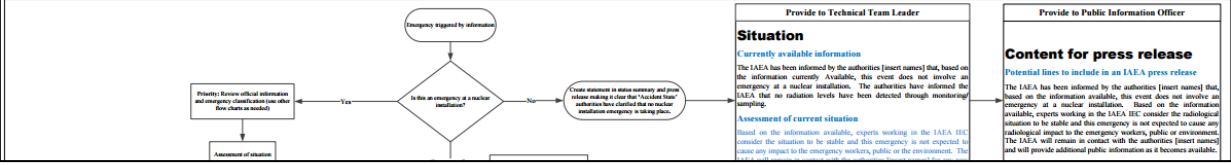
Process Overview



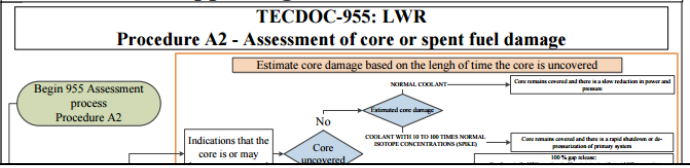
Critical Safety Function Assessment and Prognosis for a Severe Accident at a Nuclear Power Plant



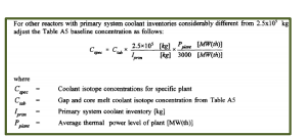
Nuclear Installations Specialist Assessment Process for an Emergency at a Nuclear Power Plant



Supporting Technical Material



Supporting Material for Nuclear Installations Specialist Assessment Process for an Emergency at a Nuclear Power Plant

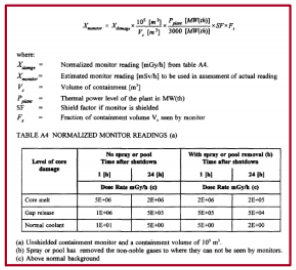


For other reactors with primary system coolant inventories considerably different from 2.5×10^5 kg adjust the Table A5 baseline concentration as follows:

$$C_{spec} = C_{cal} \times \frac{2.5 \times 10^5 \text{ [kg]}}{I_{prim} \text{ [kg]}} \times \frac{P_{plant} \text{ [MWt(th)]}}{3000 \text{ [MWt(th)]}}$$

where:

C_{spec} = Coolant isotope concentrations for specific plant
C_{cal} = Gap and core melt coolant isotope concentration from Table A5
I_{prim} = Primary system coolant inventory [kg]
P_{plant} = Average thermal power level of plant [MWth)]



$$X_{monitor} = X_{design} \times \frac{10^2 \text{ [m}^3\text{]}}{V_c \text{ [m}^3\text{]}} \times \frac{P_{plant} \text{ [MWt(th)]}}{3000 \text{ [MWt(th)]}} \times 10^{-SF} \times F_v$$

where:

X_{design} = Normalized monitor reading [mGy/h] from table A4.
$X_{monitor}$ = Estimated monitor reading [mSv/h] to be used in assessment of actual reading
V_c = Volume of containment [m^3]
P_{plant} = Thermal power level of the plant in MW(th)
SF = Shield factor if monitor is shielded
F_v = Fraction of containment volume V_c seen by monitor

TABLE A4 NORMALIZED MONITOR READINGS (a)

Level of core damage	No spray or pool Time after shutdown		With spray or pool removal (b) Time after shutdown	
	1 [h]	24 [h]	1 [h]	24 [h]
	Dose Rate mGy/h (c)		Dose Rate mGy/h (c)	
Core melt	5E+06	2E+06	2E+06	2E+05
Gap release	1E+06	5E+05	5E+05	5E+04
Normal coolant	1E+01	5E+00	5E+00	2E+00

(a) Unshielded containment monitor and a containment volume of 10^5 m^3.
(b) Spray or pool has removed the non-noble gases to where they can not be seen by monitors.
(c) Above normal background

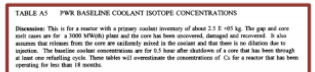


TABLE A5 PWR BASELINE COOLANT ISOTOPE CONCENTRATIONS

Discussion: This is for a reactor with a primary coolant inventory of about 2.5 E +05 kg. The gap and core melt cases are for a 3000 MW(th) plant and the core has been uncovered, damaged and recovered. It also assumes that releases from the core are uniformly mixed in the coolant and that there is no dilution due to injection. The baseline coolant concentrations are for 0.5 hour after shutdown of a core that has been through at least one refuelling cycle. These tables will overestimate the concentrations of Cs for a reactor that has been operating for less than 18 months.

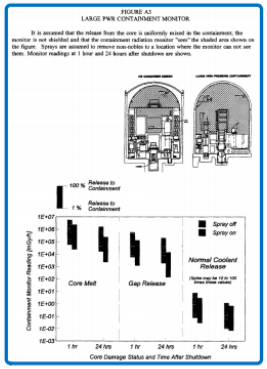


FIGURE A3
LARGE PWR CONTAINMENT MONITOR

It is assumed that the release from the core is uniformly mixed in the containment; the monitor is not shielded and that the containment radiation monitor "sees" the shaded area shown on the figure. Sprays are assumed to remove non-noble to a location where the monitor can not see them. Monitor readings at 1 hour and 24 hours after shutdown are shown.

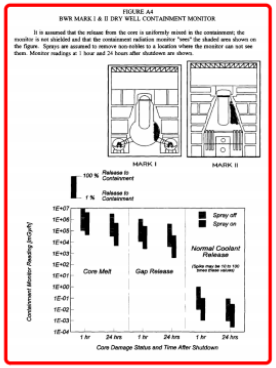


FIGURE A4
BWR MARK I & II DRY WELL CONTAINMENT MONITOR

It is assumed that the release from the core is uniformly mixed in the containment; the monitor is not shielded and that the containment radiation monitor "sees" the shaded area shown on the figure. Sprays are assumed to remove non-noble to a location where the monitor can not see them. Monitor readings at 1 hour and 24 hours after shutdown are shown.

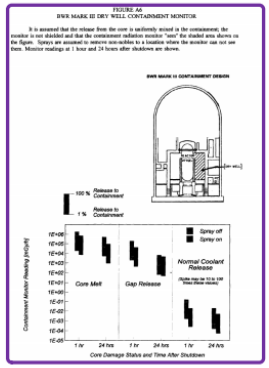


FIGURE A6
BWR MARK III DRY WELL CONTAINMENT MONITOR

It is assumed that the release from the core is uniformly mixed in the containment; the monitor is not shielded and that the containment radiation monitor "sees" the shaded area shown on the figure. Sprays are assumed to remove non-noble to a location where the monitor can not see them. Monitor readings at 1 hour and 24 hours after shutdown are shown. This area corresponds to the wet well in other BWR designs.

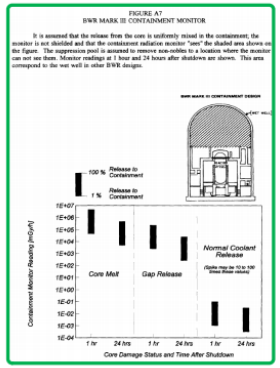


FIGURE A7
BWR MARK III CONTAINMENT MONITOR

It is assumed that the release from the core is uniformly mixed in the containment; the monitor is not shielded and that the containment radiation monitor "sees" the shaded area shown on the figure. The suppression pool is assumed to remove non-noble to a location where the monitor can not see them. Monitor readings at 1 hour and 24 hours after shutdown are shown. This area corresponds to the wet well in other BWR designs.

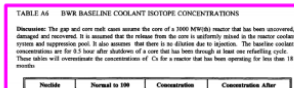


TABLE A6 BWR BASELINE COOLANT ISOTOPE CONCENTRATIONS

Discussion: The gap and core melt cases assume the core of a 3000 MW(th) reactor that has been uncovered, damaged and recovered. It is assumed that the release from the core is uniformly mixed in the reactor coolant system and suppression pool. It also assumes that there is no dilution due to injection. The baseline coolant concentrations are for 0.5 hour after shutdown of a core that has been through at least one refuelling cycle. These tables will overestimate the concentrations of Cs for a reactor that has been operating for less than 18 months.

Nuclide	Normal to 100	Concentration	Concentration After

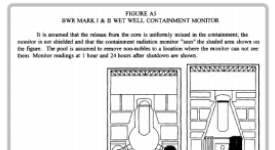


FIGURE A5
BWR MARK I & II WET WELL CONTAINMENT MONITOR

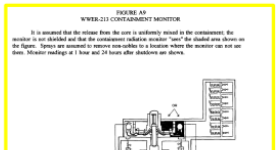


FIGURE A9
WWER-213 CONTAINMENT MONITOR

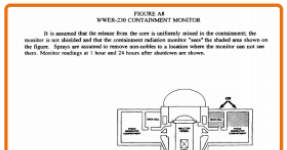


FIGURE A8
WWER-230 CONTAINMENT MONITOR

It is assumed that the release from the core is uniformly mixed in the containment; the monitor is not shielded and that the containment radiation monitor "sees" the shaded area shown on the figure. Sprays are assumed to remove non-noble to a location where the monitor can not see them. Monitor readings at 1 hour and 24 hours after shutdown are shown.

Example: Critical Safety Function Assessment

IAEA 60 Years Atoms for Peace and Development

Event details

In this section you will enter basic information about the event details. This information will be automatically filled into the Reactor Assessment Report which is generated at the end of this process.

Country*: Select Country

Name of facility*:

Reactor unit being assessed*:

EMERGENCY CLASSIFICATION ASSESSMENT

CRITICAL SAFETY FUNCTIONS AND KEY BARRIERS

RELEASE

SAFETY AND AUXILLARY SYSTEM STATUS

The purpose of this section is to focus the Technical Team to consider the current status of safety and auxiliary systems. The evaluation of the technical team in this section should support and complement the evaluation of the critical safety functions. Once this section is complete, the Technical Team should consider if their answers support the answers provided in the next section and the previous section.

Is there power available?

Justification (Optional)

ELECTRIC POWER +

Spent fuel conditions

Justification (Optional)

Radiological release conditioning and monitoring

Justification (Optional)

SITUATION PROGNOSIS

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Instructions

Evaluate the status of the spent fuel. When assessing the spent fuel conditions, consider wet and dry fuel as well as cooling systems.

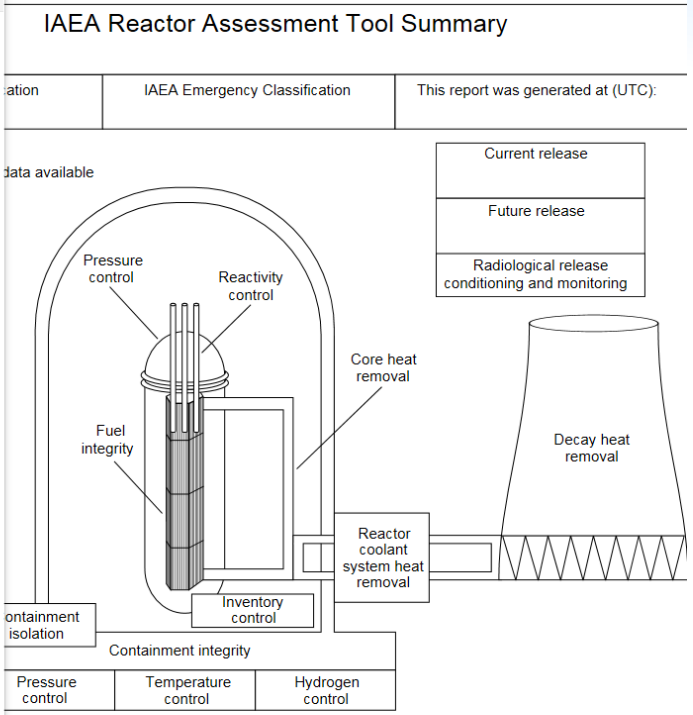
- Function normal:
  Spent fuel management is functioning as designed for both wet and dry storage.
- Function degraded:
  There are issues with spent fuel management for wet or dry storage which may include elevated temperatures, lower water level in pool and/or external damage (to the containers and/or the pool).
- Failure:
  Spent fuel is damaged.

Background:
Spent fuel management is comprised of:

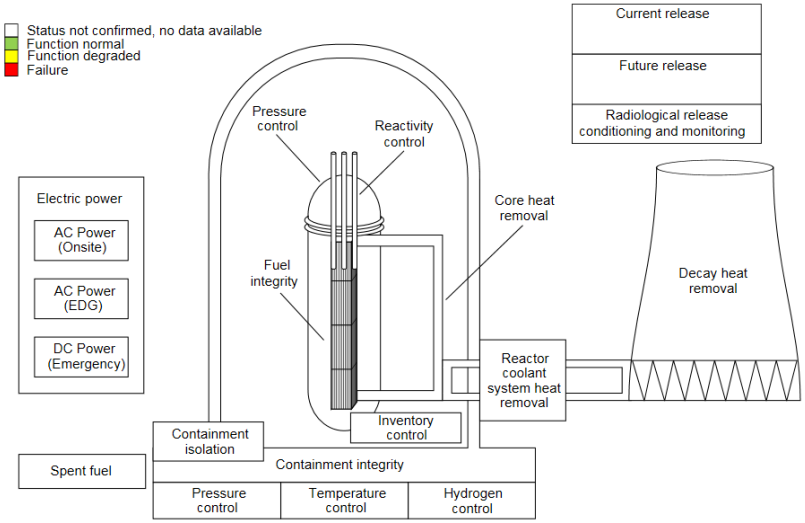
- Reactivity control (poisoned racks and/or solutions)
- Geometrical configuration (bundle storage analysis)
- Adequate cooling
- Physical integrity
- Radiological monitoring

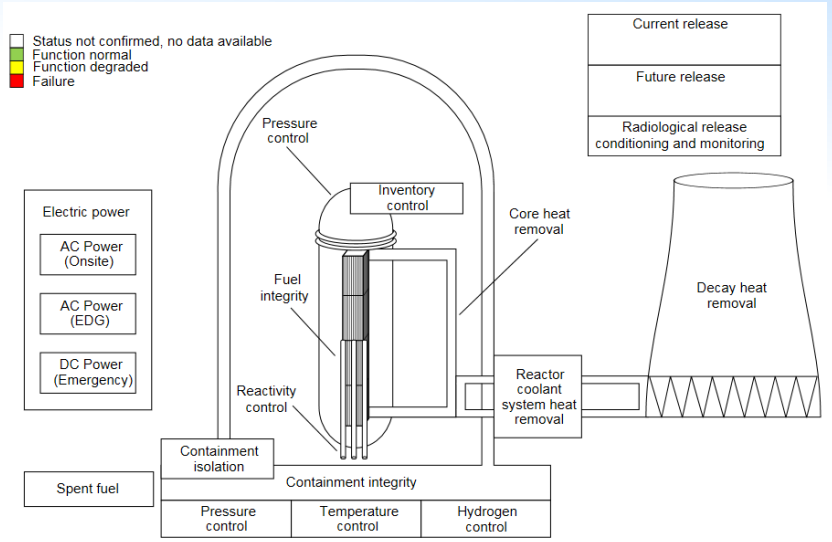
Simple questions to consider:

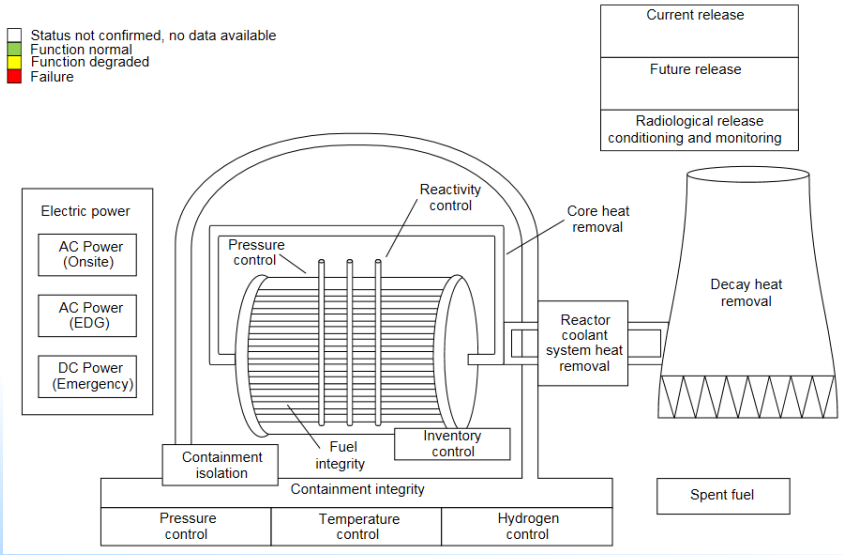
- Are there abnormal radiological indications of associated with spent fuel?
- What is the expected lifetime (coping time) of the station batteries?
- Is there an abnormal storage configuration or mechanical failure (e.g. dropped bundle or foreign object)?
- Is there a visible loss of coolant inventory or flow obstruction of the coolant medium?

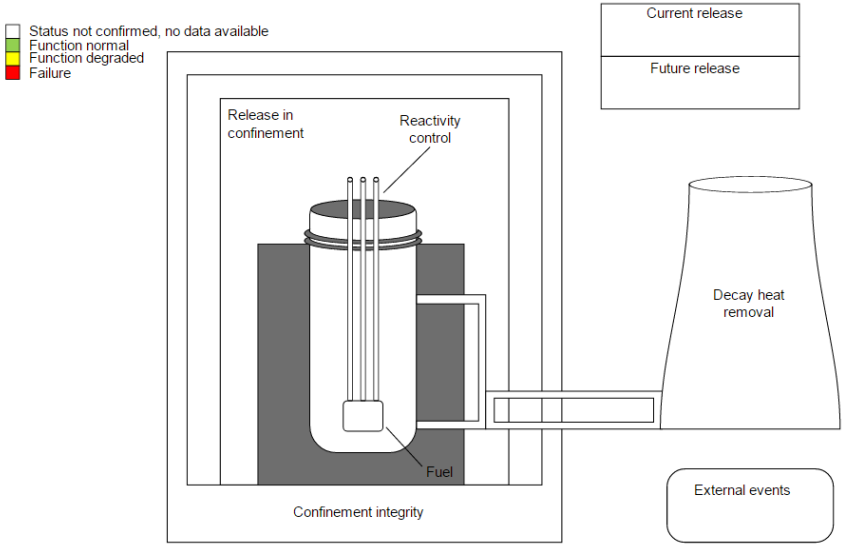


Example: Visual Outputs





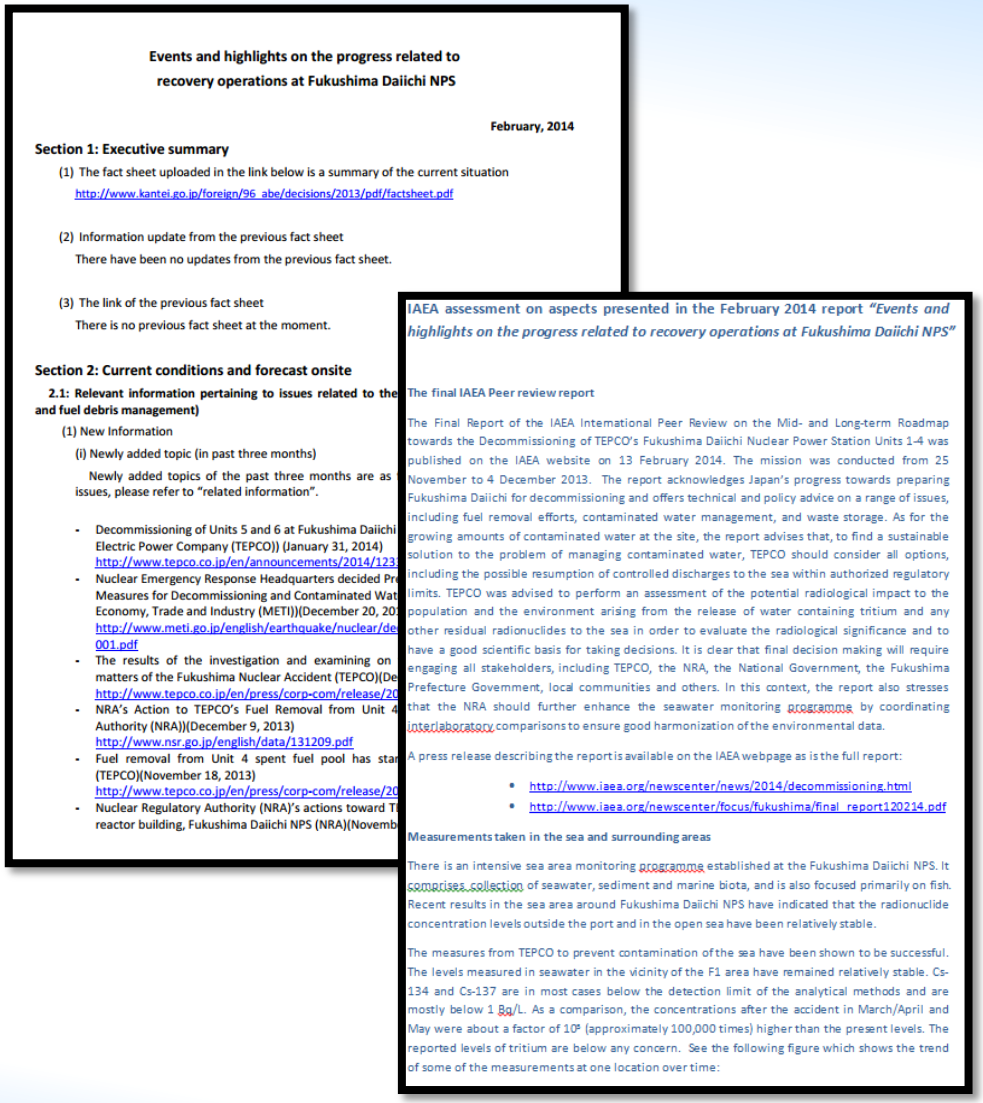




Example of Clear Public Messages

Based on these reports and the information that has been made available, the IAEA considers the public is safe and sees no reason why this should not continue to be the case in the future.

…[IAEA] considers that the food supply chain is safely under control. The food supply in Japan remains safe.



Events and highlights on the progress related to recovery operations at Fukushima Daiichi NPS

February, 2014

Section 1: Executive summary

(1) The fact sheet uploaded in the link below is a summary of the current situation
http://www.kantei.go.jp/foreign/96_abe/decisions/2013/pdf/factsheet.pdf

(2) Information update from the previous fact sheet
There have been no updates from the previous fact sheet.

(3) The link of the previous fact sheet
There is no previous fact sheet at the moment.

Section 2: Current conditions and forecast onsite

2.1: Relevant information pertaining to issues related to the and fuel debris management)

(1) New Information

(i) Newly added topic (in past three months)

Newly added topics of the past three months are as issues, please refer to "related information".

- Decommissioning of Units 5 and 6 at Fukushima Daiichi Electric Power Company (TEPCO)) (January 31, 2014) http://www.tepco.co.jp/en/announcements/2014/123
- Nuclear Emergency Response Headquarters decided Pr Measures for Decommissioning and Contaminated Wat Economy, Trade and Industry (METI))(December 20, 20 http://www.meti.go.jp/english/earthquake/nuclear/de 001.pdf
- The results of the investigation and examining on matters of the Fukushima Nuclear Accident (TEPCO)(De http://www.tepco.co.jp/en/press/corp-com/release/20
- NRA's Action to TEPCO's Fuel Removal from Unit 4 Authority (NRA))(December 9, 2013) http://www.nsr.go.jp/english/data/131209.pdf
- Fuel removal from Unit 4 spent fuel pool has sta (TEPCO)(November 18, 2013) http://www.tepco.co.jp/en/press/corp-com/release/20
- Nuclear Regulatory Authority (NRA)'s actions toward T reactor building, Fukushima Daiichi NPS (NRA)(Novemb

IAEA assessment on aspects presented in the February 2014 report *"Events and highlights on the progress related to recovery operations at Fukushima Daiichi NPS"*

The final IAEA Peer review report

The Final Report of the IAEA International Peer Review on the Mid- and Long-term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4 was published on the IAEA website on 13 February 2014. The mission was conducted from 25 November to 4 December 2013. The report acknowledges Japan's progress towards preparing Fukushima Daiichi for decommissioning and offers technical and policy advice on a range of issues, including fuel removal efforts, contaminated water management, and waste storage. As for the growing amounts of contaminated water at the site, the report advises that, to find a sustainable solution to the problem of managing contaminated water, TEPCO should consider all options, including the possible resumption of controlled discharges to the sea within authorized regulatory limits. TEPCO was advised to perform an assessment of the potential radiological impact to the population and the environment arising from the release of water containing tritium and any other residual radionuclides to the sea in order to evaluate the radiological significance and to have a good scientific basis for taking decisions. It is clear that final decision making will require engaging all stakeholders, including TEPCO, the NRA, the National Government, the Fukushima Prefecture Government, local communities and others. In this context, the report also stresses that the NRA should further enhance the seawater monitoring programme by coordinating interlaboratory comparisons to ensure good harmonization of the environmental data.

A press release describing the report is available on the IAEA webpage as is the full report:

- http://www.iaea.org/newscenter/news/2014/decommissioning.html
- http://www.iaea.org/newscenter/focus/fukushima/final_report120214.pdf

Measurements taken in the sea and surrounding areas

There is an intensive sea area monitoring programme established at the Fukushima Daiichi NPS. It comprises collection of seawater, sediment and marine biota, and is also focused primarily on fish. Recent results in the sea area around Fukushima Daiichi NPS have indicated that the radionuclide concentration levels outside the port and in the open sea have been relatively stable.

The measures from TEPCO to prevent contamination of the sea have been shown to be successful. The levels measured in seawater in the vicinity of the F1 area have remained relatively stable. Cs-134 and Cs-137 are in most cases below the detection limit of the analytical methods and are mostly below 1 Bq/L. As a comparison, the concentrations after the accident in March/April and May were about a factor of 10^5 (approximately 100,000 times) higher than the present levels. The reported levels of tritium are below any concern. See the following figure which shows the trend of some of the measurements at one location over time:

Incident and Emergency Centre (IEC)

Global focal point

for emergency preparedness and response

for nuclear and radiological safety or security related emergencies, threats or events of media interest

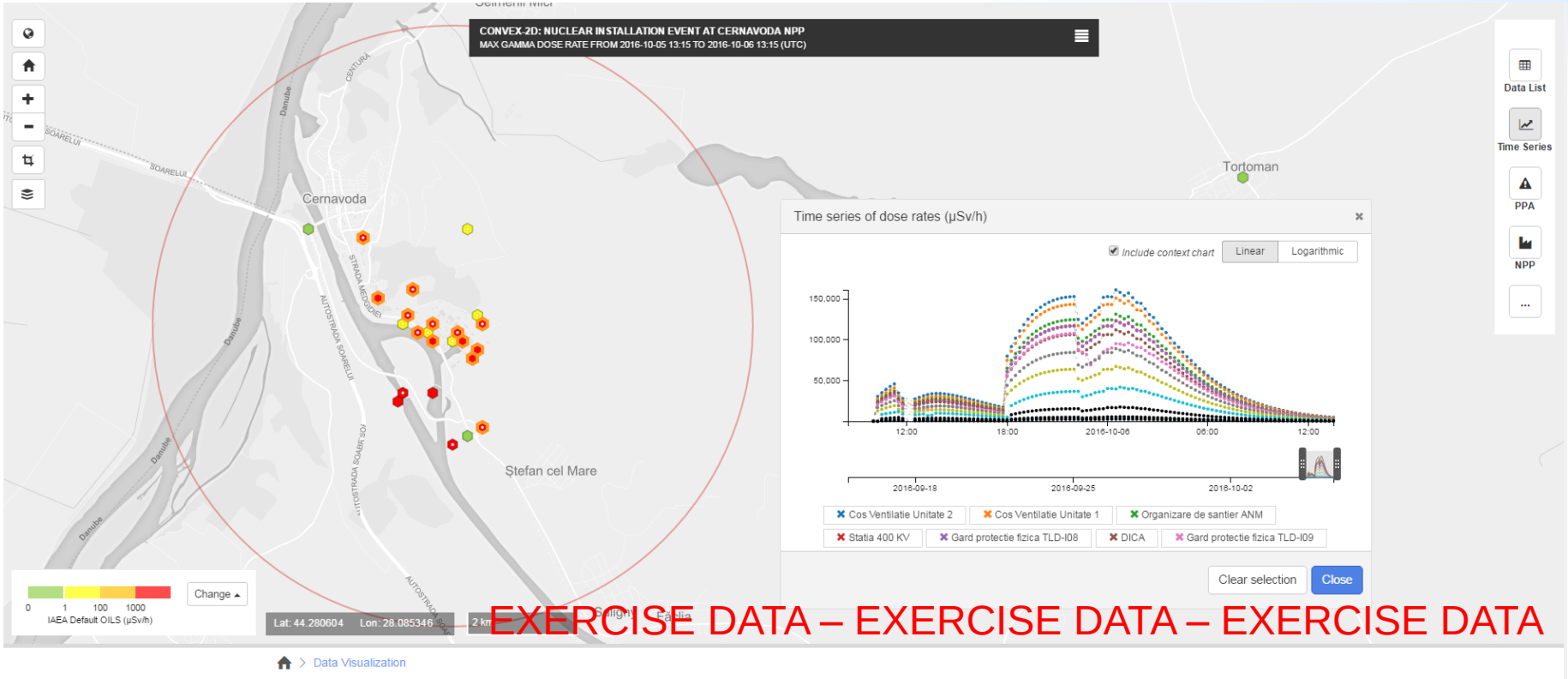
and

world's centre for coordination of international emergency preparedness and response assistance

IAEA

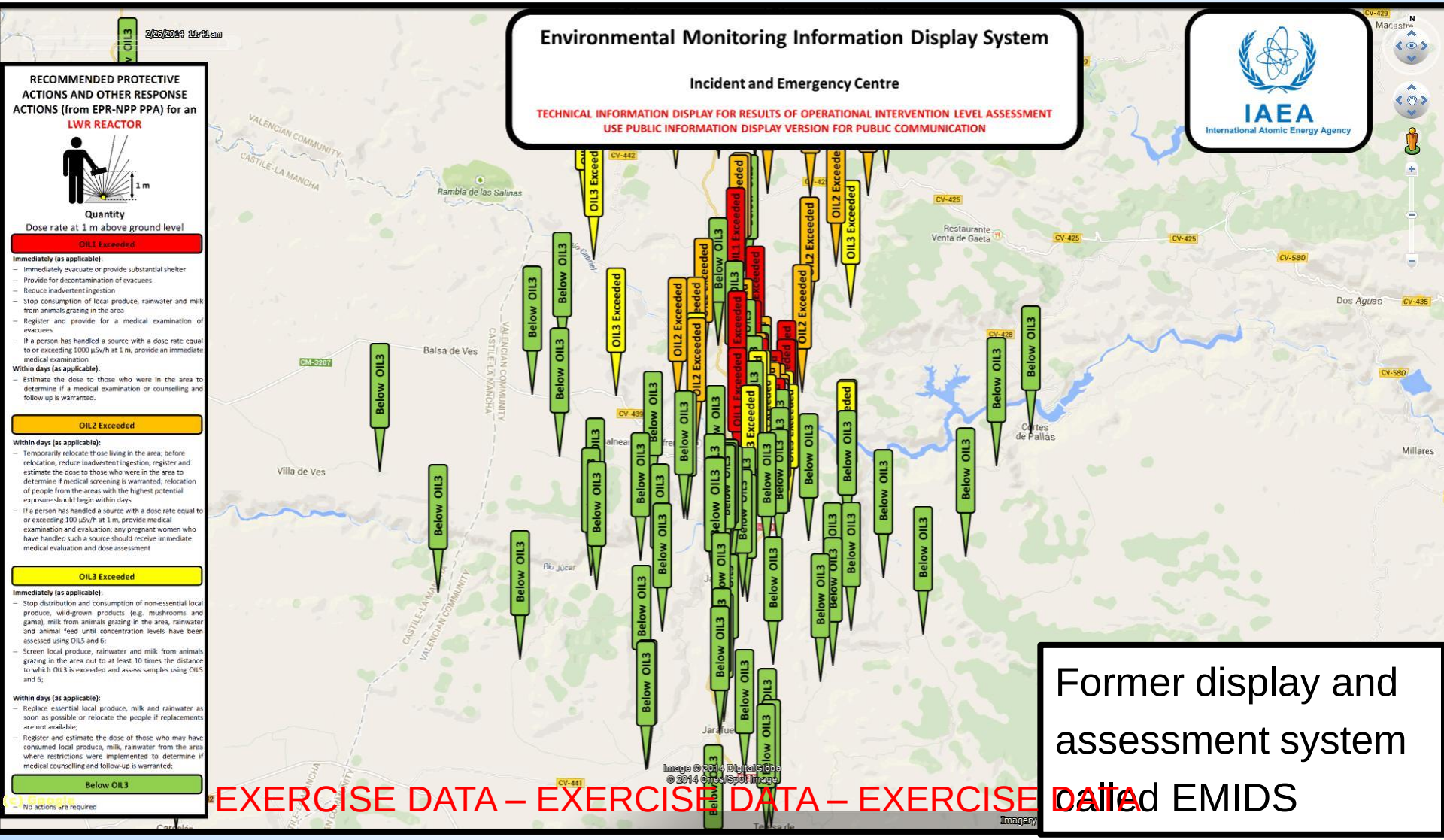
IEC
Incident and
Emergency Centre

Example: Communication of Emergency Monitoring Data



EXERCISE DATA – EXERCISE DATA – EXERCISE DATA

Example: Communication of Emergency Monitoring Data



Former display and assessment system called EMIDS

Example: Automatic Report Generation Leads to Consistent Quality Output

IAEA
International Atomic Energy Agency

Incident and Emergency Centre
Reactor Status Assessment Report

On the 2016-10-12 09:18 UTC, Unit 1 at Essenbach in Germany was assessed by the Technical Team in the Incident and Emergency Centre. The following is a report on the currently understood status of this reactor unit at that time.

Declared emergency classification level

The declared emergency classification level is important as it can have an impact on the public protective actions which are required to be implemented. A declaration of General Emergency implies a situation which would require urgent protective actions to be taken immediately for the public near the plant when this level of emergency is declared.

The currently declared emergency classification is **Alert**. The technical justification for this classification is based on the following:

IAEA assessment of the emergency classification level

Based on the information which has been shared with the IAEA (summarized in Table 1), experts working in the IAEA Incident and Emergency Centre have evaluated information about the event provided by the official authorities. The IAEA considers that the current situation can be classified as Site Area Emergency based on international safety standards. The technical justification for this classification is based on the following:

Current situation assessment and prognosis overview for Unit 1

Table 1: Current emergency classification assessment at Unit 1.

Category	Issue	Current Status	Technical justification(s)
Critical safety functions and key barriers			
Reactivity	Reactivity control	Function degraded	
Fuel	Fuel integrity	Failure	
Decay heat removal	Decay heat removal	Function degraded	
	Core heat removal	Function degraded	
	Reactor coolant system heat removal	Function normal	
	Reactor coolant system pressure control	Function normal	
	Core inventory control	Function normal	
Containment Integrity	Containment Integrity	Function degraded	
	Isolation	Function degraded	
	Temperature control	Function normal	
	Pressure control	Function normal	
	Hydrogen control	Function normal	
Release			
Release	Is there a release taking place?	Release (no protective actions required)	
Safety and auxiliary system status			
Electric Power	Is there power available?	Function normal	
	AC Power (onsite connection)		

	expected to change in the next 12-48 hours.		
Release	Describe any potential for release	Release (protective actions required)	

Figure 1: Currently assessed critical safety function status at Unit 1.