An Online Risk Monitor System (ORMS) to Increase Safety and Security Levels in Industry

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Abstract. The main idea of this research is to develop an Online Risk Monitor System (ORMS) based on Living Probabilistic Safety Assessment (LPSA). The article highlights the essential features and functions of ORMS. The basic models and modules such as, Reliability Data Update Model (RDUM), running time update, redundant system unavailability update, Engineered Safety Features (ESF) unavailability update and general system update have been described in this study. ORMS not only provides quantitative analysis but also highlights qualitative aspects of risk measures. ORMS is capable of automatically updating the online risk models and reliability parameters of equipment. ORMS can support in the decision making process of operators and managers in Nuclear Power Plants.

1. Introduction
Over the past years, many nuclear power plant (NPP) organizations have performed probabilistic safety assessments (PSAs) to enhance the safety level of NPP. These PSA studies is an effective tool because it assist plant management to get more benefits for plant safety but any PSA used to support decision making must have a defensible basis therefore it is very important that regulatory body accept Living PSA. LPSA provides basis for risk informed approach to decision making.

A risk monitor is mainly used to calculate instantaneous risk \cite{1}. The first risk monitors were put into operation in 1988. The number of risk monitors worldwide has increased to over 150. The risk monitors are used for quantitative analysis as well as qualitative analysis such as safety function, safety system. There are different types of risk measures like:

- Baseline risk which is the numerical value of the risk (CDF, LERF, etc.) calculated by the PSA with all components available to carry out their safety function.
- The average risk which is normally calculated by the Living PSA for full power operation, Average risk is calculated when average maintenance unavailability Introduced and it is always greater than the baseline risk.
- The point-in-time risk is the level of risk is related to a specific plant. The point-in-time risk will change as the plant configuration and environmental factors change as shown in figure.1 \cite{2}.

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The ORMS presented in this article capable to calculate changes in configuration and reliability of components in NPP. ORMS is based on full power, internal event Level 1 PSA and update risk models regularly and automatically.

2. **Structure of Online Risk Monitor System (ORMS)**

The basic structure of ORMS consists of five modules known as:
- Reliability Data Update Module (RDUM)
- Running Time Update
- Redundant System unavailability Update
- Engineered Safety Function (ESF) Unavailability Update
- General System Update
These five modules are shown in Figure.2. The first two modules RDUM and Running Time Update receive information from D-I&C (Digital Instrumentation and Control) system, analysed data quantitatively and supply feedback to Reliability Data Base. The remaining three modules receive information from monitoring unit & system design change unit and analysed data qualitatively. The qualitative and quantitative output of these three modules in combination with reliability data base module is provided to living PSA model respectively. After getting information the online risk model makes a quick calculation of following factors;

- Core damage frequency
- Importance factor
- Allowed configuration time
- Qualitative risk information

In view of calculation, the online risk model makes it possible to shut down plant if risk exceed over a limit and continue updating process if risk levels liaise within limits.

To prevent failures Reliability Centered Maintenance (RCM) gathered and compares all updated data for analysis [3]. The purpose of comparison in RCM is to identify needed changes in the existing program and thereby optimize the facility’s Preventive Maintenance program.

3. Specification of Modules in ORMS

3.1. RDUM and Running Time Update

The RDUM work in such a way that it uses Bayes’ Theorem and combination of different distributions for the calculation and updating of parameters, Figure. 3 describe this concept clearly. Two types of distributions have been used.

(1) Beta distribution with binomial likelihood function for the calculation of demand failure probability. Equation 1 and 2 explain the key results of these distributions and the calculation process or steps can be seen from literature [4].
\[ \alpha_{\text{post}} = k + \alpha_{\text{prior}} \]
\[ \beta_{\text{post}} = n - k + \beta_{\text{prior}} \]

Figure 3 Function of RDUM

(2) Gamma distribution with Poisson likelihood function to update running time, equation (3) and (4) explain final results.

\[ \alpha_{\text{post}} = x + \alpha_{\text{prior}} \]
\[ \beta_{\text{post}} = t + \beta_{\text{prior}} \]

3.2. Redundant, ESF and general system Unavailability update

The function of these three modules is to make qualitative analysis of data and provide this information to LPSA model. The redundant and ESF modules receive information from monitoring unit, while general system module updated as changes occur in system design. The logical configuration of monitoring system is shown in figure 4.
Figure 4 Logical Configuration of monitoring system

There are three main steps in figure 4:
(i) Signal generation process which includes human operator’s judgment and proper action (push button), normal operation of command generation equipment
(ii) Success of command transmission through electrical wire or pressure sensing line
(iii) Normal response of the actuating device to a given command. The Fault tree analysis is made to find the unreliability (failure probability) in the control command generation process.

The system unavailability increase risk level. Let us consider that $R_1$ represent enlarged value of risk measure in Core Damage Frequency (CDF) when component is not performing its function. $R_0$ is the reduced CDF when component is in operation (means component available). In terms of $R_1$ and $R_0$ the increase $\Delta R$ in risk level associated with the Allowed Outage Time (AOT) then:

$$\Delta R = R_1 - R_0$$

Using the above expression, Allowed Outage Time can be calculated as below:

$$r = \text{Allowed Outage Time single-event}$$

$$= (R_1 - R_0) \times d$$

And

$$R_y = \text{AOT risk calculated on annul basis}$$

$$= f \cdot r$$

$$= f \cdot (R_1 - R_0) \times d$$

$R_1$ and $R_0$ obtained from PSA data.

4. ORMS Graphical Interface

The graphical interface of ORMS enables a user to calculate and update data within a few minutes. The login screen is shown in figure 5.
After providing user name and password the main page of ORMS open as shown in figure 6.

Now at this stage if user wants to calculate operational failure rate than after assign the values of number of failures and number of demands, RDUM-1 will provide required results and if it is needed to update running time than RDUM-2 execute updating process, these steps are shown in figure 7.
5. Conclusion
To achieve safety standards the utilization of risk monitors in decision making process seems obvious. In this paper Online Risk Monitor System (ORMS) has been developed to measure qualitative and quantitative aspects of data. Five modules of ORMS has been explain which are capable of updating Reliability data base, LPSA model and risk model calculation. With the help of ORMS the operator can update PSA model to online risk monitor model. In literature limited data is available for LPSA, so presented work also provide a useful guide line for new researcher to understand the concept of LPSA and risk monitoring.
References

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