CRA
risk analysis

Tech Spec Optimisation at Torness Nuclear Plant

Garth Rowlands, Consultant at CRA

PSAM 2019 Dec 2019.

CRA
risk analysis

QUALITY
LEADERSHIP
INTEGRITY

What will we talk about today?

Content

- This presentation will provide a practical example of the application of risk informed approaches to improve operations at a nuclear power station using the PSA.
- It will describe the processes followed and explain some of the issues faced along the way (e.g. interpreting the results) and how they were overcome.

Background

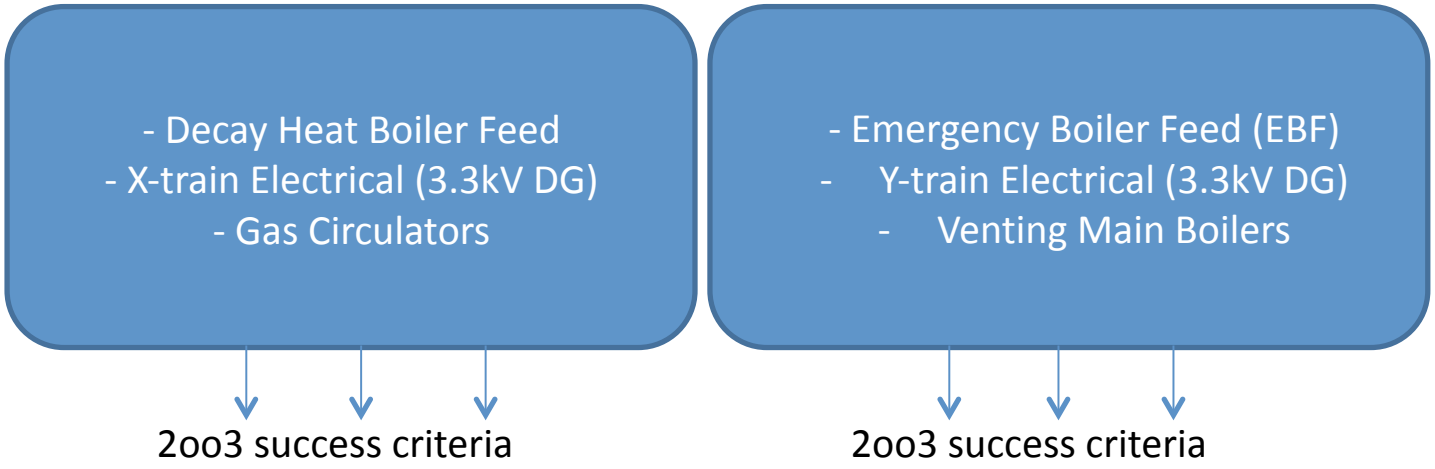
Technical Specifications

- Technical Specifications are used at AGR nuclear power stations to control the level of equipment unavailability during normal operation.
- Historically, at Torness Nuclear Power Station, there have been high numbers of unplanned Technical Specification entries due to faults on the Post-Trip Sequence Equipment (PTSE). The PTSE is a logic based system which automatically starts equipment required to ensure sufficient cooling is achieved post reactor trip.
- These entries have occurred due to a very conservative definition of operability of the PTSE in the Technical Specifications.

Background

PTSE

- PTSE at Torness is split into two independent trains (X & Y)
- Each train is divided into functions which send the 'start' signals to groups of related equipment. Furthermore, each function is divided into the four branches (referred to as quadrants) of the primary cooling circuit (A, B, C and D)
- Each quadrant function sends the signal via three channels (A, B, C).
- Two of the three channels are required to operate.



Background

Current procedure after loss of single PTSE channel

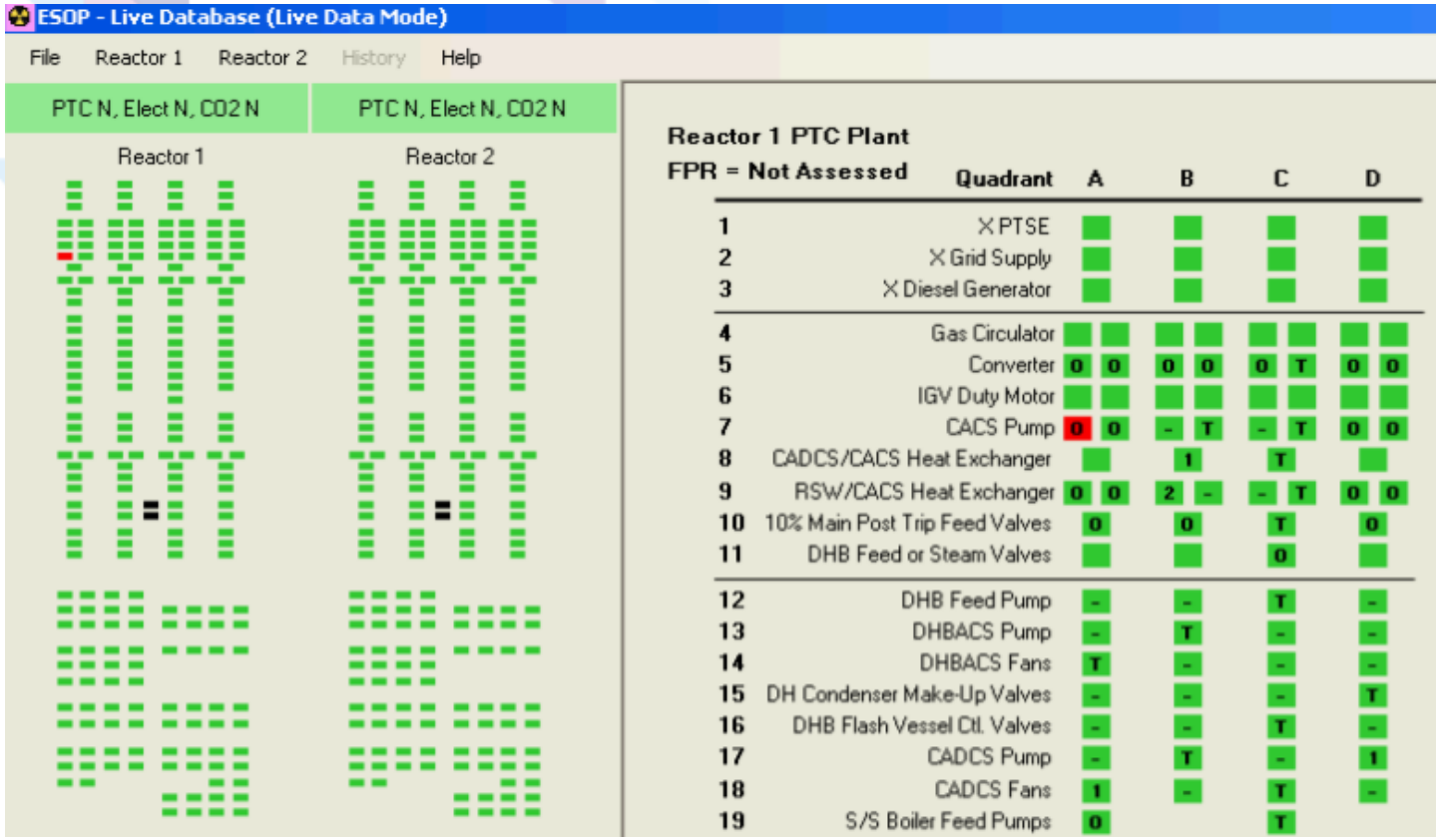
- The Technical Specifications stated that 'If any channel of PTSE is unavailable for a section of the PTSE, then that section of the PTSE is considered to be inoperable'.
- Therefore if any (one) channel of PTSE is unavailable the operator must assume that the entire section (referred to as a function throughout this presentation) in that quadrant is unavailable.
- Availability of the channel must be restored within three hours and if it cannot be restored within this time the Post-Trip Cooling (PTC) equipment associated with the PTSE function in that quadrant is considered to be inoperable and the operators need to consult Tech Specs and the station risk monitor (ESOP) to determine the appropriate follow-on actions.
- This practise is overly restrictive given that each PTSE function can fulfil its safety function with two out of the three channels operational.

Background

Risk Monitor – ESOP (Essential System Outage Program)

- Custom interface developed in UK for Risk Spectrum.
- Used to inform time limits for continued operation (Action Completion Times).
- ESOP calculates ‘Full Plant Ratio’ (FPR). This is the factor by which the station risk has increased compared to the value with all plant available. It is similar to the Risk Increase Factor (RIF) calculated by Risk Spectrum.

ESOP Interface Screenshot



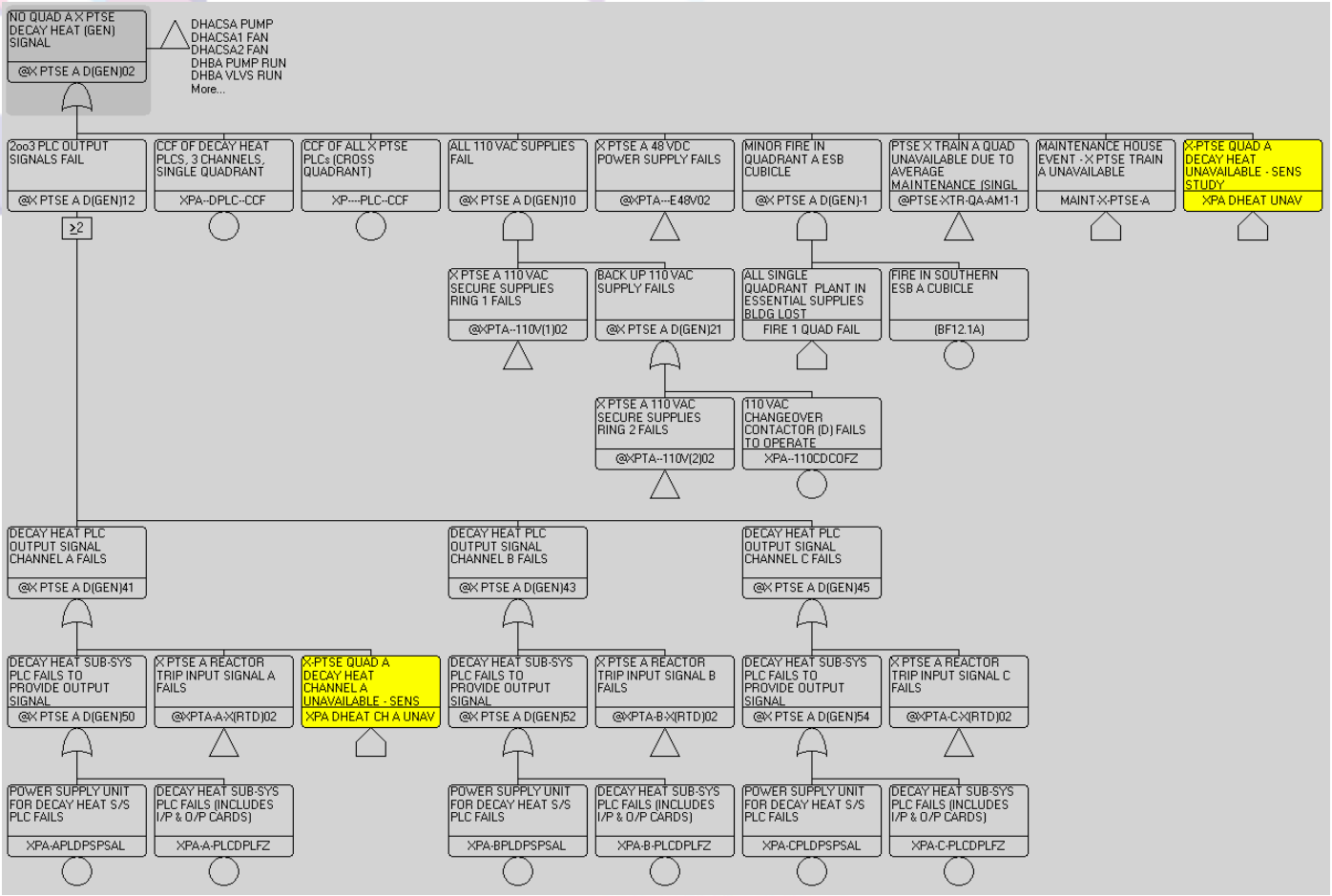
Sensitivity Study

Effect of changing PTSE inoperability definition

- Study was performed to determine the potential impact on risk (the frequency of a large radioactive release) of changing the PTSE inoperability definition.
- House Events (HEs) were added to the Fault Trees (FTs) representing failure of each of the PTSE functions in each quadrant.
  - One HE to discount a single channel in each of the PTSE functions in each quadrant.
  - One HE to discount the entire PTSE function in each quadrant.

Sensitivity Study

Effect of changing PTSE inoperability definition



Sensitivity Study

Effect of changing PTSE inoperability definition

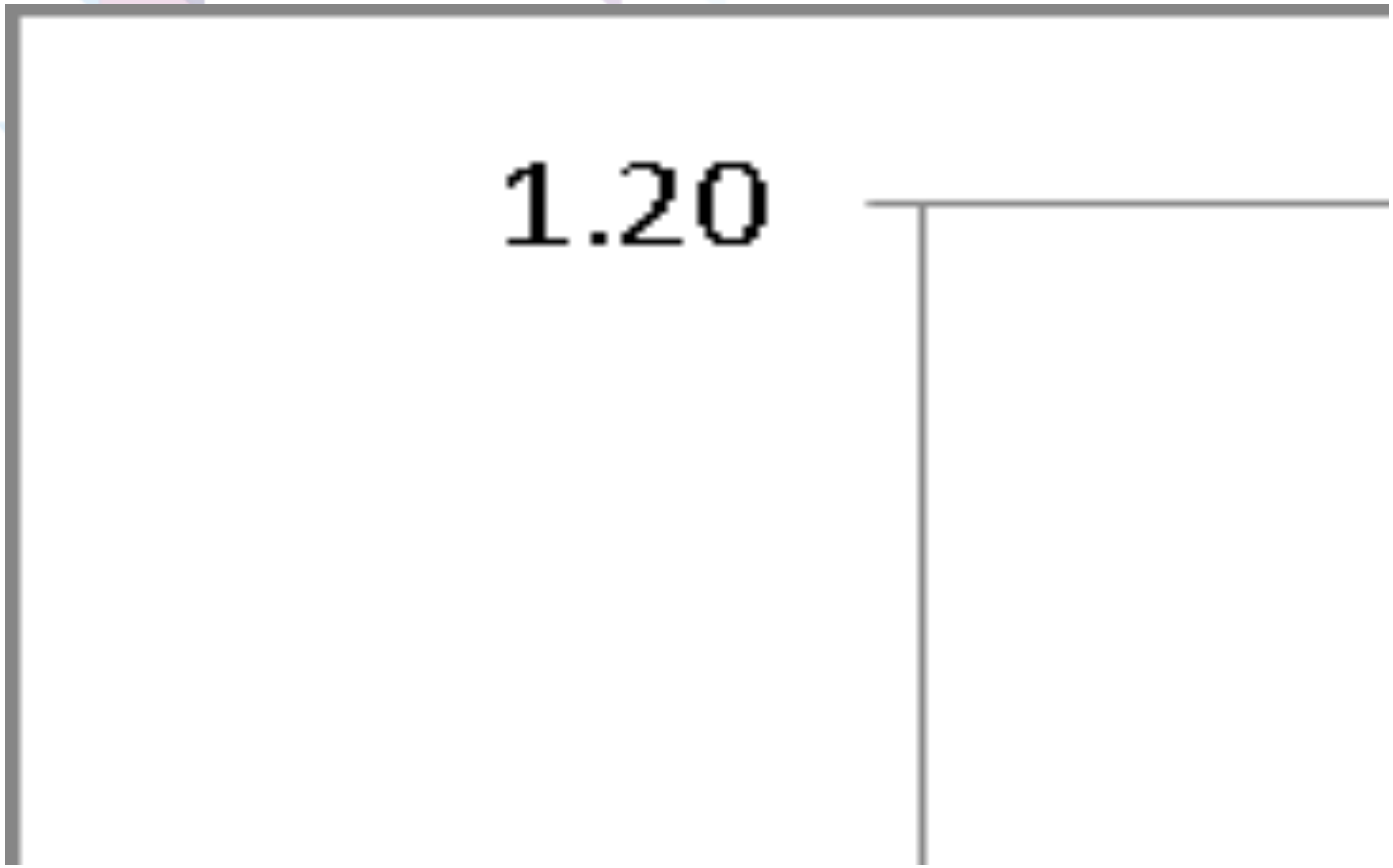
- The risk frequency was determined with Channel A set unavailable for each of the X-PTSE and each of the Y-PTSE functions in:
  - Individual quadrants;
  - All quadrants together (extremely conservative).
- The risk frequency was also determined with Channel A set unavailable for ALL of the X-PTSE or ALL of the Y-PTSE functions.
- The results are compared to the risk frequency where the entire PTSE function in a quadrant is set unavailable (current Tech Spec operability definition).

Results

- The results show that there is a very small (if any) increase in risk frequency when Channel A is unavailable in any single quadrant for any of the PTSE functions (the maximum observed FPR is 1.016, indicating a less than 2% increase in risk frequency).
- Even if Channel A is made unavailable in all quadrants of each PTSE function, the maximum observed FPR is only 1.065.
- If Channel A is made unavailable in all PTSE functions in each quadrant, the observed FPR is 1.04.
- Where entire quadrant is unavailable for a function of X- or Y-PTSE, and all other plant is available, the maximum risk frequency increase is approximately 120%.
- Note that these values are based on unavailability over a full year. In practice increase to annualised risk will be much smaller.

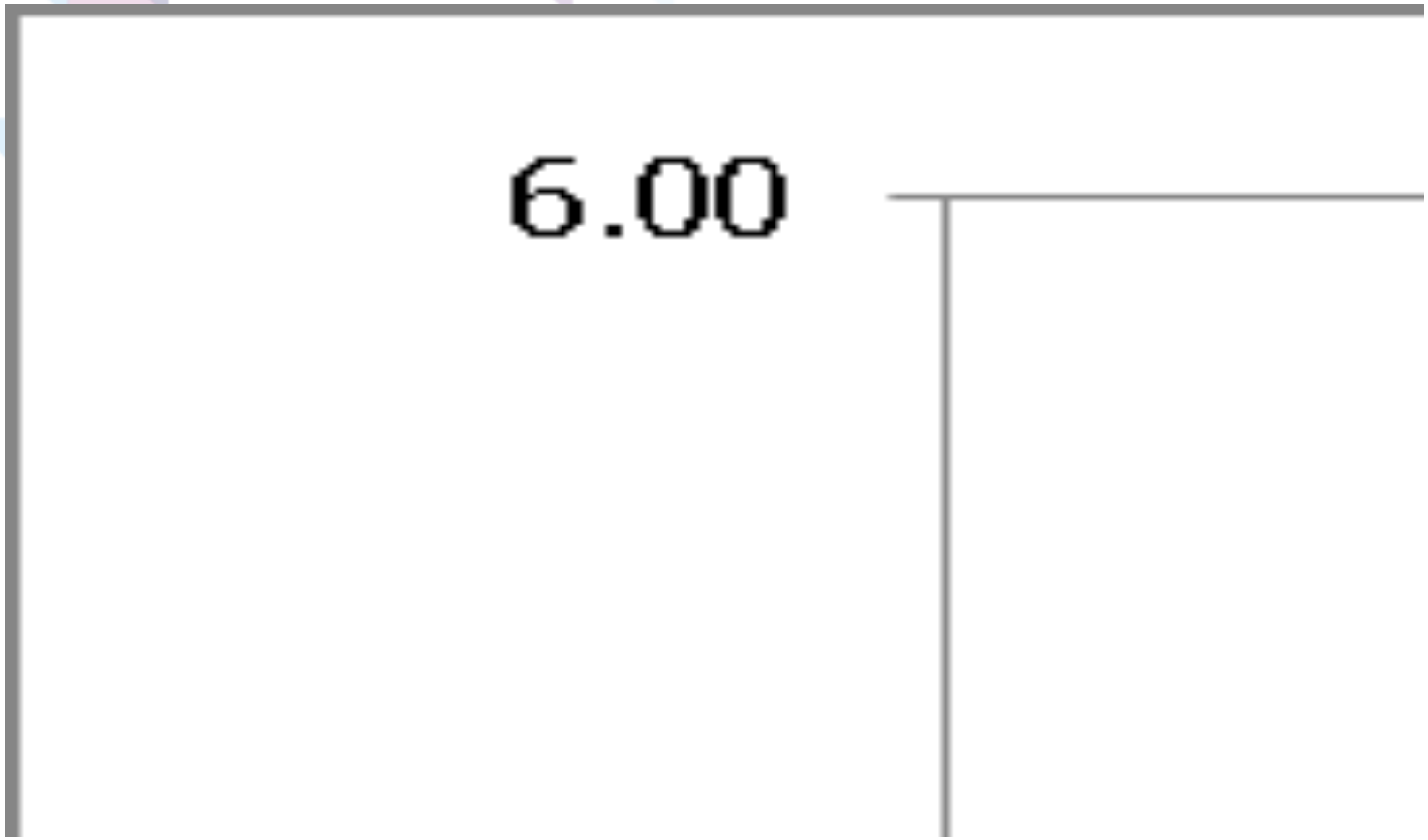
Results

FPR with a single PTSE channel (Channel A) made unavailable for each PTSE function (individual quadrants/ all quadrants)



Results

FPR results with all three PTSE channels made unavailable for each PTSE function (individual quadrants)



Results

'Typical' Maintenance states

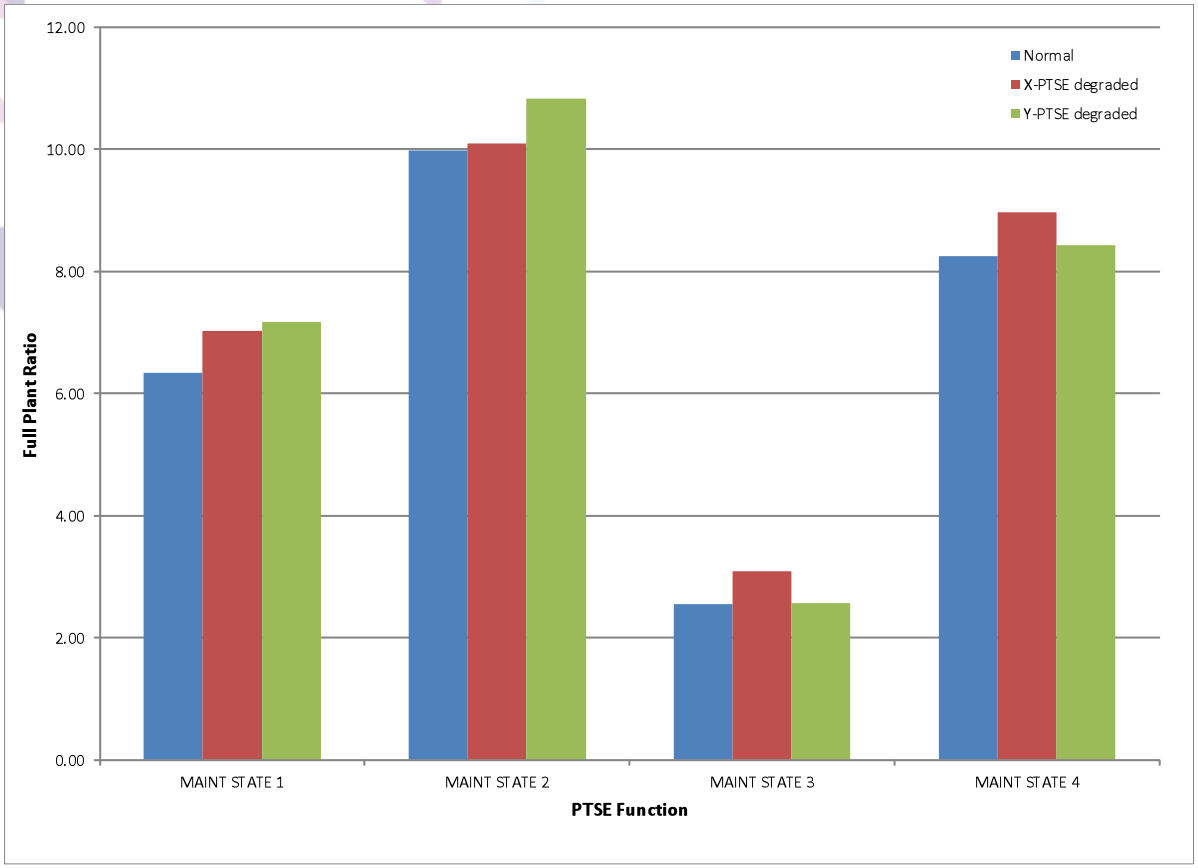
- PSA results are also routinely produced for four representative maintenance states. These are used to assess the potential impact of modelling changes on maintenance case results. For example:

Equipment on maintenance	ESOP Maintenance HEs (set to True)
X-train Diesel Generator in Quadrant D	MAINT-3KDG--DX
Converter in Quadrant B2	MAINT-GCVFC-B2
Y-train PTSE in Quadrant C	MAINT-Y-PTSE-C
Auxiliary Boiler 4	MAINT-AUXBLR-4
110V UPS Supplies in Y Train Quadrant C	MAINT-1UEIN1CY

- Results show only modest changes in FPRs in the cases where the X/Y-PTSE has been degraded. X PTSE for Maintenance State 3 shows the largest increase in FPR at 21.5%.

Results

FPR results for Maintenance Cases



Conclusions

Effect on FPR

- Risk frequency increase where a single channels is unavailable, is less than 2%. This very small increase in risk is understandable given that 2oo3 channels are required per quadrant
- Where all three channels are unavailable in one quadrant, and all other plant is available, the maximum risk frequency increase is approximately 120%.
- Hence the current practise of assuming a function of PTSE in a quadrant is unavailable when one channel is made unavailable greatly over-estimates the increase in risk.
- For the Maintenance States, only relatively modest FPR increases were observed.

Changes implemented

Procedure updated

- The Tech Spec operability requirement has been redefined, supported by the PSA analysis results, but also taking into account PTSE reliability improvements and operational history.
- If a single channel is unavailable on a PTSE function, the operators now have 72 hours instead of three hours to address the fault.
- This allows for investigation and repair of the inoperable channel of the PTSE logic system, giving greater operational flexibility and reducing the risk of unnecessary reactor trips.
- The effects of new procedure will continue to be monitored during operation.

CRA
risk analysis

CRA is a diverse, specialist risk analysis consultancy employing a multi-disciplined team to service the requirements of the safety and mission critical industries.

crarisk.com