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EUROPEAN PARTNERSHIP FOR RADIATION PROTECTION RESEARCH
RRADEW

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# Strengthening Nuclear and Radiological Emergency Resilience Under Conflict Conditions: Insights from a Spanish Expert Panel under the RRADEW Project on a Missile Strike Scenario at a Nuclear Power Plant

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GOBIERNO DE ESPAÑA
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Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

# WORK PACKAGES. OBJECTIVES & LINKS

- WP1: 3 Representative scenarios. Based on a missile strike on a hypothetical Ukrainian nuclear power (~ 50 km from a major urban area)
  - A: Missile strike on a reactor operating at full power;
  - B: Missile strike on a reactor in cold shutdown;
  - C: Missile strike on a dry spent-fuel storage cask.

  → Fuel-damage fractions
  → Release pathways (D1)
  → Isotopic inventories

- WP2 - Framework to characterise resilience at different levels in the context of nuclear emergencies in armed conflict situations

  Scenarios evaluated across multiple dimensions: social (local coping capacities within communities), economic (long-term impacts of protective measures on economic performance), political, informational, and public health (effective dose assessment and wellbeing)

  Decision-support system: FRAMESS & JRODOS → Resilience enhancement: Effectiveness of improved measurement strategies and the repurposing of existing infrastructure

  **Community-level**

- WP3 – Cases studies on Resilience. Complementary case studies
  - the war in the former Yugoslavia
  - the war in Ukraine
  - the Czech Republic as a neighbouring country affected by the conflict
  - the nuclear accident in Japan

**Resilience attributes**

**Scenarios**

- WP4 - Strategies for building resilience

  Provide recommendations for improving global resilience to future nuclear or radiological emergencies in the context of war and armed conflict or disasters → "Scenario-based" approach → design and define a set of strategies, optimising protection and minimising the negative consequences on physical and mental health and social well-being

  Stakeholder workshops

**Societal impacts**

- WP5 - Ethical challenges

**Distributive justice and "forced" resilience of citizens**

**Challenges for emergency responders**

**Infrastructures damages**

**Consequences for scientific research**

- Do the same ethical principles apply in armed conflict situations as in peaceful situations? Is their relative importance the same in a society at war or in peace?
- Are the potentially affected populations and responders aware of/in agreement with such considerations?
- Does the perception of ethics differ in societies currently in an armed conflict, in those close to being drawn into such a situation, or those at a distance.

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# PANEL SCOPE AND CORE OBJECTIVES

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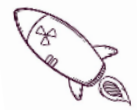
- Translating theoretical research and operational experience into robust actionable strategies
- Main purpose:
  - collaborative forum of experts → analyze and reinforce existing EPR&R frameworks

**Complex scenario** **Multi-threat scenario**

- Missile attack on a NPP in an armed conflict scenario



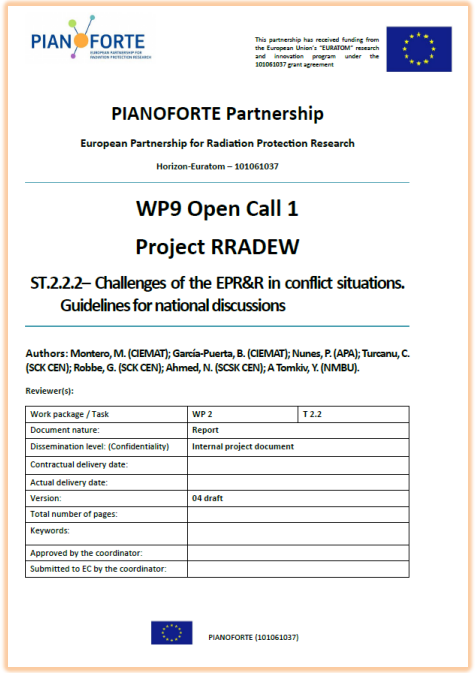
- Purpose:

**Analyse Vulnerabilities** & **Assess & Enhance Capabilities** → **Recommendations**

**Strengthen Resilience.**

# METHODOLOGY

- **Strategic thinking** and in-depth discussion
- Design the case study
- Documentation shared with the panelists



PIANOFORTE

This partnership has received funding from the European Union's "EURATOM" research and innovation program under the 101061037 grant agreement

**PIANOFORTE Partnership**

**European Partnership for Radiation Protection Research**

Horizon-Euratom – 101061037

**WP9 Open Call 1**

**Project RRADEW**

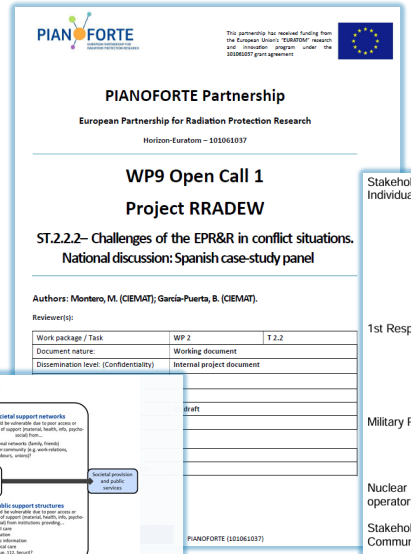
**ST.2.2.2– Challenges of the EPR&R in conflict situations. Guidelines for national discussions**

Authors: Montero, M. (CIEMAT); García-Puerta, B. (CIEMAT); Nunes, P. (APA); Turcanu, C. (SCK CEN); Robbe, G. (SCK CEN); Ahmed, N. (SCSK CEN); A Tomkiv, Y. (NMBU).

Reviewer(s):

| | | |
|---|---|---|
| Work package / Task | WP 2 | T 2.2 |
| Document nature: | Report | |
| Dissemination level: (Confidentiality) | Internal project document | |
| Contractual delivery date: | | |
| Actual delivery date: | | |
| Version: | 04 draft | |
| Total number of pages: | | |
| Keywords: | | |
| Approved by the coordinator: | | |
| Submitted to EC by the coordinator: | | |

PIANOFORTE (101061037)



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**ST.2.2.2– Challenges of the EPR&R in conflict situations. National discussion: Spanish case-study panel**

Authors: Montero, M. (CIEMAT); García-Puerta, B. (CIEMAT).

Reviewer(s):

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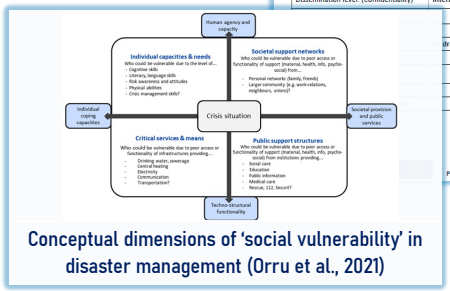
draft

PIANOFORTE (101061037)




Conceptual dimensions of 'social vulnerability' in disaster management (Orru et al., 2021)

**COMMUNITY RESILIENCE MEASURES**

Table 1 provides a summary of some of the infrastructural and policy measures that can enhance community resilience of an EPR& R system during a radiological event in wartime.

*Table 1: Infrastructural and policy measures for enhancing the resilience of an EPR&R system due to a radiological event in wartime.*

| Infrastructural measures | Policy measures |
|---|---|
| **Rebuilding and strengthening infrastructure:** Repairing and upgrading essential facilities (e.g., health centers, shelters, utilities, etc.) with external aid and donations from unaffected regions to restore critical functions quickly. | **Government provision of reconstruction laws, development funds and regulations:** Enacting legal frameworks, allocating resources and ensuring transparency in community rebuilding and fair use of funds. |
| **Implementation of disaster protection alternatives:** Developing protective structures and systems (e.g., decontamination zones, containment zones, radiation shields, engineered barriers, etc.) to minimize exposure risks. | **Promotion of polycentric governance:** Establishing multi-level decision-making (local, regional, national, international) to ensure flexibility, redundancy and prevent over-reliance on a single authority. |
| **Deployment of site monitoring systems and measurement devices:** Installing radiation detectors, environmental | **Active engagement of local government in resilience planning:** Empowering local authorities with resources and authority to |

| Stakeholder | Well-being | Dignity/Autonomy | Justice/Fairness | Prudence/Precaution |
|---|---|---|---|---|
| Individual Citizens | Access to critical services (food, shelter, water, medicine, power); Collateral damage; Distress and psychological trauma; Impacts on family networks; guilt, survivour syndrome; In post event phase - difficulties in obtaining compensation syndrome | General loss of freedom; Loss of control with evacuation; Need for information at all levels; Data privacy with measurements/ health impacts; when and where possible, participation in decision making | Special consideration of children and other family members; Impacts on the vulnerable (old, sick, young, disadvantaged); balancing survival and well-being; | Variability in ability and inclination to listen to authorities and abide by the rules, norms and regulations; Recognising uncertainties in protective actions (sheltering, evacuation) can be outweighed by military risks (eg likelihood of being hit by missiles) |
| 1st Responders | Special need for protection, training and information | Informed consent to remain in dangerous areas (e.g. nurses and medical staff); Respect their rights and their fear/perception of risk. It should not be their sacrifice | TRIAGE Choices - they have to make the decisions about who to save when responding; balancing responder needs against the common good; consideration of their own family | Competence of responders to undertake tasks; Leading by example? |
| Military Personnel | War casualites; Avoidance of sharing intelligence with the enemy; Need for psychological support | Respect for heirachy in following orders; Soldiers do not constantly debate decisions; Respect for the rules of engagement | Putting themselves at risk to protect populations | |
| Nuclear Facility operators | Psychological stress | Responsibilities to not to abandon work stations. Keep IAEA guidelines | Consideration of their own family against nucear safety and security | Reactor shutdown in times of threat |
| Stakeholder | Well-being | Dignity/Autonomy | Justice/Fairness | Prudence/Precaution |
| Communites | War collateral damage; solidarity and keeping communities together | Self-sustainability; providing access to resources to allow self-action (e.g. measurement); respect for all cultures and religions | Intergenerational equity; Rights to decide what is resilient enough; Non-discrimination of cultures or ethnicity | Clear responsibilities and accountability; Who has the power to make decisions and under what circimstances; Dealing with dis and mis information |
| Nation | Giving up assets in peace negotiations | Afronts to dignity; impacts on cultural values; Clear lines of accountability, responsibility | Right of refuge of civilians from other countries; Varying impact on different parts of society (military, front line, responders) | Balancing energy needs (eg keeping NPP running) against military radiological risks |
| Authorities | They need to be informed themselves. Do not want panic or stress | Responsibilities to address not only legal issues, but also values and common good | Responsibility to take decisions and prioritiize | Do reference values (tolerability) change in wartime? |

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# METHODOLOGY

- Phases of an emergency
- Three Pillars of Strategic Discussion

| | EMERGENCY PHASES | | |
|---|---|---|---|
| **PILLARS** | **EMERGENCY (EARLY RESPONSE)** | **TRANSITION & RECOVERY** | **PREPAREDNESS** |
| **VULNERABILITY ANALISIS** | Potential **weaknesses** of the EPR&R system, critical infrastructure (energy, transport, communications, health…) and the population in the phase of disruptions introduced | | |
| **IDENTIFICATION OF CAPACITIES** | Discussing existing technical, logistical, organisational, and communication **capacities** that must be developed, acquired, or strengthened to reduce overall risk | | |
| **STRENGTHENING MEASURES** | Proposing concrete, viable societal, environmental, economic, operational, or governance **measures to improve resilience**—either reducing vulnerabilities or increasing core capabilities | | |

# SPANISH PANEL PARTICIPANTS: 11 ORGANISATIONS

| Expert Group | Their Critical Role |
|---|---|
| Civil Protection (DGPCE) | Strategic national coordination |
| Nuclear Safety Regulator (CSN) | Regulator and essential technical knowledge |
| Civil Emergency Planning (DGPCE) | Unique intervention capabilities |
| Military & CBRN Experts (MDE, UME, EMDNBQ) | Specialised knowledge in defence and response to unconventional threats. |
| First responders (MDE, UME, SUMMA 112, Madrid Council) | On-the ground perspective |
| Health services (CECOSS, IGESAN, HCD, CSVE, SUMMA 112, HGUGM) | Population treatment and surveillance |
| Municipal Council of Madrid | Local coordination emergency teams |

**CSN**: Consejo de Seguridad Nuclear
**DGPCE**: Dirección General de Protección Civil y Emergencias (Ministerio del Interior)
**MDE**: Ministerio de Defensa
**UME**: Unidad Militar de Emergencias
**EMDNBQ**: Escuela de Defensa NBQ del Ejército de Tierra

**SUMMA 112**: Servicio de Urgencia Médica de la Comunidad de Madrid
**CECOSS**: Centro Coordinador de Seguimiento Sociosanitario
**IGESAN**: Inspección General de Sanidad
**HCD**: Hospital Central de la Defensa
**CSVE**: Centro Sanitario de Vida y Esperanza
**HGUGM**: Hospital General Universitario Gregorio Marañón

# AGENDA

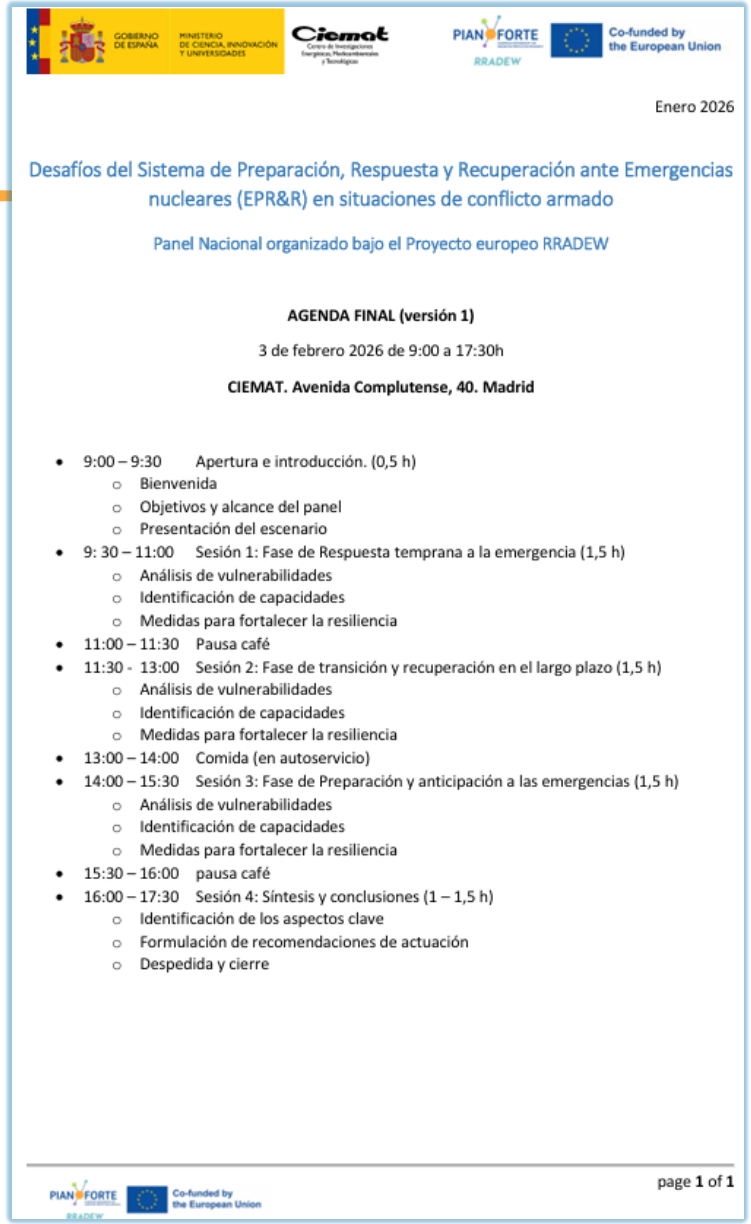
- **Introductory session:**
  - **Welcome**
  - **Objectives and scope**
  - **Presentation of the scenario**

- **Session 1**: The Immediate Emergency Response Phase
  - Critical hours and days immediately following the radiological release.
  - Analyse the **system's ability to execute a coordinated response** under the extreme pressure of a **combined radiological and military crisis**.

- **Session 2**: The Long-Term Recovery and Transformation Phase
  - Explore the multi-year challenges of recovery.
  - Analyse how to not only **restore functionality** but to leverage the crisis as an **opportunity for transformation**.

- **Session 3**: The Preparedness and Anticipation Phase
  - To **stress-test the foundational assumptions** of peacetime preparedness against the corrosive effects of a **conflict environment**.
  - Evaluate the **robustness of existing plans, systems, and community assets** before the radiological event occurs
    - How a **wartime context degrades baseline preparedness** and what anticipatory measures can counteract this erosion.

- **Synthesis Session (4)**: Formulating Actionable Recommendations
  - **Synthesize the key insights from the day's discussions into a coherent set of prioritized, actionable recommendations.**



Enero 2026

Desafíos del Sistema de Preparación, Respuesta y Recuperación ante Emergencias nucleares (EPR&R) en situaciones de conflicto armado

Panel Nacional organizado bajo el Proyecto europeo RRADEW

**AGENDA FINAL (versión 1)**

3 de febrero 2026 de 9:00 a 17:30h

**CIEMAT. Avenida Complutense, 40. Madrid**

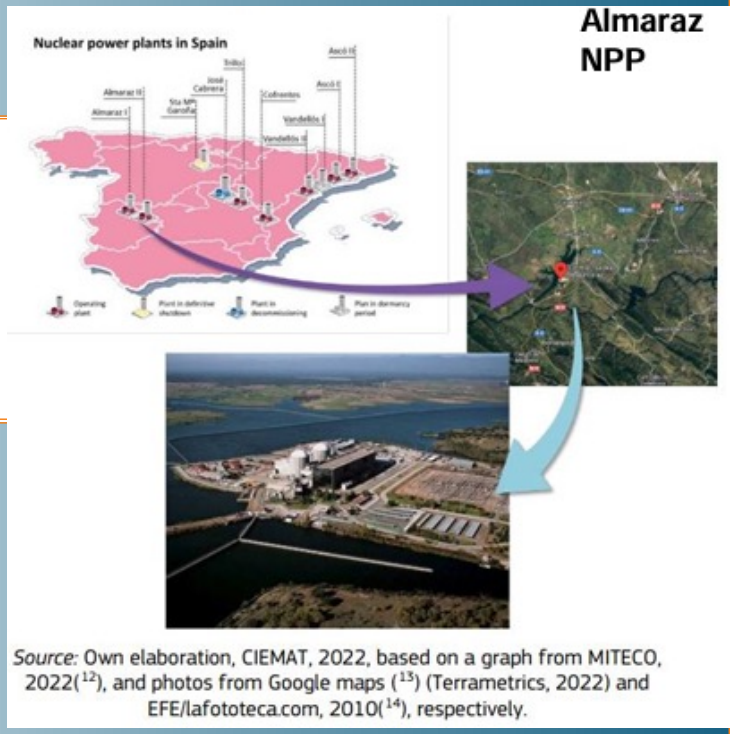
- 9:00 – 9:30 Apertura e introducción. (0,5 h)
  - Bienvenida
  - Objetivos y alcance del panel
  - Presentación del escenario
- 9: 30 – 11:00 Sesión 1: Fase de Respuesta temprana a la emergencia (1,5 h)
  - Análisis de vulnerabilidades
  - Identificación de capacidades
  - Medidas para fortalecer la resiliencia
- 11:00 – 11:30 Pausa café
- 11:30 - 13:00 Sesión 2: Fase de transición y recuperación en el largo plazo (1,5 h)
  - Análisis de vulnerabilidades
  - Identificación de capacidades
  - Medidas para fortalecer la resiliencia
- 13:00 – 14:00 Comida (en autoservicio)
- 14:00 – 15:30 Sesión 3: Fase de Preparación y anticipación a las emergencias (1,5 h)
  - Análisis de vulnerabilidades
  - Identificación de capacidades
  - Medidas para fortalecer la resiliencia
- 15:30 – 16:00 pausa café
- 16:00 – 17:30 Sesión 4: Síntesis y conclusiones (1 – 1,5 h)
  - Identificación de los aspectos clave
  - Formulación de recomendaciones de actuación
  - Despedida y cierre

# STARTING THE PANEL

- Introductory session
  - Basic Resilience, EP&R & Risk concepts
  - Objectives of the panel



- Case study
  - Assumptions & starting points
  - Description of the attack scenario: 2 strikes
    - Accident (SBO), Source term, timeline, consequences
  - Emergency & intervention phases

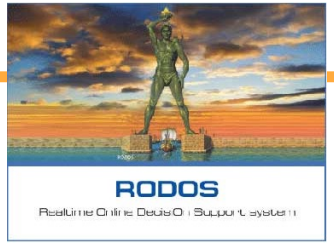



*Source:* Own elaboration, CIEMAT, 2022, based on a graph from MITECO, 2022([12]), and photos from Google maps ([13]) (Terrametrics, 2022) and EFE/lafototeca.com, 2010([14]), respectively.

- Radiological criteria
  - ICRP criteria (1 – 20 -100 mSv/y)
  - Spanish emergency nuclear plan (PLABEN)
    - Emergency planning zones around the NPP
    - Contamination levels (Nordic Guidelines, 2014)
    - Foodstuff control criteria (Council Regulation (Euratom) 2016/52)
    - Countermeasures
    - Recovery actions

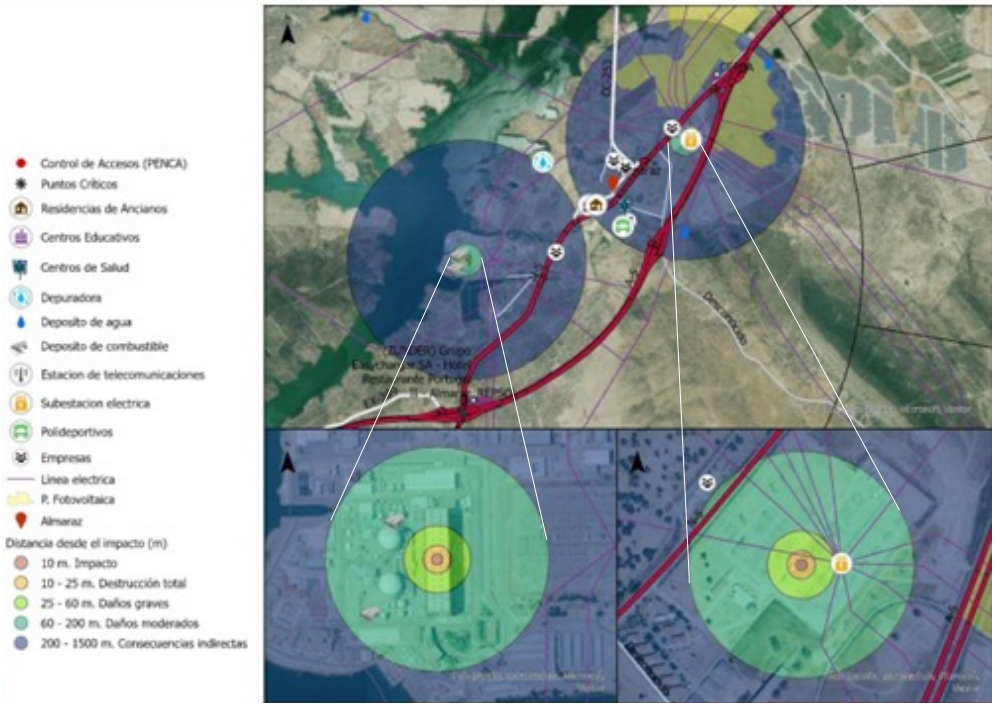
# CASE STUDY

- 2 impacts hit basic infrastructures around a Spanish NPP, close to the Portuguese border




- Release 22.5 hours after the impact STSBO accident – NUREG/CR-7110, Vol. 2):

U.S.NRC
United States Nuclear Regulatory Commission
*Protecting People and the Environment*



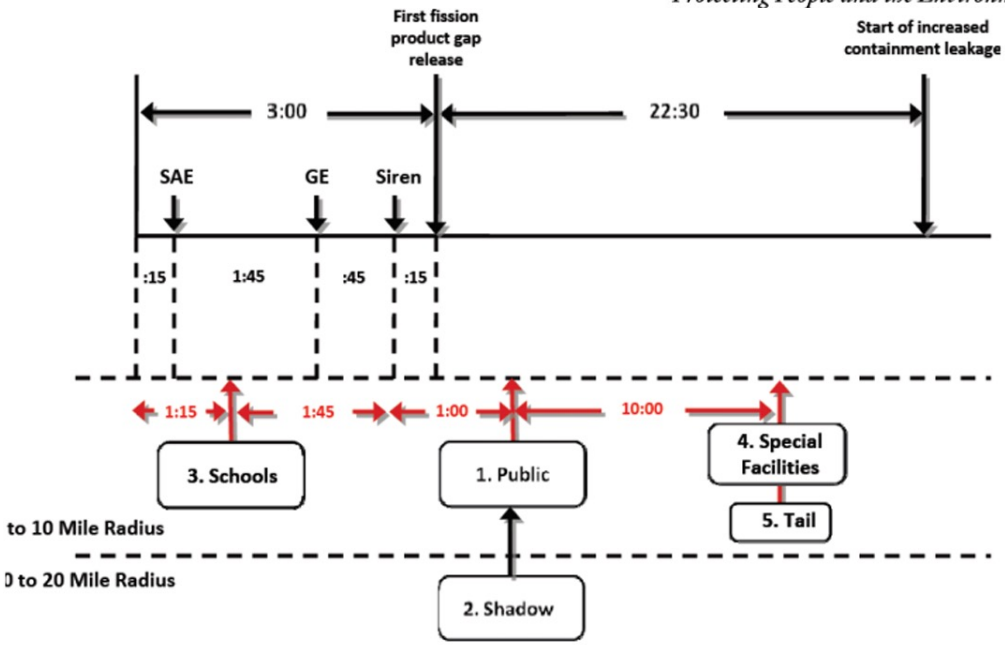




**Figure 6-4 Unmitigated STSBO emergency response timeline**

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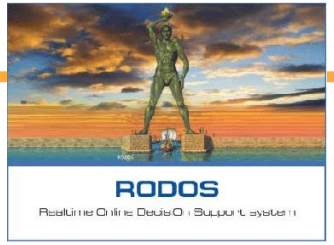
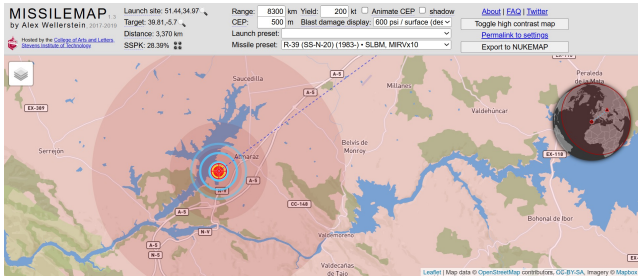
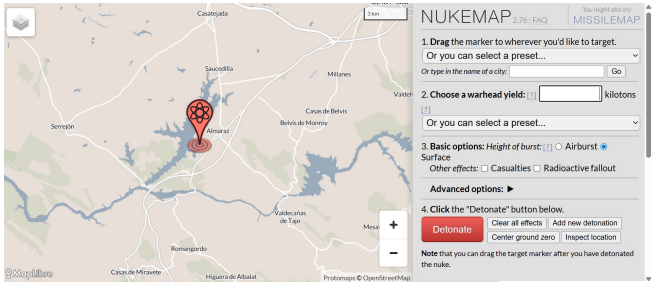
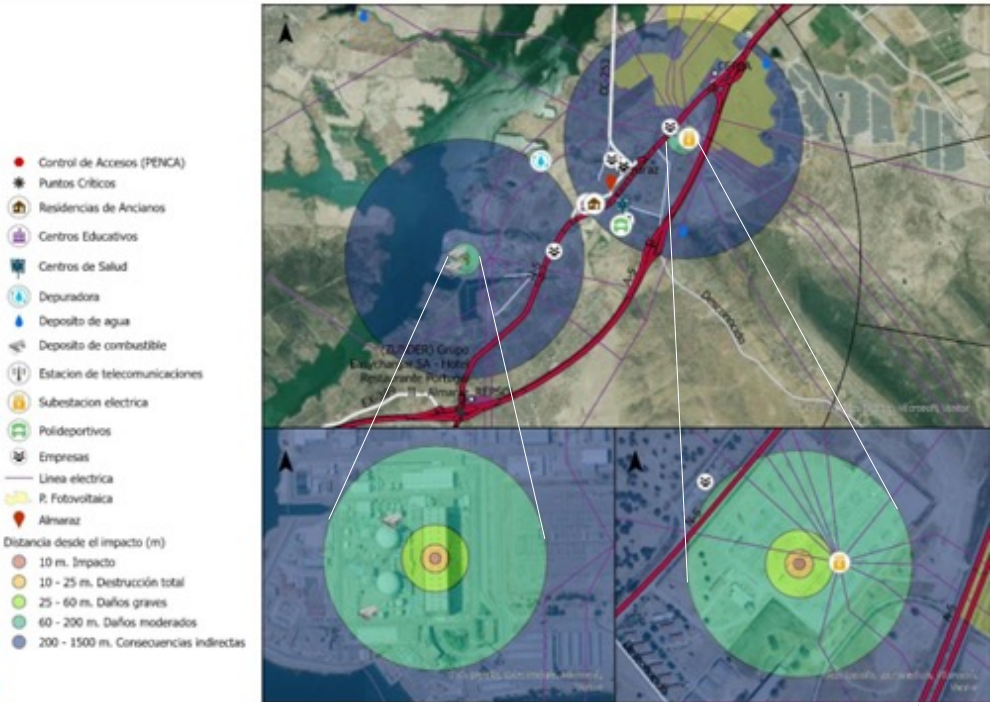



MISSILEMAP →
https://nuclearsecrecy.com/missilemap




← NUKEMAP
https://nuclearsecrecy.com/nukemap/




UN SAFER GUARD →
https://unsaferguard.org/map/index.es.php

UN SaferGuard
Securing ammunition, protecting lives

International Ammunition Technical Guidelines

Home | IATG | IATG Implementation Support Toolkit | Additional Resources | A-MAP

Explosion Danger Area Calculator

This calculator can be used to estimate range danger areas when planning the destruction of ammunition by open detonation. It may be used for 'quick planning' on demolition ranges with existing danger areas. If used on demolition areas with no formal danger areas the user should remember that the distance produced by these equations is that distance outside which no more than one fragment would be expected to fly. **They are NOT absolutely safe.**

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# CASE STUDY

## CONSEQUENCES

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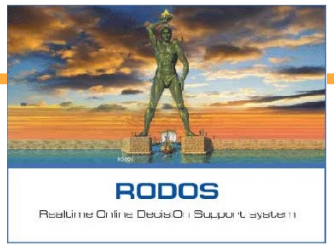
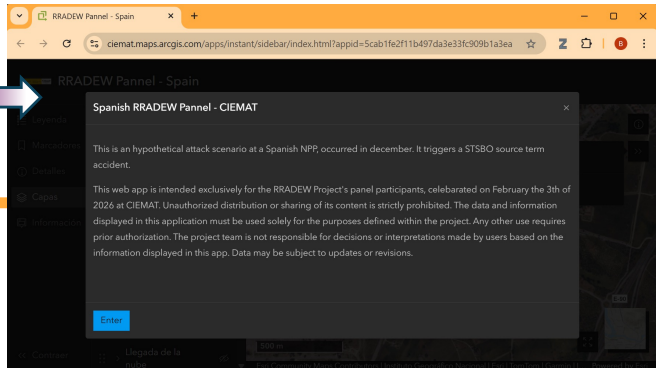
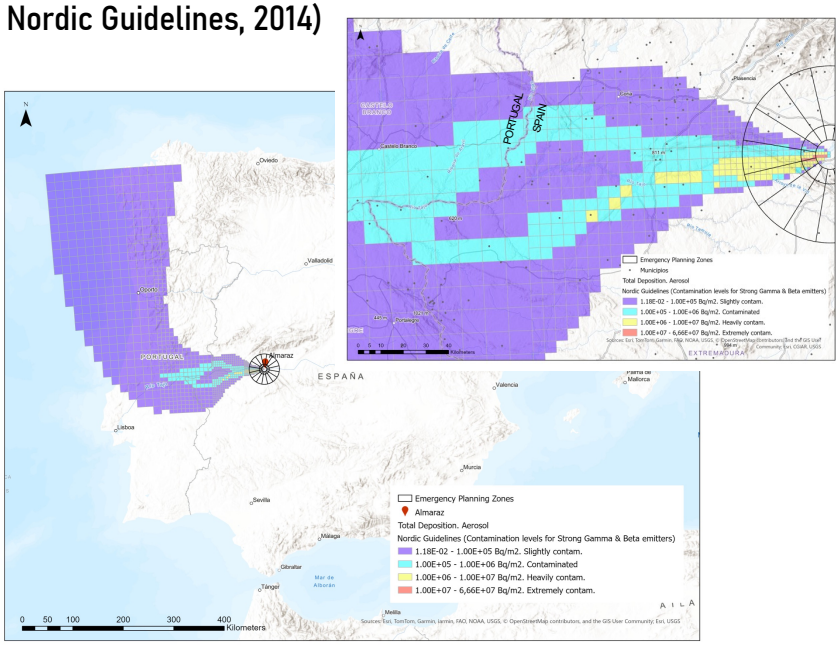
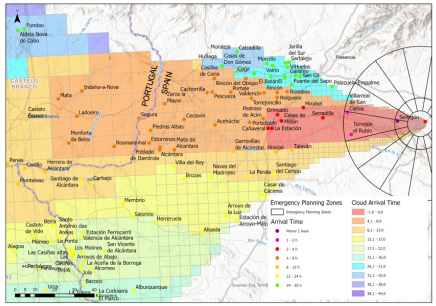


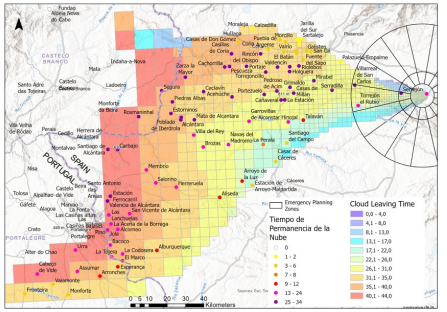

Total deposition aerosols
(Activity concentration classification - Nordic Guidelines, 2014)



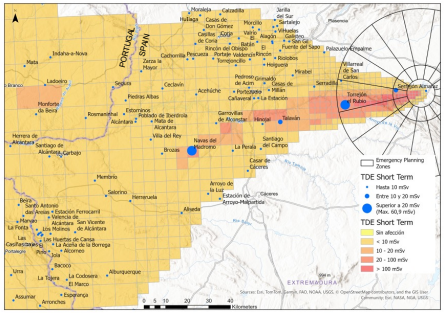

Cloud arrival time after the emission occurs



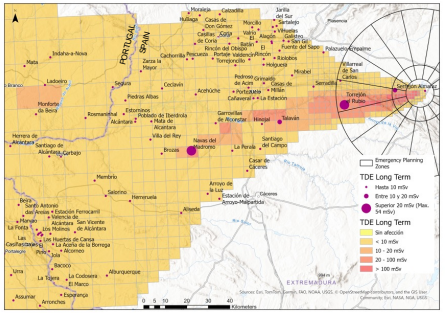

Cloud leaving time after the emission occurs




Total effective dose. Short time

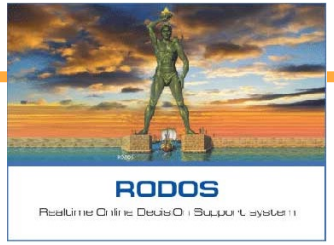


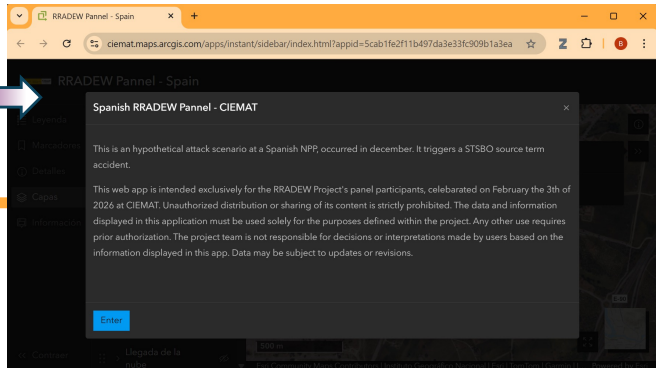

Total effective dose. Long time



# CASE STUDY

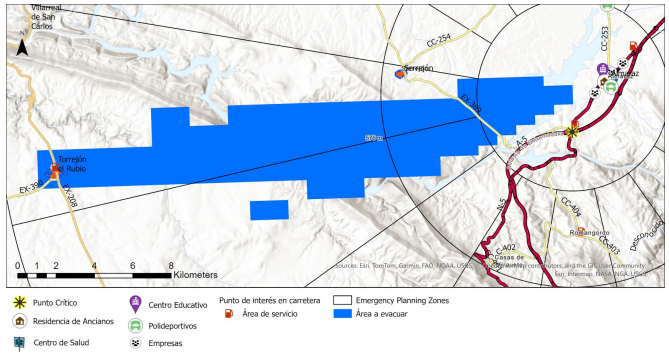
https://ciemat.maps.arcgis.com/apps/instant/sidebar/index.html?appid=5cab1fe2f11b497da3e33fc909b1a3ea

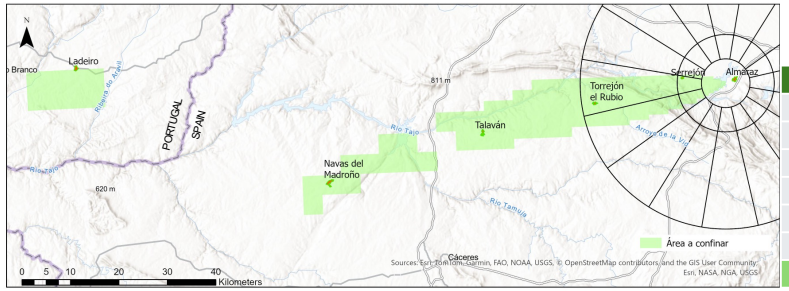



## COUNTERMEASURES

### Evacuation

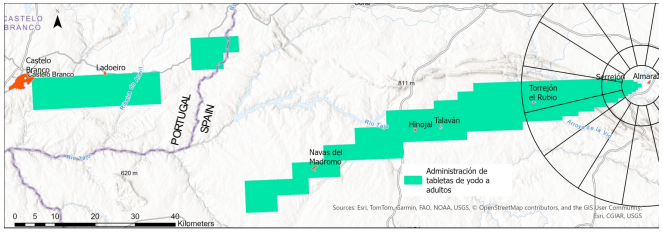


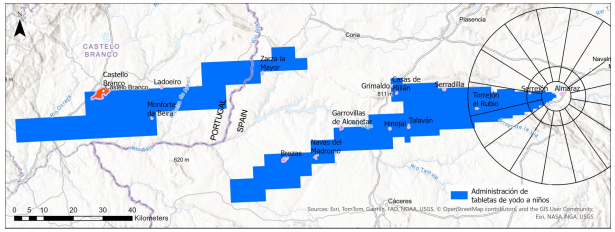

### Sheltering

| MUNICIPALITY | COUNTRY | INHABITANTS |
|---|---|---|
| Almaraz | Spain | 1259 |
| Talaván | Spain | 914 |
| Navas del Madroño | Spain | 1429 |
| Torrejón el Rubio | Spain | 599 |
| Serrejón | Spain | 412 |
| Ladeiro | Portugal | 1290 |
| Total | | 5903 |

### Iodine tablets for adults




### Iodine tablets for children



# PANEL RESULTS

| | EMERGENCY PHASES | | |
|---|---|---|---|
| **PILLARS** | **EMERGENCY (EARLY RESPONSE)** | **TRANSITION & RECOVERY** | **PREPAREDNESS** |
| **VULNERABILITIES** | Loss of plant capabilities (impact on control room) and critical internal alarm dependencies.<br>Fragmented communications between multiple systems (partial outages; limited interoperability).<br>Decentralisation of essential resources and care services. | There is no proper development plan or structure in place for the transition and recovery process.<br>Decentralisation of competences between administrations at regional and national levels. | Lack of preparedness culture in society and low awareness of self-protection. |
| | Limited CBRN specialised personnel. Lack of first responders training.<br>Lack of CBRN mechanisms in municipalities and lack of facilities for irradiated patients; risk of hospital saturation if not filtered in situ. | Misinformation in the media and on social networks<br>Needs of dedicated and unsystematised psychosocial care and support groups. | CBRN training should be more widespread implemented. |
| | Risk of continued attack and confinement/evacuation dilemmas under persistent threat.<br>Technical and logistical limitations for Iodine prophylaxis. | Loss of livelihoods and ways of life, limited access to medication, and interrupted continuity of care. | Unrealistic simulation exercises. |
| | Collapse of evacuation routes due to spontaneous people leaving the area.<br>Complex clinical priorities (patients with severe blast injuries vs. radiological pathologies), healthcare bottlenecks and public panic all of which complicate logistics. | Resistance to return and risk of uprooting among the evacuated people.<br>Spontaneous volunteering without a structured coordination mechanism. | Lack of institutional coordination. Potential issues in case of hybrid war. |
| | Decentralized screening capabilities still immature.<br>Out-of-hospital services insufficiently prepared for a CBRN event. | Prolonged and uncertain environmental recovery times. | Manage misinformation and encourage the population to use official, reliable sources of information. |
| | Vulnerable population (elderly, disabled) difficult to mobilise.<br>Social mistrust and adverse reaction; low perceived community resilience.<br>Lack of information and misinformation. | Support capacity exists, but a network must be created<br>The functioning of the system is dependent on personal relationships | Potential technical and logistical limitations in distribution protocols of iodine tablets from the warehouses. |
| **CAPACITIES** | Early activation of alerts and surveillance by the national defense forces, prior to impacts. | Environmental monitoring networks and sampling plans | Consolidated plans at national, regional and local levels. |
| | Redundant communication channels. | Availability of expert groups for independent assessments (scientific, environmental, health). | There is a robust institutional framework. |
| | Iodine prophylaxis: national stockpile and production capacity. | Inventories of materials and equipment in Civil Protection | There are available technical resources. |
| | Classification and Decontamination Stations (ECDs, in Spanish for first radiological screening. | Hospitals' laboratories trained in specialised analysis, and within international networks | There is a wide social network. |
| | The Spanish regulator (CSN) has modelling capabilities to provide technical guidelines for dealing with the emergency | Operational coordination tools in emergency services | There are official communication channels. |
| | Public warning system (Es-Alert) and local public address systems to communicate immediate confinement or evacuation orders. | --- | --- |
| **RECOMMENDATIOS** | Perform periodic communication tests in degraded mode to increase the systems interoperability. | Formalize a Radiological Transition Commission to coordinate sampling, restrictions, and return. | Strengthen training and awareness-raising. |
| | Better standardised radiological screening implementation, to ensure the derivation of the patients to the "optimal" hospital. | Evaluation of risk on critical infrastructures to planning their protection and control. Priorise the water supply systems over agricultural use. | Prioritise the faithful reproduction of real conditions in simulation exercises. |
| | Create a mobile specialised unit for irradiated patients. | Set up an agile communication system based on clear, rapid messages via official channels, technical credibility and transparency. | Create guidelines for better, rapid, clear and official communication channels. |
| | Better, rapid, clear and official communication channels | Design safe return routes with transparent criteria and in phases. | Create diversified communication strategies in order to adapt messages and channels to different populations groups. |
| | Set up specific distribution points for iodine tablets in municipal centers and stores | Create an integrated zonal decontamination plan. | Strengthen the social fabric of the community. |
| | Refine confinement/evacuation criteria considering radiological risk and war risk. | Create a continuity care plan for displaced people. | Homogenise inter-agency proceedings. Framework agreements and joint exercises, including CBRN training at extra hospital level |
| | Strengthen out-of-hospital NBC training. | Include economic support and recovery plans for families and the local productive sector. | Logistic and technical improvements: for distribution of iodine tablets; equip hospitals with radiation detectors; and strengthen communication redundancies. |
| | Promoting public self-protection and preparing basic survival kits for the first 72 hours. | Create a psychosocial and communitarian support catalogue. | Promote stable interinstitutional coordination. Create a digital management system for volunteers' accreditation. |
| | Cross-border harmonisation and coordination of response plans. | Engage citizens and stakeholders in the monitoring and recovery . | Consolidate "lessons learnt" in order to strength the preparedness culture. |

# PANEL RESULTS: RECOMMENDATIONS

| | PREPAREDNESS |
|---|---|
| RECOMMENDATIOS | Strengthen training and awareness-raising. |
| | Prioritise the faithful reproduction of real conditions in simulation exercises. |
| | Create guidelines for better, rapid, clear and official communication channels. |
| | Create diversified communication strategies in order to adapt messages and channels to different populations groups. |
| | Strengthen the social fabric of the community. |
| | Homogenise inter-agency proceedings. Framework agreements and joint exercises, including CBRN training at the extra-hospital level. |
| | Logistic and technical improvements: for distribution of iodine tablets; equip hospitals with radiation detectors; and strengthen communication redundancies. |
| | Promote stable interinstitutional coordination. Create a digital management system for volunteers' accreditation. |
| | Consolidate "lessons learnt" in order to strength the preparedness culture. |

# PANEL'S CONCLUSIONS

**Analysis of the simulated scenario: a missile attack against a Spanish NPP and its associated electrical infrastructure.**

**Solid technical and regulatory foundation**

**Vulnerabilities in inter-administrative coordination and social resilience**

- **Key findings**:
  - **Operational Capacity**:
    - Spain has **elite response units** (UME) and a **highly experienced regulator** (CSN).
    - However, the **decentralisation** of essential services hampers a unified and coordinated response.
  - Main significant **operational risks → Communication Gaps**:
    - **Fragmentation of communication systems**, and
    - **Vulnerability to "hybrid warfare":** network outages, disinformation.

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  - **Social Factor**:
    - **Low risk awareness** among the general population
      - ✓ Can undermine "soft resilience"
      - ✓ Could lead to **chaotic public reactions** and the **saturation of healthcare services**
  - **Health Priority**:
    - **Need to standardise pre-hospital radiological triage**, to prevent the overload of reference medical centres.

The implementation of the recommendations of the Spanish panel, together with those from the other panels held within the framework of the **RRADEW project**, would strengthen the EP&R system, improve its effectiveness, and, in the long term, build **resilience** to nuclear emergencies in armed conflict scenarios.

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RRADEW

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# Thank you for your attention!

Strengthening Nuclear and Radiological Emergency Resilience Under Conflict Conditions:
Insights from a Spanish Expert Panel under the RRADEW Project on a Missile Strike Scenario at a Nuclear Power Plant

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