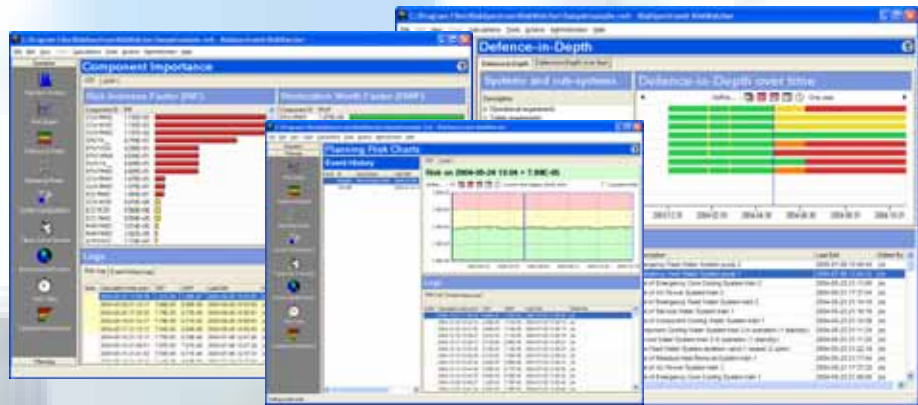


## RiskSpectrum Users Group Meeting, UK 2007



**Risk Monitor Status and Experience World-Wide**  
**Johan Sörman, Relcon Scandpower**  
**Sweden**

## Risk Monitor Defined by IAEA

- ***A plant specific real-time analysis tool used to determine the instantaneous risk based on the actual status of systems and components.***
- ***At any given time, the Risk Monitor reflects the current plant configuration in terms of the known status of the various systems and/or components.***
- ***The Risk Monitor is based on, and is consistent with, the Living PSA. It is updated with the same frequency as the Living PSA.***
- ***The Risk Monitor is used by plant staff in support of operational decisions***

## Risk Monitor Benefits

- **Manage plant operational safety**
- **Support scheduling activities**
- **Achieve greater flexibility in plant operations**
- **Provide justifications for carrying out maintenance on-line**
- **Provide information on the risk importance of components that are in service as well as out of service**

## How are Risk Monitors Used Today?

### **On-Line by control staff for:**

- Input of information
- Monitoring risk qualitatively and quantitatively
- Calculating Allowed Outage Time and cumulative risk

### **Off-line for planning:**

- Future maintenance outages
- Long term risk profiling
- Analysis of cumulative risk
- Evaluation of unplanned events
- Feedback – lessons learnt

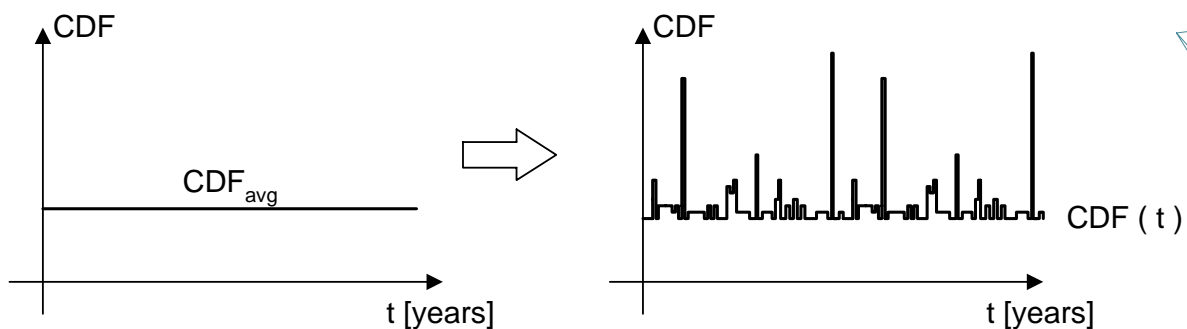
## How are Risk Monitors Used Today (cont)?

### Provides...

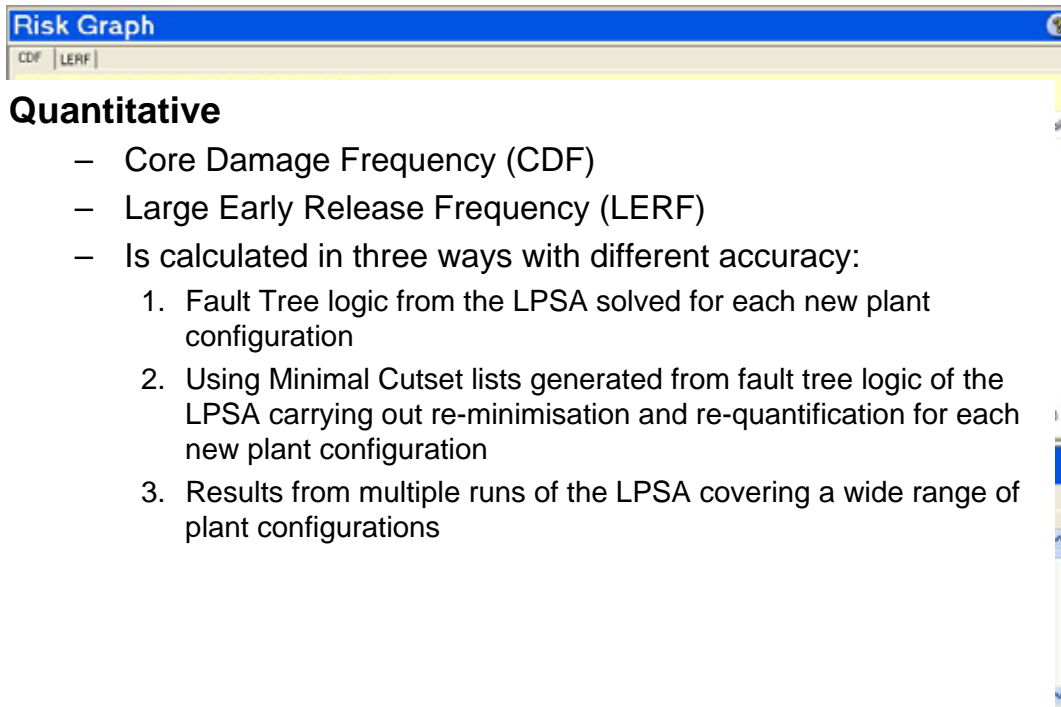
- information about which components should be returned to service prior to taking others out of service and which components are the most important ones during maintenance outages
- input into whether more maintenance can be carried out on-line without increasing the overall risk
- input into maintenance planning – avoid peaks in risk

## Risk Monitor Model vs PSA Model

- Risk monitor provide point-in-time risk,  $CDF(t)$ , for the current plant configuration and environmental factors
- PSA provides average risk,  $CDF_{avg}$ , using average initiating event frequencies and maintenance unavailabilities



## Risk Monitor Output



### Quantitative

- Core Damage Frequency (CDF)
- Large Early Release Frequency (LERF)
- Is calculated in three ways with different accuracy:
  1. Fault Tree logic from the LPSA solved for each new plant configuration
  2. Using Minimal Cutset lists generated from fault tree logic of the LPSA carrying out re-minimisation and re-quantification for each new plant configuration
  3. Results from multiple runs of the LPSA covering a wide range of plant configurations

## Risk Monitor Output



### Qualitative

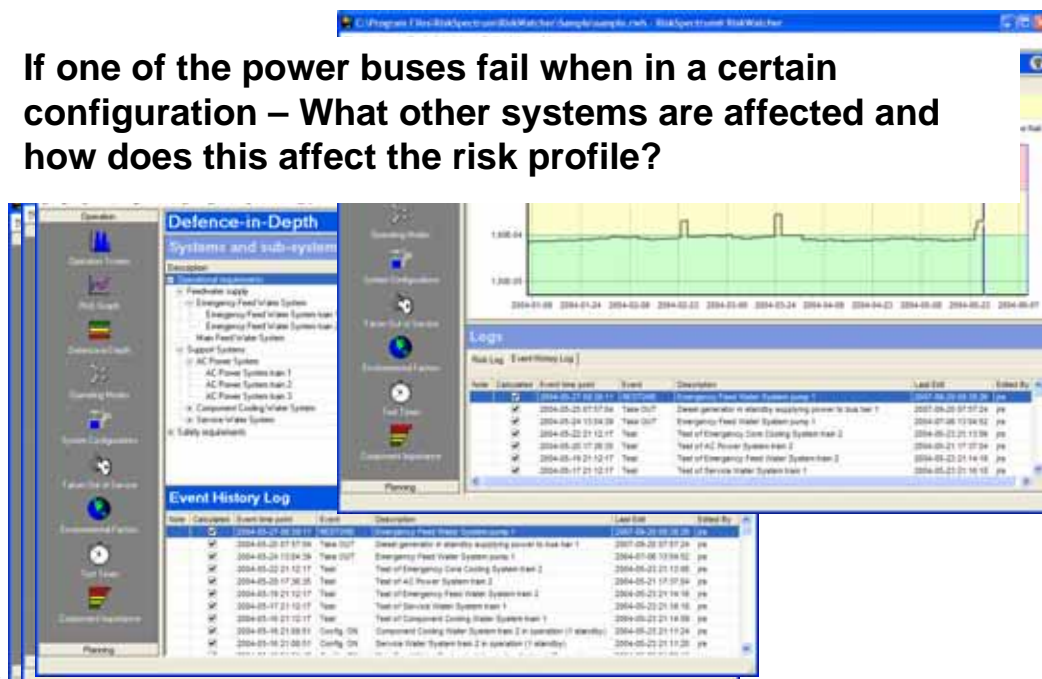
- Indicate the level of availability of safety systems
- Green, yellow, orange and red
- Evaluated using fault tree logic

## Quantitative vs Qualitative Results

- **Complement each other:**
  - When the qualitative risk measure indicate a degraded condition of a system, the quantitative risk measure may still be in the lower or moderate risk band
  - Removes concerns related to uncertainties in CDF and LERF
- **Current good practise is to use the quantitative and qualitative risk information together as part of an integrated risk-informed decision making process**

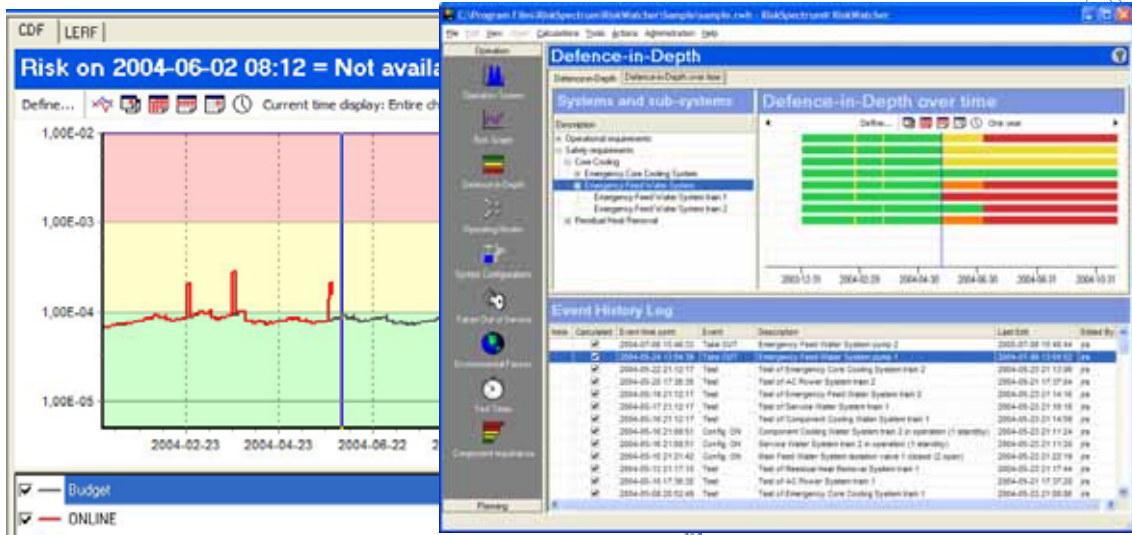
## Ex. What-If analyses

- **If one of the power buses fail when in a certain configuration – What other systems are affected and how does this affect the risk profile?**



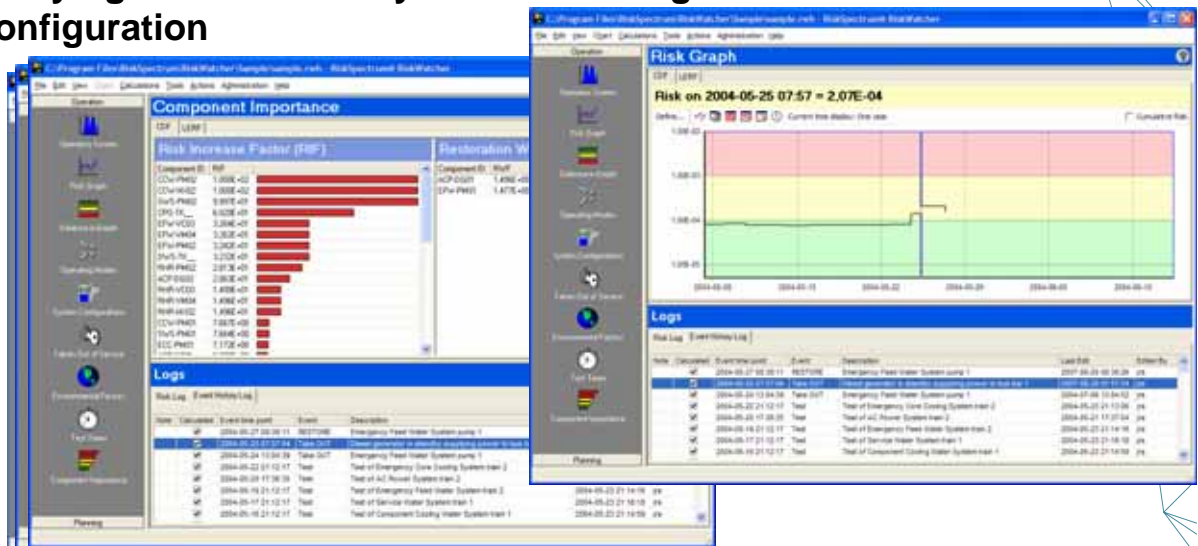
## Ex. What-If analyses

- Evaluate planned activities with regard to risk. Compare with alternative options



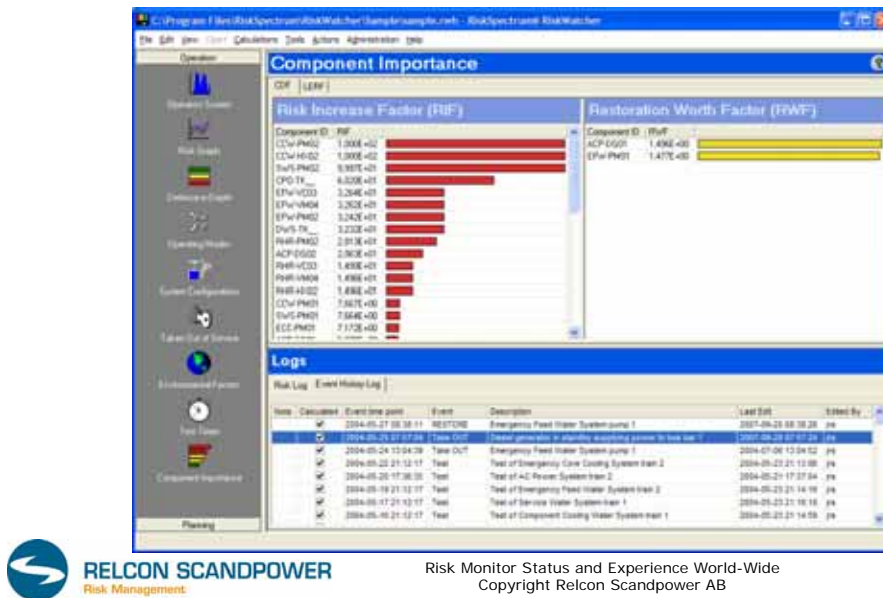
## Ex. Component Importance

- ◆ Before entering a different configuration you may want to investigate how the risk profile will change and if there are any specific components that needs verifying their availability before entering that configuration



## Ex. Component Importance

- ◆ Which components should you restore to service prior to taking others out of service?



## US Practice

### Regulatory Requirements: US Practice

- In the 1980s, the US NRC became concerned about the number of transients and scrams initiated as a result of problems with balance of plant systems and components
- The evaluation was initiated whether a some kind of “maintenance rule” was necessary
- As a result of NRC staff activities, in particular the maintenance team inspections, the NRC decided that the need for such a rule existed

## US Practice

- **This determination rested primarily on the following conclusions:**
  - Proper maintenance is essential to plant safety;
  - There is a clear link between effective maintenance and safety as it relates to such factors as:
    - the number of transients and challenges to safety systems, and
    - the associated need for operability, availability and reliability of safety equipment

## US Practice

### **Maintenance Rule 10 CFR 50.65 a(4):**

- “Before performing maintenance activities (including but not limited to surveillance, post-maintenance testing, corrective and preventive maintenance), the licensee shall assess and manage the increase in risk that may result from the proposed maintenance activities”



## US Practice

- To address the requirements of the “Maintenance Rule” most US plants installed RM in the 90:ies to assess and manage risk associated with maintenance activities
- Due to the wide variety of benefits associated with using a RM, plants in other countries have installed RM tools

## Experiences from Risk Monitor Use in the USA

- **The successful implementation of a Risk Monitor is dependent on:**
  - Support from top management at plant
  - Guidance in terms of safety goals or regulatory framework in which to make decisions
  - Understanding that application of risk information does not give away safety margins
  - Make results from the Risk Monitor part of discussions on risk status in e.g. the morning status reports

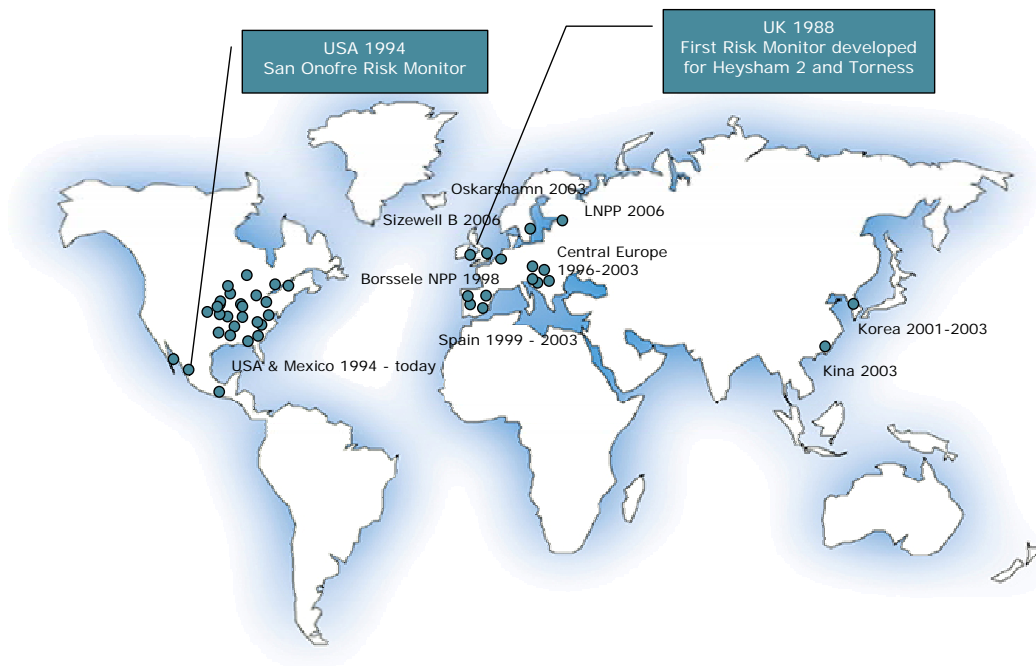
## Experiences from Risk Monitor Use in the USA

- **The use of risk informed approaches allows both regulator and the industry to focus on important safety issues**
- **INPO Performance Indicator Index from 1995 to 2004 for US plants show that plants with risk informed decision making activities have increased profitability with no degradation in safety compared to other plants**
- **The transition to risk-informed regulation requires a “culture change” by both regulators and utilities**

## Risk Monitor Use in Europe

- **For many years the risk informed approach supported by PSA models (via risk monitor) was, and is still in many countries in Western Europe, not accepted. The PSA models were considered not detailed enough. Today however...**
- **Utilities and authorities in Spain, UK, Netherlands, Czeck Rep., Slovakia, Slovenia and Hungary have embraced the risk-informed decision making way of working and RM are installed**

## Risk Monitor Use World-Wide



## Costs

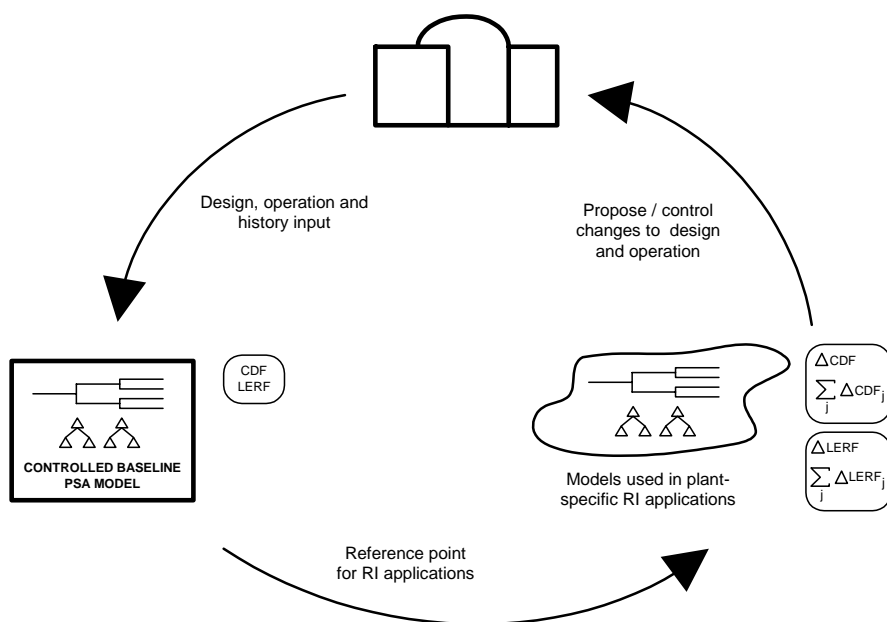
- **Studies [1, 2] show that the benefits from the Risk Monitor arising from the increase in revenue from the plant exceed that of the costs involved in implementing Risk Monitor**
- **Main contributors to this positive effect:**
  - The Risk Monitor provide the justification for carrying out maintenance when the reactor is at power
  - Questions are focused on more overall plant safety and vulnerability than they are on straight compliance to regulations
  - Facilitates license renewal application, power upgrades, increasing allowed outage times for equipment maintenance and repair, control room redesign, event safety evaluations, discussions with regulators, etc.

1. *Risk Monitors*, Charles Shepherd, IAEA and OECD WGRisk 2004
2. *The Nuclear Industry's transition to risk-informed regulation and operations in the United States*, Andrew C. Kadak, et. al. 2006

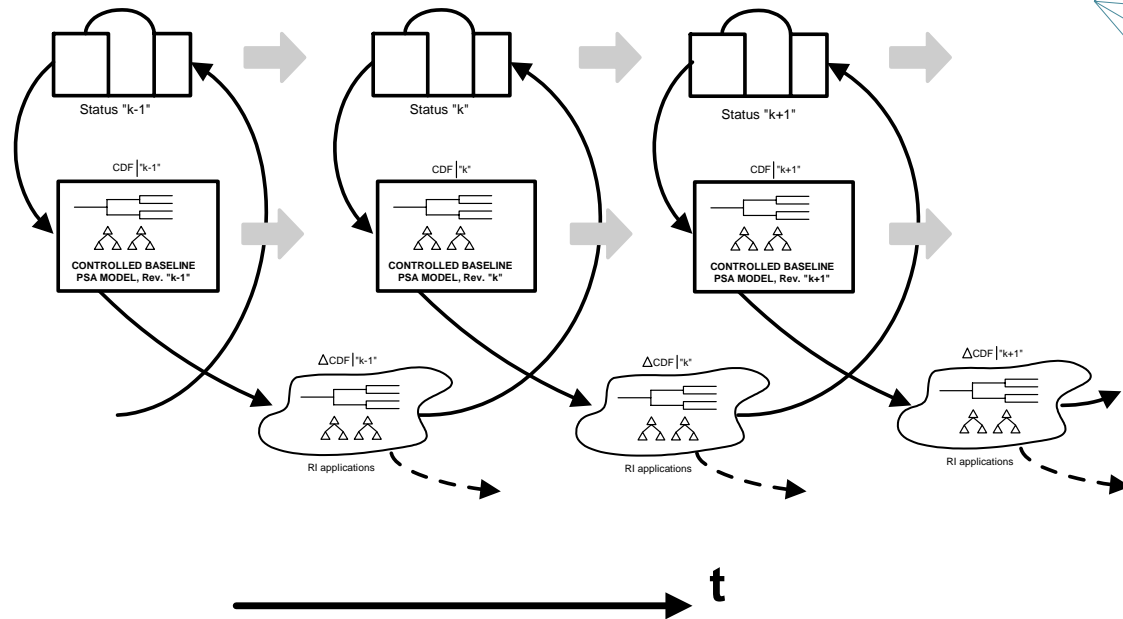
## Findings Sizewell B, UK

- Run-times using RiskSpectrum RiskWatcher are reduced by ~90% compared to running the PSA model in RiskSpectrum PSA Professional
- Accuracy of quantification is consistent, whether done within RiskSpectrum RiskWatcher or RiskSpectrum PSA Professional
- RiskSpectrum RiskWatcher run-times are significantly affected by component removals / re-instatements to service

## Managing Living PSA and Risk Monitor Models



## Managing Living PSA and Risk Monitor Models



## To Consider in the Future

- **Speeding up analyses with pre-solved master MCS list and merge, BDD, etc**
- **System out of Service**
- **Post-Processed analyses**
- **System and Test Procedure Importance (Test Worth)**
- **Test optimisation tool**
- **Fussel Vesely (FV)**

## Conclusions

- **Risk Monitors are definitely here to stay as it is the natural step for establishing a wider use of the PSA**
- **The use of risk informed approaches allows both regulator and the industry to focus on important safety issues**
- **Experience show that the benefits from the Risk Monitor arising from the increase in revenue from the plant exceed that of the costs involved in implementing and maintaining Risk Monitor**

