

# ETH - RISKMONITOR: LINKING PLANT ON - LINE MONITORING TO RULE - BASED ASSESSMENT AND EMERGENCY PLANNING FOR NUCLEAR ACCIDENTS

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## Abstract:

The ETH-RISKMONITOR is a DSS designed to assist real case on-line remote monitoring of nuclear power plants for abnormal event categorizing based on plant condition, and its evolvement, issuing of recommended alert grades, prompt determination of endangered / exposed sectors in a territory and on dose and health effects mapping. It is an application on linking plant on-line monitoring to rule-based assessment and emergency planning for nuclear accidents.

## INTRODUCTION

The Polyproject " Risk and Safety of Technical Systems", an interdisciplinary research project undertaken by the Swiss Federal Institute of Technology (ETH) -Zürich aims at providing a coherent framework for critical, comparative evaluation and development of methods and practical tools in risk analysis and safety management of complex technical systems, the operations nature and scale of which may entail health and environmental hazards. The nuclear risk assessment and safety management issues have found a natural place within the above project.

One central result of this approach was ETH-RISK (Gheorghe et. al.,1994)-an early intervention-oriented software package meant as a component in Decision Support System (DSS), GIS based/oriented dealing with emergency preparedness and management, and later performing integrating functions such as:

- 1) - anamneses of experts and decidents, in order to infer from the **natural languages**; statements, the nature of abnormal events in nuclear power plants;
- 2) - abnormal event categorizing based on plant condition, and its evolvement;
- 3) - issuing of recommended **alert grades** (e.g. Warning, General Alert, Radiation Alert);
- 4) - prompt determination of endangered or otherwise exposed sectors in the territory; and of the cantons falling within the incidence of these;
- 5) - definition of **accident source terms**;
- 6) - probabilistic / deterministic environmental dispersion scenarios;
- 7) - dose and health **effects mapping**;
- 8) - complex mapping of zones of recommended **countermeasures** (sheltering, administration of stable iodine tablets, evacuation, relocation);

- 9) - filling reports to relevant **emergency management** authorities.

## AN INTEGRATIVE APPROACH

As a feedback received from exercising with ETH-RISK (e.g. from nuclear regulatory bodies, from NPP operators, etc.), a shorthand version primarily assembling the functions 2, 3, 4, and 7 in the aforementioned enumeration was designed. ETH-RISKMONITOR is the code name for the result of an exercise to meet the respective propositions. ETH-RISKMONITOR is an expeditious software facility designed for the on-line supervising by authorized agencies, of the operational status of the nuclear power units in Switzerland. ETH-RISKMONITOR was developed as a research exercise within Polyproject "Risk and Safety of Technical Systems" at the Swiss Federal Institute of Technology ETH -Zürich. In essence, this DSS simulates a dynamic, on-line updated data-base coupled to an alert and fast consequence assessment facilities via a rule base system. The code modules:

- i) perform a synoptic, or a parameter-by-parameter monitoring of the operating of the nuclear power units (e.g. Beznau-blocks 1 and 2-, Leibstadt, Goesgen, and Muehleberg);
  - ii) signal and record departures of the monitored parameters - pressures, temperatures, levels / concentrations, dose rates in critically important parts of the system-from the normal / acceptable operational ranges of variation;
  - iii) correlate unacceptable departures from normality to alert grades, based on the legally enforced criteria, procedures and practices in Switzerland;
  - iv) upon a very minimal input, including e.g. the NPP location, prevailing wind direction, general type of weather (with high / low consequences), severity of the accident in comparison to the Swiss reference accident, and assumed degree of sheltering of the potentially exposed population, provide a fast-if rough-preliminary evaluation of the expected consequences of the abnormality, should a release effectively occur.
- Three modules would embody the functions above:
- MONITOR.GEN, which concentrates the **database and monitoring functions**;
  - MONITOR.RUL linking abnormal occurrences to alert grades via **accepted rules**;- ALERT that

incorporates **accident consequence assessment** procedures.

Within the monitoring mode the user may wish to keep the code into displaying the on-line reported values of all the parameters of a given NPP unit. A shorthand synoptic table, a list of full-name parameters and their values, or "topical" lists-of all parameters of the pressure / temperature / level etc. type can be displayed and watched as these vary in time. Alternatively, each and every parameter can be put on display, together with its full description (index, measuring point at the plant, measuring units, etc.), and current value. The existing software allows the user to make changes as far as the description of the parameters, altering e.g. their names, indexes, characteristic value etc., or to add new parameters to the list of those already monitored, or to delete some parameters from the lists.

The general organization of the information is "vectorial"; each file contains one variety of information: name of parameters to be monitored, their index in the power plant documents; denomination of the measuring points, physical units, the most expected value in normal plant operation, and six significant limits of variation (attention, critical, accident, upper and lower levels) - 11 species altogether.

#### OFF-LINE AND ON-LINE REGIMES

There are two regimes into the monitoring mode of the code: off-line, and on-line, with reference to the data transmission from the nuclear installations targeted for monitoring. To simulate an accident, while in the on-line data transmission regime, a series of instructions are available through the menu of the code. Once the code operator is out of any doubt that the departure of the plant parameters from their routinely expected values signals an accident with offsite consequences, one may activate the facts-to-alert- grades module of the code.

The current version of the code offers an interim solution to the problem. Pending a satisfactory definition of a comprehensive set of rules linking various combinations of (Level 1) plant condition parameters departing from their respective ranges of normality, on the one hand, and the legally enforced alerting grades in Switzerland i.e. **Warning, General Alert, Radiation Alert**; on the other hand, a minimal set of alternative / complementary facts is used instead, to quantify the alert grade via regulatory rules.

As conceived, the rules are simple **logical operations OR and AND** that are performed on facts such as various managers propositions or decisions, the condition of some components (e.g. emergency cooling pumps), the values of some (actually, only a few) plant control parameters etc. and amounting to one of the alert grades. The algorithm and coding would therefore reflect these, inevitably introducing precautions of the type "insufficient information", or "check this information" for contradictions. In the context, "information" means the set of assumptions on what facts occurred and concurred in the abnormal event in question. A pointer is made available to the user, to select (combinations of) facts. The code will make it a rule to always take up the

worst alert grade that may emerge from the user-chosen combination of facts. Such an approach would stress expert judgement against the sought automation of the analysis and assessment process, which however is believed to be only a transient difficulty.

In operating this code sequence the user is requested to carefully examine the inventory of facts in display, and then point to one or several of these, as indicated by the monitoring process and/or resulting from other insights. A visual expression of the rules articulating the facts and linking the logical result to a certain alert grade will then be displayed for examination. If unsatisfied with the outcome, the user may repeat the process.

At this point it is to be reminded that, as all components or spin-offs of the ETH-RISK system, ETH-RISKMONITOR abides by a policy of advising the emergency manager, yet never deciding instead of him (her). A visual expression of the rules articulating the facts and linking the **logical results** to a certain alert grade will then be displayed for examination.

#### ACCIDENT CONSEQUENCES

Once the alert grade established, a series of graphic helps will be activated, and on-line helps and prompts will lead the user through a series of procedures that would materialize in a shorthand sort of fashion the current Swiss dose concept.

In broad lines, the user:

- will use a cursor to select and point at the NPP location on the Switzerland's map;
- will set the dominant wind's direction (using arrow keys) and will watch as the code will draw the 120 deg. angle around this, marking the endangered and exposed sectors into the territory, as defined by the Swiss legally enforced procedures;
- will assign missions to the emergency officers, confirming to the code the accomplishments of the various phases into the mission;
- will match as the code will identify the cantons falling within the incidence of the endangered / exposed sectors - and where, consequently, adoption of alert / action station is expected.

This phase consummated, further steps into the consequence assessment may be undertaken. Thus, upon giving his best guess on how the current accident relates to the Swiss reference accident as described in (HSK, 1991) and what kind of weather prevails ("weather with high consequences" or "weather with low consequences"- to use the Swiss official language), the user will be promptly given the zones where various health effects are to be expected, including the positioning of the zones on relevant maps of the territory surrounding the nuclear units in question. Also the radial distribution of doses into the territory taking into account assumed degrees of sheltering (outdoor, indoor staying, in-cellar, in-shelter) can be rendered on maps.

All the results as described express the "legal truth" in the procedural documents guiding the emergency preparedness and management in Switzerland; in particular dose mapping relies on the dose vs. distance curves. This approach was thought in tune with a

regulatory body practice, although it does not preclude the use of more elaborate accident consequence analysis tools. ETH-RISKMONITOR has been written for the IBM PC family. It is less demanding than ETH-RISK in terms of hardware performance. Any system beginning with the 286 series will do. However, given the association of ETH-RISKMONITOR to ETH-RISK, the standard requirements for the latter, i.e. a 33 MHz or higher clock, a 8 MB RAM, and an EGA or VGA graphic adapter and color monitor are recommended.

### ON-LINE FACILITIES

Whenever at runtime, one may:

- save a graphic screen as recoverable bitmap;
- print a text (ASCII) hardcopy of the screen.

### CONCLUSIONS

The ETH-RISKMONITOR is an expeditious software facility designed for the on-line supervising by authorized agencies, of the operational status of the nuclear power units in Switzerland. This software was developed as a research exercise within Polyproject "Risk and Safety of Technical Systems", at the ETH-Zürich.

### REFERENCES

Gheorghe A. V., Vamanu D.V. (1994) - "ETH-RISK: A Pilot Knowledge and Decision Support System for Nuclear Power Accidents Emergency Management", in Proceedings of The International Emergency Management and Engineering Conference, TIEMEC '94, April 18-21, 1994, Hollywood Beach, Florida, USA.

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