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Decision support systems and emergency response exercises – lessons and issues

D.S. Slavnicu, D.V. Vamanu, D. Gheorghiu,
V.T. Acasandrei and B.I. Vamanu

"Horia Hulubei", National Institute of R&D for Physics and Nuclear Engineering,
PO Box MG-6, Magurele, Atomistilor Street 407, Romania

Abstract. The paper reports on the experience and specific findings of a research team involved in emergency preparedness and response management activities using the decision support systems (DSS) RODOS and MOIRA in conjuction with domestic radiological assessment tools. Two cases are discussed – the *ConvEX 3, 2005*, international alert exercise targeting a CANDU reactor at Cernavoda nuclear power plant in Romania, and *Oltenia 07* – a nation-wide drill around a scenario involving transborder effects from a VVER reactor at Kozloduy, Bulgaria.

1. INTRODUCTION

The paper glosses on the experience of a research-oriented team routinely involved in emergency preparedness and response management activities, with the assimilation, implementation, and application of decision support systems (DSS) of continental reference in Europe, and the development of supportive, domestic radiological assessment tools. Two exemplary cases are discussed – the ConvEX 3, 2005, international alert exercise targeting a CANDU reactor at Cernavoda nuclear power plant in Romania, and Oltenia 07 – a nation-wide drill around a scenario involving transborder effects from a VVER reactor at Kozloduy, Bulgaria.

In May 2005, the International Atomic Energy Agency has conducted a comprehensive nuclear alert exercise, code-named ConvEx-3. More than 20 countries in Europe and overseas have participated, in an attempt to verify the capability of assessment and reaction to a significant abnormal event in a nuclear facility, with Cernavoda Nuclear Power Plant, Romania selected as a test ground. The second event relates to the organization, by the Romanian General Inspectorate for Emergency Situation, of an emergency drill to test near-site response capabilities in the case of a transborder accidental release at the Kozloduy NPP, on the Danube river.

2. EVALUTION METHODS

The major league players in the exercises above were RODOS (*Real-Time, On-Line Decision Support System for the Management of Nuclear Emergencies in Europe*) and MOIRA (*A Model-Based Computerised System for Management Support To Identify Optimal Remedial Strategies For Restoring Radionuclide Contaminated Aquatic Ecosystems And Drainage Area*) developed by multinational consortia within the EU Framework Programmes 4, 5, and 6. In the domestic league, specific roles were allocated to RAT (*Radiological Assessment Toolkit*) – an open-ended software platform of an MS&V (*Modeling, Simulation and Visualization*) profile that assemblies requisite source term, environmental transport, dosimetric, dose-effect, and dose/derived intervention level-countermeasure correlated facilities connected to GIS and physical data libraries to perform as a RODOS input assistant, an independent assessor, and an on-the-job tester and trainer. The MOIRA DSS was used for special

requirements regarding the medium-long term contamination of drinking water and fish, or the people's exposure.

RODOS [1, 2] is a heavy-weight facility operating from a graphics station, covering the early (1–7 days) as well as the intermediate and long (ingestion) phases (months, years) in the development of an accidental release, dwelling comprehensively in health, environmental, and economic consequences considerations.

RAT ('*Radiological Assessment Toolkit*') is, on the other hand, a lighter-weight player mainly focusing on NIPNE's emergency assistance business – a part of institute's mission statement. Based on a predecessor developed for U.S. NRC in-house exercises [3] and drawing upon the U.S. NRC/DOE/EPA's technical specifications [4] RAT is designed to operate at a PC desktop/laptop level, dwelling in fast assessments of radioactive inventories, source terms, environmental dispersion dose and derived response levels.

MOIRA [5] is designed to provide, *inter alia*, for a reliable assessment of possible alternative rehabilitation strategies for the aquatic environment.

The working sequence went as follows:

Step 1: the ancillary RAT assistant has expeditiously provided 8-hour meteo forecasts emphasizing the wind and precipitation regime at, and near the accident site, with a potential coverage of the mesoscale. To this effect, the RAT team has developed a dedicated software capable of offline-browsing a public meteorological forecast data resource – the *UK.Weather.com* in order to mine-out parameters of prime consequence in determining the motion and the dispersive properties of masses of air overflowing the Cernavoda NPP area prior, and during the (simulated) abnormal release. These include *wind direction and speed*, an inference of the *cloud cover*, and the *precipitations.*

Step 2 has seen RODOS at work, given the input described. For the sake of illustration, several RODOS capabilities are presented in the sequel, as reflected in the *ConvEX-3* drill.

The source terms were back-engineered, trial-an-error fashion, from the doses that would warrant certain responses on certain areas, as deemed adequate by the drill planners. In particular, the Kozloduy scenario employed a modified reference source term for a VVER 1000 reactor – available in the database of the RODOS system.

3. RESULTS AND CONCLUSION

The first information required by the decision makers has targeted the appropriateness of *early countermeasures*– sheltering and evacuation of population, administration of iodine tablets – and the dose levels expected in the potentially affected area. Fig. 1 illustrates the doses consecutive to the first round in the (virtual) release that was assumed to last for 4 hours.

Based on this evaluation the RODOS system recommended the administration of iodine tablets to children, in a specified and charted area [6]. Complementarily, RAT has also engaged in the *radiological assessment* and the *countermeasure design*. However, in contrast with RODOS – that was bearing the prime responsibility for issuing, near-real time manner, information of immediate relevance for directing the response, RAT has adopted a strategy of *alternative situations coverage,* based on '*what if*' scenarios, that means preventive knowledge of what the doses should be e.g. *if* the atmosphere is class A, or B, C, D, E, F; and *if* the release can be categorized as 'ground', or 'elevated'; and *if* the release was, or was not, under rain. Fig. 2 presents countermeasure areas following from RAT assessments conducted as described.

On *ConvEX* Day-2, a controlled release through the stack was assumed and the true wind direction was taken into account. On these, RODOS had no countermeasure to recommend, as the predicted doses fell below the normative levels.

For the regional scenario, contamination of part of the Danube river catchments was simulated in line with the radioactive release postulated for Day-1. Fallout of Cs-137 and Sr-90 was calculated using

RODOS, and the results were used to estimate long term radiological consequences by hydrological pathways, using the MOIRA system.

The evaluation of expected doses from fish in the Danube river indicated that no countermeasure is warranted; on the other hand, restrictions on drinking water appeared advisable.

The RODOS and RAT systems offered, similarly, support to the Civil Defense during OLTENIA drill, providing the required information on the area to exercise mitigating intervention (like evacuation) in a limited neighborhood of the town of Bechet (Fig. 3).

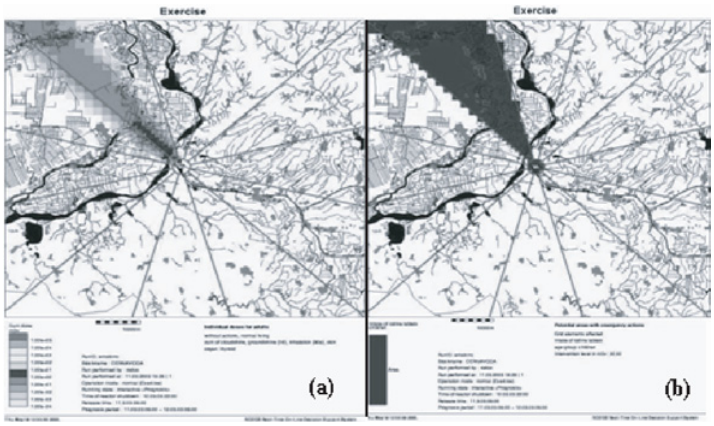

Figure 1. RODOS results: thyroid dose distribution for adults in case of no-countermeasures (a) and potential area affected by countermeasures: administration of iodine tablets for children (b).

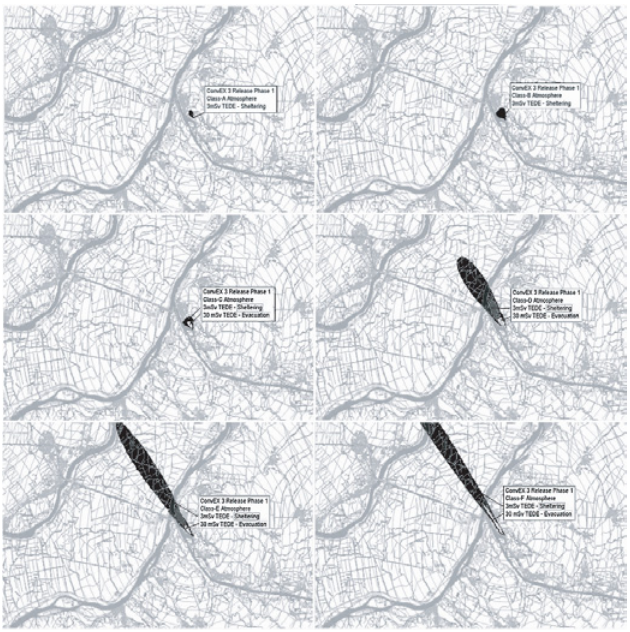

Figure 2. RAT results: reference dose areas, by atmospheric stability (Pasquill A, B, C, D, E, F).

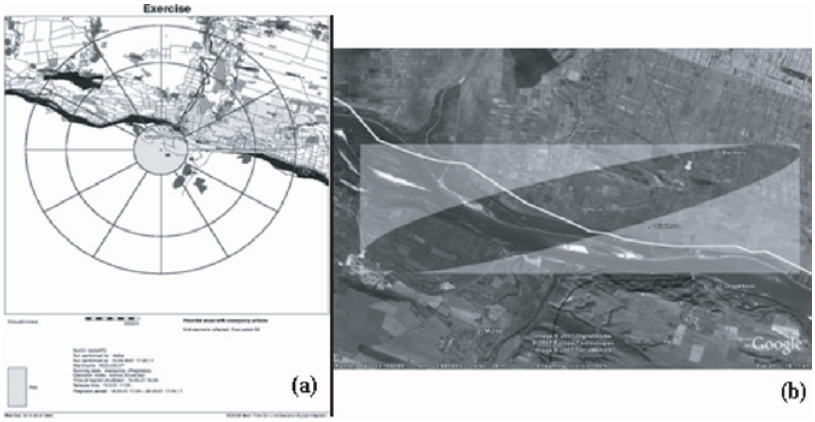

Figure 3. Evacuation area at Bechet, near Kozloduy, by (a) RODOS, and (b) RAT.

Drill debriefings have outlined several *shared findings*. These have confirmed:

(i) the effective role and weight that tends to be retained, in actual practice, by the extra-academic – civil defense and regulatory – authorities for the decision support systems in the response to abnormal nuclear events;

(ii) the productive complementarity of major, reference DSSs like RODOS, developed for cross-national compatibility and comparability purposes, on the one hand, and home-made facilities traditionally developed and deployed in vocational research institutions, enjoying the leverage that follows from an organic evolvement, responsive to local needs and drawing upon effectively available resources; and

(iii) the merits of employing expert systems to avoid stress and psychological pressure, confusion or inappropriate decisions in the early phase of emergencies.

On a more analytic and meditative line, these authors have also detected;

(iv) a need for re-designing the MS&V interfaces of, especially, the heavy-weight DS systems, in order to meet the quest, on behalf of the emergency managers and field operators, for more flexibility and speed in generating and solving '*what if*' scenarios, especially in the pre-action phase of response to a crisis;

(v) a neat preference for, and higher solicitation of the Early-Phase tools available with the DS systems, as compared to the Late-Phase-, cost-efectiveness-, feedback-, even ALARA-oriented etc. components;

(vi) a persistent difficulty with integrating official, standard, professionally-recognized meteo data resources into the emergency-management-oriented DS process, attributable to a variety of factors including the rigidness and complexity of the established data formats, the lack of a *casual* communication of the parties, costs not discriminating profit-drive from societal urgencies, and a certain ambiguity of mission statements, of national meteorologies and the radiological expertise – an issue that needs to be addressed with, perhaps, more candor and will of co-operation; and

(vii) the *interim* value of devising effective *and* law-complinat ways and means to data-mine Internet-based meteo and other (e.g. GIS) data resources, to fill pressing operational needs of DS systems – also calling for equipping the DS with the appropriate, tapping interfaces.

Acknowledgments

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